Teaching Ecological Sanitation in Schools

A compilation of manuals and fact sheets
(March 2010 edition)

Peter Morgan and Annie Shangwa

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Teaching Ecological Sanitation in Schools

Demonstrating the effect of urine on vegetables and maize in small "ring beam" gardens

Peter Morgan and Annie Shangwa

Demonstrating the effect of urine on vegetables and maize

Urine is always disposed of and never used, but in fact it is a very valuable source of nitrogen and other minerals which plants can use to increase their growth. Urine, when diluted with water can have a dramatic effect on the growth of many green vegetables, maize, trees and other useful plants. Because no one believes this, it makes sense to demonstrate the effect of urine treatment of plants at the school.

The method

The aim of this school experiment is to show the pupils, teachers and visitors that urine can be used as a fertilizer for green vegetables, maize and trees. A section of the school garden is chosen for the trials, cleared of other plants and levelled off. The experiment is performed in a series of miniature gardens called ring beam gardens. These are small gardens enclosed in a ring of bricks. This defines the area of the garden and special amounts of urine can be added. It is an experiment. In real life people are more likely to grow vegetables in specially prepared vegetable gardens.

Preparing the ring beam gardens

Bricks were taken and arranged in four rows, each with three ring beams. A total of 12 ring beams were made in this experiment.

The trainer, Mrs Annie Shangwa talks to the pupils to describe the experiment they are about to perform to show the effect of urine on plants.

Plants chosen

Rape, spinach, maize and banana were chosen for this first experiment. Seedlings of rape, spinach and maize were found and also 3 small banana plants.

Different treatments

For each plant (rape, spinach, maize and banana) there were three ring beams. In the first the natural soil was used. This was very poor soil and maize planted in it during the rainy season grew very poorly. In the second ring beam diluted urine was added. In the third ring beam some of the natural soil was removed from inside the ring beam and replaced by toilet compost. Also to this third ring beam diluted urine was added. So for each type of plant the treatment was as follows:

1. **Treatment 1** watering only on natural soil
2. **Treatment 2.** Application of diluted urine twice a week. For each ring beam treated in this way 800mls of urine was diluted with 2400litres of water (3:1) and added to the garden. This was measured uring a jam jar of capacity 400mls.
3. **Treatment 3**. This was the same urine treatment as treatment 2. But toilet compost had been added to the natural poor soil.

The urine was collected in 2 litre empty milk bottles. Schoolboys were asked to go to their existing toilet and provide the urine. This was done at the request of the trainer and the teacher and the boys collected the urine quite happily. In the home urine can be collected in various ways. Urine can be collected in potties, for girls and women and in containers for men. Also a funnel fitted in the cap of a plastic container can be used in a private place in the garden. This is called a “desert lily” or “eco-lily.”


Urine was collected from the boys in bottles. The soil within each ring beam is loosened up.


In one series of ring beams six buckets of natural soil were removed from inside the ring beam. Half of this was replaced together with 3 buckets of compost.


The soil in each ring beam was loosened and levelled off and then the seedlings were planted. Approximately the same number of seedlings were planted in each ring beam for each plant.

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The arrangements of maize plants (left) and spinach, maize ands banana (right).


Preparation of the diluted urine, first by the trainer, then by the pupils. A 400mls jam jar was used. This mixture added to urine treated ring beams was 800mls of urine to 2400mls of water. This was applied with a bucket and spread over the soil in each ring beam between plants.


The diluted urine was applied twice a week (Mondays and Fridays) to each treated ring beam. Water was applied to untreated ring beams. On other days all the ring beams were watered to keep the plants healthy.

The watering of all plants continued regularly with urine treatment twice a week. The seedlings and small bananas were planted on 31st January 2008 and the rape and spinach were cropped on 5th March, 5 weeks later.

The results were as follows (shown as average weight of plant in grams and number of plants in brackets)

Plant	no urine	urine only	urine plus compost
Rape	**15.125 (24)**	**103.88 (18)**	**121.90 (21)**
Spinach	**42.22 (9)**	**165.45 (11)**	**135 (12)**

Thus the urine treatment alone increased the weight of rape by 6.8 times and of spinach by 3.91 times. The treatment with urine and compost increased the weight of rape by 8 times and of spinach by 3.19 times. It is not known why the increase in weight of spinach was less with both urine and compost treatment. However the results are clear enough. The application of urine to green vegetables like rape and spinach is very considerable and was very noticeable in the experiment. The same applied to the effect on maize.

The untreated and urine treated plants. In each case for rape, spinach and maize the effect is very noticeable.

Rape growing on natural soil in Chisungu school. On the left watered only, on the right treated with diluted urine.

Spinach growing on natural soil in Chisungu school. On the left watered only, on the right treated with diluted urine.

The effect on maize was also very dramatic as these photos show. The effects of urine alone was very significant, but the combined effect of compost and urine even more so. The experiment impressed everybody!

Miniature experiments showing effect of urine

Plants like maize and spinach respond very well to urine and can be used to show the effect of urine on plant growth very well. The experiments can be shown in small pots, 10 litre buckets, ring beam gardens and vegetable beds.


Experiment in small pots. Here a single maize plant has been grown in each small pot filled with garden topsoil. Diluted urine has been added to the two pots on the left almost daily. Only water on the right. The effect of the urine application is striking and valuable as a training aid.


In this experiment a single maize plant has been placed in a bucket of road sand and another with a 50/50 mix of road sand and toilet compost. A 3:1 water urine mix has been added to each bucket twice a week. The difference in growth is very significant. This demonstration shows the effect of the humus like soil in conve rting the nitrogen in urine (which cannot be used by plants) into a nitrate nitrogen which can be used by plants. Special bacteria (nitrifying bacteria) in the soil change the urine nitrogen into nitrate nitrogen. The road sand has few of these bacteria but when compost is mixed with the poor sand the bacteria are present in the soil and can thus convert the nitrogen into a form which can be taken up by plants. In other buckets the maize is planted in a mix of soil and road sand in which no urine is added. In this case the growth is increased compared to the road sand alone, but not as great as when urine is added. The urine contains much nitrogen, which when converted has a significant effect on the growth of maize and many green vegetables.

Teaching Ecological Sanitation in Schools

Gardens trials with urine on vegetables grown in buckets, basins, ring beam gardens and vegetable beds

Peter Morgan and Annie Shangwa

Garden trials with urine on vegetables grown in buckets, basins, ring beam gardens and vegetable beds.

Before an outreach programme can begin it is important to test for the effect of urine and toilet compost on valuable food plants at the school. This can be done as a series of simple but very important experiments on a small scale before the larger scale use of them method is implemented. In this way the teachers and pupils can get an idea as to how effective the urine treatment is on a variety of plants. Urine treatment is known to have a positive effect on most green vegetables like spinach, cabbage, rape, covo and tsunga, and also onion, tomato, beans and maize. It also helps the growth of valuable plants like lemon geranium, which is mosquito repellent and

Ways of testing for the effectiveness of urine in buckets and basins.

The simplest way is to start promoting the use of urine on a small scale by using 10 litre buckets or basins (even those made of cement, using the basin as a mould). Two buckets or basins can be chosen for each selected plant. The same type of soil is placed into both and then the urine application can start with one of the two basins, with the second basin being treated with water only. It is best to plant the seedlings in both basins or buckets and then keep them well watered before urine treatment begins. A week is normally enough, so that the young plants can establish themselves in the soil. If urine is applied too early it may slow down or even kill the young seedlings.

The urine should first be diluted with water, 3 parts water to 1 part urine. A convenient measure is a plastic jam jar of 400mls capacity. This is diluted with 1200mls water (3 jam jars). Each 10 litre basin or bucket should receive 400mls of diluted urine, three times a week with water being applied regularly to keep the plants healthy.

Several examples of the effect of urine


Onion – treated and untreated after about 2 months.
Many trees respond well to urine treatment like mulberry, gum and banana.


Maize responds exceptionally well to urine treatment. The extent of maize growth is related to the dose of urine. Also pumpkin responds well.


Cabbage treated with urine after 2 months (urine treated 9X the weight).
Spinach also responds well to urine treatment. The leaves can be cropped as the plants grow, particularly for spinach.

Ways of testing for the effectiveness of urine in ring beam gardens.

These are small, round gardens and were used in the preliminary trials at the Chisungu school with rape, spinach and maize. They are useful because the can be easily cared for and treated with diluted urine. The seedlings are planted and watered for a week before urine treatment. The dose of urine for a 1m diameter ring beam garden is about 3 litres of 3:1, three times a week. In practice two 400mls jam jars full of urine are added to a bucket or small watering can and six jam jars of water are added to make up the 3:1 mix. This is applied to the soil within the ring beam garden three times a week. The garden is also watered at other times.


Green beans in ring beam garden


Mixed crop in ring beam garden: cabbage, tomato and garlic in a single ring beam garden. To enhance the crop of tomato, comfrey liquid feed has also been added (see section)

Spinach


Spinach crop (over a 12 month period 26kg of spinach was cropped from a small 1m diameter ring beam garden using urine treatment. On the right spinach has been planted in 2 ring beams in which very poor soil was placed. Urine treated spinach yielded 7 times the crop compared to spinach that was watered only.

COVO


Covo plants also responded very positively to urine treatment when planted on very poor soil. In this case production within the ring beam was increased by 5 times as a result of the urine treatment. Signs of nutrient deficiency can be seen in the leaves of plants.

Ways of testing for the effectiveness of urine in vegetable beds

In this case a part of a vegetable bed (a new bed or an existing bed) is chosen and dug and prepared for the trial. Ideally the treated section and the untreated section should be the same size, but this is not essential. The seedlings are planted and watered for a week before urine treatment. The amount of diluted urine applied depends on the area of the bed and the number of plants. For an experimental bed about one metre square, the same amount of diluted urine is applied as in the ring beam. That is about 3 litres of diluted urine (3:1) three times a week (Mondays, Wednesdays and Fridays).

RAPE

Rape, before and after urine treatment in two beds. The treated bed was about 1 square metre in area. After about 4 weeks the average weight of each rape plant had increased by four times (45gms treated, 11gms untreated) as a result of urine treatment. Treated section nearest camera.

Untreated rap show signs of nutrient deficiency. Pale green leaves reveal lack of nitrogen. Mauve leaves reveal lack of potassium.

RAPE

Rape at second cropping after a further 6 weeks. After the first cropping the plants continued to be treated in the same way (about 3litres of 3:1, three times a week). In this case the average weight of treated plants was about 7.5 times that of untreated plants.

TSUNGA

A bed of tsunga was planted around 18th June and divided into treated and untreated sections. The treated zone was about 2 square metres in area. the first cropping was made on 21st July, about 4.5 weeks later. At first about 3 litres of 3:1 water and urine was applied, three times a week to the treated area. After the second week this was increased to 6 litres, three times a week. Each plant was weighed at cropping. The urine treatment increased the average weight of each plant by 3.6 times (treated 47.15gms, untreated 13.63gms).

The tsunga bed early in in the trial and on the day of first cropping 4.5 weeks later. The untreated section is on the left hand side of the bed. The average increase in weight of plants was 3.6 times.

Increasing the output of vegetables in beds using diluted urine at the school

We have already seen that diluted urine can have a remarkable effect at increasing vegetable production in ring beam gardens at the school. The next stage is to test the same principles in larger vegetables beds in the garden.

The earliest trials were undertaken with spinach and rape, both of which respond very well to urine treatment. The beds were prepared and rape and spinach seedlings planted.

Planting spinach seedlings on March 25th 2009

By April 14th differences were appearing between urine fed and water fed plants. On left the water fed plants were lighter in colour than the urine fed plants in the background. On right photo, the urine fed plants are growing at the same rate as the commercially fed plants o the right.

Watering the spinach with dilute urine and water.

By May 8th 2009, the urine fed plants are larger and greener than the water fed plants (left photo) and also compared to commercial fertilised plants.

The plants on left photo show urine fed spinach (left) and plants fed with commercial fertiliser (right). Right photo – the plants are cropped on May 8th. The plants were fed 2li of urine diluted with 8 litres of water in a watering can twice a week. The technique is simple and effective.

Teaching Ecological Sanitation in Schools

Increasing the yield of maize on poor soils using urine and toilet compost as fertilisers

Peter Morgan and Annie Shangwa

Increasing the yield of maize on poor soils using urine and toilet compost as fertilisers

Maize is the single most important crop in Southern and Eastern Africa, being the staple diet for hundreds of millions of people living in the sub-region. And most of these people live on poor soil which is unable to provide sufficient nutrients for a full harvest of this precious crop. When manure is available it certainly helps to increase crop yields – but manure is commonly unavailable especially in the peri-urban and urban areas. Commercial fertilisers are normally vital to attain a good crop, but these are expensive and often scarce. Growing maize in back yard plots is a common way of growing food in the peri-urban and urban settlements of Zimbabwe and some surrounding countries. Small garden plots also surround homesteads in the rural areas.

In Zimbabwe maize takes about 4 months to grow, mature and produce cobs. Maize seed is normally planted in mid November, with the crop being harvested in late February or March. This period also coincides with the hottest time of the year when plant growth is at its greatest. Also the rains are best from December to February. However in recent years climate change may be having an effect on the reliability of the rains, and periods of below average rainfall are now interspersed with heavier rain.

Maize is a hungry feeder and nitrogen its main nutrient. Where commercial fertilisers are used an initial dose of "Compound D" is used (containing a mix of nitrogen, phosphorus and potassium) followed by ammonium nitrate – the best source of commercial nitrogen.

Earlier experiments carried out in Epworth revealed that urine is an excellent source of the nutrients for maize. Urine contains an abundance of nitrogen, but almost 100% of this is wasted and never

put to use. In an era when food is short and fertilisers both scarce and expensive, urine can become a valuable commodity to increase the yield of maize and also green vegetables and other valuable crops. This was demonstrated in the school garden in earlier experiments.

Previous work carried out in Epworth revealed that about one litre of urine was required by each plant during the growing season to attain good sized cobs and this amount has been used again on the trials described in this book in the school garden.

The strongest seedlings seem to grow when planted in rich soil or compost rather than poor soil. This leads to early vigour of the seedling and later to a healthier plant. So the best crops grow when the seed or seedlings are planted in a plug of good soil or compost rather than in the poor soil. Maize is always planted in the garden or the fields as seed, with often two seeds being planted in a single "planting station" in case one fails to germinate. So if the soil is poor it is best to plant the seed in a "plug" of compost – the amount being the same as can be contained in a pea tin (about 400mls). Compost derived from an ecological toilet like a *Fossa alterna*, or from the garden (leaf or garden compost) is ideal. The seed then germinates in a richer soil which adds vigour to the young plant.

Whilst it is not the normal method, there may be some sense in planting maize seed in richer soil held within seed trays and nurturing and artificially watering the young seedlings during the first two critical weeks of their life. This may overcome the probability of poor germination if the rains are poor at this crucial time. The seedling can then be planted in the "plug" of compost dug in each "planting station." Seeds are planted about 30cm apart in rows about 90cm apart. Whether the seedling grows from seed planted in the ground direct or from a transplanted seedling, the urine is applied weekly from the time the plant is about 5cm high. This will be about 2 to 3 weeks after planting seed.

The method of urine application may vary, but one of the best is to apply 125mls of a 50/50 mix of urine and water to each plant followed by a pea tin of water (400mls) once a week until the time when the first tiny cobs appear. Then the dose is doubled to 250mls of the 50/50 urine water mix followed also by the tin of water once a week. The additional water helps to push the diluted urine into the soil and under the surface after application. This reduces the loss of nitrogen from the urine. Using this method a full litre of urine can be applied per plant over most of the full life of the plant extending into the "grain filling" stage when the cobs are growing fast.

Urine can also be applied neat (125mls once a week) with the rain diluting the urine and pushing its down into the soil. But rain can be unreliable and for smaller plots which surround the homestead the method described above is more efficient if some water is available.

A plastic pill bottle with a wire handle serves as an excellent urine dispenser. This one contains 125mls of liquid. The bucket contains diluted urine – in this case 50% urine and 50% water. After urine application (either 125mls or 250mls of the 50/50 mix, the urine is allowed to seep into the soil and is then a further 400mls of water is added from a pea tin.

Planting maize seed

Planting seed in the soil direct

The normal method is to plant the maize seed directly in the soil. If the soil is poor it is best to plant the seed or seeds in a "plug" of good soil or compost placed in a small hole made in the soil. This will provide a better medium for germination of the seeds and produce a seedling of greater vigour. Since most seeds will germinate if well watered a single seed may be good enough. In the past two or more seeds were placed in each planting station, but this may be unnecessary. A "pea tin" of good soil or compost (400mls) is enough.




A hole is scooped out in the soil and the compost added. The seed or seeds are then placed within the compost and pushed in and covered over.

Planting seed in seed trays

The early germination and vigour of the young seedling is important for a good healthy plant. Where early rains may be unreliable with the result of poor germination and where the number of plants is hundreds rather than thousands, it may be more effective to plant the seeds in seed trays which are watered regularly and then transplant the seedlings into the field, plot or garden when the plant has germinated and is between 2 and 3 weeks old. This may seem a curious method, but the trials undertaken at the school indicate that the resulting crop may be far greater.


Maize seeds being planted in seed tray on 26th December 2008 and then transplanted into the field on 7th January. The seeds had been soaked in water for 3 days prior to placing in the seed tray. Thus a period of about 2 weeks elapsed between initial soaking and transplanting.


Transplanting the young healthy seedling from seed tray to field.

Maize trial 1


The field is marked and holes made for the seeds . 25th November 2008.


A tin of hybrid seeds and urine dispensers. Sewing the seed


The fields 3rd Feb. 09 and 25th Feb.09. The small plants to the left have not been treated, those to the right treated with 125mls neat weekly.

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By March 10th the cobs were enlarging considerably. April 14th. 2 days before harvesting.

Harvesting day – April 16, 2009


Picking the cobs on harvesting day. Extremes of growth a large cob fed with urine and a small cob not fed with urine.


Holding cobs of varying sizes. Plants not fed with urine on this poor soil were tiny. The urine treatment increased the mean weight of cobs by 76 times!

Maize trial 2.


An area of field was cleared and planted with 5 rows of maize seedlings on 7th January 2009. One row was watered only and left untreated with urine. The other 4 rows where planted with seedlings held in a plug of leaf compost placed in a hole made in the plating station.


Each seedling was extracted from the seed tray and planted in the plug of leaf compost.


Each plant was then watered.


A 50/50 mix of urine and water was then made up in a bucket by adding 2 litres urine followed by 2 litres of water.

Using the 125mls pill bottle urine dispenser 125mls of this diluted urine was added to each plant in a hollow made around the plant. This was followed by 400mls of water.


This routine was followed weekly (125mls of diluted urine per plant followed by 400mls water) until small cobs first appeared. Then the dosage of urine was doubled by applying 2 X 125mls of diluted urine followed by 400mls water. This application was continued until a full litre of urine has been applied per plant. Photos on 3rd Feb. and 9th Feb. 2009

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Harvesting day – 16th April 2009


Stripping plants from urine fed plants and also fr om plants not fed with urine.


Measuring the cobs on a scale. The difference between urine fed and unfed plants is huge.


The soil is so poor that without plant food a maize cob remains tiny. These small unfed maize cobs and the much larger urine fed cobs are shown in the s in the experiment are shown in the photo on right.

Maize trial 3

This was the most successful of the maize experiments undertaken at Chisungu. Seedlings planted 11th January, 2009


After clearing the field two rows of 15 holes were dug in the soil


Each hole was filled with a pea tin full (400mls) of toilet compost taken from a *Fossa alterna.*


The two rows of planting stations were thus prepared for planting


Maize seedlings were then carefully extracted from the seed tray each between 2 and 3 weeks old.


Each seedling was then planted in the plug of toilet compost and watered.


The diluted urine was then prepared by mixing equal volumes of urine and water in a bucket (2litre + 2litre).


Using the pill bottle dispenser 125mls of the diluted urine (50/50) was applied to each plant. The soil was dished around each plant for form a basin in which urine and water could be poured.


The seedlings were well watered 400mls or more. The rows of seedlings on 21st January. During periods of poor rainfall the plants were watered artificially.


The maize plants during the initial growth period on 29th January 2009.

The plants on 3rd February and 9th February 2009

The plants after further growth

The plants on 21st February and 6th March 2009. Cob formation started on week 9 or 10. At this time the dose of diluted urine (50/50 with water) was increased from 125mls to 250mls followed by watering.


By 10th March the cobs were forming very rapidly. This later technique – planting seedlings in toilet compost and applying diluted urine followed by watering) was far more effective than the technique of planting seeds in the poor soil and applying neat urine diluting mainly with natural rainfall.

HARVESTING DAY – 16th April. 2009


Harvesting the cobs from the urine fed plants (left) and also from plants nearby in the same field which were not fed urine


Unfed maize in the untreated parts of the garden developed small cobs. Urine treated plants large cobs. The effect is startling.

RESULTS ON HARVESTING DAY

All the maize cobs were harvested on 16th April a few weeks after litre of urine had been applied to each plant over the main growing period and also a few weeks after urine application had stopped. The maize cobs continue to crow after the last application of urine. Also carbohydrates are transferred from leaf to cob during the later part of the grain filling stage.

Each maize cob was weighed on a delicate weighing machine from treated and untreated sections of the garden. Striking differences were found in the weight of cobs found in urine fed plants compared to plants grown nearby without urine.

THE RESULTS

	Total gms	**no.cobs**	**mean wt/cob**
Maize trial 1			
a) Untreated plants	30gm	14	2.14 gms
b) Treated plants	15 992gm	98	163.18gms
Increase in production	X 76.25		
Maize trial 2			
a)Untreated plants	2gm	5	4.6gms
b) Treated plants	5 488gm	39	140. 71gms
Increase in production	X 30.59		
Maize trial 3.			
a) Treated plants	7172gm	28	256.14gms
b) Surrounding plants	257gms	18	14.27gms
Increase in production	X 17.94		

Explanations

Whilst individual cobs weights cannot be shown here, there were huge differences between urine treated and untreated plants. Also there was much variation within each group, some urine fed plants being small, but most being large. Also a considerable variation exists between the mean cob weights of urine treated and untreated maize plants in different parts of the garden. All plants in this trial were fed a total of 1 litre of urine, but the results reveal that the application of urine alone was not the only influencing factor on final cob weight. The experiment reveals that the condition of the soil as well as the amount of urine applied has a large influence. The soil in some areas of the garden were clearly more fertile than others, with previous applications of compost, manure or even chemical fertilizer having an influence. These differences in soil fertility are not obvious from viewing alone.

Of particular interest is the variation in mean cob weight between the three trials. Trial 2 revealed the smallest mean cob weight (140. 71gm) and trial 3 the largest (256.14gm) with trial 1 (163.18gms) in an intermediate position. There may be several reasons for this. The ground soil where trial 1 and 3 took place appears to be richer than the ground soil in trial 2. Also the trial 2 plants were in a tree shadow until mid morning. Mean weight was highest in trial 3 which was close to trial 1, but the method of planting the maize and applying the urine was different. Planting seedlings rather than seeds in poor soil helped increase the final crop. Also the method of diluting the urine (50/50) with water and applying first and then applying water to push the urine into the ground also helped. This trial and earlier ones reveal that it helps to plant seed in small amounts of compost to get a strong seedling. Where the early rains are unreliable it helps to plant seedlings in trays or in a small area where artificial watering is possible.

The variation in cob size of untreated plants varied a great deal in the garden which revealed a great variation in soil nutrients. Mean cobs size varied from 2.14gms in the poorest soil to 4.6gms intermediate soil to 14.27gms in soil to which some compost had been added. The overall conclusion is that urine application has a huge effect on the growth of maize and the final crop of cobs produced. Increases of 18 times production and also 30 times and 76 times were recorded.

From a practical perspective growing seedlings in seed trays and then transplanting them is not the most convenient method of planting maize seeds. Under practical conditions and were water is available it is best to plant the seed in a plug of compost at each planting station and water these sites regularly by hand. Then the seed if offered the best chance to gain vigour at an early stage. Once the seeds have germinated and the seedlings are 2 to 3 weeks old then the application of diluted urine can begin at each planting station with the addition of extra water being applied. This extra water drives the urine below ground level reducing the loss of ammonia and also offers the plant more water. This procedure may be important in poor sandy soils which do not hold moister well and also where climate conditions are changing, with periods of poor rains followed by periods of good rains or even excess rain.

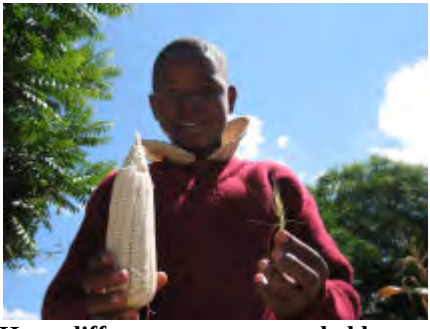
Various techniques already exist in traditional practice for improving the quality of poor soils. These include adding cow manure to the fields before planting and also digging in maize stalks and other compostable materials prior to the rains. A large cupped handful of compost placed within a scooped out hollow of soil made at every planting station helps to increase crop production.

The maize and vegetable trials at the school is having a large impact on the surrounding communities who are beginning to use these techniques, especially the addition of compost to soils and particularly the collection and addition of diluted urine to crops. The

acceptance of this method by teachers and senior community leaders has helped this new approach to gain acceptance.


The pupils and teachers participated in cropping and measuring the maize cobs.


The pupils are active at every stage of the trials




Huge differences were revealed between urine treated maize and untreated maize. On the left photo the largest cob (urine treated) and the smallest cob (not urine treated) are shown!

Teaching Ecological Sanitation in Schools

Planting single trees near pit toilets

Peter Morgan and Annie Shangwa

Planting trees near pit toilets

In the *Arborloo* concept a tree is usually planted in topsoil added to the pit when it has almost filled up with a mix of excreta, soil and ash. However it is also possible to dig or drill a hole near to the pit and plant a tree long before the pit is full. In fact it is possible to plant a tree near a pit toilet even at the same time the toilet is built. In this way the tree will grow at the same time as the toilet is in use. Very often the trees are planted in shallower pits dug near to the toilet pit.


A hole has been dug about a metre away from the toilet. The hole is filled with a mix of compost and soil and a young tree is planted.


The tree site is surrounded by bricks, watered and cared for.

Planting trees in deeper tubular pits dug near the main pit

It is also possible to drill a deeper tubular pit near to the main pit with an auger so that the tree pit is the same depth as the pit which will fill up with excreta. In these photos shown here the pit was dug at a school and for convenience was one metre deep. A tubular pit was drilled also a metre deep and filled with a mix of garden compost and soil. A mulberry tree was then planted on top. Under these conditions the tree roots have underneath them a tube of rich humus like soil through which they can penetrate easily to greater depths. The taproot is able to go deep and eventually tap the nutrients derived from the excreta which penetrate the soil beneath and around the pit.


An earth auger is being used to drill a tubular hole about a metre deep next to the toilet. When the auger has been filled with soil it is extracted from the hole and the soil removed.


The earth auger filled with soil. A mound of soil extracted from the auger


A view of the drilled hole. A mix of compost and soil is placed down the hole.


A young mulberry tree has been planted in a bucket and is now transferred into the head of the drilled hole filled with fertile soil.


School girls drill the hole and plant a mulberry tree in a mix of soil and compost placed into the drilling. Water from the hand washing device irrigates the tree.

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A case of two trees being planted next to an *Arborloo*

In this case a mulberry tree was added first in a hole dug down about 0.5m and about 0.5m outside the supporting ring beam. This was filled with a mix of good soil and compost. Some months later a tubular hole was drilled 0.5m from the ring beam on the other side. A gum tree was planted in a mix of compost and god soil added to this hole.


Planting the original mulberry in a hole dug near the ring beam (7th January 2009). Later drilling a second hole near the ring beam and planting a gum tree (13th July 2009).

Both trees have grown well as this photo taken on 16th February 2010 shows Periodically diluted urine was added to each tree to accelerate its growth.

Recycling the nutrients in the pit with a tree

In this case the tree or trees planted in smaller pits dug or drilled next to the main pit will eventually perform the recycling of the nutrients held in the toilet pit. Tree root growth is encouraged by planting the tree in good soil and feeding the tree. The tree itself will decide at what time the organic pit contents are suitable for invasion. The roots will invade the soil around the pit first. Toilet pits contain a large amount of valuable nutrient material which normally remains unused and is therefore wasted. In this concept they are tapped by the tree itself and can therefore be utilised in the form of fruit, timber, fuel and medicine, depending on the choice of tree chosen. Where trees are grown around the pit during the filling stage of the pit it is best to plant gum trees which grow fast and where the foliage quickly rises above the toilet. In the case of trees being planted on filled *Arborloo* pits a much wider range of trees can be planted. This is because excessive foliage around a toilet can reduce the efficiency of a vent pipe if it is fitted. The exchange of nutrients takes place underground, and is therefore safely out of sight and out of mind. This method can be used on both old filled pits and also newer pits which are filling. Damage to the pit lining is possible – but by this time the pit may have filled - only time will tell!

A method of recycling nutrients from standard pit toilets – with a tree! The technique works with both lined and unlined pits. With lined pits gaps can be left in the brickwork allowing nutrients from the excreta to percolate through the wall into the soil surrounding the pit.

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Teaching Ecological Sanitation in Schools

Planting a ring of trees around toilet pits

Peter Morgan and Annie Shangwa

Introduction

Pit toilets can be made more ecological if the nutrients in the composting excreta are recycled in some way and the threat of pollution of the environment is reduced compared to the standard pit toilet. There are various ways of achieving this.

First the pit can be dug shallower, perhaps between 1m and 2m deep rather than 3m (in the standard VIP) to increase the distance between the pit contents and the ground water table below. Thus the risk of underground contamination will be reduced. Second trees can be planted around the pit. This can have two beneficial effects. The first is to withdraw nutrients from the soil surrounding and beneath the pit. Trees tapping nutrients derived from the excreta will grow faster. Fast growing taproots of some trees can do this effectively. The gum tree is one example. The other benefit is that the tree will extract and transpire nutrients from the ground surrounding the pit, thus reducing the potential for ground water pollution further.

Some trees respond very positively to high levels of nutrient derived from excreta. The gum tree *Eucalyptus grandis* is one. Its increased growth as a result of urine application has been described in another manual. Its increased growth resulting from a combination of urine application and planting in dog manure is also dramatic as shown in the photo below. These photos reveal that this species of gum can tolerate and respond to high levels of nutrients derived from excreta.

The effect of high levels of manure on the growth of the gum tree. On the left the gum tree is in its original planting jacket. The tree on the right has been transplanted to soil to which a high level of dog manure was mixed.

Planting trees in a rosette formation

In this case 5 trees were planted in a rosette formation around the pit with the 6th position occupied by the hand washing facility and its water supply and miniature garden. Each hole was drilled about one metre deep and about one metre away from the toilet. The deep drilling is filled with a mix of compost and top soil. This assists the young tree roots to penetrate deeply into the soil around the pit. The pit fills with excreta as the trees grow. The tree roots tap nutrients from the soil surrounding the pit.

Holes are marked around the pit about a metre from the structure. A series of holes are drilled with an earth auger (diameter 150mm). The holes are drilled down to a metre. In this case 5 holes were drilled around the pit.

The earth auger can be weighted by a pupil standing or sitting on it. The auger is emptied after every filling. Loose soil is scooped out of the drilling.

Preparation and mixing of soil and compost


Soil and compost are mixed together in equal proportions. Compost is gathered from a compost heap or from under trees where leaves have fallen.

Tree planting


Each hole is filled with the mix of soil and compost and watered.
The young tree is then taken out of its plastic bag and planted in the compost.


The soil is levelled and watered


Each tree is planted in turn sand surrounded by a circle of bricks to demarcate. A layer of leaves is added as a leaf mulch.


The trees are then watered 5th October 2009


The trees are watered regularly. Diluted urine (2 litres in a 10 litre watering can of water) applied each week to two trees accelerates their growth.

Steady growth of the gum trees

These gum trees were given about a month to stabilise and then fed diluted urine every week to accelerate the growth. 2 litres mixed with 8 litres of water (total 10 litres of 4:1) were enough to feed 2 trees.


19th November 2009


December 8th 2009


15th February and March 12th 2010

Planting young trees where the growth has been accelerated by the application of dilute urine prior to planting around the toilet pit

A series of young gum trees were transplanted from their original planting bags into new deeper (50cm) planting bags and treated with dilute urine for a few months before being transplanted around the toilet pit. The compost used in the new bags was derived from a *Fossa alterna.* Another manual deals with this subject. During this preliminary growth period, the growth of trees was accelerated considerably prior to planting around the toilet pits.

First a series of 5 holes were drilled around the pit about one metre deep and one metre away from the structure.

The accelerated trees were taken on to site. The trees were carefully extracted from its bag by cutting the bag open with a knide and carefully lowering the 50cm column of composted soil in which the roots were growing down into the hole. Gathered compost was then place around and below the tree to fill the hole. Note that at first the trees were extracted by pulling the column of compost out of the bag from the end, but this method damaged some of the roots. The ideal method is to keep the column of compost in tact and carefully introducing it down the hole and surrounding by rich compost soil. The aim is to plant the column of compost and enclosed roots without disturbing the roots of the tree. This column is surrounded by compost to fill the hole. The soil within covered with mulch made of leaves or grass.


The method of extracting the column of compost by pulling from one side was not satisfactory.

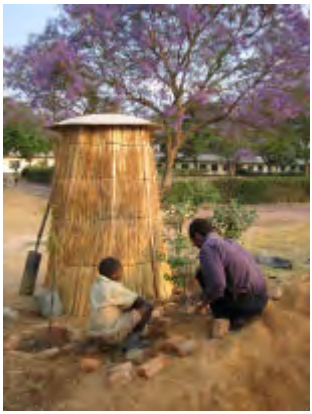

The best method is to cut the bag and take out the full column of compost in tact.


Compost is first added to the hole and then the full column of compost surrounding the tree roots is carefully lowered into the hole.


Once the tree is positioned correctly in the hole compost is carefully added to fill the hole around the tree.


Each hole is planted and protected in turn around the pit. A ring of bricks is added around each tree and covered with grass or leaf mulch. Each tree is thoroughly watered. Watering continues daily.

Views of the rosette of trees around the pits



Two toilet pits were encircled by gum trees at the school in October 2009.

The trees are thoroughly watered soon after they are planted (9th Oct. 2009).

The area around the new pit and its circle of trees is levelled off. The newly planted trees and the toilets are inspected by government officials and staff of the Ministry of Health.

Rapid growth of the trees




Adding diluted urine to accelerate the growth of the trees. 16th February 2010


March 2nd 2010. The grass conical structure has been replaced (upgraded) by a brick structure (left of photo). Trees now higher than toilets!

Pruning the trees

In this case the gum tree *Eucalyptus grandis* has been used. When the tree reaches the height of the toilet or just beyond it is best to prune the lower branches of the trees to promote upward growth. The foliage will then quickly rise above the level of the toilet and vent pipe. Vent pipes work better if the air flow around them is not disturbed by trees.

The lower branches are carefully pruned to a level just below the green new growth of the tree trunk.

After pruning the tree will start to grow upwards faster. The weekly application of diluted urine (1 litre urine + 4 litres water) on each tree continues. Regular watering is also required on younger trees in addition to urine treatment. Eventually the tree will tap nutrients from the pit contents.

Teaching Ecological Sanitation in Schools

The effect of urine on tree growth

Peter Morgan

Introduction

Urine is known to accelerate the growth of many plants including green vegetables and maize. A great deal of evidence is now available to prove this without question. The urine is best diluted either before it is applied or by water applied following the application of neat urine. Urine also can have a considerable effect on the growth of important trees which provide fruit, timber, fuel or shade. This manual describes how urine can be used to accelerate the growth of trees held in bags before planting in the ground or after planting has taken place.

1. Effect of urine on gum tree *Eucalyptus grandis*

Gum trees planted in two 10 litre buckets on 20th March 2009. One of the trees was fed 125mls urine + 275mls water (400mls) with extra watering once a week after the trees had become established. Right photo on 19th April.

Effect of urine treatment becomes more apparent. Left photo 6th May 2009 and right photo 9th July 2009.

Dramatic photo showing effect of urine on the growth of *Eucalyptus grandis* taken on 30th August 2009

Method of applying urine to young trees held in planting bags

A pill bottle holding about 125mls of urine is poured into a 400ml tin which is then topped up with water, This is then poured on the soil around the treated tree. More water is poured on during the dry season to keep the tree well irrigated. This water applied after the diluted urine has been applied helps to the drive the nitrogen rich urine beneath the ground.

Accelerating the growth of tree before planting near toilets

Several trees respond to the application of diluted urine and this can be undertaken before planting the tree in the ground as well as continuing after the tree has been planted in the ground. In another experiment several gum trees (and mulberry trees) were planted in longer planting bags before transfer to the ground during the dry season. The best time to plant trees near toilets (or at any place) if regular watering cannot be guaranteed is during the early part of the rainy season. It is possible to accelerate the growth of trees prior to ground planting by transferring the seedling tree either into a bucket or into a deeper planting bag, which can be placed in a position where more regular watering and urine application is possible.

A series of gum trees (*Eucalyptus grandis*) were planted in deeper planting bags half a metre in depth filled with compost from *Fossa alterna* toilet and treated with urine every week. This considerably accelerated the growth of the trees compared to trees held in the original seedling bags. Left photo dated 9th July 2009 and right photo 6th October 2009.

Left: Original trees in smaller bags. Right: Original trees in smaller bags compared to transplanted trees in larger bags and urine fed.

Evidence from the field

The most dramatic results so far achieved have taken place in the valuable tree *Eucalyptus grandis.* This tree is being tested in several sites in Epworth, both at the school and within the outreach program. The young trees were originally purchased from the Forestry commission nursery in Harare. Some have been planted directly as purchased from the nursery, others fed with a diluted water urine mix before final planting near the toilet. The trees on trial have been planted in a tubular pit drilled between 0.5m and 1.0m from the edge of the pit – that is from the edge of a ring beam in the case of the *Arborloo* or from the edge of the slab in the case of toilets which are built on brick lined pits. The amount of urine added to each tree varies slightly but a practical guideline consists of making up a mix of 2 litres of urine and 8 litres of water (4:1) in a ten litre watering can and applying this to 2 trees once a week. That is added 1 litre of urine + 4 litres of water for each tree weekly. The trees are watered regularly in addition until the roots have reached deeper layers. Circles of bricks are laid around each tree and mulch made of leaves or grass added on top.

Banana and mulberry also respond well to urine treatment, and several other tree species are being tested.

Left: Effect of urine on growth of mulberry. Right: Mulberry planted at end of upgraded well water run-off being watered with diluted urine.

Trials in the school and outreach program


Transplanting gum trees around a pit toilet. Left: standard trees in a rosette around pit in the outreach program. Right accelerated trees in a rosette around pit at the school.


Trial in the outreach program. Trees planted 19th November 2009 (left) and growth by 15th February 2010. This is just less than 3 months.


Trial in the school. Trees planted on 9th October 2009 (left) and growth by 16h February 2010. This is just over 4 months. Urine treatment stopped during the school holidays.

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Teaching Ecological Sanitation in Schools

Planting and fertilising a woodlot of gum trees

(using diluted urine as a fertiliser)

Peter Morgan and Annie Shangwa

Planting a woodlot of gum trees and accelerating the growth with diluted urine

The evidence derived at the school for the beneficial effect of adding diluted urine once a week to gum trees, prompted the headmaster to request that a woodlot of gum trees be planted in the school. The rapid growth rate of gum trees treated with diluted urine weekly, in both the school and the outreach environments provided sufficient evidence for extending this concept to woodlots. Fuel is in short supply in Epworth, as it is in most parts of Zimbabwe and an effective and simple method of growing more timber, using excreta as a source of nutrients seemed like a viable and practical concept.

Choice of tree species

Many species of gum trees are available for this type of work. The project had used the fast growing *Eucalyptus grandis* in its first trials. This had proved very successful. However another fast growing and drought resistant species *Eucalyptus tereticornis* was more easily available at the time of planting and was chosen. Whilst gum trees are known to take up large amounts of water from the soil, they are valuable in many ways – not least for building and for fuel. Their use around toilets helps to reduce the flow of fluids from the pit and thus helps to reduce the potential of underground water contamination.

The trees were purchased from the Forestry Commission Nursery

Site selection and drilling holes for tree planting

School staff chose the most suitable site for planting and holes were drilled with the 170mm diameter earth auger used to drill other holes for trees. Holes were drilled 0.6m deep and 1.5m apart.


The earth auger fills up with soil and this is removed after each filling and placed back in the hole to drill deeper.


Soil is removed by knocking the auger with a bar to loosen the soil then emptying by hand or with a stick

Filling holes with good soil

Each hole is filled with rich soil or a mix of compost and excavated soil. This helps the plant roots penetrate more quickly into the soil.


A source of rich soil has been located and excavated for use in the woodlot.

Tree planting

Each tree is carefully taken out of its planting bag and placed in a hole made in the soil within the drilled hole. The soil is pressed down around the tree. The tree is thoroughly watered. It is a good idea to place a "mulch" of leaves or grass over the soil around the tree to reduce the loss of water by evaporation after watering.




Each tree is carefully planted and watered in each planting hole

The trees are watered regularly if there is no rain. Gum trees in woodlots like all other planted trees are best planted during the rainy season, especially if sources of water are distance or scarce. In this case water is taken from the school well fitted with a hand pump. Urine application starts about 2 weeks after planting to allow the trees to establish.

Collecting urine

In this trial urine was collected from the urine tank connected to the boys urinal. A modified plastic “Blair pump” is used to pump out the urine. Large amounts of urine can be collected from the tank and one of the best ways of using this is to dilute it with water and feed trees.


Collecting the urine from the urine tank

Urine application

Urine is diluted with water before being applied to the trees. 2 litres of water are diluted with 8 litres of water in 10 or 12 litre bucket or watering can. This is a 4:1 dilution and is enough to treat two trees. Thus each tree is given one litre of urine. The urine is applied once a week. After the urine has been applied each tree is given a further 5 litres of water.


A 2 litre plastic milk bottle (opened up) serves as a measure. The bucket or watering can is filled up with water.


Each tree is fed individually with the diluted urine either from a bucket or from a watering can

Watering

When the trees are young they need to be watered regularly, especially if the rains are poor or if the trees are not planted in the rainy season. As the roots penetrate more deeply they rely less on watering. If a tree shows signs of dying it should be replaced.


Liberal watering helps a lot in the first few weeks


Later editions of this manual will reveal the growth of trees in this woodlot

Teaching Ecological Sanitation in Schools

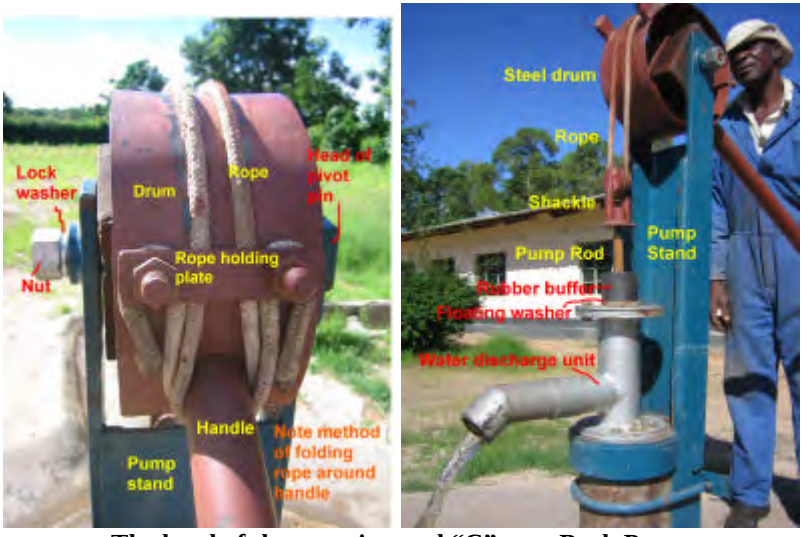
Maintaining the school hand pump

Peter Morgan

Introduction

The school hand pump is a very important piece of technology at Chisungu School. It serves 2500 pupils and staff. The pump itself is called a Zimbabwe Bush Pump. The Bush Pump was first designed in Zimbabwe in 1933 and several adaptations of the original design have been used in national programs. The current national standard is known as the "B type Bush Pump" and has been the national standard hand pump since 1989. Over 40 000 pumps of this type have been installed throughout Zimbabwe. The model used in the Chisungu school is not the "B" type but an experimental design known as the "C" type Bush Pump. This differs from the "B: type in having an experimental head which uses a rope to link the pump head to the pump rods. The pump can also be used with smaller steel pipes under the ground than the "B:" type. The Chisungu school is one of several dozen locations where the pump is being tested and evaluated.

The school pupils in the "ecosan" group have been trained in maintaining the pump head, which basically involves tightening some of the bolts and ensuring that the rope is in good condition. These photos show some of the activities of the program linked to the school pump.



The head of the experimental "C" type Bush Pump

Pupils adjusting the rope of the pump head


A large spanner is used to secure the nuts on the pump head


Pupils making a rubber buffer for the steel handle at the rear of the pump


Pupils making the rubber buffer anchor and also improving the pump apron where the water is collected in buckets.

Teaching Ecological Sanitation in Schools

The brick building demonstration unit

Peter Morgan

Introduction

The method of brick construction for a toilet superstructure in the shape of a “horseshoe” rather than an open spiral has merit because it uses fewer bricks and because less experienced people can build it without the fear of collapse. This is due to the shape of the structure which does not have a free standing wall. A special demonstration and training unit has been built at the school so less experienced or inexperienced people can practice. The unit also serves to demonstrate that even brick structures bonded with weak cement mortar (16 parts pit sand to 1 part cement) can be strong and durable and yet can be taken apart and rebuilt with relative ease. Brick structures of this type can be built relatively quickly (in an afternoon) and taken apart quickly. Most bricks used in the rural program are off poorer quality, but if higher quality fired bricks are used they can be used for construction and after some years taken apart and used again. Higher quality fired bricks can also be built on edge using this technique – a method which uses fewer bricks.


A standard 1.1m diameter concrete slab is made and placed in the demonstration site and raised on bricks. Two treated gum poles are mounted in front of the slab in drilled holes.


Using bricks as mould strong concrete is laid around the poles and also all around the slab over the bricks which support the slab.


The unit is being built and the final unit ready for use.


Bricks are brought in and stacked neatly for use. The unit is explained by the school children to government officials at the school.

A curiosity of interest – during the demonstration an owl observed the event.

Teaching Ecological Sanitation in Schools

(Outreach program)

Building an Arborloo with a conical structure

Peter Morgan and Annie Shangwa

Introduction

This method uses a ring beam made of concrete with a shallow pit dug within the ring beam. This is capped by a concrete slab. The superstructure is built by drilling holes around ring beam and inserting a ring of 6 treated gum poles. The roof in this case was an experimental domed design made of cement impregnated hessian. Nails were driven through the roof into the poles to secure. Also a length of gum pole was secured by nails near the head of each upright gum pole. Once the superstructure frame had been made, a suitably sized door frame was made to fit the two main king posts at the front of the toilet. The whole superstructure was then covered by hessian sheer. The door was covered separately with hessian sheet. Finally the hessian was covered with a thin cement slurry made by mixing cement and paint and applying this to the material.

The ring beam in this cases caste to one side and positioned in a suitable position. At first experimental cans were placed within the ring beam to see if these would support the poles, but they would not. Holes for the poles were drilled around the ring beam.

6 treated gum poles were placed inside the drilled holes and the experimental domed roof fitted. A matching door frame was made to fit within the two front posts.


The hessian sheet was attached to the poles and secured with small nails made with cut pi eces of 3mm wire.


Several generations were involved in the construction ranging from the young pupils and their instructor (Mrs Annie Shangwa) to an older builder who was being shown the method.


The door frame was fitted with rubber hinges (see another file) and then covered with a sheet of hessian


Meanwhile the hole was dug down inside the ring beam (in this case after the superstructure was built). In this case an experimental fibreglass slab was used to cap the pit.

Applying cement paint to the structure


The cement paint was made by mixing 4 litres of PC 15 cement with e nough water to make into a thin paint which was applied with a large brush. A small tin of salt was added to the water to help hardening of the paint.


The paint was applied all over the hessian sheet with a second layer being added. The final structure painted.

Teaching Ecological Sanitation in Schools

(Outreach program)

How to upgrading a family well (without a windlass)

Peter Morgan and Annie Shangwa

Introduction

It is now well known that improvements in the design of the "head-works" of a well (the surrounding concrete apron and water run off) can improve both safety of the well from a child's point of view and also the quality of the water. Building a strong concrete "apron," raised collar and water run-off helps stop wastewater discharged at the head of the well pouring back into the well chamber. The water run off leads unused or waste water away from the well head. This water can be utilised effectively by planting a valuable tree at the end of the run-off. This manual describes how a well in the "schools outreach program" was upgraded with an improved head-works but built simply without a windlass system.

Views of the original well head and down the well chamber

1. Preparing the new concrete well apron

A new well slab is made with a raised collar and raised rim. This will function as the well apron and channel water into the run-off channel and avoid waste water running back into the well. In this case the apron was made 2m in diameter with a central well access hole 30cm in diameter.

The well apron is made to one side of the well in strong concrete (4 parts river sand and 1 part Portland cement (10 litres). Steel shuttering is used.

Using a shaped piece of timber the rim of the apron is raised about 3cm high and 3cm wide all round apart from the section where the water will spill over onto the water run-off. Here an extension of the slab is made. The central portion of the run-off has a raised collar surrounding the well access hole.


Stages in making the well apron.


An extension to the apron is made on one side to allow water to flow off into the water run-off channel.


After a week of curing (being kept wet at all times) the apron is moved on to the existing well slab


The new well apron is set in position so that the water run-off channel will carry water slightly down hill to a seepage area planted with a tree


The new well apron is laid on the exiting well slab and cement bonded in position

Making the water run-off channel

In this method the water run-off channel is made using a length of cement impregnated hessian moulded over plastic laid over an asbestos sheet. Two layers of hessian are used with a cement mix made into paint with water.


The hessian cement water run-off channel 1.5m long


The hessian cement water run-off channel is laid down as shown and supported by bricks. Water must flow down the channel along a gentle slope.


Cement mortar is used to secure the water run-off channel in position. Next a 1m deep hole is drilled at the end of the run-off channel in preparation for tree planting.


Drilling the hole with an earth auger can be good fun. The hole is about 15cm wide and 1m deep.


A mix of compost and soil is placed down the drilled hole. This combination will help the tree to grow fast together with the water which is discharged down the run-of. A mulberry tree is planed over the hole.


A neat circle of bricks is laid around the tree. A leaf mulch is added to the soil.


Once the tree is established it can be fed every week with a 4:1 mix of urine and water (8 litres + 2 litres urine) mixed in a watering can. Routine maintenance involves keeping the well head clean. A tin lid is placed over the well access hole. This system can be upgraded with a windlass later.

Teaching Ecological Sanitation in School

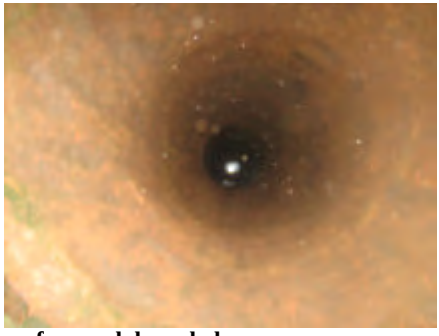
(Outreach program)

How to upgrade a family well (with windlass)

Peter Morgan and Annie Shangwa

Introduction

Many family wells have been dug in Zimbabwe, possibly as many as 200,000. They are commonly dug in most of the communal lands where the ground water table is moderately high, and also in deeper localities. Also they are common in several peri-urban settlements around the towns and cities. In recent years they have become more common as sources of drinking water even in the cities. The best way of improving water quality taken from wells is to fit a hand pump sealed to the concrete well cover. Also locating the well away from pit toilets reduces the risk of underground pollution. However it is now well known that improvements in the design of the "head-works" that is the surrounding apron of the well also helps improve water quality. Building a strong concrete "apron" and water run-off helps to stop wastewater at the head of the well pouring back into the well chamber. Also fitting a windlass helps because the rope or chain does not lay on the ground where it may pick up contamination. This manual describes how a well in the schools outreach program was upgraded with an improved head-works and windlass system.



The existing well on the surface and down below

STAGES OF CONSTRUCTION

It is assumed that the well exists and is capped by some sort of concrete slab. The well hygiene is improved by improving the apron, making a water run-off, adding a windlass system and planting a tree at the end of the run-off. Water is channelled from the apron down the run-off to irrigate the tree.

1. Making the windlass system

This can be made using several methods. Two methods are described. Both use treated gum poles as windlass supports which also act as bearings. The two gum poles are embedded in a high strength concrete anchor which also provides an opening for access of the bucket into the well.

Method one for windlass mounting

Two steel shutters and bricks are used to make the windlass mounting. The outer diameter of the inner shutter is 30cm and the inner diameter of the outer shutter is 40cm. A very strong mix of river sand and PC15 Portland cement is made up and added between the shutters with 3mm wire as reinforcing. Two plastic bottles have the tops cut off and are used to house the gum poles.

The outer shutter is then removed and a series of bricks are laid to surround the two opened plastic bottles which will later house the treated gum pole windlass supports.

Stages in making the windlass support anchor


The outer shutter has been removed. Bricks are laid down to surround the opened plastic bottles


The brick moulds are filled with concrete well supported by 3mm wires for reinforcing. The outer shutter is then replaced and an additional layer of concrete added.


More bricks are added around the plastic bottles together with more reinforcing wire. The concrete is then shaped. The inner shutter must be removed before the concrete has set hard.

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A windlass is then prepared from steel, The drum section of 65mm pipe is 30cm long with the shaft made of 20mm round bar. 30cm of round bar project from either side of the drum. The handle measures 18cm long and 15cm. Two gum poles measuring 90cm long and 75-80mm wide are cut.


Two holes are drilled with a brace and bit 25mm wide and 75mm down through the two poles. In one of the poles the hole is opened up with a wood chisel as shown.


The two gum poles are then mounted centrally in each opening made by the plastic bottle. Very strong concrete (3:1 with river sand) is rammed into the opening around the poles to secure. The windlass is then mounted on the poles and a wooden piece nailed in the open slot to hold the windlass. The concrete is left to cure for a week.

Method two for windlass mounting

In this method the windlass support poles are mounted closer together directly into the concrete anchor. This is a simpler method. The poles are drilled and chiselled in the same way and mounted in very strong concrete supported by lots of 3mm wire as reinforcing.




Making the water run-off channel

In this method the water run-off channel is made using a length of cement impregnated hessian moulded over an asbestos sheet. Two layers of hessian are used with a cement mix made into paint with water.


The hessian cement water run-off channel 1.5m long

Adding the windlass system to the well


Strong cement mortar is laid around the hole in the well slab and the windlass anchor and support unit is placed on top.


Bricks are laid around the existing well slab as a mould which is filled up with strong concrete to make a rim and apron around the slab.


The run off is then placed in a channel running slightly down hill from the apron and mounted in a strong cement mortar mix.


A hole is drilled with an auger at the end of the run-off. A mulberry tree will be planted in this.


The hole is drilled down about one metre and filled with a mix of compost and soil. The mix is being prepared in this photo.


The soil compost mix is added to the hole and the mulberry tree planted on top


The area around the tree is levelled off and surrounded by bricks and a leaf mulch is added.

The completed well. A fitting tin lid is prepared to make a well cover. Diluted urine can be used to fertilise the tree. 2 litres of urine diluted in a 10 or 12 litre watering can or bucket of water can be added once a week. As the tree grows larger extra manure or compost can be added to the soil surrounding the tree. The advantage of planting a tree at the end of the well run-off is that the tree will receive water regularly.

Teaching Ecological Sanitation in Schools

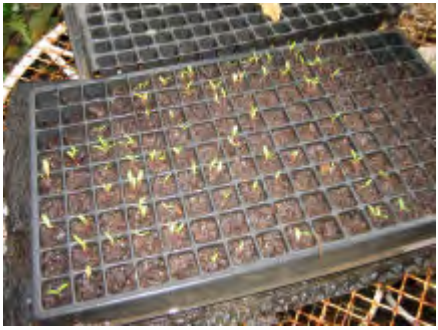
Growing spinach from seed and fertilising with urine in homestead gardens

Peter Morgan and Annie Shangwa

Introduction

Part of the schools outreach program involves showing householders how to enhance the growth of vegetables and maize with diluted urine. In some cases the homesteaders are given seeds to plant and in other cases small seedlings grown in seed trays. The effect of urine on the growth of spinach is particularly spectacular. This effect has already been described in other manuals. The homesteaders vary in their reaction to the application of urine on vegetables. Those who have seen the school experiments are more inclined to accept the method. The acceptance by the school teachers also helps. But the best method is to demonstrate the effect in homesteads.

Growing spinach in seed trays



Spinach can be grown in seed trays easily. But the normal method is to sow the seeds in a protected part of the homestead garden and provide with shade.

Mr Kano the school teacher shows the pupils how to plant the seedlings in a prepared bed. Compost is added to the bed if possible and the soil well turned.


Seeds from the seed tray are planted in the garden and covered with dry grass. They are watered regularly


The beds of spinach grow well if cared for and watered and given a dose of diluted urine every week. In this case about 2litres of urine in a watering can of water (about 10 litres) every week has made a big difference to the crop.


Chinese cabbage were also planted in the beds as well as spinach in this garden in the outreach program


Chinese cabbage and spinach are popular vegetables.


Pumpkin are also growing with the spinach in another outreach garden.


Most green vegetables respond well to the application of diluted urine.

~~4~~

Open day at the school

The importance of an open day

Whilst the chosen pupils and teachers are busy at work with their ecological sanitation projects, it is very possible that most of the other teachers and pupils and also members of the community remain unaware of the importance of the work being carried out in ecological sanitation within the school grounds. In fact experience at Chisungu has shown that the project has attracted much attention, but a fuller explanation is also required to a wider audience. .

The best way of exposing this work is to hold "open days" where other teachers and members of the community together with important leaders of the community and other influential people, including government officials and members of important organisations are in attendance. Such an event took place at the Chisungu School on Friday 3rd April 2009. It was attended by the Bishop and Pasters of the Methodist Church, who run the school, by government officials, including the Deputy Minister of Education Headmasters, Councillors, Elders of the community and other organisations including UNICEF. The day prior to open day was used as rehearsal day when the 60 staff members of the school were given their own tour and explanation. The following photos show a snapshot of this important event in the Ecosan calendar of the school.


Traditional dancing and official high table


Explanations given in maize garden and at the toilet sites.


The *Arborloo* explained and also the method of collecting urine from the boy's urinal.


The Headmistress and her staff listen to the pupils explaining their work


The toilet designed for the 'girl–child" is the most popular but also the most expensive and complex to make.


Both toilet systems and the use of urine on plants are explained by the pupils themselves.


A large audience of several hundred people were gathered. A proud group of girl pupils who had performed the plant trials and helped build the toilets.

Prize Giving Day and Certificates (November 27th 2009)


A proud day for all. Mrs Annie Shangwa (Project Manager) and Mr Alphabet Kano (Project Teacher). Part of the group after receiving prizes and certificates.

A copy of the certificate presented to Dhiriza Moreblessing

Schools *"Ecological Sanitation"* Programme

FACT SHEET

1. Demonstrating the effects of urine and toilet compost on maize plants in buckets containing road sand

***Buckets A and B contain road sand**
***Buckets C and D contain a 50/50 mix of road sand and toilet compost**
*** All buckets have been planted with maize seedling**
***Buckets A and C have been watered only**
***Buckets B and D have been fed with a 3:1 mix of water and urine twice a week**

WHAT DOES IT SHOW US

1. Maize does not grow well on road sand
2. Adding urine to road sand does not help much
3. Mixing road sand with toilet compost helps a lot
4. Adding urine to a mix of road sand and toilet compost is best

WHY?

1. Road sand is very sterile and contains almost no plant food like nitrogen.
2. Urine contains a lot of nitrogen
3. Maize plants like lots of nitrogen
3. But even adding urine to road sand does not make the plants grow much faster
4. This is because although urine contains nitrogen it is a type of nitrogen that cannot be used by maize
5. The nitrogen in urine must be converted into a form of nitrogen that can be used by plants
6. This change takes place in soil which contains soil bacteria which changes the urine nitrogen into plant nitrogen
7. The soil bacteria are contained in good soil and toilet compost but not in sterile road sand
8. So the urine we add to road sand is of little use to the plants
9. To release plant nitrogen from urine so it can be used by plants it must be converted first by the soil bacteria found in good soil or toilet compost.

CONCLUSION
To get the best effect of urine which contains much nitrogen very poor sandy soil is best mixed with good soil or toilet compost.

Schools *"Ecological Sanitation"* Programme

FACT SHEET

2. Demonstrating the effects of urine and toilet compost on maize plants in buckets containing poor sandy soil.

***Bucket A contains poor sandy soil (from Chisungu school garden)**
***Bucket B contains poor sandy soil (from Chisungu school garden)**
***Both buckets have been planted with a single maize seedling**
***Bucket A has been watered only**
***Bucket B has been fed with a 3:1 mix of water and urine twice a week (100mls urine + 400mls water)**

WHAT DOES IT SHOW US?

1. Maize does not grow well on poor sandy soil
2. Adding diluted urine to poor sandy soil helps the growth of maize considerably.

WHY?

1. Both road sand and poor sandy soil contain very few nutrients for plant growth.
2. Unlike road sand poor sandy soil does contain some soil bacteria which helps change the urine nitrogen into plant nitrogen
3. The effect would be even better if the poor sand was mixed with toilet compost or fertile soil

Notes

Poor sandy soil is very common in many parts of Africa. Crops do not grow well on it.

However there are sufficient soil bacteria in poor sandy soil to convert urine nitrogen into plant nitrogen

Plants grow much better if the poor sandy soil is also mixed with fertile soil or compost.

The compost can be made in the garden or can be taken from toilets that make compost.

For many plants like maize and green vegetables, the growth of plants can be increased even further if the mixture of poor soil and fertile soil or compost is treated with diluted urine.

The urine contains much nitrogen but this urine nitrogen must be converted into plant nitrogen by soil bacteria before it can be taken up and used by the plants.

Schools *"Ecological Sanitation"* Programme

FACT SHEET

3. Demonstrating the effects of urine on maize plants in basins containing poor sandy soil.

*** Each basin has been filled with poor sandy soil**
***Each basin has been planted with a single maize seedling**
*** The basin on the left has been watered only**
***The other basins have been fed with 400mls of a mix of urine and water (300mls water + 100mls urine) twice a week.**

WHAT DOES IT SHOW US?

1. Maize does not grow well on poor sandy soil
2. Adding diluted urine to poor sandy soil helps the growth of maize considerably.
3. Maize can use up any nutrients in poor soil quickly
4. The nutrients in urine contain all the food that is required for complete growth of maize including full maize cob production. The more urine the bigger the cobs!

Schools *"Ecological Sanitation"* Programme

FACT SHEET

4. Demonstrating the effects of urine and toilet compost on maize plants in small pots containing garden topsoil.

***All four small pots were filled with garden topsoil**
***All four pots were planted with a single maize seedling**

*** The two pots on the left have been fed with 20mls (bottle cap full) a 3:1 mix of water and urine every other day.**
*** The two pots on the right have been fed with water only.**

WHAT DOES IT SHOW US?

1. Even good soil can benefit from the use of diluted urine.
2. A maize plant can use up the food (nutrients) in a small volume of soil quite quickly.
3. Urine appears to provide the maize plant with all the food it needs.

Schools *"Ecological Sanitation"* Programme

FACT SHEET

5. Urine trials in basins and buckets

The effects of diluted urine on plants can be show by testing the growth of plants in small containers. In each case shown below 400mls of a 3:1 mix of water and urine was added to the basin 3X per week together with normal watering (left side) and watering only (right side).

Effect of urine treatment on Tsunga and Onion

Effect of urine treatment on cabbage and tomato

Effect of urine treatment on spinach and mulberry tree

Schools *"Ecological Sanitation"* Programme

FACT SHEET

6. Urine trials in ring beams

The effects of diluted urine on plants can be show by testing the growth of plants in small "ring beam gardens." In each case shown below about 3 litres of a 3:1 mix of water and urine was added to the ring beam garden 3X per week together with normal watering. The result is abundant growth.


Effect of urine treatment on Spinach and Cabbage


Effect of urine treatment on Tsunga and Rape


Effect of urine treatment on Covo and Maize

Schools *"Ecological Sanitation"* Programme

FACT SHEET

7. Growing mulberry from cuttings

***Many trees can be grown on "Arborloo pits"**
***The can be fruit trees, trees for fuel, trees for medicine, indigenous trees, shade and ornamental trees**
***Trees can grow from seed, fruit, tubers or cuttings**
***One of the easiest trees to grow and one of the most valuable is the Mulberry.**
Mulberry trees can be grown from cuttings taken from older trees.
***The mulberry fruit is a wonderful source of vitamins**
***The mulberry will grow large and provide fruit for many generations once it is established.**

Growing the mulberry tree from cuttings


cuttings taken from tree


Cuttings grow roots and leaves in the seed trays or small bags.


They are then transferred into buckets or direct into the soil.

Schools *"Ecological Sanitation"* Programme

FACT SHEET

8. Comfrey – a magic plant

***Comfrey is a very valuable plant and a source of many important plant nutrients.**
***Comfrey is the best source of non-chemical potassium so far known to organic gardeners.**
***Potassium is valuable for growing many important crops like tomato, potato, onion and others.**
*** Comfrey is able to effectively remove nutrients from the soil and make them available in the leaves.**
***Comfrey can be used as leaf mulch (leaf layer over soil around plants) on vegetables. ***
Comfrey can also be converted into liquid fertiliser.
***The nitrogen content of this liquid comfrey can also be enhanced by the addition of urine.**
***Comfrey is also an excellent food for rabbits and chickens. Comfrey also has medicinal properties.**

***Comfrey is an excellent addition to the compost heap.**

***Many plants benefit from a generous supply of potassium. It is essential for the best yields of fruit. The tomato is an example. If there is too much nitrogen, the plant will grow with luxuriant green vegetative growth, but the fruiting may be poor.**

Comfrey can be grown in vegetable gardens, buckets and ring beams

Comfrey can be grown together with other plants. It is a good all round food for chickens and rabbits as it contains minerals and is quite rich in protein.

Schools *"Ecological Sanitation"* Programme

FACT SHEET

9. Growing tomatoes using urine and comfrey

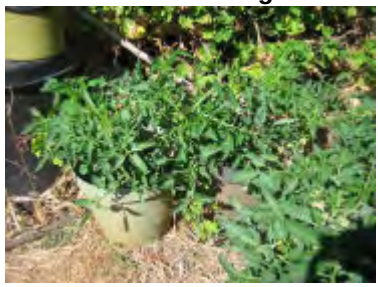
***Tomatoes are an important crop in our diet**
*** Tomatoes respond well to urine treatment as the plants can grow large because urine contains much nitrogen.**
***But tomatoes also need potassium and other minerals in their food to make good fruit. Nitrogen is not enough**
***Tomatoes need extra potassium to fruit well.**
***This potassium can come from comfrey leaves which have been made into liquid food.**

Preparing Comfrey Liquor

Comfrey is a remarkable plant which sucks up nutrients (food) from the soil and places it in the leaves. It has lots of potassium which is good for fruiting plants like tomatoes. Onions and potatoes also like potassium as well as fruiting trees.

Comfrey can be made into a liquid food for plants. Take a large bucket or container (about 35 litres). Fill with water and add comfrey leaves (you must grow them first). Add up to 2 kg of comfrey leaves cut up and 2 litres urine. Let the brew stew for about 2 weeks – stir from time to time. The leaves will break down. After 2 weeks add another 2 litres of urine. Stir and the mix is ready. Dilute with water.


The cut comfrey leaves have been added to the 35li water followed by 2litres urine. This is allowed to ferment for 2 weeks with stirring. Another 2 litres urine is added before using.

Two healthy tomato seedlings are then planted in a bucket (or more in a bed) containing toilet compost or good soil. In this case Roma tomato (plum tomato) which is resistant to disease). They are watered without urine for a week or more. Then a water urine mix (400mls of 3:1) is applied 3x a week for several weeks + watering. This makes the plant grow larger. But they need extra potassium to fruit well!


As soon as flowers start to show (or even before) the special comfrey mix is applied also using a 3.1 mix of comfrey liquor and water (about 400mls 3X per week per container). The plants are also watered daily. This provides the extra potassium as well as nitrogen for good fruiting. Large numbers of fruits result from this treatment.