

Dry Terra Preta Sanitation in case of disaster when sanitation infrastructure is destroyed, in order to prevent outbreak of colera and typhus

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1 Introduction

Soon after the earthquake in Haiti in 2010 cholera broke out killing several thousand people. No matter where the bacteria came from, the spread of the disease was due to the break down of sanitation infrastructure.

Given the circumstances in the aftermath of the earthquake people failed to separate feces and urine from drinking water, thus closing the infectious chain and as a result leading to the outbreak of cholera.

This strategy paper proposes an easy and cheap way of protecting people's health after break down of sanitation infrastructure as a consequence of disaster. It shall be shown, how in this critical situation the vicious circle of infection can be interrupted with simple means by effectively separating drinking water from feces and urine.

2 Dry Sanitation strategy in the aftermath of disaster

In case of disaster, when sanitation is destroyed and no provisional infra-structure like a camp has been built up yet, outbreak of epidemic diseases like typhus and cholera is an immediate impending hazard to health.

In such a situation it is important to collect and keep feces and urine separate from water right from the beginning. Providing people with easy to handle emergency toilets that need neither water nor infrastructure and as few skills as possible of how to use them is an absolute necessity.

As a matter of principle a functioning emergency strategy by local administration or international help organisations is necessary. It needs materials and devices on the one hand and instructions and skilled staff to pass these instructions to the people concerned on the other hand, in order to make sure that the strategy works.

2.1 What it needs

The following devices, materials and instructions are suggested to be held in store for easy deliverance in case of disaster, enabling hygienic defecation of people in affected areas:

On the material basis, providing or organizing five things to people is essential:

- I. Closable buckets as improvised toilets**
- II. Litter to cover feces (biochar-powder)**
- III. Closable canisters together with funnels and bio-active powder for starting fermentation of urine.**
- IV. Woody material for composting urine.**
- V. Pyrolysis stoves for cooking and producing biochar, that can be used as litter for the toilets.**

Concerning communication the following has to be conveyed to the people concerned:

Instructions of how to use these devices and materials for defecation and urination and the **conviction** of how important this is for everyone's health and survival in case of disaster.

Skilled staff has to help organize this on the spot and make sure people follow the instructions. This will only work, if local administration is cooperating.

The objective is to prepare the Ministry of Interior and regional administration beforehand, so that buckets, biochar-powder and instructions are held in store by the administration of the affected country and skilled staff is available to be sent to the disaster area immediately.

As a consequence regional administration or disaster protection organisations provide and deliver:

Ad I: Buckets for waterless fermentation of feaces

Ad II: Biochar-powder (inoculated with lacto-fermentation and/or soil microbes)

The necessary number of packages containing eleven 10 litre plastic buckets piled up into each other and 10 loose lids are sent to the region concerned. The most upper bucket filled with biochar-powder and closed with the eleventh lid. Instruction of how to use these waterless emergency toilets is printed on the buckets in English, Arabic, Chinese, Spanish, French, regional languages and as pictograms. One small shovel goes with each bucket.

2.2. How it works - the purpose of the buckets and the biochar-powder

The buckets are to be used as improvised toilets and storage buckets for feaces. Covering each poo with a small portion of the biochar-powder will help prevent smell and suck up humidity. The inoculation of the powder with lacto-fermentation and/or soil bacteria will steer the fermentation of feaces into a hygienizing direction. Out of experience this is the case, when a mould like white layer has covered the feaces and no smell has developed. For this purpose the buckets have to be closed with the lid after each defecation. Otherwise smell might develop, in which case the content would have to be composted with special care, in order to reach purification in a later step.



Fig. 1: Even an empty ketchup bucket with lid will do as toilet in case of disaster.¹



Fig. 2: Biochar, a shovel and molasses or vinasse with microbes for fermentation. In general fresh feaces contain their own lacto-fermentation microbes, that will start the fermentation process. To add lacto-fermentation microbes and/or soil microbes in a sugar solution however is more secure.

It has to be stated here, that fermentation of feaces is no guarantee for total hygienization, but definitely helps steering the process below the infection threshold.

¹ Unless otherwise specified all photographs and drawings © Roland Wolf.

Draft text of instruction to be printed on the buckets

These buckets save your life. Use them for defecation, for poeing only. Use the biochar-powder of the full bucket to cover the poo (feaces) you have dropped into one of the empty buckets. Use the small shovel to portion the litter (biochar-powder). Cover the poo with litter. Do use as little litter as possible. Do not bury your poo, just cover it, in order to save precious litter and make it last longer. Use water only for washing yourself afterwards. Do not wash yourself over the bucket with your poo inside! Make sure no water rinses into this bucket. Close the bucket with the lid after each poo. Keep it closed until next poeing. In case you use toilet paper for cleaning yourself, collect the used paper in one of the empty buckets and close it each time afterwards, in order to keep flies away.

If possible mix the coalpowder with soil, sawdust or dry leaves to make it last longer. One 10 litre bucket should take approximately one month for one person to fill it with poo and litter.

Try to urinate as little as possible into the bucket. Please pee into the canisters each time instead, before you start poeing into the bucket.

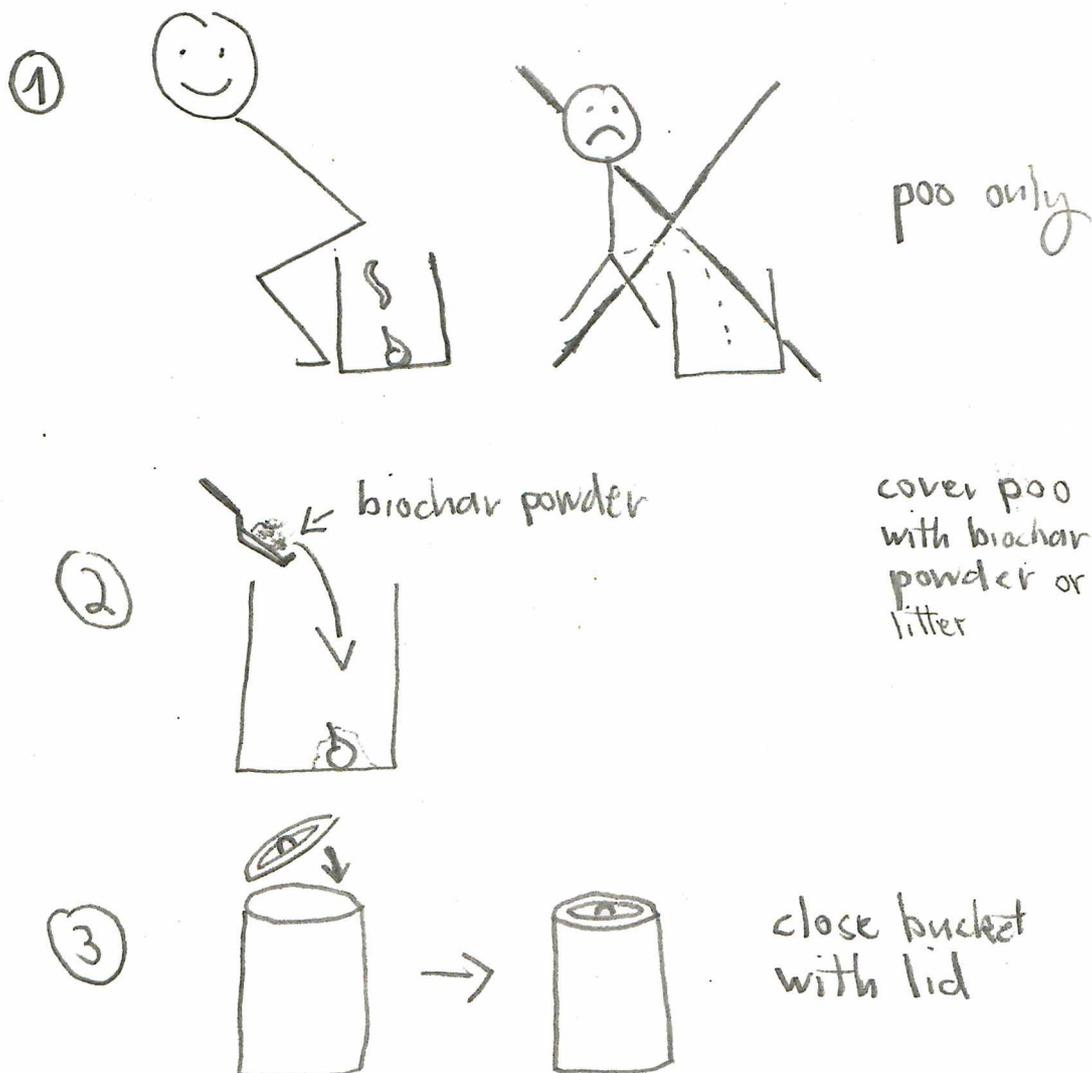


Fig. 3: Draft pictograms of how to use the buckets as toilets to be printed on the buckets

2.3 Composting the poo

Easy instruction for Composting your poo, to be printed on the buckets:

When the bucket is full, compost your poo, in order to hygienize it. Chose a place in the shadow, in order to compost your poo. Mix it therefore with other organic waste like garden cuttings, kitchen waste, straw, sawdust or other woody material. Use a stick for mixing, if you do not have a garden fork or shovel.

Keep it damp, in order to keep up composting. But make sure it does not get too wet, so that no water and infectious bacteria leak out. In case of too much rain, cover it with a covering sheet.

In case that civil defence has developed a strategy in advance, a goal this paper is aiming to achieve, local administration or help organizations will organize the collection and the composting of the content of full buckets. They will exchange them against food and new biochar-powder.

Supplement to the instruction on the buckets in this case: Hand in the closed buckets, you have filled with your feaces (and toilet paper) to local administration, that organizes their composting.

2.4 Composting the pee

Ad III: Closable canisters together with funnels and bio-active powder for starting the fermentation of urine

People are asked to urinate into canisters every time and before using the buckets for defecation. For this reason the following material is provided and delivered:

- Canisters fitted with screw caps of ten litre volume
- Funnels, having a diameter of at least twenty centimetres, that fit into the opening of the canisters, thus usable for both males and females of every age.
- Packages containing a mixture of 300 gramm sugar and whey-powder, inoculated with lacto-fermentation or soil microbes. Poured into the canister it creates together with the urine a solution suitable for fermentation. Thus emission of poisonous and smelly ammonium from the urine is prevented and the nitrogen conserved in living cells of the microbes instead.



Figs. 4, 5: A canister with a funnel on top forms a very simple but efficient urinal, a bucket with a lid does too, if nothing else is available.

Instruction of how to use the canisters again is printed on the canisters in English, Arabic, Chinese, Spanish, French, regional languages and as pictograms.

Instruction: Urinate into the canisters only. Fill the content of one package of sugar and whey-powder into the canister and pee into the canister. Close the screw lid of the canister after each pee. When the canister is full, compost its content on woody material. If composting is not possible, leave it closed.

Easy instruction for composting fermented urine to be printed on the canisters:

Spread woody material as composting bed in a shadowy place preferably underneath a hedge or a tree. If you dispose of a garden, chose an adequate place in the shadow there. Pour the fermented urine over the composting bed. Make sure it gets sucked by the composting bed and does not leak out. In order to reach all the surface of the composting bed do not make it wider than your arm is long. In case of too much rain, cover the composting bed with a covering sheet. But make sure it does not dry out on the other hand, because then composting will stop and mould might spread. If accepted in your community, you can pee on the composting bed directly.

Advice for local administration or help organisations:

The instruction for composting fermented urine stresses the use of woody material as underlying bed. The purpose of this is to get the carbon-nitrogen relation for the composting process approximately right. The more surface the woody material offers, the better the process functions. Sawdust or pellets mixed with biochar-powder and inoculated with soil microbes would be ideal, to start the composting. The inoculation can occur with local soil taken from underneath a hedge.

The more illiterate the instruction receiving community is, the more the success will depend on help organizations or local administration to communicate instructions orally or through pictograms.

Ad IV: Woody material for composting:

Local catastrophe administration will have to instruct people to gather carbon-rich composting material for urine composting or to deliver at least one 10 litre bag of wood pellets per person per week. Preferably the sawdust or pellets are enriched with biochar. This will result in a Terra Preta-like more stable and fertile compost for gardening.



Figs. 6, 7: Mixing the biochar into the composting bed, ready to absorb fermented or fresh urine.



Fig. 8: Pouring the fermented urine on the composting bed.

2.5 Producing biochar

Ad V: Pyrolysis stoves for cooking and producing biochar as a by-product:

The local administration or help organizations are advised to deliver perforated steel cylinders as pyrolysis stoves (best case) or instructions of how to build them from two waste tins with the help of a hammer and a nail (worst case), in order to provide simple devices for making water boil or cooking meals.

While cooking food these stoves produce biochar as useful waste, which can be used as litter for the feaces in the buckets or as aggregate to the urine composting bed.

At the same time these stoves produce far less smoke and use twigs, pellets or husks as fuel more efficiently than open cooking fires. Hazard of fire and smoke poisoning are reduced considerably.

It is not the purpose to describe the construction of these stoves here in detail. Some of their many advantages can be summarized as follows:

- low cost and easy self made production from waste tins or a construction kit
- Efficient and carbon negative use of organic fuel
- health protecting low smoke emission



Fig. 9: „Beaner camp stove“ from Worldstove (worldstove.com), a simple steel cylinder with holes...²



Fig. 10: ...fitting into a perforated beverage can, channeling the oxygen needed for the burning of the wood gas that is escaping from the woodchips, pellets or other woody material used as fuel filled into the cylinder.³



Fig. 11: The flame of this model lasts for about 15 minutes, leaving biochar behind after cooking. Bigger versions of similar stoves produce longer lasting flames enabling the cooking of whole meals.⁴

² Hiram Cook: „WorldStove's Beaner Campstove - First Burn“ on <http://www.youtube.com/watch?v=-UnRAtPAKjw> (July, 31st, 2014). Stove cylinder shone is designed and propagated by worldstove (worldstove.org).

³ Ibid.

⁴ Ibid.

As worst case administration is neither prepared, nor has it a strategy. Then people will have to be advised to gather waste plastic buckets with lids, as available in the garbage of fast food restaurants originally containing mayonaise or mustard. After an earthquake or a tsunami some empty buckets will be available in the rubbish heaps. Lids will have to be improvised then.

If no biochar (charcoal) is available people are advised to gather woody material, soil or leaves as litter. If nothing else is available they can use sand to cover their feaces with. Thus people gain time until composting is organized on a larger scale. For this worst case scenario help organizations will have to develop an emergency plan on how to improvise simple sanitation in buckets and how to instruct people on the site.

2.6 Commode chairs

In any case people are encouraged to reuse old chairs and adapting them as commode chairs by making a hole into the seat. If hammer, saw and nails are available commode chairs can be constructed from broken waste planks. The commode chair is preferably to be constructed exactly the size for the bucket to fit underneath.

2.7 The Costs

Costs for dry sanitation per 10 persons without VAT and transportation

11 buckets with lid:	5,50 Euro
10 litres of biochar-powder, inoculated with microbes	5,00 Euro
10 small hand shovels:	5,00 Euro
10 canisters with screw lid:	5,00 Euro
10 funnels	5,00 Euro
10 packages of a 300 gram mixture of sugar- and whey powder inoculated with lacto-fermentation microbes:	5,00 Euro
100 litres of wood-pellets	20,00 Euro
1 pyrolysis stove (perforated steel cylinder):	10,00 Euro
Costs per 10 persons:	60,50 Euro
Costs per person:	6,05 Euro

3 Sophisticating the system as organization improves – an example

Once a camp infrastructure is build up dry Terra Preta humus toilet shelters will be constructed using construction timber and/or cloth. 120 litres waste bin containers on wheels will be used to receive the feaces instead of the original 10 litre buckets.

The following pictured description shows how such a sanitation system can be build up by a handful of people within a few days for a camp-site of 300 people. It is considered transferable to disaster-scenarios and extendible in duration of use easily. Upscaling in quantity is considered possible too.

3.1 Providing 300 persons during a one-week open-air conference with dry Terra Preta humus toilets

Based on a paper for the Terra Preta Sanitation Conference in Hamburg-Harburg 2013 by Robert Strauch and Roland Wolf, scientific advisor: Dr. Jürgen Reckin

The European Permaculture Conference 2012 was held on a community site in Escherode, near Kassel in Germany. This open-air conference of about 300 participants had to be provided with dry sanitation for the duration of two weeks, because there was not enough flush water available.

3.2 The task

A waterless, easy to construct solution for approximately 300 people had to be found. Since permaculture supports and designs sustainable self sufficient land management, the chosen strategy had to be healthy, climate friendly and humus producing at the same time.

Aim of the conference was to reuse and recycle as many materials and resources originating from the site itself as possible for the construction of the camp infrastructure.

These criteria are valid for the management of disaster situations too, when infrastructure has to be improvised in a very short period of time.

The permaculture design team decided to use **Terra Preta technology**, in order to transform feaces and urine into black soil humus. At the same time lacto-fermentation of feaces and urine was to reduce the risk of infection to a minimum.

3.3 The solution

Ten dry humus toilets were built as a modular system from cheap building timber and cloth. A changing team of four to six people achieved this task in a period of three days. One-hundred-and-twenty litre plastic waste containers on rolls, available on the site, were used as containers to receive the feaces.

Workshop preparing the maintenance:

A weekend-workshop identified the materials on site, that would serve as **coverage for the feaces**. This turned out to be a mixture of **pulverized charcoal** from local fireplaces and the community's central wood furnace, **local loam** and **wood chaff**. These ingredients were collected and mixed on site:



Fig. 12: Mixed litter ready for covering feaces, consisting of charcoal, loam, sawdust and leaves.



Fig. 13: The coverage material was disposed in buckets with shovels or cups inside the toilet cabins.



Fig. 14: Terra Preta toilets made of timber and cloth with easy to empty waste containers underneath.

Instructions on how to use the toilet and the litter for coverage of the faeces were displayed in every humus-toilet, in order to prevent smell and keep away flies. Since users were all literate it did not need a pictogram. This will be different in other parts of the world.



Fig. 15: User's instruction in English

3.4 Maintenance during the conference

Lacto-fermentation and soil microbes were added into the toilet bins for hygienic purification, smell absorption and as starter for the desired fermentation and humification process.

Every bin was emptied twice during the two-week conference. A three-shift team of three people each to maintain and clean the toilets three times a day was organized. It proved difficult to cover the used toilet paper with litter sufficiently. Flies could easily feed on the uncovered faeces attached to the toilet paper and commute bacteria to the kitchen. It therefore is recommended to collect the toilet paper apart in closable bins and compost it separately.

The content of the bins was used for Terra Preta production during and after the conference, in order to produce fertilizer for the garden site on which the conference took place.

This can be adapted to refugee-camps in the way, that inhabitants use this fertilizer for building up gardens in an otherwise perhaps infertile environment.

The urine separation:

In order to reduce the urine input into the dry humus toilet, urinals for men were constructed using old plastic canisters as material.



Fig. 16: Canisters cut open as urinals for men.

For women special urinals had to be constructed.
Herefore a female construction team used their gender specific experience for the design-needs of women:



Fig. 17: Female urinal from outside with hand washing station and covered gutter as sewer.

The urine was stored in a one-cubic-metre-container. Sugar and lacto-fermentation microbes were added for purification, in order to prevent the emergence of ammonium. The liquid was used as fertilizer on the fields later.



Fig. 18: IBC-container for yellow and grey water storage

3.5 The Costs

Costs per 10 persons in Germany

One 120 litres waste container:	37,00 Euro
Litter (costs of collecting and mixing 12 litres of the powder for coverage on site)	15,00 Euro
Hand shovel:	0,50 Euro
Untreated construction timber for one cabin:	40,00 Euro
IBC-Container (1000 litre volume) calculated down proportionally to ten persons:	1,00 Euro
Cost per 10 persons without VAT and transportation:	93,50 Euro
Cost per person without VAT and transportation:	9,35 Euro

The maintenance team was recruited from participants of the camp. In case of a disaster camp the team members will be rewarded according to the local circumstances and resources available. A well organized maintenance team, cleaning the toilets three times a day, is the key to success.

4 Conclusion

This paper outlines the basis for a worldwide strategy of introducing dry sanitation as integral part of civil defence.

First aim of this proposed strategy is to make the outbreak of infectious diseases less probable in situations, when sanitation infrastructure has broken down, as it often does as consequence of disaster.

It therefore offers a very simple technique of collecting faeces and urine in buckets and canisters. The fermentation and composting processes have as main goal to minimize infection hazard. The production of fertilizer is a desirable by-product for the longterm survival of the community but not the first priority aim in this case.

The costs for material may be reduced considerably the more this strategy is upscaled. Thus cost reduction would rise with the amount of ordered material.

Encouraging people to improvise with used material from rubbish heaps as they are normally available in the aftermath of catastrophe, in order to build up their provisional emergency infrastructure very fast is another possibility of reducing the costs and empowering people to take their fate into their own hands.

This is why the example of the build up of sanitation infrastructure for a permaculture conference has been chosen as a role model, because reuse and redesign of used material easily available is one of the main strategies in the permaculture movement, in order to solve urgent problems ecologically and at low costs. This pattern is considered transferable to finding solutions in disaster situations.

In any case it will need skilled local or foreign experts on the spot respected by the local population, in order to serve as instructors and role models in the aftermath of disaster. Only then will it be possible to install and propagate the simple dry sanitation system outlined in this paper.

Climate and culture with its local believes and taboos vary all over the world. Therefore it needs a different approach and a different technique whenever and wherever a disaster happens. Only when this is taken into consideration there will be a chance to realize the sanitation system explained above.

On the one hand it needs a top down strategy from the United Nations favouring waterless sanitation in case of disaster. On the other hand it needs national and regional preparation of a strategy for a functional dry sanitation system adapted to each region and culture.

Every ecosystem and culture of the world has its own resources and knowledge available that will favour a slightly different solution of how to install a simple and life protecting dry sanitation system in case of break down of sanitation infrastructure.

In any case it will need experienced experts on all levels of civil protection from the United Nations Advisory Board on Water and Sanitation down to the local level of public health authorities. Therefore it is the purpose of this paper to suggest the installation of dry sanitation specialists worldwide on all levels of civil protection.

Dry sanitation expertise has to become part of the curriculum of medical staff, architects, urban planers, plumbers and water treatment engineers.

The author of this paper wants to contribute to the establishing of this network of experts in this field, in order to raise the chances of survival for people having to face the devastating effects of disaster events.

But beyond emergency situations dry sanitation systems have the potential of becoming more sophisticated and eventually taking over the place of flush water sanitation, once humanity has realized its potential of protecting clean water, building up fertile compost and finally enhancing water storage capacities of our soils worldwide.

Roland Wolf

Duisburg, Germany in July 2014