Swiss Water & Sanitation Consortium

Blue Schools

Linking WASH in schools with
environmental education and practice

Catalogue of Technologies

1st Edition

Introduction

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A Blue School offers a healthy learning environment and exposes students to environmentally-friendly technologies and practices that can be replicated in their communities. It inspires students to be change agents in their communities and builds the next generation of WASH and environment sector champions.

The Catalogue of Technologies aims to support project staff, education authorities and school stakeholders in selecting the appropriate Blue Schools technologies that can be put in place in a particular school. It provides references to low costs technologies with particular focus on sustainable land and water management, gardening and solid waste management. The environmentally-friendly technologies are meant for students to experience them at school, learn how they work and get inspired to replicate some of them at home and in their communities.

This catalogue proposes a selection of low-cost technologies for the following topics of the Blue Schools Kit.

- 3. The Watershed around My School
- 4. My Drinking Water
- 5. Sanitation and Hygiene
- 6. Growth and Change
- 7. From Soil to Food
- 8. From Waste to Resources.

For each topic, an introduction is provided to clarify the basic key concepts and the concept that are less common. The purpose of each technology, as well as its advantages and disadvantages are outlined.

This catalogue is a compilation of references from the WASH in School (WINS) community of practice as well as other sectors related to the Blue Schools' topics. It can evolve: Future editions of this Catalogue will benefit from inputs and feedback from users and experts from around the world. Feedback form available at the Water and Sanitation Consortium website: http://waterconsortium.ch/blueschool/

Users of this document are also encouraged to refer to the other materials of the Blue Schools Kit i.e. the Concept Brief, the Facilitator's Guide and the Catalogue of Technologies. These can be downloaded on the Swiss Water and Sanitation website.

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Water is the driving force of all nature.
Leonardo da Vinci

Image source: Wharton, Upenn

INTRODUCTION

The Watershed around My School

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Water retention and infiltration

Flood management

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"Watershed" is a hydrological term that defines a certain area of land where precipitation collects and drains off into a common outlet, such as into a river, bay or other body of water. It contains all surface and groundwater in that area. Other terms in use are: catchment area, catchment basin, drainage area, and river basin.

A watershed is characterized by its topography, shape, size, soil type, and land use. Problems (such as flooding, soil erosion or water table decrease) arise, if water and/or land is not managed appropriately. Activities such as deforestation, intensive agricultural practices, overuse or pollution of water bodies or inappropriate spatial planning can result in severe threats to human health which can affect down-stream population, in terms of quality and quantity of water available. This highlights the necessity to safely manage water and land, and thus to create increased knowledge and awareness of students regarding risks but also show pathways for improvement to the watershed around the school.

The technologies presented in this chapter can be applied around a school or in the community to improve erosion control, increase water infiltration and water retention in the soil, increase water availability and, all together, contribute to better flood management. In general, reducing water run-off where rain falls contributes to reduced flooding.

The following chapters show different technologies, some with considerable costs in terms of investment and labour.

3.1_Planted hedgerows

THE VETIVER SYSTEM

EROSION CONTROL | MICROENTERPRISE | WATER INFILTRATION | WATER RETENTION

ADVANTAGES

- withstands heavy rainfall
- flexible for following of contours
- retains soil moisture
- serves as fire or wind breaks
- source of animal fodder
- improves soil fertility
- Improves water infiltration
- source of marketable essential oils

DISADVANTAGES

- requires warm weather and full sun for ideal growth

Image source: TVNI

Outline Description of Technology

The Vetiver System is a system of erosion control and soil and water conservation that involves the planting of hedgerows of deep rooted Vetiver plants (*Vetiveria zizanioides*). The Vetiver can also be harvested and used as animal fodder and as a source of marketable oils.

Where Can It Work

The system is used in more than one hundred countries for soil and water conservation, infrastructure stabilization, pollution control and waste water treatment. It is a warm weather plant, suitable for use in the tropics, semi-tropics, and areas that have a Mediterranean climate where there are hot summers, and winters are temperate. In regions with extreme winters, hot summers or poor, saline soil conditions Jiji grass, is an alternative.

How does It Work

Vetiver hedgerows are planted along the contours of the terrain. Nursery plants or slips are typically planted 10 – 15 cm apart on the contour to create, when mature, a barrier of stiff grass that acts as a buffer and spreader of down slope water flow, and a filter to sediment. Full sun is required for the healthiest plants. Partial shading stunts its growth, and significant shading can eliminate it in the long term by reducing its ability to compete with more shade-tolerant species. (Vetiver.org)

Cost Considerations

This is a very low cost system with plant and labour costs varying from country to country.

Additional Resources

FAO Vetiver Network Vetiver Installation Guide WOCAT Vetiver System

ADVANTAGES

- rehabilitates degraded land
- reduces soil erosion
- simple maintenance
- combines well with planting pits
- bunds do not readily wash away
- retains runoff in planting area
- can be added in areas already under cultivation

DISADVANTAGES

- stone bunds require a readily available source of stones
- if ground between bunds is uneven water can pool and attract mosquitoes
- time consuming

Image source: SSWM.info

3.2_Bunds

CONTOUR BUNDS | SEMI-CIRCULAR BUNDS

EROSION CONTROL | WATER INFILTRATION | WATER RETENTION

Outline Description of Technology

Bunds are among the most common techniques used in agriculture to collect surface run-off, increase water infiltration and prevent soil erosion. Their principle is relatively simple: by building bunds along the contour lines, water runoff is slowed down, which leads to increased water infiltration and enhanced soil moisture. (SSWM)

Where Can It Work

Using different designs, bunds are applicable to even and uneven grounds (with a gentle slope of up to 5 per cent). Bunds are usually constructed either with soil or stones. Bunds are generally applied to sloping fields in order to reduce water runoff and erosion and may also be functional for severely degraded soils. Contour bunds can only be constructed on even ground, whereas semi-circular bunds can also be applied to uneven terrain. (SSWM)

How does It Work

Contour lines need to be demarcated. Boulders, stones and cobbles are collected from the surface of the land and carried towards the demarcated lines. Larger stones are used to make a simple foundation in a 5 - 10 cm deep trench, and smaller stones are put on top of the constructed wall. The smaller stones on the higher side act as filters. In areas where stones are scarce, soil can be formed into ridges. Bunds should more or less follow the contour and the literature recommends that the distance between bunds should be about 10 - 30m apart. The recommended height of bunds is about 25cm on average, but can range between 15 - 30 cm. (TECA)

Cost Considerations

The costs for the implementation of bunds depend strongly on the choice of design. For contour bunds, working time of approximately 32 person days is estimated per hectare. If machinery can be used, the time required reduces. For stone bunds, increased costs may apply where stones are rare. (SSWM)

Additional Resources

FAO SSWM TECA Wocatpedia

3.3_Radical terraces

DEFORESTATION | EROSION CONTROL |
WATER INFILTRATION | WATER RETENTION

ADVANTAGES

- controls soil erosion
- increases water retention in soil
- increases fodder availability
- increases crop productivity
- reduces soil runoff

DISADVANTAGES

- establishing terracing is expensive and tends to require government subsidy
- if poorly done landslides can occur
- reduces the area of cropped land

Image source: Helvetas, Nepal

Outline Description of Technology

A method of hillside terracing that involves earthmoving operations that create reverse slope bench terraces which have properly shaped risers stabilized with grass or trees on embankments to avoid collapse.

Where Can It Work

This method is suitable where soil erosion is due to high runoff on steep slopes, deforestation, low crop production and lack of fodder.

How does It Work

Radical terraces are designed to; reduce soil losses through enhanced retention and infiltration of runoff, to promote permanent agriculture on steep slopes, and to promote intensive land use where land availability is low and the demand for food is high. It is important to protect topsoil when terraces are being created so that it can be laid onto the terrace once it is formed. Newly established terraces should be protected in the first or second year of the establishment. After establishing a terrace, a riser is shaped and grasses or shrubs/trees are planted soon after. Napier grass is commonly planted and is used as forage for livestock. Risers on radical terraces are seen as a new production niche of forage as a result of land shortage and a strict zero grazing policy. (WOCAT)

Cost Considerations

This technology requires a significant investment. Factors that affect the cost are labour, soil structure and slope. The labour cost in Rwanda in 2011 was estimated at USD 1.6USD per day. (FAO)

Additional Resources

FAO WOCAT

3.4_Gully control

GULLY PLUGS | CHECK DAMS

FLOOD MANAGEMENT | EROSION CONTROL | WELL RECHARGE

Outline Description of Technology

A check dam (or gully plug) is a small, temporary or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows for a certain design range of storm events. A check dam can be built from wood logs, stone, pea gravel-filled sandbags or bricks and cement.

Where Can It Work

Gully control is appropriate in any region where deterioration of the watershed is evident and runoff has led to soil erosion and the formation of gullies.

How does It Work

Gully plugs or Check Dams can be constructed in a variety of ways. Brush fill is the continuous filling of small gullies with brush materials. Earth plugs, which are small earthen structures whose main purpose is to hold water and let it percolate into the ground. Woven-wire check dams are small barriers which are usually constructed to hold fine material in the gully. The main objective of brushwood check dams is to hold fine material carried by flowing water in the gully. Log check dams made of logs and posts are placed across the gully. They can also be built of planks, heavy boards, slabs, poles or old railroad ties. Loose stone check dams made of relatively small rocks are placed across the gully. The main objectives for these dams are to control channel erosion along the gully bed and to stop waterfall erosion by stabilising gully heads.

Cost Considerations

The cost in India is reported to be between USD 200-400 for temporary dams (made from brush wood, rocks, soil) and USD 1,000- 3,000 for permanent dams (made from stones, bricks, cement), depending on the length and height. (SSWM)

Additional Resources

FAO SSWM_Check Dams and Gully Plugs

ADVANTAGES

- water speed is slowed, reducing erosion
- no trench design required because existing gully drainage pattern is utilized
- can assist recharge of shallow wells
- can reduce salinity in groundwater
- cost effective
- can be made using locally available materials

DISADVANTAGES

- can silt up and reduce infiltration
- unclear land tenure can result in problems to do with ownership of the structure
- if designed incorrectly can block passage of fish

Image source: Veli Pohjonen

3.5_Sand dam

PRECIPITATION HARVESTING

ADVANTAGES
- lowest cost form of rainwater
- harvesting for quantity harvested
- suitable for community ownership and management
- saves time spent collecting water
- increases food production
- year round clean water source
- transforms local ecology

DISADVANTAGES
- requires regular rainfall to be productive
- funding may be required
- external technical input typically required as dams can fail when not correctly constructed

Image source: Excellent Development

Outline Description of Technology
Sand dams (sometimes called groundwater dams) store water under the ground in an existing riverbed. A sand dam is a small dam build above ground and into the riverbed of a seasonal sand river. A sand storage dams storage capacity increases over time.

Where Can It Work
Sand Dams are suitable for rural areas with semi-arid climate in order to store seasonally available water to be used in dry periods for livestock, minor irrigation as well as for domestic use. The riverbed needs to have a coarse sandy sediment with impervious bedrock underneath (or clays like black cotton soil). These conditions are typically found in arid and semi-arid regions.

How does It Work
To construct a sand dam, a deep trench is dug across the valley wall or stream, reaching the bedrock or other stable layer like clay. A concrete or masonry wall is then built on the underlying rock bars across the river channels so that it can trap and hold back the sand brought by the river during flooding. The height may be 2 - 5m high depending on the depth of the underlying rock or other stable layer. The dam should be positioned in an area in the riverbed where rainwater from a large catchment area flows through a narrow passage.

Cost Considerations
The cost of an average sand dam with a minimum life span of 50 years and storage of at least 2000 m3 is about USD 7500 (2-4 meters height and 20 meters length).To cut costs, local labour should be mobilised and involved in this process (community involvement) In one example in Kenya the community covered about 40% of the overall construction costs by being involved in the construction of sand storage dams by provision of labour and raw materials through sand dam management groups. (SSWM)

Additional Resources
SSWM Wocatpedia

3.6_Subsurface dam

PRECIPITATION HARVESTING

ADVANTAGES

- stores seasonal water resources
- protects against evaporative loss
- reduces contamination of water by livestock
- protected water storage discourages breeding of mosquitoes
- an inexpensive structure engaging whole community

DISADVANTAGES

- labour intensive and most communities would require external assistance to implement
- can reduce groundwater in downstream area

Image source: infornet-biovision.org

Outline Description of Technology

A subsurface dam stores water below ground level in an existing riverbed by obstructing the groundwater flow of an aquifer.

Where Can It Work

Subsurface dams are suitable for rural areas with semi-arid climate in order to store only seasonal available water to be used in dry periods for livestock, minor irrigation as well as for domestic use. The optimum zone for constructing a subsurface dam is on gentle slopes in the transition zone between hills and plains (as opposed to sand dams which are built on steeper slopes). Finding suitable places to build the dam is harder when the river is wider. In view of an efficient reservoir it is important that it is based upon impermeable beds or bedrock are underlying the reservoir.

How does It Work

A trench is dug across the valley or stream, reaching to the bedrock or other stable layer like clay. An impervious wall is constructed in the trench, which is then refilled with the excavated material. (SSWM)

Cost Considerations

Typically, subsurface dams are less expensive and easier to maintain than sand dams, but also have less capacity. They can be built with locally available material but labour requirements are intensive and specific expertise is needed. Subsurface dams, basically made out of clay, were constructed in Kenya, with a capacity of 425 to 1342 m^3 and at a cost of USD900-1600 in 2006. (VSF)

Additional Resources

FAO SSWM VSF Water For Arid Lands

3.7_Field trenches

FLOOD MANAGEMENT | PRECIPITATION HARVESTING | WATER INFILTRATION | WATER RETENTION

ADVANTAGES

- can significantly reduce runoff rates
- and volumes

DISADVANTAGES

- clogging or silting is an issue in areas with fine soil particles in upstream catchment
- high maintenance
- can fail if improperly sited or receiving too much debris
- limited to relatively small catchments

Image source: kkobeclan.com

Outline Description of Technology

Field (or infiltration) trenches increase precipitation harvesting by breaking the slope of the ground and therefore reducing the velocity of water runoff. By decreasing runoff, they enhance water infiltration and prevent soil erosion. Trenches can be an extension of the practices of ploughing fields.

Where Can It Work

Field trenches can be formed in all soil types and are not dependent on slope or rainfall conditions. While continuous trenches are good for dry regions, interrupted bunds can be helpful for water harvesting in regions with higher rainfall.

How does It Work

Infiltration trenches are excavated trenches, a minimum of 1m deep, filled with gravel or crushed stone. For optimal performance, trenches are constructed along contour lines, similar to contour bunds. Therefore, the lines need to be marked before starting digging. When digging the trench, the excavated soil is placed downslope along the edge of the trench. Crops are then planted on the elevated land between the trenches. The design of contour trenches can be continuous or intermittent. The optimal distance between two trenches depends upon the slope of the field, where steeper grounds require less distance.

Cost Considerations

The costs for field trenches depend on the cost of the filling material, and the labour needed (which can differ according to soil conditions). Due to their simple construction, only basic material is needed for building trenches, such as stakes, shovels, picks, crops, and possibly a tractor (depending on the slope of the field). (SSWM)

Additional Resources

SSWM_Field Trenches SSWM_Storm water Management

3.8_Contour and eyebrow trenches

GROUND WATER AND FLOOD MANAGEMENT | EROSION CONTROL | SOIL MANAGEMENT

ADVANTAGES

- can restore underground aquifers and recharge dried spring water sources after a few years
- can stabilize terrains and prevent erosion as well as land-slides
- enables the reestablishment of vegetal cover in some cases

DISADVANTAGES

- heavy labour
- continuous tranches can provoke land-slide in case of heavy rain fall
- the trenches must be thoroughly looked after (cleaned) year after year
- plants planted in the system must be protected (especially from cattle) to allow their establishment

Image source: Helvetas Nepal

Outline Description of Technology
Contour trenches (or swales) are dug on a slope in order to retain rain water in the soil. Contour trenches are applied in areas with slopes up to 30%. Above this threshold, the smaller eyebrow trenches are built for stability reasons.

Where Can It Work
Applicable anywhere.

How does It Work
As rain water run down slopes, it takes away precious top soil (this phenomenon is called erosion). Contour swales will pacify the water flow, keeping it on the terrain together with top soil. This system can be joined beneficially with planting trees or shrubs to retain soil even more, and prevent land-slide. If well chosen, these plants can contribute to provide livelihood options to the community.

Cost Considerations
The main costs are labour oriented.

Main source:
NEPCAT Fact Sheets (Helvetas Nepal)

Additional Resources
Permaculture News

3.9_Infiltration ponds

FLOOD MANAGEMENT | PRECIPITATION HARVESTING | WATER INFILTRATION | WATER RETENTION

Outline Description of Technology

An infiltration basin or pond is a facility constructed within highly permeable soils that provides temporary storage of storm water runoff. An infiltration basin does not normally have a outlet to discharge excess water. Instead, outflow from an infiltration basin is through the surrounding soil. An infiltration basin may also be combined with an extended detention basin to provide additional runoff storage for both storm water quality and quantity management.

Where Can It Work

Infiltration basins have been used globally to manage water resources. Care should be given in areas prone to mosquitoes because of the risks of standing water.

How does It Work

Ponds are formed through digging generally to a depth of 1 - 4m, deep enough to avoid excessive algae growth and shallow enough to avoid anaerobic conditions developing in the base of the pool. Intake surfaces or structures should be formed so as to minimize input of silt to the ponds. Sedimentation basins can reduce silt load before water enters infiltration pond. Where possible maintaining good cover of indigenous grasses in the run-off area can significantly reduce silting.

Cost Considerations

Costs are variable based on size and location. A percolation pond with a capacity of 10,000 - 15,000 m3 costs approx. USD 5,000 - 15,000 in India (SSWM)

Additional Resources

SSWM_Microbasins SSWM_Ground Water Recharge SSWM_Soil Aquifer Treatment

ADVANTAGES

- facilitates groundwater recharge
- improves soil moisture
- increases agricultural productivity
- can be used to recharge shallow
- wells, boreholes and springs
- can reduce salinity in groundwater

DISADVANTAGES

- can silt up easily due to lost vegetation cover in catchment area
- de-silting requires time and money
- maintenance requires communal effort
- high evaporation rates
- high cost of construction if done at scale

Image source :http://www.downtoearth.org.in/

3.10 Reforestation

INTEGRATED WATER RESOURCE MANAGEMENT | EROSION CONTROL | WATER INFILTRATION | WATER RETENTION

Outline Description of Technology

Planting trees is a very important tool for integrated water resource management. When trees are planted in sufficient number and bigger areas, reforestation can occur. This results in decreased soil erosion, and increased water infiltration and retention in the area. This is especially important where human activities have resulted in deforestation of land, be it for construction of houses and cities, be it for agricultural activities. Without plant cover, erosion can occur and sweep the land into rivers. The agricultural plants that often replace the trees cannot hold onto the soil and many of these plants, such as coffee, cotton, palm oil, soybean and wheat, can actually worsen soil erosion. And as land loses its fertile soil, agricultural producers move on, clear more forest and continue the cycle of soil loss. Reforestation and tree planting can break this vicious cycle.

Where Can It Work

If appropriate tree species (native) are chosen, it is applicable anywhere in the world where soil conditions and water availability allow. Watering in the initial phase may be necessary.

How does It Work

Please refer to slides 7.3, 7.8 and 7.8a in the Catalogue of Practical Exercices concerning deforestation and tree planting solutions.

Cost Considerations

The costs are moderate, depending on the tree seedlings used. The main costs are labour-oriented.

Additional Resources

Wikipedia

ADVANTAGES
- facilitates groundwater recharge
- improves soil moisture
- can be used to recharge shallow
- wells, boreholes and springs

DISADVANTAGES
- Needs some nursing at initial stage and management as well as protective measures in the long-term
- considerable costs if done at scale

Image source : Fastenopfer Madagascar

Topic 4_My Drinking Water

When the well is dry we will know the worth of water.
Benjamin Franklin

Image source: Water for Africa (http://www.waterforafrica.org.uk/our-birthday-story/)

Water sources/uptake

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- Parachute or tarp harvesters (4.2)
- Spring and water source protection (4.3)
- Protected hand dug well (4.4)
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- Biosand filter (4.21)
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INTRODUCTION

My Drinking Water

Drinking water or water used for food preparation should be free from microbial, chemical and radiological pollutants. The provision of drinking-water that is not only safe but also acceptable in appearance, taste and odour is of high priority.

Unsafe drinking water may be contaminated by faeces and/or toxins and may also be unacceptable due to suspended solids. Its consumption can result in infectious diseases, such as gastroenteritis, cholera, and typhoid, among others. Contaminated water is estimated to result in more than half a million deaths per year.

The selection of the water source has high influence on the water quality. To avoid time-consuming and expensive treatment, if possible sources with a high water quality and low health risks should be selected. Groundwater or spring water – if the catchments are adequately constructed and the sources are protected –are generally of higher quality than open surface water.
But, even if water of high quality is available at the source, it may get contaminated due to unhygienic transportation and storage container or polluted water abstraction tools.

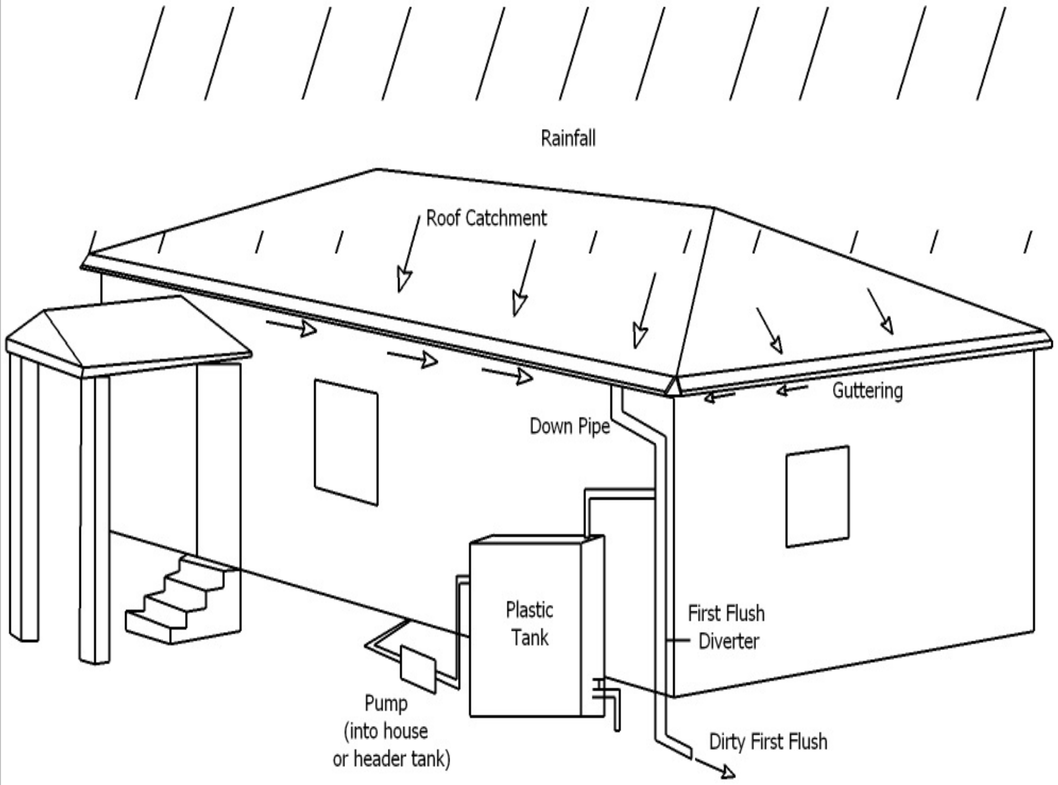
Consequently, safe water provision at the school demands the attention of three aspects, ranging from source to consumption:

1. Identify an appropriate water source and assure it’s appropriate catchment and protection;
2. Identify adequate strategies and options for water distribution, transport and storage;
3. Determine appropriate and feasible water treatment: options and technologies to guarantee user safety.

The following chapters present some innovative approaches to collect water from new sources, outline different options for drinking water storage at the school compound as well as in classroom and describe a number methods for drinking water treatment that could be practised in schools. It is important to note that technology itself will not solve any problem if not adequately managed and applied.

4.1_Rooftop harvesting

PRECIPITATION HARVESTING | WATER ACCESS | WATER STORAGE



ADVANTAGES
- excellent alternative water source
- flexible designs and capacities to suit diverse needs
- simple, owner-managed technology
- avoids loss of good quality water
- restricts flooding

DISADVANTAGES
- limitations due to rainfall, size of catchment area, and size of tank
- chance contamination from air pollution and dirt
- storage tank construction adds to cost
- maintenance essential if water is to be potable

Image source: SSWM

Outline Description of Technology

Rainwater Harvesting (RWH) is a method of collecting and conserving surface runoff rain water for storage and use. RWH has been in practice for centuries but gross misuse of existing water sources has led to global awareness and its increased importance off-late.

Where Can It Work

Applicable anywhere with rainfall in excess of 300mm annually.

How does It Work

Rooftop harvesting systems include; rain, roof catchment areas, a conveyance system (gutters, down pipes), storage units or tanks (over ground / underground), and a distribution system (pipelines, pumps). In addition, there are some aspects like filter/screens, first-flush diverters, disinfection methods and overflow management pipes required to complete the RWH system. Periodic inspection of the system is imperative to preserve quality, reduce contamination and ensure full use of the system. It does not require skilled labour.

Cost Considerations

RWH is site specific and it is difficult to give an overall cost estimate. Rain and catchment area are free of cost, especially if RWH is integrated during construction. The cost of the conveyance system, filters and typically the storage tank, which occupies 30-70% of the total costs, needs to be factored in. A study in India put the cost of constructing RWH at Rs 1.30 / litre / household. In 2013, the EPA reported construction cost at approx. USD 4 - 6 / gallon (3.78 litres) / person. (SSWM) PITCHAfrica constructed underground storage tanks in Kenya between 2012 and 2015 for USD 80 / 1000 litres of capacity.

Additional Resources

Appropedia, SSWM SSWM Rainwater Harvesting(rural)
SSWM_Rainwater Harvesting (urban)

4.2_Parachute or tarp harvesters

PRECIPITATION HARVESTING | WATER ACCESS

ADVANTAGES

- demountable, portable, high yield
- easily cleanable
- can be shared between families
- inexpensive
- can recharge wells and supplement roof systems with additional capacity
- ideal alternative to roof top harvesting where roofs are too small or property ownership is uncertain

DISADVANTAGES

- requires group for easy installation and demounting

Image source: PITCHAfrica

Outline Description of Technology

Parachutes *can be used as* demountable and portable rain harvesters inverted and raised off the ground with bamboo poles or locally available sticks. The parachute suspension lines serve as guide wires staked into the ground and stabilizing the inverted 'chute'. Effective smaller rain harvesters can also be made with a simple tarp, propped on sticks and directing water to a central tank. (PITCHAfrica)

Where Can It Work

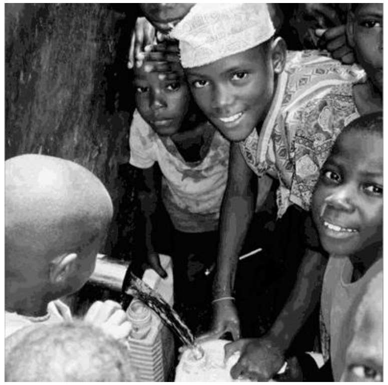
Parachute or Tarp *harvesting* can be used anywhere where access to water is difficult and rainfall is in excess of 300mm annually.

How does It Work

These harvesters can be used as a stand alone device to harvest water, recharge wells and water storage tanks. They can also be coupled to with a water filtration and storage system to provide potable water supply. A 7m diameter *Rainchute* can harvest more than 25,000 litres annually in a semi-arid region. This is in excess of 70 litres every day year round.

Cost Considerations

Depending on size, single *Rainchute* costs between USD 150 - 300. Attachable Supports, such as bamboo poles are sourced locally.



Survival active

4.3_Spring and water source protection

Water source protection involves the protection of surface water sources (e.g. rivers) and groundwater sources (e.g. spring protection) to avoid water pollution. As many surface water sources are used for drinking water purposes, protection is vital. Generally, three basic strategies exist for protection, prevention, treatment and the restoration of natural ecosystems (UNEP).
Wateraid SSWM

SSWM

4.4_Protected hand dug well

The traditional and still most common method of obtaining groundwater in rural areas of the developing world is by means of hand-dug wells. These are best where the water table is not lower than 6m. A hole is dug until the groundwater level is reached. Inflowing groundwater is collected and extracted with the help of pumps or buckets. Protection of the surrounding areas must be ensured to prevent contamination.
SSWM

Express Tribune

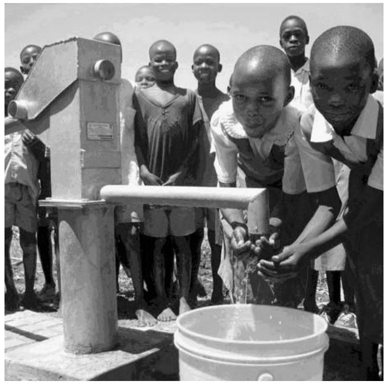
4.5_Tube well or borehole

A tube well is a type of water well in which a long 100–200 mm wide stainless steel tube or pipe is bored into an underground aquifer. It is important to determine that the aquifer is not contaminated and is being recharged. The lower end is fitted with a strainer, and a pump lifts water for irrigation. The required depth of the well depends on the depth of the water table. (Wiki)

appropedia

4.6_Treadle pump

A treadle pump is a human-powered suction pump that sits on top of a well and is used for irrigation. It is designed to lift water from a depth of 7m or less. The pumping is activated by stepping up and down on a treadle, which are levers, which drive pistons, creating cylinder suction that draws groundwater to the surface. (Wiki)



Geography Blog

4.7_Hand pump

Hand pumps are manually operated pumps. There are many different types of hand pump available, mainly operating on a piston, diaphragm or rotary vane principle with a check valve on the entry and exit ports to the chamber operating in opposing directions. (Wiki)

Ropepumps.org

4.8_Rope pump

In a rope pump a loose hanging rope is lowered into a well and drawn up through a long pipe with the bottom immersed in water. On the rope, round disks or knots matching the diameter of the pipe are attached which pull the water to the surface. They can be operated by hand, pedals, motors or wind. It is commonly used in developing countries for both community supply and self-supply of water and can be installed on boreholes or hand-dug wells. Protection of the surrounding areas must be ensured to prevent contamination. (Wiki)

4.9_Water storage tank: brick

WATER STORAGE

Outline Description of Technology

Brick cement tanks are a low cost option for storing water gained through water harvesting. They are cheaper than ferrocement tanks and easier to build.

Where Can It Work

Applicable in any region where you have access to clay based soils and or a brick supply.

How does It Work

Ground tanks should always be designed as either hemispherical (half ball shape) or cylindrical because those shapes equalize the pressure of water and soil whether the tanks are full or empty. Depending on the size of the tank, water extraction can be done using gravity, hand-pumps or other pumps, or with a bucket. Tanks should not be located near a pit latrine/toilet or rubbish or on an ant hill. Avoid building the tank next to a tree as the roots may undermine the foundation and dry leaves will block gutters. The height of the gutters should be higher than the proposed tank height. Do not site tanks where heavy vehicles will pass close to tank foundations.

Cost Considerations

The cost of underground tanks can be high and variable in cost per m3 of storage (average around USD30-40 per m3 of storage), sometimes a lot more depending on various factors. Sub-surface hemispherical tanks made from stone masonry and bricks/cement in Ethiopia cost in the range of 113 - 219 Euro per m3 of storage. In Kenya, brick/cement tanks cost USD37 per m3 of storage (21m3 tank cost USD780). In Sri Lanka, brick tanks cost USD28 per m3 of storage (5m3 tank cost USD140). (Akvopedia)

Additional Resources

Akvopedia IRCWash

ADVANTAGES
- inexpensive to construct
- easier to construct than ferrocement tanks
- can be made with local materials

DISADVANTAGES
- small capacity
- requires maintenance to avoid cracking and leakage

Image source: Akvopedia

4.10_Water storage tank: ferrocement

WATER STORAGE

Outline Description of Technology
Even small 1000-2000 litres ferrocement tanks can be effective for the storing of water (or food). They can be constructed with various agricultural waste materials (e.g. dry leaves or grass) in combination with cement and cloth fibre. The larger 5000-10’000 litres pumpkin tank (4.13) uses similar principles in its construction.

Where Can It Work
Applicable anywhere with rainfalls of 300mm per year or more.

How does It Work
A 2m3 (2000 litres) ferrocement water tank can be built by forming a cage of steel reinforcement bars, covered with chicken wire mesh. An alternative is to start with an inner form of metal sheets, which is later removed. For smaller tanks, a sack filled with sand is used as the formwork. Once this structure is established, a cement mixture is applied. As ferrocement is much stronger than masonry, the thickness of the walls is in the range of 10-30mm. During curing (at least 10 days, although 30 is better) the cement is kept wet and wrapped in plastic sheet. These tanks will be a lot cheaper than a plastic tank, have a lifetime of at least 25 years, and are easy to repair in case of cracks. The technology is extremely simple to implement, and semi-skilled construction workers can learn it with ease. Such tanks have been used on a wide scale in Asia and in some African countries, and there is huge scope for increased use of rainwater harvesting systems.

Cost Considerations
Ferrocement tanks: USD26 - USD50 per m3 storage depending on size (e.g. 11m3 for USD550, 46m3 for USD1,200). The Rain Foundation indicate a cost of between 40-100 Euro per m3 storage for ferrocement tanks (including everything like materials, transport and labour).
(Akvopedia)

Additional Resources
Akvopedia Rainwaterharvesting.org CWD
NEPCAT Fact Sheets (Helvetas Nepal)

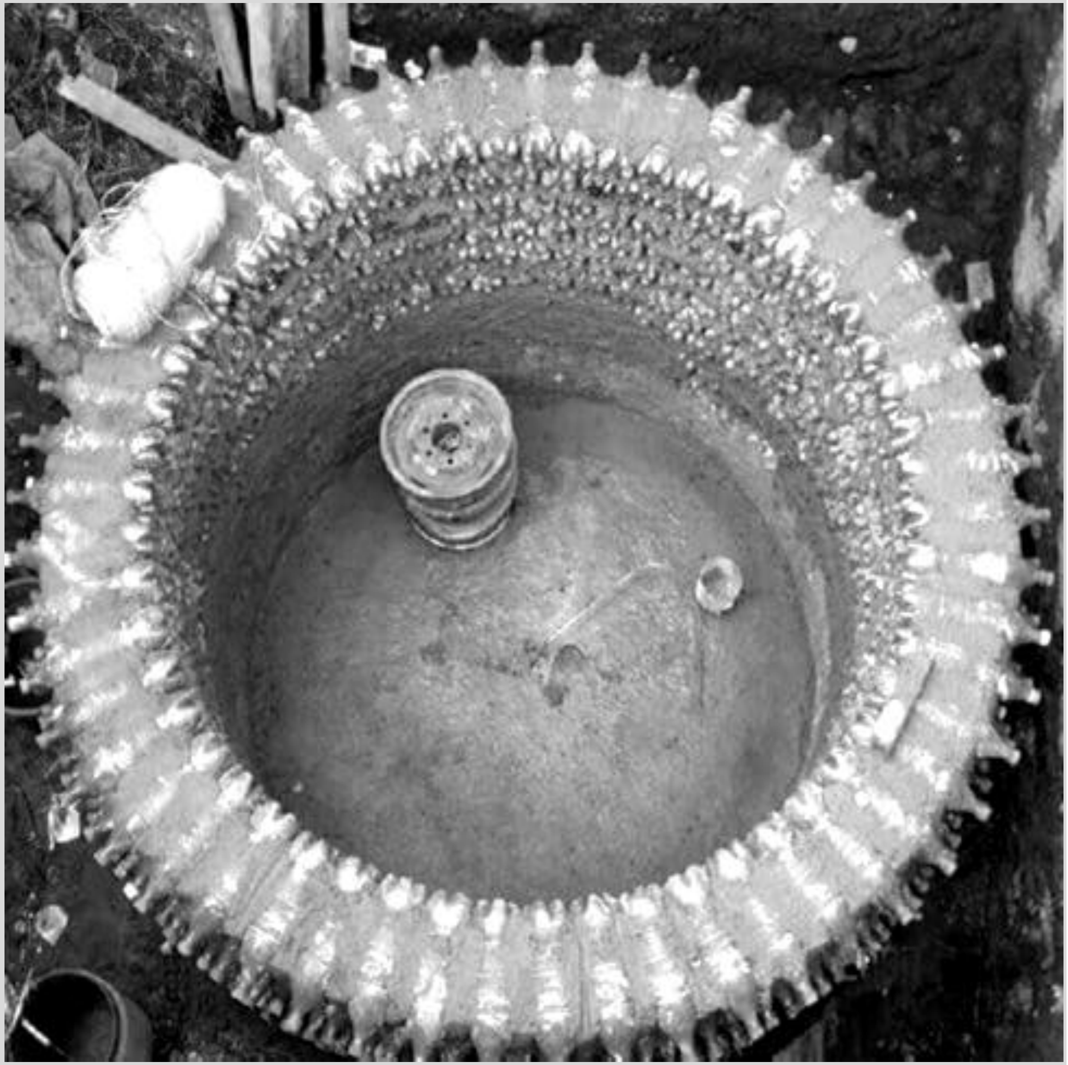
ADVANTAGES
- formwork can be reused
- inexpensive to construct
- can be used to store rainwater or food

DISADVANTAGES
- moulds become unwieldy at larger sizes.

Image source: Helvetas Nepal

4.11_Water storage tank: plastic bottle

ECO TEC
WATER STORAGE



ADVANTAGES
- inexpensive to construct
- easier to construct than ferrocement tanks
- can be made with local materials

DISADVANTAGES
- small capacity
- requires maintenance to avoid cracking and leakage

Image source: www.niftyhomestead.com

Outline Description of Technology
Used water bottles filled with soil and non-organic waste are used as bricks for the construction of a water tank.

Where Can It Work
Applicable in regions where plastic bottles are being used and discarded and there are no effective ways of recycling them.

How does It Work
This tank is constructed using 1.5 litre plastic bottles. Bottles are filled with soil or non-organic waste then used as bricks for the construction of water tanks and latrines. This concept has been adopted in the community of Mwera in Zanzibar, where two 10,000 litre water tanks have been constructed using 'bricks' made from reused water bottles. The weight of plastic reused to build the tanks was considerably less than the conventional plastic 'SIM tank.' The sustainable water tanks use significantly less cement than a conventional brick tank and are much stronger and more durable than either construction alternative. (Ecologue)

Cost Considerations
The tank requires plastic bottles, river sand, cement and reinforcement twine or wire.

Additional Resources
Nifty Homestead Peace Corps

Total Tanks

4.12_Plastic SIM tank

Plastic tanks for rainwater harvesting and water storage up to 10,000 litres can be purchased in most countries. These tanks typically last for 4-5 years.
akvopedia

University of Warwick

4.13_Pumpkin tank

The Sri Lankan Pumpkin Tank, and the associated construction technique was developed with World Bank support for use in Sri Lanka but is universally applicable and can be constructed in part with unskilled labour. Materials are metal frame, chicken wire and sand and cement.
Practical Action_Domestic Tank

Pinterest

4.14_Underground ferrocement tank

Ferrocement is a system of reinforced mortar or plaster (lime or cement, sand and water) applied over layer of metal mesh, woven expanded-metal or metal-fibres and closely spaced thin steel rods such as rebar. It is ideal for constructing above or under-ground rainwater storage tanks. (Wiki)
Practical Action USAID

www.obelink.nl

4.15_Plastic storage and distribution tank

A properly designed plastic storage and distribution must be affordable, portable, durable and easy to use. It must have a tap to withdraw water in a sanitary manner (reduce contamination by hands or dipping utensils). Yet, it is important that the mouth is still big enough and the tap removable in order to be properly cleaned. It must have a coverable (screw-cap) opening for filling and cleaning.

Helvetas, Benin

4.16_Solar pump / small distribution systems

Small water distribution systems equipped with solar pumps allow the distribution of safe water to schools, health centres as well as to the community.
Helvetas Benin

Helvetas, Nepal

4.17_Gravity flow water supply systems

True to their name, gravity flow systems take advantage of gravity to transport water from a source to a service area located at a lower elevation. From the intake, water is transported continuously by a transmission line to one or several storage tanks. Higher capacity distribution pipelines then supply water to public and/or private tap stands.
NEPCAT Fact Sheets (Helvetas Nepal)

ADVANTAGES

- disinfects viruses, bacteria and protozoa
- commonly known technology
- can be applied with locally available resources
- treats also turbid water

DISADVANTAGES

- recontamination risk during storage
- energy-intensive, requires energy (fuel, wood, electricity)
- time-consuming application
- not suitable for treating large volumes

Image source: Scott Akerman (CC BY 2.0)

4.18_Boiling

WATER TREATMENT

Outline Description of Technology

Boiling is the world's oldest, most common water treatment technology.

Where Can It Work

The technology is commonly applied at school/household scale. Due to the effort required with heating up the water, it is never used at big scale.

How does It Work

WHO recommends to heat up water to a rolling boil for one minute. Pathogens are sensitive to heat and the disinfection process, which is called pasteurization starts at 60°C. At a temperature of 100°C it takes about 1 Min. to disinfect the water. Ideally, the water is cooled and stored in the same vessel in order to minimize chances of re-contamination. Boiling kills pathogens but does not remove turbidity or chemical pollution from drinking water.

Cost Considerations

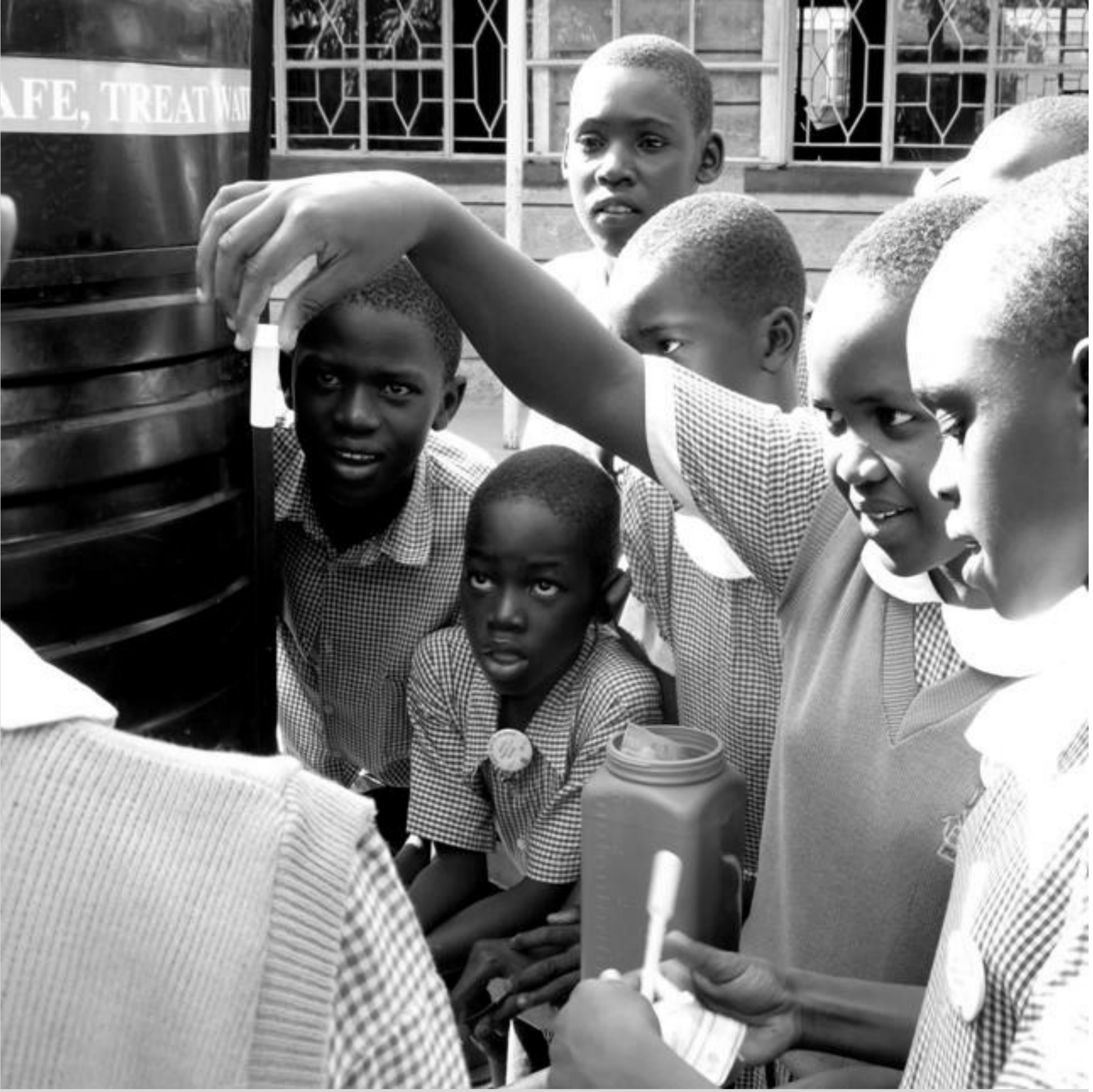
It requires time to collect wood for cooking or fuel or electricity has to be purchased. The energy required to heat up 1L of water from 20°C to 100°C and let it boil for one minute takes about 360 kJ/L. The energy content of hardwood is about 14.9 MJ/kg. If hardwood is burnt with an efficiency of 50%, about 50g of wood have to be burnt to boil 1L of water. The energy content of Kerosene or Diesel fuel is about 43.1 MJ/kg. If burnt with an efficiency of 50%, it takes about 16ml of Kerosene to boil 1L of water.

Additional Resources

Safe Water School Manual SSWM HWTS

4.19_Chlorination

WATER TREATMENT



Outline Description of Technology

Chlorine is a widely used chemical disinfectant. Different brands of chlorine products are available in local markets. They may contain a concentration of 0.5 to 10% chlorine. Commonly used products are: 1) Liquid Sodium Hypochlorite (NaOCl), which can be generated from salt using electrolysis (it is however not stable and has to protected from sunlight and heat), 2) Sodium dichloroisocyanurate (NaDCC), usually very stable in tablet form, and 3) Solid Calcium Hypochlorite (Ca(OCl)2), known as Bleaching Powder.

Where Can It Work

Water disinfection with Chlorine is broadly applicable. Batch system chlorination can be applied for small to larger water storage containers while also continuous chlorination systems exist for water supply schemes.
Technologies for the local production of chlorine using electrolysis are available (for example WATA) and successfully have been used for water treatment in schools.

How does It Work

Chlorine reacts within a relatively short contact time of 30 Min. Water quality influences the inactivation by chlorine as particulate, colloidal & dissolved constituents react with the free chlorine and consume it. Turbid water needs pre-treatment to reach a turbidity of less than 5 NTU. The pH of the water should be between 6.8 and 7.2.
WHO recommends that there should be a residual concentration of free chlorine of $\geq$0.5mg/L after at least 30 Min. contact time. At the point of delivery, the minimum residual concentration of free chlorine should be 0.2 mg/L (WHO 2017).

Cost Considerations

A locally purchased bottle of liquid Sodium Hypochlorite for the treatment of 1'000 litres of water costs about 0.1 to 0.5 USD.
A Mini-WATA, which produces about 500ml of Chlorine in 3h using salt and water, costs 150 USD. If no electricity is available locally, a solar panel needs to be purchased.

Additional Resources

Safe Water School Manual SSWM HWTS WATA WHO Helvetas Benin

ADVANTAGES

- disinfects viruses, bacteria and protozoa
- simple to use
- low cost
- provides residual disinfectant (protects water against recontamination)

DISADVANTAGES

- challenges in disinfecting Cryptosporidium
- changes water taste
- highly turbid water needs pre-treatment
- chlorine is a corrosive chemical and precaution must be taken for handling

Image source: Eawag

4.20_Ceramic water filter

WATER TREATMENT

Outline Description of Technology

Different types of ceramic filters exist (e.g. pot-shaped filter, candle filter). The removal effectiveness depends on size of the pores in the clay. Ceramic filters usually have a pore size of about 100nm. Pore size and permeability of the ceramic filters are a function of burnable components and the pressure applied during production. The quality of locally produced filters can be highly variable.

Some ceramic filters are coated with colloidal silver. This leads to a higher disinfection efficiency and contributes to the reduction of recontamination risks in stored water. However, potential adverse health risks of silver leaching are disputed.

Where Can It Work

Ceramic water filters usually are designed to treat a volume of 20 to 30L. They are commonly used at household scale. Ceramic water filters can also be placed in class rooms of schools.

Ceramic water filters are not very ideal for the treatment of very turbid water as the particles in the water clog the filters, leading to a frequent need for filter cleaning.

How does It Work

Water is filtered through porous ceramic material – either through a candle filter or through a pot-shaped filter. Most filters are effective at removing about 99.9% of protozoa and 99.99% of bacteria, but do not remove viruses. The flow rate in ceramic water filters is about 1-2 litres per hour. Insufficient cleaning and unhygienic maintenance of filters can lead to recontamination of the treated water.

Cost Considerations

Ceramic water filters including housing cost between 10 to 45 USD.
The replacement of candles or clay filters cost between 4 to 10 USD.

Additional Resources

Safe Water School Manual SSWM HWTS

ADVANTAGES

- removes bacteria and protozoa
- simple application
- local production possible
- no requirement for chemicals or energy

DISADVANTAGES

- limits effectiveness against viruses
- recontamination risk during storage
- quality of locally produced filters is variable
- requires regular cleaning if water is turbid
- fragile material can lead to filter breakage

Image source: Eawag

4.21_Biosand filter

WATER TREATMENT

Outline Description of Technology

Water in a biosand filter is passed through several layers of sand and gravel with different grain size. Microorganisms living in the so-called "Schmutzdecke", a biologically active layer on the top of the filter, consume bacteria and other pathogens in the water. Biosand filters remove about 90% of Bacteria and Viruses and about 99% of Protozoa. The microorganisms in the biological layer consume organic matter dissolved in the water and therewith also improve the chemical water quality. In addition to predation, sediments, cysts and worms are trapped in the spaces between the sand grains or adsorbed to the material. Biosand filters have a very long lifespan, they may still be performing satisfactorily after 10 years. Their installation therefore could be useful in remote areas with limited access.

Where Can It Work

Biosand Filters are commonly applied at household scale or can be placed in the yards of schools. Designed as Slow Sand Filters the technology is also used for water treatment in larger scale water supply schemes.
Biosand filters are not very ideal for the treatment of water with a turbidity of more than 50 NTU as the particles in the water will clog the filters, leading to a frequent need for filter cleaning.

How does It Work

The surface of the filter is always submerged under water. This leads to the formation of the "Schmutzdecke", the biologically active layer on top of the filter, allowing bacteria and pathogen removal. After passage through the filter, the water is collected in a safe storage bucket.
Cleaning or drying of the filter destroys the "Schmutzdecke". 2-3 weeks of operation are required for the biological layer to build up and for the filter to perform satisfactorily again. The Biosand filter designed by CAWST has a recommended flow rate of 0.4 litres/minute measured when the inlet reservoir is full of water.

Cost Considerations

The installation of a household scale biosand filter costs about 40 to 75 USD.

Additional Resources

Biosandfilter Safe Water School Manual SSWM HWTS

ADVANTAGES
- high removal of protozoa, lower removal of bacteria and viruses
- simple application
- local production possible
- no energy or chemical requirements
- very robust installation and long lifespan

DISADVANTAGES
- disinfection efficiency lower than other technologies
- needs matured (2-3 weeks) biological layer to be effective ("Schmutzdecke")
- filter is clogging at high turbidity (>50 NTU)
- no residual protection against recontamination

Image source: SSWM

4.22_Solar water disinfection (SODIS)

WATER TREATMENT

ADVANTAGES

- high removal of bacteria and protozoa. Lower removal of viruses
- uses locally available materials (sunlight, and PET-bottles)
- very low cost
- no change in water taste
- recontamination unlikely if stored in bottles used for treatment

DISADVANTAGES

- highly turbid water needs pre-treatment
- weather dependency
- long treatment time (some hours to two days)
- limited volume of water that can be treated
- requires a large supply of intact, clean and properly sized bottles

Image source Eawag

Outline Description of Technology

SODIS uses transparent PET-bottles to treat the water. Teaching SODIS in school has a strong didactic effect because the application is simple and children can directly apply the method they learnt at school in their homes.

Where Can It Work

As SODIS uses PET-bottles, only small volumes of water can be treated at once. SODIS is not very ideal for the treatment of water with a turbidity of more than 27 NTU as the particles in the water will shield pathogens from irradiation. Pre-treatment of turbid water is necessary. Sufficient sunlight is required.

How does It Work

Contaminated water is filled into transparent PET plastic bottles and is exposed to the sunlight for 6 hours. During cloudy days, bottles are being exposed for 2 consecutive days. During exposure, the sunlight destroys the pathogenic bacteria, viruses and protozoa.
A solar radiation intensity of at least 500 W/m2 is required during 5 hours. A synergy of UV-A radiation and temperature occurs if the water temperature rises above 50°C. At this temperature, water is safe for consumption after 1 hour of solar exposure.
Solar water disinfection kills 99.99% of Bacteria and Protozoa and 90% of viruses.

Cost Considerations

The only resources required are empty, transparent PET-bottles.

Additional Resources

SODIS Safe Water School Manual HWTS

Topic 5_Sanitation and Hygiene

Hygiene is two thirds of health
Lebanese Proverb

Image source: https://aglobalhf.squarespace.com

Hand washing stations

- Tippy tap (5.1)
- Tap Up Hand Sink (5.2)
- Foot Pump Operated Hand washing Station (5.3)
- Hand washing Station (5.4)
- Soap making (5.5)

Toilet facilities

- Single Ventilated Improved Pit (VIP) Latrine (5.6)
- Urine Diverting Dry Toilet ECOSAN toilet (5.7)
- Twin Pits for Pour Flush (5.8)
- Arborloo (5.9)

INTRODUCTION

Sanitation and Hygiene

Good hygiene and sanitation pracitces are very important in preventing infectious diseases in general, and water-borne diseases in particular. Hence, this topic focuses on promoting technologies that interrupt and limit spreading of diseases. If technologies are used in every days life, sound hygiene practices can save life (and especially young lives).

This topic presents a small selection of hand-washing stations and toilet facilities, which can be built with very low or medium costs. Most of them are not only appropriate for schools, but can be replicated in the home of the students. For an extended overview of various types of sanitation technologies consult the Compendium of Sanitation Systems and Technologies (Eawag). Technologies to store and treat drinking water is covered in topic 4 and technologies to keep the surrounding environment clean is from waste is covered in topic 8.

The use and maintenance of the infrastructure as well as good hygiene practices is key to success. Examples for how it can be introduced and discussed with students in a practical and fun way are demonstrated in the Catalogue of Practical Exercises.

SSWM

5.1_Tippy tap

A tippy tap style hand sink can be made by several ways. The most common way is to find a container (i.e. a large can, bottle or pot) and drill a hole near the top. A string and a pedal are attached at the top of the container allowing the water to flow out.
SSWM

SSWM

5.2_Tap up hand sink

Hand washing is hygienic when the user does not contaminate the water outlet. In this case a bucket with a valve added at the bottom serves as a hand sink. The principle is that the water outlet is continuously washed and that water is collected in a second bucket and the grey water can be recycled when the bucket is full.
SSWM

Camping kitchen box

5.3_Foot pump operated hand-washing station

A simple, low cost foot pump operated system that pumps clean water from a storage bucket through a pipe into an adjacent bucket, allowing for the easy recycling of grey water.

Practical Action

5.4_Hand washing station

A semi-permanent or permanent hand-washing station can be constructed in brick and ferrocement.
Unicef

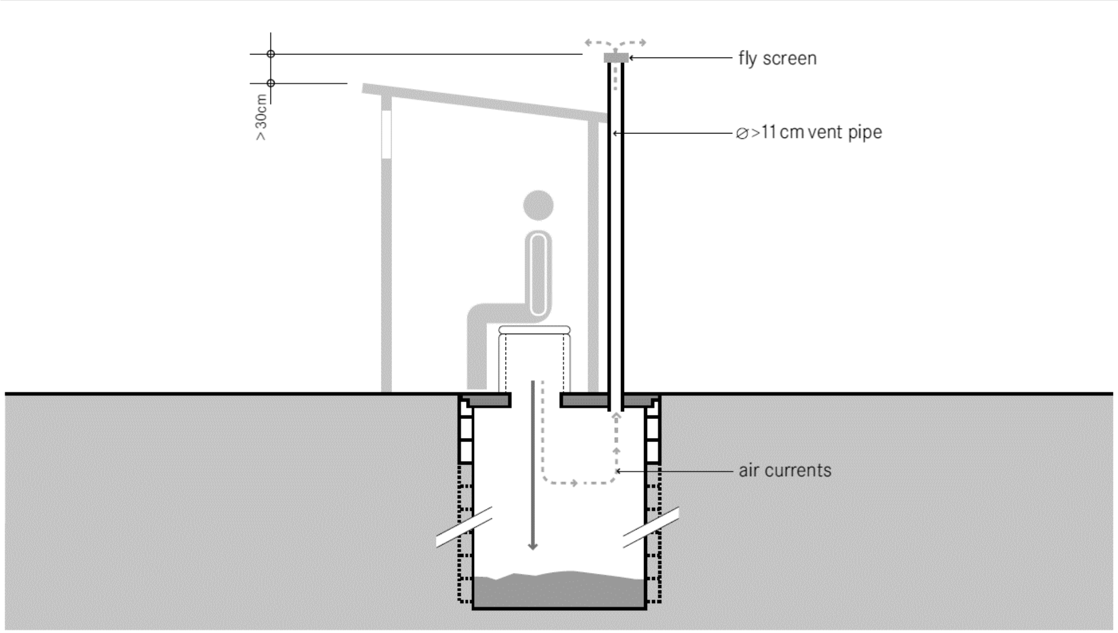
5.5_Soap making

The WHO has stated that the use of soap is the most effective method for increasing hygiene in a population. Washing hands with soap after using the toilet or cleaning a child and before handling food can reduce rates of diarrheal disease by 48-59 per cent. To make soap you need two ingredients, lye and oils.
ZmeScience World Bank

Refer to Exercise 5.9 in the Practical Exercise Catalogue for instruction to make soap

5.6_Single Ventilated Improved Pit (VIP) Latrines

SANITATION



ADVANTAGES

- flies and odours are significantly reduced (compared to non-ventilated pits)
- can be built and repaired with locally available materials
- low (but variable) capital costs depending on materials and pit depth
- small land area required

DISADVANTAGES

- low reduction in BOD and pathogens with possible contamination of groundwater
- costs to empty may be significant compared to capital costs
- sludge requires secondary treatment and/or appropriate discharge
- health risks from flies are not completely removed by ventilation
- pits are susceptible to failure and/or overflowing during floods

Image source: Eawag

Outline Description of Technology

The single VIP is a ventilated improved pit (VIP). It is an improvement over the Single Pit because continuous airflow through the ventilation pipe vents odours and acts as a trap for flies as they escape towards the light. Despite their simplicity, well-designed single VIPs can be completely smell free, and more pleasant to use than some other water-based technologies.

Where Can It Work

Single VIPs are appropriate for rural and peri-urban areas. In densely populated areas they are often difficult to empty and/or have insufficient space for infiltration. VIPs are especially appropriate when water is scarce and where there is a low groundwater table. They are not suited for rocky or compacted soils (that are difficult to dig) or for areas that flood frequently. Make sure that they provide adequate privacy for boys and girls. Care should be taken that objects, such as trees or houses, do not interfere with the air. stream. The vent works best in windy areas, but where there is little wind, its effectiveness can be improved by painting the pipe black.

How does It Work

As liquid leaches from the pit and migrates through the unsaturated soil matrix, pathogenic germs are absorbed to the soil surface. In this way, pathogens can be removed prior to contact with groundwater. A minimum horizontal distance of 30 m between a pit and a water source is normally recommended. The ventilation also allows odours to escape and minimizes the attraction for flies. Wind passing over the top creates a suction pressure within the vent pipe and induces an air circulation. Air is drawn through the User Interface into the pit, moves up inside the vent pipe and escapes into the atmosphere. The heat difference between the pit (cool) and the vent (warm) creates an updraft that pulls the air and odours up and out of the pit. Flies that hatch in the pit are attracted to the light at the top of the ventilation pipe and are trapped by the flyscreen and die.

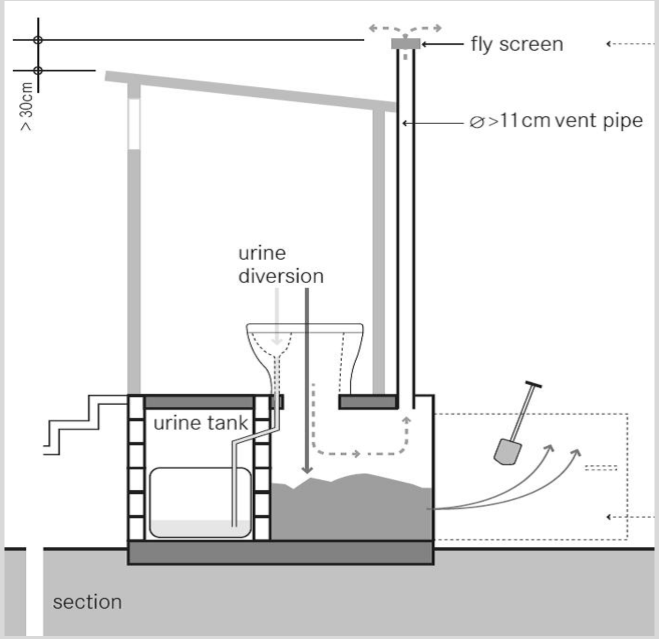
Cost Considerations

The costs can vary depending on which materials are used (cement, burnt bricks, etc.) and are around USD600 to USD 800.

Additional Resources: COMPENDIUM WEDC

5.7_Urine Diverting Dry Toilet – ECOSAN toilet

SANITATION



ADVANTAGES

- low risk of pathogen transmission
- uses of dried faeces as soil conditioner
- uses of processed urine as a fertilizer

DISADVANTAGES

- manual removal of dried faeces is requires (cultural barrier)
- requires constant source of cover material

Image source: Eawag

Outline Description of Technology

Urine diverting dry toilets (UDDTs) are used to collect and store urine and faeces separately. Faeces will only dehydrate when the vaults are well ventilated, watertight to prevent external moisture from entering, and when urine and anal cleansing water are diverted away from the vaults. These toilets can be constructed indoors or with a separate superstructure.

Where Can It Work

Ecosan toilets are suitable for rocky and/or flood prone areas or where the groundwater table is high.

How does It Work

Ecosan toilet is a simple-to-use technology and requires no or low operating costs if self-emptied. It can be built and repaired with locally available materials. These toilets work best with adequate training and acceptance to be used correctly.

Cost Considerations

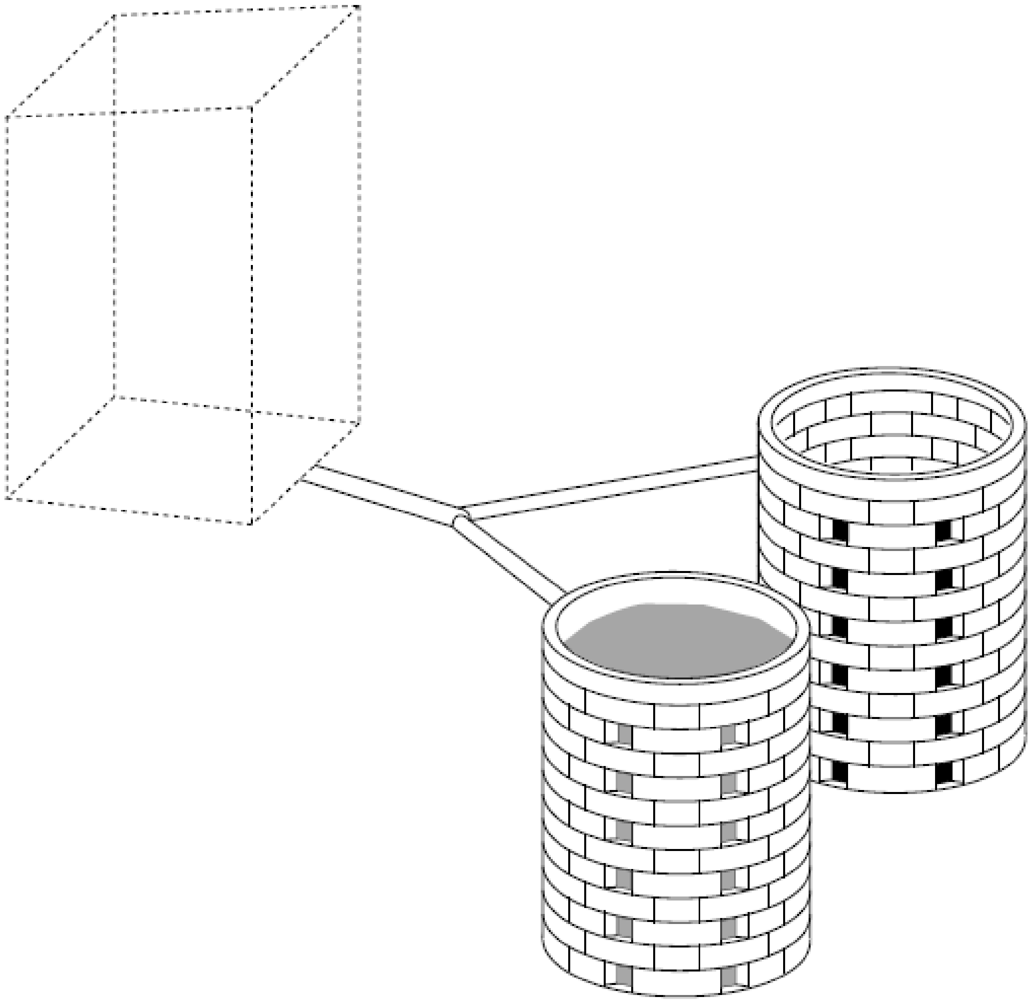
Although the costs can vary depending on which materials are used (cement, burnt bricks, etc.), urine diverting dry toilets are a low-cost option because they require no regular mechanized emptying or desludging. Existing toilets in Africa range from USD400 to USD1200 per unit.

Additional Resources

ECOSAN COMPENDIUM

5.8_Twin Pits for Pour Flush

SANITATION



ADVANTAGES

- low risk of pathogen transmission
- flies and odours significantly reduced
- small land area required

DISADVANTAGES

- manual removal of humus is required (cultural barrier)
- risk of groundwater contamination due to leachate
- not suitable with a high groundwater table

Image source: Eawag

Outline Description of Technology

Twin Pits for Pour Flush consist of two alternating pits connected to a pour flush toilet. The waste water is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel.

Where Can It Work

This is a water-based (wet) technology that is ideal for socio-cultural contexts using water rather than toilet paper to clean themselves. It can be located inside the house, since the water seal prevents odours and flies.

How does It Work

Twin Pits for Pour Flush is a very satisfactory and hygienic sanitation system. The pits require a longer retention time (two years is recommended) to degrade the material before it can be excavated safely. Therefore the pits should be of an adequate size to accommodate a volume of waste generated over 1-2 years.

Cost Considerations

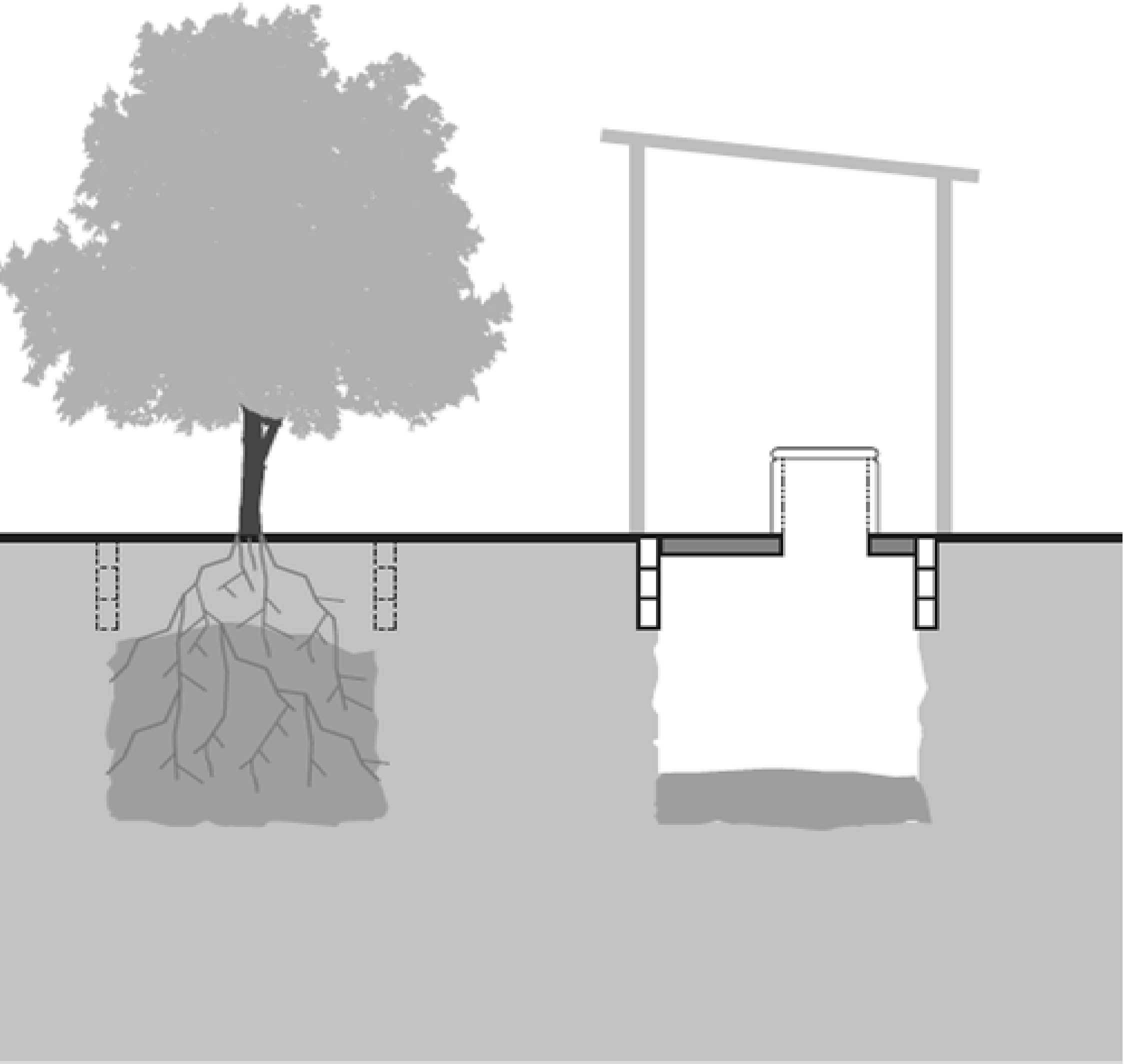
Although the costs can vary depending on which materials are used (cement, burnt bricks, etc.), Twin Pits for Pour Flush are a low-cost option because they require no regular mechanized emptying or desludging. Existing toilets in India (for household usage) are around USD500 per unit.

Additional Resources

Twin Pits Manual COMPENDIUM

5.9_Arborloo

SANITATION



ADVANTAGES

- low risk of pathogen transmission may encourage income generation (tree planting and fruit production)

DISADVANTAGES

- depending on the local conditions the content of a covered pit or Arborloo could contaminate groundwater resources until it is entirely decomposed
- not suitable with a high groundwater table

Image source: Eawag

Outline Description of Technology

When a Single Pit or a Single VIP is full and cannot be emptied, "fill and cover", i.e., filling the remainder of the pit and covering, is a viable low-cost option. The Arborloo is a shallow pit that is filled with excreta and soil/ash and then covered with soil; a tree planted on top of the nutrient-rich pit will grow vigorously.

Where Can It Work

Filling and covering a pit is an adequate solution when emptying is not possible and when there is enough space to continuously dig new pits. The Arborloo can be applied in rural, peri-urban, and even denser areas if enough space is available (like on most school compounds).

How does It Work

To decommission a pit, it can simply be filled with soil and covered. The full pit poses no immediate health risk and the contents will degrade naturally over time. Planting a tree in the abandoned pit is a good way to reforest an area, provide a sustainable source of fresh fruit and prevent people from falling into old pit sites. Other plants such as tomatoes and pumpkins can also be planted on top of the pit if trees are not available. A new pit must be dug after the pit is full, this is relatively labour intensive.

Cost Considerations

The Arborloo is the lowest cost sanitation solution presented in this manual. Depending on the materials used for the superstructure costs can range from USD 60 to USD 150 per unit.

Additional Resources

SSWM Arborloo Book COMPENDIUM

Topic 6_Growth and Change

To call women the weaker sex is libel.
Mahatma Gandhi

Image source: Men engage (https://menengage.org)

Breaking the silence

- Examples given in the Catalogue of Practical Exercises

Managing menstruation hygienically and safely

- Cloth Menstrual Pads (6.1)
- Menstrual Cups (6.2)
- Dedicated Latrines and Clothes Washing (6.3)

Safe reuse and disposal solutions

- Safe disposal: Collecting, transporting and Incinerating in nearby hospital
- Safe disposal (not preferable): incinerating on-site (8.6)

INTRODUCTION

Growth and Change

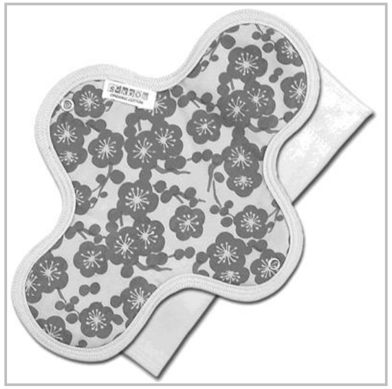
As children grow, changes in their bodies occur, accompanied by an evolution of their minds, feelings and understanding of psycho-social differences between males and females. Their needs also will evolve in many ways. This section of the Blue Schools Kit addresses in priority the young women's needs when they reach puberty, namely menstrual hygiene management (MHM). These needs may appear mostly physical, but they also have strong emotional repercussions. Respect for those needs are very important to ensure young women can fully and harmoniously take their place in their families and communities.

This section provides some ideas on how schools can support adolescent girls or female teachers in managing menstrual hygiene with dignity. Adequate sanitary protection materials and water and sanitation facilities make managing menstruation possible, and reduce stress and embarrassment. It can even increase girl's attendance rate (no missed school days during menstrual periods) or avoid complete drop out of school.

This section is based on a sound approach of MHM developed by the Water Supply and Sanitation Collaborative Council (WSSCC):

- **Breaking the silence** – fostering the understanding that menstruation is a fact of life, and a distinct biological female attribute that women should be proud of, not ashamed by.
- **Managing menstruation hygienically and safely** – ensuring adequate water, cleansing and washing materials and private spaces for managing menstrual flows hygienically and privately, and with dignity, in the home and in public spaces.
- **Safe reuse and disposal solutions** – ensuring mechanisms for safe reuse, collection and disposal of menstrual waste in an environmentally safe manner.

For more information consult the technical background section of topic 6 in the Catalogue of Practical Exercises.



Sckoon

6.1_Cloth menstrual pads

Cloth menstrual pads absorb the menstrual flow during a woman's period, and are an alternative to disposable sanitary napkins. They are less expensive than disposable pads, reduce the amount of waste produced and may also have health benefits. Generally they are made from layers of absorbent fabrics (such as cotton or hemp) which are worn by a woman while she is menstruating. After use, they are washed, dried and then reused. (Wiki)

Ruby Cup

6.2_Menstrual cups

A menstrual cup is usually made of flexible medical grade silicone and worn inside the vagina during menstruation to catch menstrual fluid. Menstrual cups are shaped like a bell with a stem. Every 4–24 hours, a cup needs to be removed and emptied, then rinsed and reinserted. In general they can be reused for five years or more. They are more practical, cheaper, and eco-friendly than pads. (Wiki) SSWM

SSWM

6.3_Dedicated latrines and clothes washing

Girls need to have privacy particularly during their menstrual cycle. A dedicated latrine with a private area for clothes washing and drying is important.

Topic 7_ From Soil to Food

A society grows great when old men plant trees whose shade they know they shall never sit in.
Greek Proverb

You can solve all the world's problems in a garden.
Geoff Lawton
Permaculture Research Institute of Australia

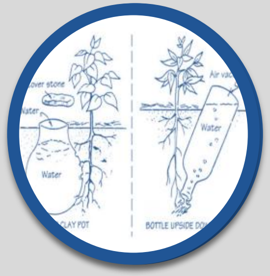
Image source: survivopedia

Cultivating and enhancing soil

- Using Compost (7.1)
- Mulching (7.2)
- Natural pesticides (7.3)
- Urine Fertilization (7.4)
- Natural fertilisers (7.5)
- Liquid Manure (7.6)
- Gardening with Charcoal (7.7)
- Seed sowing (7.8)
- Crop planning (7.9)
- Making compost (8.1)

Water retention

- Mulching (7.2)
- Planting Pits (7.10)



Efficient irrigation practices

- Buried Pot Manual Irrigation (7.11)
- Bucket or Bottle Drip Irrigation (7.12)

Sustainable homestead and smallholder farmers vegetable gardening

- Keyhole Garden (7.13) and Banana circle (7.13.2)
- Vertical Gardening (7.14)
- Permaculture Design (7.15) and Permaculture “Mandala” garden (7.15.2)

Trees and reforestation

- Agroforestry (7.16) and Janeemo agroforestry (7.16.2)
- Farmers Managed Natural Regeneration (7.17)
- Reforestation (3.10)

INTRODUCTION

From Soil to Food

Growing food is essential for human beings and as population has expanded, more and more land has been cleared for agriculture and other pursuits. Unfortunately, the land and soil is often exploited in an unsustainable way and loses its productivity within few years only. Why people then move on and clear more land to turn it into fields again. It is accompanied by soil degradation, soil erosion, increased water run-off and flooding, decreased biodiversity, just to name a few.

This topic provides ideas on how to act against such a virulent circle. It shows technologies for growing food which are appropriate for schools and communities, which allow to:

- Cultivate soil that can both retain water and drain appropriately to keep nutrients in the soil;
- Grow food and irrigate efficiently;
- Keep trees and forests to retain and infiltrate rain water in the area;
- Establish Low External Input Sustainable Agriculture (LEISA) as an alternative to agro-chemicals.

The processes such as soil erosion, water run-off, flooding, etc. are highly linked to sustainable water and land management practices and thus, ideally the technologies presented in *topic 3 the watershed around my school*, should be combined. More information on the problematic processes linked to agricultural production can be found in the technical background of chapter 7 in the Catalogue of Practical Exercises.

ADVANTAGES

- promotes soil living micro-organisms that are fundamentally important for creating healthy soils and, consequently, healthy plants and food.
- improves soil aeration
- improves soil water holding capacity
- provides plants with essential nutrients and aids in the suppression of plant diseases.
- increases health and productivity of plants

DISADVANTAGES

- none

Image source: Terre des hommes / Bangladesh

7.1_Using compost

SOIL ENHANCEMENT

Outline Description of Technology

Compost is organic matter that has been decomposed. It is the man-made equivalent of the natural humus which can be observed in forests' soils. The productivity of lean soils can be improved by applying compost. Hence, by applying compost, soil is enhanced through increasing nutrient content and fostering beneficial soil bacteria. This helps improving the physical and chemical properties and contributes to enhance the capacity of the soil to store air and water.

Where Can It Work

Applicable anywhere.

How does It Work

Before planting, compost is applied to the soil to a depth of 15 - 25 cm. If the soil is very poor, you can add more compost. Compost releases nutrients slowly and will not damage plants. Throughout the growing season you can add compost mixed with soil as a top dressing (about 1cm). When using compost for the potted plants, potting soil can be made with 1/4 to 1/3 of mature compost and the rest soil or sand. Composting improves water infiltration and reduces water run-off. Do not put plants in pure compost. Plants need coarser particles such as sand and soil in order to root properly.

Cost Considerations

Labour costs only

Resources

SSWM

7.2_Mulching

SOIL ENHANCEMENT | WATER RETENTION

Outline Description of Technology

Mulching is the placing of material on the soil surface to maintain moisture, reduce weed growth, mitigate soil erosion and improve soil conditions. Mulching can help to improve crop yield and optimise water use.

Where Can It Work

Mulch can be used in fields before and after planting, as well as around young crop plants. It is especially useful for high-value vegetable crops, and for growing crops in dry areas, during dry-season cropping, and in places where the soil is easily eroded by heavy rains. Where soil erosion is a problem, slowly decomposing mulch material (low nitrogen content, high C/N-ratio) can provide a long-term protection compared to quickly decomposing material (SSWM). High C/N ratio material for mulching can bind nutrients and cause malnutrition of plants. Plant growth needs to be observed for signs of nitrogen deficiencies (i.e. yellow/pale leaves).

How does It Work

Mulch tilling involves covering bare soil with mulch or plant litter to prevent or reduce the evaporation of soil moisture and minimise the erosive energies of rain falling directly onto soil particles. Mulching is different from soil amendment. Materials for mulching is usually crop residue such as maize stove, sorghum trash and wheat straw. In cases where these are not available, or are eaten up by animals, straw, shredded bark or cardboard, wood chips, etc.

Cost Considerations

Where materials are locally available it is a matter of labour costs. If not mulching can be expensive as it is labour intensive to obtain, transport and disperse.

Additional Resources

SSWM

ADVANTAGES

- prevents evaporation
- retains soil moisture
- controls soil erosion
- reduces weed growth
- helps regulating soil's temperature (reduces temperature variations)
- improves soil structure and aeration
- helps maintaining and improving
- soil fertility (by enhancing organic matter, and also by protecting beneficial soil living organisms such as bacterias and worms)

DISADVANTAGES

- mulching is labour-intensive
- In moist environments, too much mulch can create rotting of the root zone
- mulch material can introduce new pests and diseases into a field.

Image source: WOCAT

ADVANTAGES
- made with locally available plants
- easy to prepare
- sustainable and efficient

DISADVANTAGES
- takes some time to prepare and be ready (see alternative if in emergency)

Image source: Greendots.ch / Burkina Faso

7.3_Natural pesticides

PEST AND DISEASE CONTROL

Outline Description of Technology
There are many ways to prepare natural pesticides, depending on local resources and on the problem one wants to treat. The recipe presented here uses Neem tree leaves, as it is quite widely available in many countries, and an efficient way to control various pests. For other natural pesticides to treat specific pests refer to the additional resource below.

Where Can It Work
Applicable anywhere.

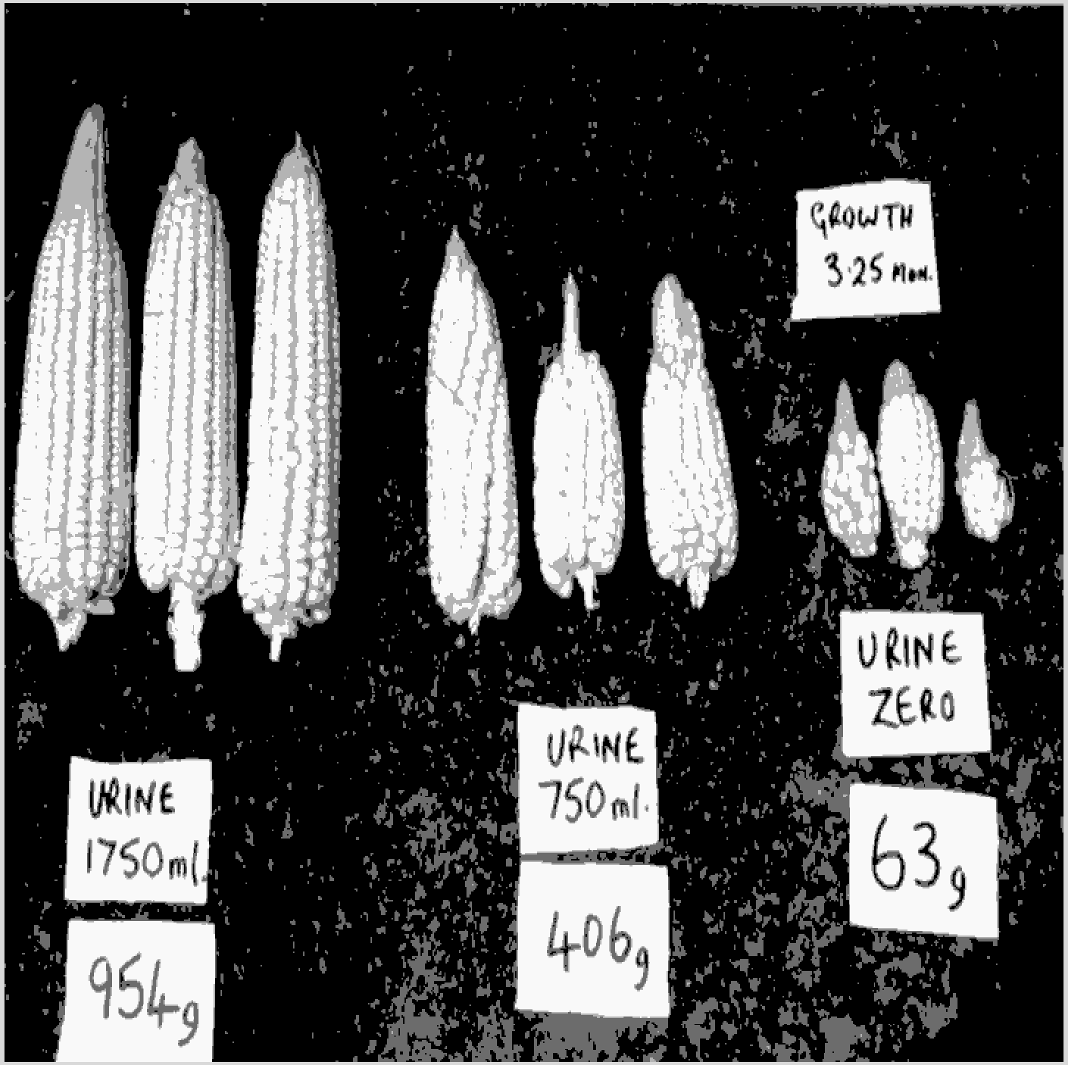
How does It Work
Collect Neem leaves fresh from the tree and chop it with a machete or a knife. Put the leaves in a container and cover the leaves with water. Then put a lid on the container and leave the mixture to rest for 3 days. Dilute the preparation 1 part water to 1 part of pesticide before sprinkling it on the plants.
Alternatively, especially if you are in an emergency to treat, you can boil the preparation 20 minutes (instead of leaving it to rest for 3 days). In that case, you don’t have to dilute the preparation, but leave it to cool down before treating the plants.

Cost Considerations
Free of costs

Additional Resources
Fourthway

7.4_Urine fertilization

SOIL ENHANCEMENT



ADVANTAGES

- may encourage income generation because of improved yield and productivity of plants
- reduces dependence on costly
- chemical fertilizers
- low risk of pathogen transmission
- low cost
- contributes to self-sufficiency and
- food security
- easy to understand techniques

DISADVANTAGES

- urine is heavy and difficult to transport
- smell may be offensive
- labour intensive
- risk of soil salinization if the soil is prone to the accumulation of salts
- social acceptance may be low in some areas

Image source: Steemit.com

Outline Description of Technology

Stored urine that has been separately collected and stored for 6 months before use, is a concentrated source of nutrients that can be applied as a liquid fertilizer in agriculture and replace all or some commercial chemical fertilizers. This factsheet focuses on small-scale urine use, which refers to the application of urine on small fields, beds, vertical or container gardens, school gardens, plant pots on terraces, rooftops etc. that can be done on a household or smaller community level without sophisticated transport and application infrastructure.

Where Can It Work

Applicable anywhere.

How does It Work

The urine is introduced into the soils via small ditches besides the young tomato crops. Then the ditches are covered to prevent ammonia loss to the air. Stored urine should not be applied directly to plants because of its high pH and concentrated form. Instead, it can be: Mixed undiluted into soil before planting; Poured into furrows, but at a sufficient distance away from the roots of the plants and immediately covered (although this should take place no more than once or twice during the growing season); and Diluted several times, whereby it can be frequently used around plants. The optimal application rate depends on the nitrogen demand and tolerance of the crop on which it will be used, the nitrogen concentration of the liquid, as well as the rate of ammonia loss during application.

Cost Considerations

Costs are primarily the labour costs. It is more pure, reliable and affordable than many chemical fertilizers which often contain heavy metals. (SSWM)

Additional Resources

SSWM (Small Scale) SSWM (Large Scale) SSWM (Urine Storage)
SSWM (Fertilizer from Urine)

ADVANTAGES
- made from raw, local materials
- increases yields

DISADVANTAGES
- smell can be strong, especially at the beginning of the fermentation process.

Image source: Greendots.ch / Burkina Faso

7.5_Natural fertilisers

PLANT TEAS

SOIL FERTILITY

Outline Description of Technology

Plant teas, or “fermented extracts” could be the subject of a book in itself. It is a natural fertiliser using virtually any green leaves. However, some plants are particularly interesting to use. For example, stinging nettles or comfrey are especially beneficial, in many ways. Don’t hesitate to use them if they are locally available in your region.

Where Can It Work

Applicable anywhere.

How does It Work

Collect a variety of leaves (at least three different, as long as they are not too thick); then chop them finely. Fill a container with the leaves, cover with water and add a handful of wood ash. Leave to ferment for a about one week (sometimes much less, especially in warm climates), stir it everyday. Usually the mixture is ready when there is no more froth forming on the surface. The scent also becomes less unpleasant when it is ready to use. Dilute before applying to plants (one part of plant tea for two parts of water) and apply it directly on the ground near the roots. Use the mixture within 2 weeks.

Cost Considerations

Free of costs.

Additional Resources

Fourthway

7.6_Liquid manure

SOIL FERTILITY

ADVANTAGES
- made from raw, local materials
- safe way to increase yields

DISADVANTAGES
- takes some time to prepare and ferment.

Image source: Greendots.ch / Burkina Faso

Outline Description of Technology
Liquid manure is an easy to make fertiliser from animal droppings, ash and water.

Where Can It Work
Applicable anywhere.

How does It Work
Liquid manure is prepared first by filling a cloth (permeable) bag with a few handfuls of cow dung (or other herbivorous animal droppings), and small quantity of wood ash. A stone is put in the bag for the weight. Then the bag is closed and tied to a stick. A container is filled with water, the bag is placed in the water, and hold in place by a stick. The mixture is covered and left to ferment in a shady place. It has to be stirred daily for a week before it is ready to use. When ready, it can be applied directly in the garden, diluted (1 part liquid manure for 2 parts of water).

Cost Considerations
Free of costs, as long as animal droppings are available.

Additional Resources
Fourthway Greendots

ADVANTAGES

- significant improvement in soil
- nutrients
- increases crop quality
- increases crop productivity

DISADVANTAGES

- a sustainable biomass is required for sustainable production of biochar

Image source: loolaboo.com

7.7_Gardening with charcoal

TERRA PRETA | BIOCHAR GARDENS

SOIL ENHANCEMENT

Outline Description of Technology

Bio-char is a fine-grained charcoal produced from the slow burning of organic matter in a low- or no-oxygen environment. Bio-char is promoted as a soil additive in order to enhance the soil black carbon content and thus the soil water and nutrient retention capacity. Terra Preta, meaning "Black Earth" in Portuguese, is a soil building technique developed by ancient Amazonian civilizations at least 7000 years ago as a solution to permanently solve the problem of poor tropical soil fertility.

Where Can It Work

Broadly applicable

How does It Work

Using a trench about 50 cm deep by width of desired bed and placing a 10 cm layer of charcoal at the bottom, water & nutrient retention is dramatically improved (the remaining space is back-filled with ordinary soil), adding a rudimentary irrigation system (1 m lengths of bamboo with all the bottom ‘node’ removed then drilled with 4 holes approximately 10 then 20 cm from the bottom of the bamboo, spaced every 1-2 m.) creates a refillable water reservoir, which slowly releases the water/nutrient into the soil planting bed.

Cost Considerations

The costs for planting pits mainly consist out of labour costs and are estimated to amount approximately USD160 per ha.

Additional Resources

Permaculture research Institute of Australia

7.8_Seed sowing

LIVELIHOOD | FOOD AUTONOMY

Image source: Greendots.ch / Burkina Faso

ADVANTAGES
- cheap
- local seeds are adapted to local condition
- possible to easily produce seeds for next growing season

DISADVANTAGES
- requires skills, knowledge (and experience)
- takes labour and time
- can be disappointing (risk of failure)

Outline Description of Technology
Growing vegetables from seeds is a cheap way to produce food. The most important thing is to carefully manage the watering, as young seedling would quickly dry out if not watered enough.

Where Can It Work
Applicable anywhere.

How does It Work
They are many methods to saw seeds, depending on the plant's needs and on local resources. Always ask for advice when there is no indications on the pack of seeds you purchased. Basically, seeds have four basic requirements in order to germinate: nutrients (i.e. a substratum), water, sunlight (warmth) and oxygen. Either seeds are directly sown in the garden (after having prepared the garden beds with compost) or they are sown in trays or pots:
1. Collect trays or pots
2. Fill them with fine and light soil (compost, sand)
3. Water the substrate
4. Sprinkle seeds on the top and cover with a thin layer of fine compost
5. Cover the tray or pot with a piece of transparent plastic or glass
6. Uncover when the seeds have germinated
7. Transplant in the garden once the plant are big/strong enough (keep them in partial shade for one or two weeks if possible)

Cost Considerations
It's free with seeds that can be easily produced "at home" (such as beans, tomatoes and peppers). Otherwise, one will have to buy small packs of seeds, if possible from a local, sustainable source. If you produce your own seeds, you will have to clean and dry them well; and store them in a dry, dark and cool place as much as possible.

Additional Resources
Seedsavers Seedsavers Blog

ADVANTAGES

- increases soil fertility
- helps in the control of weeds
- allows for varied crop production
- plant debris provides organic matter
- and nutrients to the soil
- reduces erosion
- reduces runoff and enhances
- infiltration

DISADVANTAGES

- requires labour and planning for successful implementation.
- expensive to set up
- cover and intercropping can be difficult to justify in areas with food scarcity
- to prevent from bushfires, a buffer zone around the field is necessary

Image Source: SSWM

7.9_Crop planning

CROP ROTATION | INTERCROPPING | COVER CROPPING

SOIL ENHANCEMENT

Outline Description of Technology

In many traditional agricultural systems a diversity of crops in time or space can be found. Knowing that different plants have different requirements for nutrients, a good crop planning and management is required in order to optimise the use of nutrient in the soil.

Where Can It Work

Broadly applicable and can be found practiced across many agricultural traditions.

How does It Work

Crop rotation means changing the type of crops grown in the field each season or each year. It is a critical feature of all organic cropping system, because it provides the principal mechanisms for building healthy soils, a major way to control pests, weeds, and to maintain soil organic matter. Intercropping refers to the practice of growing two or more crops in close proximity: growing two or more cash crops together, growing a cash crop with a cover crop, or other non-cash crop that provide benefits to the primary crop. Cover crop could be a leguminous plant with other beneficial effects, or it could be a weed characterised by its rapid growth and enormous production of biomass. The most important property of cover crops is their fast growth and the capacity of maintaining the soil permanently covered.

Cost Considerations

Extra expenditures include the cost of the cover crop seed as well as labour and time for planting. Also, special or alternative equipment may be needed to handle the greater amounts of residue present in no-till systems. (SSWM)

Additional Resources

SSWM Crop Selection

7.10_Planting pits

ZAI PITS

SOIL ENHANCEMENT | WATER CONSERVATION

ADVANTAGES

- increases water infiltration can help regeneration of the soil
- design of planting pits is very flexible
- high acceptability
- the soil does not need to be deep
- due to the manure placed in the pits, termites can be attracted, transporting further nutrients from deeper soils to
- the top layers

DISADVANTAGES

- high labour requirements for construction and maintenance
- during very wet seasons, water logging is possible and organic debris needs to be placed in the pits to soak up excess water
- already shallow soil gets even thinner where the pits are dug (apply compost in the pits when possible)

Image Source: ActionAid International

Outline Description of Technology

Planting pits are used as a precipitation harvesting method to prevent water runoff and thereby increase infiltration and reduce erosion.

Where Can It Work

Planting pits are most suitable on soil with low permeability, such as silt and clay. They are applicable for semi-arid areas for annual and perennial crops (such as sorghum, maize, sweet potato, bananas, etc.). Due to their easy application and quickly observable improvement of crop growth, the implementation of planting pits is usually well adopted by farmers.

How does It Work

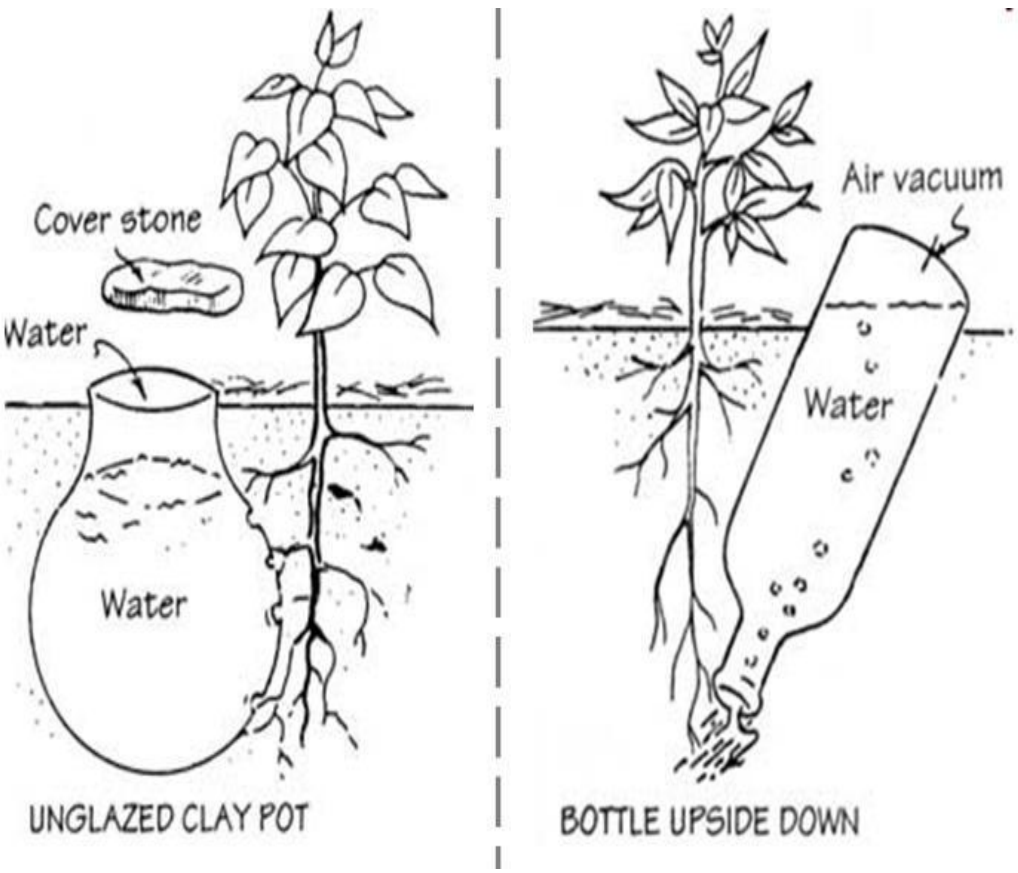
The method involves digging holes into the ground (ideally at the beginning of the dry season) in which plants like millet or sorghum can be sown later on at the start of the rainy season. The pits measure between 10 and 20cm in depth and 20 and 40cm in diameter and are spaced approximately 1m apart from each other. In addition to this, accruing excavated earth is formed to a small ridge down-slope of each hole and, if available, organic fertilizer or compost is added to the pits. The described arrangement of the planting pits ensures an efficient collection and concentration of rainfall, runoff and nutrients and therefore makes it possible to bring degraded land back into cultivation. To optimize the situation on the fields, planting pits are often used in combination with contour stone bunds.

Cost Considerations

Most costs arise because of the time needed for digging the holes and filling them with organic matter. They are therefore strongly dependent on the structure of the soil. Roughly 20 to 70 person days per hectare are needed for digging the holes and another 20 person days are required for fertilization. Usually, no equipment costs arise, because digging can be done with common tools already available.

Additional Resources

Echo SSWM Planting Pits



ADVANTAGES

- improves water-use efficiency
- directs and targets irrigation
- ensures constant water supply in the crucial phase of germination
- higher yields and germination rate
- lowers incidence of pest attack
- facilitates pre-monsoon sowing
- clay is often a locally available material
- low investment costs

DISADVANTAGES

- labour intensive
- basic training needed to install
- if water not properly filtered and equipment not properly maintained, system can clog
- manual subsurface drip irrigation avoids the high capillary potential of traditional surface applied irrigation, which can draw salt deposits up from deposits below

Image source: SSWM

7.11_Buried pot manual irrigation

CLAY POT OR PIPE IRRIGATION | BOTTLE IRRIGATION

WATER CONSERVATION

Outline Description of Technology

Manual irrigation systems are very simple, but effective methods for making water available to crops while minimising evaporative loss. Manual irrigation systems are easy to handle and there is no need for technical equipment. But it is important that they are constructed correctly to avoid water loss and crop shortfall. The systems allow for high self-help compatibility and have low initial capital costs. They can be used in almost every area, but they are especially adapted for arid areas where evaporation rates are high. Porous clay pots and pipes are a means of water application that conserve water by applying water directly to the roots of plants, thereby limiting evaporation losses

Where Can It Work

Manual irrigation methods are appropriate for small-scale farming or backyard gardening irrigation in dry and arid climates where water is scarce.

How does It Work

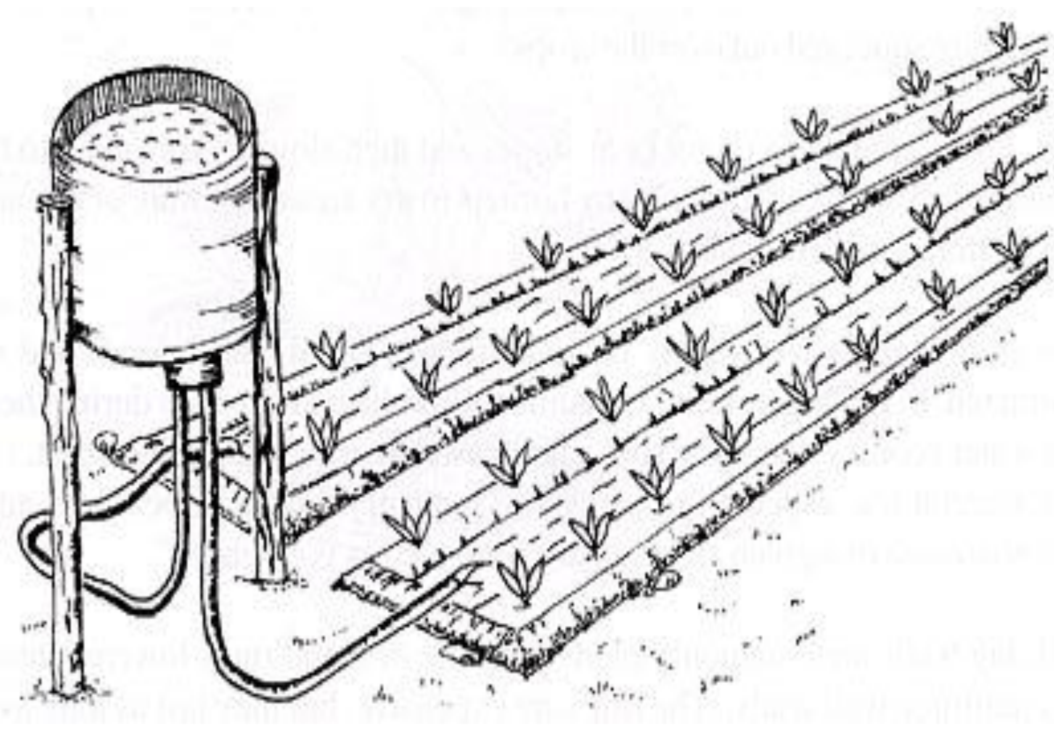
A very basic subsurface (see also subsurface drip irrigation) method consists in placing porous clay jars (or pots) in shallow pits dug for this purpose. Soil is then packed around the necks of the jars so that their rims protrude a few centimetres above the ground surface. Water is poured into the jars either by hand or by means of a flexible hose connected to a water source. Since the walls of the pots are porous (make sure to use unglazed pots), the water can seep slowly out and reach the roots of the plants. The jars can be made of locally available clay: they are of no standard shape, size, wall thickness or porosity. Instead of a clay or earthenware pod, also the sweet monkey orange fruit (Strychnos spinosa) can be used when it has been dried and the top cut off. (SSWM)

Cost Considerations

Minimal. The system simply requires a supply of clay pots, bottle or gourd type containers and labour.

Additional Resources

SSWM_Manual Irrigation



7.12_Bucket or bottle drip irrigation

WATER CONSERVATION

Outline Description of Technology
Even when rainfall is low or erratic, the bucket drip irrigation system enables farmers to nourish and grow the crops they need

Where Can It Work
Applicable anywhere.

How does It Work
A 20-litre drip bucket is placed at 1m above the ground on poles. The drip bucket is attached to a long hose that criss-crosses the crop field. The bucket is filled manually. Simple gravity provides enough pressure to force the water through the hose. Water drips through the holes in the hose, directly onto the roots of the plants. 100-200 plants can be grown using just one drip bucket system (SSWM)

Cost Considerations
A standard kit can range between USD15 and USD85 depending on the size.

Additional Resources
SSWM_Drip Irrigation SSWM_Manual Irrigation
SSWM_Subsurface Drip Irrigation

ADVANTAGES
- increased vegetable production
- Inexpensive
- no water wastage and irrigation time
- minimizes evaporative loss (if covered)
- fewer weeds grow because water is directed to crop
- water drips slowly so soil nutrients
- are not washed away
- manure teas can be fed thru pipes

DISADVANTAGES
- system can get clog and functions better with a filter system
- training required so that minimal amounts of water are used
- fields need to be fenced as animals can damage system
- reliable water source is required

Image source: FAO

7.13_Keyhole garden

KITCHEN GARDEN

SOIL ENHANCEMENT | WATER CONSERVATION

Outline Description of Technology

The Keyhole Garden model of homestead vegetable cultivation enhances the resilience of families living in areas with climate-related hazards, such as flooding and drought. Keyhole gardens have been shown to increase vegetable production in all seasons, thereby improving household food autonomy and dietary diversity.

Where Can It Work

Applicable anywhere.

How does It Work

A keyhole garden is typically a 3m wide circular raised garden with a keyhole-shaped indentation on one side. The indentation allows gardeners to add uncooked vegetable scraps, grey water, and manure into a composting basket that sits in the centre of the bed. In this way, composting materials can be added to the basket throughout the growing season to provide nutrients for the plants. The upper layer of soil is hilled up against the centre basket so the soil slopes gently down from the centre to the sides. Most keyhole gardens rise about one meter above the ground and have walls made of stone. The stone wall not only gives the garden its form, but helps trap moisture within the bed. Keyhole gardens originated in Lesotho and are well adapted to dry arid lands and deserts. In Africa they are positioned close to the kitchen and used to raise leafy greens such as lettuce, kale, and spinach; herbs; and root crops such as onions, garlic, carrots, and beets. Keyhole gardens are ideal for intensive planting, a technique in which plants are placed close together to maximize production.

Cost Considerations

The Cost is variable based on availability of plants, a supply of compost, and materials necessary to define the perimeter form of the garden.

Additional Resources

Nifty Homestead WOCAT

ADVANTAGES

- easy to maintain once built
- facilitate year round vegetable production
- increases quality and diversity of vegetables
- can provide protection against flood water intrusion

DISADVANTAGES

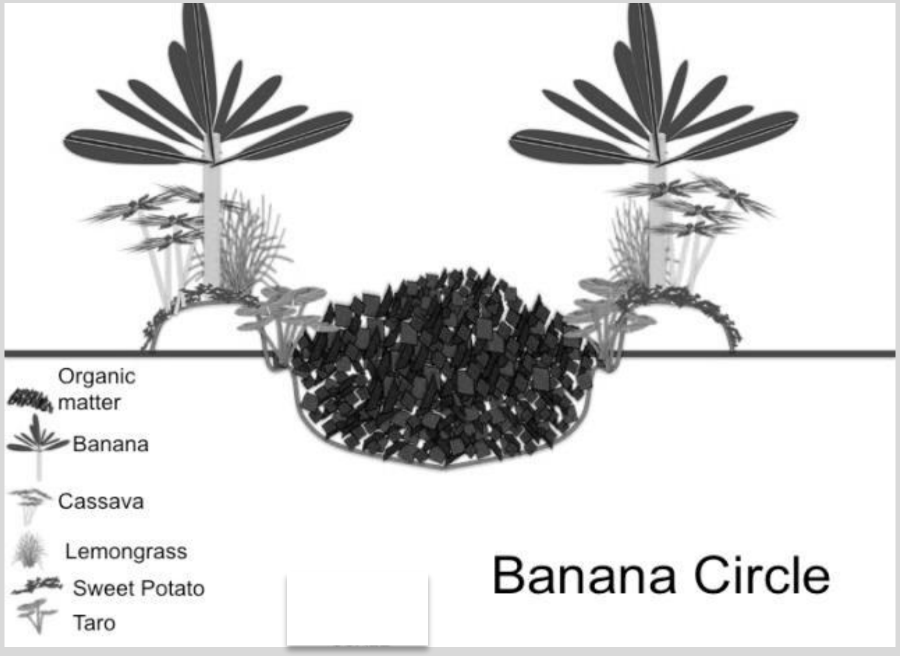
- Labour intensive to build
- raised garden requires additional soil to build up height of plinth

Image source: Terre des hommes

7.13.1_Banana circle

MULTI-LAYER GARDEN

SOIL ENHANCEMENT | WATER CONSERVATION



ADVANTAGES
- produces lots of food in a small area
- can be integrated in a Mandala garden
- allows safe use of grey water and/or humanure in the compost pit

DISADVANTAGES
- Requires additional work

Image source: A Permaculture Design Course Handbook

Outline Description of Technology

Banana circles can be seen as a variation of the keyhole garden, only in a bigger size, appropriate for planting bananas and or papayas (together with other plants)

Where Can It Work

Applicable anywhere (with appropriate adaptations).

How does It Work

The first step is to dig a 2 meters diameter (and roughly 70 cm deep) hole. The earth that has been dug is pile around the circle. This create the planting bed. Rough composting material is piled in the hole. The bananas and a variety of other plants are planted in the bed on the ridge of the circle. A path can be created to access the compost and feed it regularly to maintain fertility over time.

Cost Considerations

The Cost is variable based on availability of plants.

Additional Resources

Before starting, refer to this source to fully understand the process of establishing a banana circle:

Permaculture Design Handbook

7.14_Vertical gardens

CONTAINER GARDENS

GREYWATER MANAGEMENT | FOOD PRODUCTION

Outline Description of Technology

Vertical gardening aims to advance the productivity levels of urban and sub-urban agricultural production sites where most often available space is the biggest agricultural limitation. Plenty of different design solutions are available. The design of vertical garden depends on the available material, space and local preferences as well as on the creativity and imagination of the users. Crops that can be grown comprise food and non-food crops (e.g. ornamental plants, medical plants). (SSWM)

Where Can It Work

They can be placed on yet unused places like on the roof of houses, balconies, on the top of walls or just hung up. Were space is available, earth beds of larger surface may even be installed, but require some expert design to control water drainage and infiltration.

How does It Work

As a growing media soil, compost, vermicompost, terra preta compost, as well as aquaponic and aeroponic solutions can be used. The crops can be grown in sacks, bags, flowerpots and all kinds of available receptacles like bins, cans, tins, bottles, tanks or boxes.

Cost Considerations

Limited to cost of bag, soil, gravel, compost and plants

Additional Resources

SSWM (Greywater Towers) SSWM (Vertical Gardens)

ADVANTAGES

- local reuse of compost and reclaimed water from household or school wastes
- low cost
- minimal agricultural area required
- contributes to food security
- simple and easy to understand
- can be watered with grey water.

DISADVANTAGES

- regular watering or irrigation system has to be in place.

Image source: SSWM

ADVANTAGES
- creates sustainable life supporting systems going beyond carbon neutrality and sustainability

DISADVANTAGES
- Extra work and studies to understand and apply principles and techniques

7.15_Permaculture Design

OBSERVATION AND DESIGN

PATHWAYS BEYOND SUSTAINABILITY | REGENERATIVE FARMING SYSTEMS

Outline Description of Technology

Permaculture is a system of agricultural and social design principles centred around simulating or directly utilizing the patterns and features observed in natural ecosystems. The word permaculture originally referred to "permanent agriculture", but was expanded to stand also for "permanent culture", as it was understood that social aspects were integral to a truly sustainable system.

Where Can It Work

Applicable anywhere.

How does It Work

The co-inventor of Permaculture, Bill Mollison, has said that "Permaculture is a philosophy of working with, rather than against nature; of protracted and thoughtful observation rather than protracted and thoughtless labour; and of looking at plants and animals in all their functions, rather than treating any area as a single product system.

Hence, permaculture is primarily a landscape design technique which aims at creating beneficial links between all the elements of a household or a farm.

There is three ethical values guiding every permaculture design:

1. Care for the Earth
2. Care for the People
3. Fair share

Cost Considerations

The costs depend on the permaculture design that is planned

Additional Resources

Wikipedia Holmgren Permaculture Principles

Permaculture Research Institute Permaculture Design Course Handbook

ADVANTAGES

- allows a very dense crop association
- in varied patterns promoting improvement in soil and pest control
- avoids water wastage
- Aesthetically interesting, which encourages attendance and maintenance
- If well designed, can improve beneficial biodiversity
- Very good “demonstration” garden for a school

DISADVANTAGES

- labour intensive
- requires ahead planning/design

Image source: loolaboo.com

7.15.1_Permaculture “Mandala” garden

SOIL ENHANCEMENT | WATER CONSERVATION

Outline Description of Technology

A Mandala garden is a circular garden divided by walk-through paths and keyholes which divide it into segments. By applying mulch and compost and not needing to ever walk on the soil, digging is not required and the soil biota remains undisturbed. It is based on the principles of the keyhole garden but where each bed works like a keyhole bed with paths in between beds to facilitate access and optimize space. Mandala gardens can come in a wide variety of sizes and designs, depending on the context. This technique allows gardeners to be creative and experimental. For example, dry stone walls ponds and shrubs/small trees can be included in the design for water and fertility.

Where Can It Work

Applicable anywhere.

How does It Work

Mandala Gardens are typically larger than keyhole gardens and can vary in size from 4m to as much as 100m in diameter, where each segment of the circle is a keyhole bed. Observation, ahead planning and design are important in order to make the mandala garden functional and effective.

Cost Considerations

The Cost is variable based on availability of plants, a supply of compost, and materials necessary to define the perimeter form of the garden.

Additional Resources

Onegreenplanet PRI WOCAT

7.16_Agroforestry

GENERAL

SUSTAINABLE FARMING SYSTEM | REGENERATIVE AGRICULTURE

Outline Description of Technology
In summary, agro-forestry is a productive, diverse agricultural system where crops are mixed with trees. Trees provides enhanced fertility, protection, animal fodder and shelter, fuel, timber, fruits and other benefits.

Where Can It Work
Applicable anywhere.

How does It Work
There are many forms of agro-forestry. The basic principles are to plant many different kind of trees (diversity) and create different layers with different trees sizes. Alley cropping is the most common agro-forestry system, and perhaps the easiest way to start. In this systems, rows of diverse trees are planted (on-contour terraces is on a slope). In between those trees, crops such as cereals or vegetables are planted.

Cost Considerations
At small scale the costs are limited to costs of plants and labour. At a community scale, external funding and expertise would be needed to establish nurseries and establish production.

Additional Resources
The Farmers' Handbook Concept of Food Forest

ADVANTAGES
- yield enhancement and diversification
- soil's and fertility conservation / regeneration
- soil's moisture and evaporation regulator (shade, windbreak)
- homestead self-reliance and resilience strengthening
- biodiversity protection and increase
- adaptation to climate change and DDR

DISADVANTAGES
- requires training, research and planning
- relatively long term strategy if started from the beginning
- the trees must be pruned and taken care of regularly (but management means also more yield)

Image source: Agrieducate

7.16.1_Janeemo agroforestry

DIET ENRICHMENT | MICRO ENTERPRISE | SUSTAINABLE FUEL

ADVANTAGES
- produces biofuels for lamps, stoves
- and generators
- produces ingredients for soap
- produces biogas for cooking
- produces agricultural fertiliser
- extracts from the neem and moringa trees have important nutritional as well
- as medicinal uses

DISADVANTAGES
- requires training and planning to be effective at scale

Image source: Kusamala

Outline Description of Technology
Janeemo is an agricultural design system about ethical biofuels and their byproducts. The approach integrates Jatropha, Neem and Moringa trees, with shrubs and vegetables. These are grown in communities as living fences around household and field boundaries, intercropped with maize and other staples and planted as gardens. The food, timber and other income-generating products are used at the household level or sold locally.

Where Can It Work
In subtropical regions and any suitable for the growth of Jatropha, Neem and Moringa

How does It Work
Seeds are cultivated in a tree nursery, generally 3-4 months before the rainy season in order to give the plants time to mature and be ready for out-planting. The young trees are then able to be transplanted and have time to establish a root system before the dry season begins.

Cost Considerations
At small scale the costs are limited to costs of plants and labour. At a community scale, external funding and expertise would be needed to establish nurseries and establish production.

Additional Resources
Janeemo Julian Krubasik Kusamala

ADVANTAGES

- all the advantages of reforestation, but potentially quicker than planting new trees (by the use of existing, well adapted and established plants.)
- allows the use of natural resources (existing trees)

DISADVANTAGES

- importance to talk and exchange with appropriate community members when initiating change (not necessarily a disadvantage).

Image sources : Wikipedia (no specific credits)
http://fmnrhub.com.au

7.17_Farmers Managed Natural Regeneration (FMNR)

REFORESTATION

LANDSCAPE REGENERATION | ECOSYSTEM CONSERVATION | LIVELIHOOD

Outline Description of Technology

FMNR is a way to regrow vegetation cover with existing tree strains in arid and overgrazed regions. This technology can be applied on large area.

Where Can It Work

This technology can be applied successfully anywhere, but it is especially relevant in arid, semi-desert regions, where free-range cattle are over grazing land.

How does It Work

In semi-arid regions, one can often observe living tree stumps, which are often hardly recognizable as such because they have been repeatedly grazed upon by cattle. Those strains often have a few rods growing from them. One can select the healthiest rod and cut the others to help the tree grow only one future trunk. It is important to protect the future tree with mesh.
Observing the trees around is the best way to identify the appropriate species to conduct this activity. It is also very important to speak with local farmers to explain the scope and objectives of this technology, so that they can agree, participate and support the process. This method has a very good potential for rapid forest regeneration, which plays a crucial role in protecting natural ecosystems and supporting livelihood .

Cost Considerations

A sharp knife | Mesh to protect the strains (or any other locally available protection system).

Additional Resources

Prior to the experiment, make sure to thoroughly research FMNR in order to fully understand the principle. FMNR is a concept that has been discovered and developed by Tony Rinaudo, from World Vision Australia.
Wikipedia Farmer Managed Natural Regeneration (FMNR) FMNR (Video)

Topic 8_From Waste to Resources

Let’s be part of the Solution, not the Pollution.

Image source: http://cemex.com

Organic waste
- Green waste
- Brown waste

Resource recovery option
- Windrow composting (8.2)
- Vermicomposting (8.3)
- Anaerobic digestion (8.4)

Safe disposal (not preferable)
- Burning

Paper waste
- Used paper
- Used cardboard

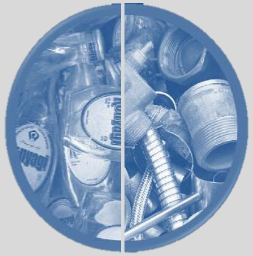
Resource recovery option
- Reuse the other side

Safe disposal (not preferable)
- Burning

Plastic waste
- PET bottle
- Packaging

Resource recovery option
- Reuse the bottles
- Sell it to recyclers

Safe disposal (not preferable)
- Burying (8.5)



Metal & Glass waste
- Pieces of metal
- Glass bottle

Resource recovery option
- Reuse metal and glass
- Sell it to recyclers

Safe disposal (not preferable)
- Burying (8.5)

Menstrual waste
- Women menstruation towel

Safe disposal
- Collecting, transporting and Incinerating in nearby hospital

Safe disposal (not preferable)
- Incinerating on-site (8.6)

INTRODUCTION

From Waste to Resources

Waste is a generic term that refers to something which is no longer used and is discarded. Problems with waste arise, if it is not managed appropriately, for instance if dumped illegally or openly burned. Open burning and inappropriate management of waste results in severe threats to human health and environmental pollution. This highlights the necessity to safely manage waste at schools and increase knowledge and awareness of students regarding risks but also show pathways for improvement.

Waste is made of different materials. For different materials also different management strategies can be applied that enhance their reuse, recovery and recycling. A precondition for this however is that the waste materials are not mixed together. If waste is segregated at source, some materials can be more easily recovered and turned into a valuable product/resource. This can significantly reduce the residual amount of waste that must then be safely disposed.

Tasks for a good waste management at the school are:
1. To identify waste streams and quantity;
2. To separate your waste into the different waste fractions.

For those fractions where no recycling/reuse or treatment is feasible, avoid, reduce, and finally, dispose it in a safe way when necessary.

The following chapters show different organic waste recycling options as well as treatment and safe disposal options for no-recyclable/recycled fractions.

Check also the Catalogue of Practical Exercises to see what you can do with each fraction.

ADVANTAGES
- pit composting is quick, easy and
- cheap as it does not require
- investment in materials
- it needs less water so it is useful for dry areas.

DISADVANTAGES
- more difficult to follow of the decomposition process in a pit than with an above ground heap.

Image source: Terre des hommes / Greendots (Bangladesh)

8.1_Compost making

SOIL ENHANCEMENT / WASTE MANAGEMENT

Outline Description of Technology
They are many ways to make compost. Regular compost, vermicompost, pit humus, terra preta, humanure or ecohumus are all products of the degradation of organic wastes. Even though they vary somehow regarding composition and structure, they have similar functions when applied to the soil. The process of high-temperature composting generates heat which kills the majority of pathogens present. The composting process requires adequate carbon, nitrogen, moisture, and air. It is generally accepted that a ratio of 50% carbon (dry, brown material) and 50% nitrogen (moist, green material) is enough. Carbon material can be up to 70% of the mix.
Two types of compost making are presented in the next slides (how to use compost is discussed in topic 7).

Where Can It Work
Applicable anywhere.

How does It Work
Compost is produced in shallow pits, approximately 20 cm deep and 1.5m by 3m wide. Layers of chopped crop residues, animal dung and ash are heaped, as they become available, up to 1.5m high and watered. The pile is protected from sunshine / excess rain, and left to heat up and decompose. It is watered as needed. After around 15–20 days the compost is turned over into a second pile and watered again. This is repeated up to three times. Compost heaps are usually located close to the garden or homesteads. Alternatively, compost can be produced in pits which are up to 1m deep. Organic material is filled to the full height of the pit. (FAO)

Cost Considerations
Costs are minimal if there is an available supply of organic materials.

Additional Resources
SSWM

8.2_Windrow composting

ORGANIC WASTE

SOIL NUTRIENT CULTIVATION

Outline Description of Technology

If you want to do compost on a bigger scale, you can implement windrow composting. Natural biodegradation of organic matter in presence of oxygen by micro-organisms, mostly bacteria and fungi, in order to produce compost. Compost can be then used for soil improvement or as growing media in the school garden.

Where Can It Work

Applicable anywhere. In cold climates composting it is a slow process

How does It Work

For good composting practice, a 50/50 mix of "green" and "brown" waste is ideal. As composting windrows needs natural aeration, the compost heap should not exceed 1.2m height to avoid compaction and should be turned periodically (15-20 days). During the degradation process, temperature of up to 70°C can be reached in the centre of the heap. This contributes to its hygienisation by killing pathogens and weed seeds. Moisture in the compost windrow should be maintained so that when the material is squeezed in hands, it should release just few drops of water and remain compact. If it is too dry, water must be added. If too wet, addition of dry materials can absorb water or turning the heap during sunny days helps increases water evaporation. Composting, a natural process, takes time and 3 to 6 months are necessary before compost is ready for use. Mature and ready compost has a dark brown colour and smells like wet earth, it can be use in the garden to improve soil quality.

Cost Considerations

Labour cost only

Additional Resources

Composting Manual ISWA

ADVANTAGES

- allows organic waste recycling
- improves physical soil property (stability, porosity, water retention)
- helps ensure a healthy, living and biologically diverse soil environment

DISADVANTAGES

- risk of soil contamination if unsorted waste is used
- smell if compost heap is too wet and not well aerated (not turned regularly)

Suitable for:

- "Green waste": grass clippings, flowers, vegetable & fruit waste, animal manure
- "Brown waste": tree trunk, branches, leaves, straw

Unsuitable for:

- Mixed waste with glass, plastic, metal
- Meat and fish waste (attract vermin)

Image source: Eawag

8.3_Vermicomposting

ORGANIC WASTE
SOIL NUTRIENT CULTIVATION

Outline Description of Technology
A process of worm composting takes place in boxes or bins. Worms convert the organic waste into a humus-like high quality compost called vermicompost or wormcompost. Bins contain a bottom layer of drainage material and bedding material (cardboard, paper) with a hole in the bin bottom to drain excess liquid. Two species of surface earthworms are suitable for wormcomposting: *Eisenia foetida* and *Lumbricus rubellus.*

Where Can It Work
Broadly applicable. Ideally, vermicomposting bin should be placed in a shady area. Ideal temperatures are between 15 and 22°C.

How does It Work
After about 2 weeks of waste composting (time needed to enhance stable vermicomposting conditions), the organic matter is added in shallow layers to the bins which contains earthworms at a density of 5 kg/m^2. The layer of organic matter added should not exceed 10 cm depth to ensure aeration for the worms and avoid overheating of the feedstock given its microbial activity. The worms can be fed with half of their body weight in waste per day. After around 30 days the organic waste is transformed by the worms into an humus-like substance.

Cost Considerations
Labour cost, construction material and worms.

Additional Resources
Vermicomposting Manual ISWA

ADVANTAGES
- allows organic waste recycling and worms production for animal feed
- Improves chemical (nutrients, pH) and physical soil property (stability, porosity, water retention)

DISADVANTAGES
- Monitoring is needed; for example, worms can drown in case of excess water in the bin.

Suitable for:
- "Green waste": grass clippings, flowers, vegetable & fruit waste, animal manure
- "Brown waste": tree trunk, branches, leaves, straw

Unsuitable for:
- Mixed waste with glass, plastic, metal
- Meat and fish waste
- Fats (grease, oil, butter, etc.)
- Dairy product and salty/vinegary waste

Image source: Ecocosas

8.4_Anaerobic digestion

FLOATING DOME | TUBULAR | FIXED DOME DIGESTER
ORGANIC WASTE
FUEL SOURCE / SOIL NUTRIENT CULTIVATION

Outline Description of Technology
The process through which organic matter is decomposed due to microbial activity in absence of oxygen and produces a energy-rich gas (biogas) and nutritious digestate. Anaerobic digestion takes place in a airtight reactor tank called digester.

Where Can It Work
Broadly applicable. Average temperatures of above 15°C are suitable, else insulation is required.

How does It Work
Particle size reduction to max. 5 cm helps for easier anaerobic digestion. Furthermore most anaerobic digestion systems operate with a feedstock of high water content (>84%), i.e. often addition of water to the waste is required. Around 30 days are necessary to degrade the organic matter and produce significant amounts of methane and carbon dioxide, as well as a slurry-like digestate. Most wet digestion systems are operated continuously, i.e. when a certain volume of feedstock is added, the same amount of digestate exits the reactor. The produced biogas collects in the top part of the reactor where a gas pipe and valve is located that can be connected to a gas stove to use the biogas as a cooking fuel. Biogas can also be fed into a gas generator to produce electricity.

Cost Considerations
Investment costs of anaerobic digesters are moderate. Construction requires skilled labour and expert design to ensure the reactor is gastight. Both biogas and digestate create added value, thus making biogas digesters interesting from an economic point of view.

Additional Resources
[AD for biowaste]

ADVANTAGES
- generates renewable biogas energy
- small land area required as systems can be constructed below ground
- conserves nutrients in the digestate

Suitable for:
- "Green waste": grass clippings, flowers, vegetable & fruit waste, animal manure

DISADVANTAGES
- incomplete pathogen removal
- gas leakage may create a risk

Unsuitable for:
- Mixed waste with glass, plastic, metal
- "Brown waste": tree trunk, branches, leaves, straw

Image source: Eawag

ADVANTAGES
- avoids waste dissemination with the wind

Suitable for:
- non-reusable/recyclable plastic waste
- non-reusable/recyclable non-organic and non-hazardous waste

DISADVANTAGES
- damages landscape
- none sustainable solution

Unsuitable for:
- liquid waste
- organic waste
- hazardous/contaminated waste

Image Source: SASAHARAMBEE

8.5_Burying waste

NON-RECYCLED WASTE

SAFE WASTE DISPOSAL

Outline Description of Technology

Burying or dumping organic and hazardous/contaminated waste poses a threat to the environment as they pollute soil and water bodies. However, when plastic or other non-organic "inert" waste can not be recycled, burying waste remains the easiest and safest option.

Where Can It Work

Applicable anywhere where land is available to dig and that is neither in areas with very high groundwater levels or bordering surface waters (river, lake, sea).

How does It Work

A hole is dug and surrounded by a small berm and ditch to avoid rainwater flowing into the hole. The bottom of the hole should be well above (>2m) the highest groundwater level. If possible, a clay layer at the bottom and covering the walls can avoid further water leaching into the surrounding area. Waste is then dumped into the hole and then covered with a layer of soil to contain the waste (avoid wind transport as well as birds and vermin). When the hole is full of waste add a final soil cover to build a slightly elevated hill. Then dig a new hole in a new place.

Cost Considerations

Labour cost and soil cover if not available on site.

Additional Resources

Manual landfill

8.6_Waste incineration

HAZARDOUS WASTE

SAFE WASTE DISPOSAL

ADVANTAGES

- avoids pathogen dissemination
- decreases diseases spread
- avoids groundwater contamination

DISADVANTAGES

- threat to air quality and public health when not well managed
- releases harmful gases

Suitable for:

- hazardous/contaminated waste

▪Unsuitable for:

- non-hazardous mixed waste with plastic

Image Source: De Montfort

Outline Description of Technology

When dealing with hazardous waste which cannot be safely stored nor transported to places where it can safely be disposed (e.g. nearby hospital), it can be burnt on-site in a De Montfort incinerator. Care should be taken for the temperature to be kept to a sufficient level which allows a complete combustion process in order to ensure pathogen killing and reduce the risk of harmful gases emissions.

Be careful: it is highly discouraged (and even prohibited in most countries) to put non-hazardous plastic waste into the incinerator, as incomplete combustion will result in adverse impact on the environment !

Where Can It Work

Applicable only in places where skills on how to build, operate and maintain proper waste incinerators are present.

How does It Work

Detailed instructions on construction, operation and maintenance are provided in De Monfort incinerator document.

Cost Considerations

500-1500 USD per incinerator

Additional Resources

De Montfort

List of references and additional resources (1/5)

A lot of the technologies presented in the catalogue are accompanied by useful hyperlinks you can open by right clicking on it. Here is the list of these resources:

Title	Link
3.1_Planted hedgerows	http://www.fao.org/3/a-ad420e.pdf http://www.vetiver.org/KEN_vetiver-for-farmers.pdf http://www.vetiver.org/USA_Vetiver%20Installation%20Guide_2012.pdf https://qcat.wocat.net/en/wocat/technologies/view/technologies_938/
3.2_Bunds	https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/bunds https://wocatpedia.net/wiki/Contour_bunds_and_ploughing
3.3_Radical terraces	http://www.fao.org/3/a-au298e.pdf https://qcat.wocat.net/en/wocat/technologies/view/technologies_1553/
3.4_Gully control	http://www.fao.org/docrep/006/ad082e/AD082e01.htm
3.5_Sand dam	https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/sand-dams-and-subsurface-dams https://wocatpedia.net/wiki/File:Pioneering-sand-dams-brochure-a5-16pp-lr.pdf
3.6_Subsurface dam	http://www.fao.org/fileadmin/user_upload/drought/docs/Subsurface_Dams.pdf https://www.sswm.info/sswm-university-course/module-4-sustainable-water-supply/further-resources-water-sources-hardware/sand-dams-and-subsurface-dams https://www.samsamwater.com/library/Sub_surface_dams_-_a_simple_safe_and_affordable_technology_for_pastoralists.pdf
3.7_Field trenches	https://www.sswm.info/content/field-trenches https://www.sswm.info/content/stormwater-management
3.8_Contour and eyebrow trenches	http://lib.icimod.org/record/33883 http://www.icimod.org/nepcat https://permaculturenews.org/2015/07/24/how-to-build-a-swale-on-contour-successfully/
3.9_Infiltration ponds	https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/micro-basins https://www.sswm.info/content/surface-groundwater-recharge https://www.sswm.info/content/soil-aquifer-treatment
3.10_Reforestation	https://en.wikipedia.org/wiki/Reforestation

List of references and additional resources (2/5)

Title	Link
4.1_Rooftop harvesting	http://www.appropedia.org/Rainwater_Harvesting_(Practical_Action_Technical_Brief) https://www.sswm.info/archived-perspective-notice https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/rainwater-harvesting-(rural) https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/precipitation-harvesting/rainwater-harvesting-(urban) http://www.icimod.org/nepcat https://www.samsamwater.com/library.php?cat=rwh
4.2_Parachute or tarp harvesters	http://pitch-africa.org/
4.3_Water storage tank: brick	http://akvopedia.org/wiki/Brick_cement_tank https://www.ircwash.org/sites/default/files/217-81IR-6933.pdf
4.4_Water storage tank: ferrocement	http://akvopedia.org/wiki/Classical_ferrocement_tank http://www.rainwaterharvesting.org/methods/modern/fctanks.htm https://www.ircwash.org/sites/default/files/217-82IR-6932.pdf http://lib.icimod.org/record/33883 https://www.samsamwater.com/library.php?cat=rwh
4.5_Water storage tank: plastic bottle	http://nellhamilton.com/sustainable-east-africa/projects/plastic-bottle-water-tanks-mwera/ https://insteading.com/blog/plastic-bottle-homes/ https://www.youtube.com/watch?v=zcOkeJgANK8
4.6_Plastic SIM tank	http://akvopedia.org/wiki/Plastic_water_tanks
4.7_Pumpkin tank	https://answers.practicalaction.org/?tmpl=unsupported
4.8_Underground ferrocement tank	https://pdf.usaid.gov/pdf_docs/pnaeb709.pdf
4.9_Plastic storage and distribution tank	www.obelink.n
4.10_Spring and water source protection	https://www.wateraid.org/uk/publications/protection-of-spring-sources-technical-brief https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/groundwater-sources/water-source-protection http://www.icimod.org/nepcat
4.16_Solar pump / small distribution systems	http://waterconsortium.ch/publications/mini-water-system-networks/
4.17_Gravity flow water supply systems	http://lib.icimod.org/record/33883 http://www.icimod.org/nepcat
4.18_Boiling	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf https://www.sswm.info https://www.hwts.info

List of references and additional resources (3/5)

Title	Link
4.19_Chlorination	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf https://www.sswm.info https://www.hwts.info https://www.antenna.ch/en/activities/water-hygiene/ www.who.int/water_sanitation_health/publications/drinking-water-quality-guidelines-4-including-1st-addendum/en/ http://waterconsortium.ch/results/local-production-of-chlorine-for-water-treatment-and-disinfection-purposes/
4.20_Ceramic water filter	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf https://www.sswm.info https://www.hwts.info
4.21_Biosand filter	https://www.biosandfilters.info/ https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWP/safewaterschoolmanual.pdf https://www.sswm.info https://www.hwts.info
4.22_Solar water disinfection (SODIS)	http://www.sodis.ch/methode/anwendung/ausbildungsmaterial/dokumente_material/sodismanual_2016_lr.pdf https://www.hwts.info
5.1_Tippy tap	https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-home/simple-handwashing-devices
5.4_Hand washing station	http://www.rotaryindiawashinschools.com/Downloads/Documents/GroupHWfacilitiesinschoolDesignManual_10212016112035AM.pdf
5.5_Soap making	https://www.zmescience.com/other/feature-post/making-soap-home/ http://documents.worldbank.org/curated/en/681501468141299225/pdf/323020Handwashing1handbook02005.pdf
5.6_Single Ventilated Improved Pit (VIP) Latrines	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sesp/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf http://www.flowman.nl/wedcschoolsanitation20081007.pdf
5.7_Urine Diverting Dry Toilet – ECOSAN toilet	www.wecf.eu/english/publications/2006/ecosan_reps.php www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sesp/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf
5.8_Twin Pits for Pour Flush	www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sesp/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf
5.9_Arborloo	https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/fill-and-cover-/-arborloo www.ecosanres.org/pdf_files/PM_Report/Appendix1_The_Arborloo_book_a.pdf www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/schwerpunkte/sesp/CLUES/Compendium_2nd_pdfs/Compendium_2nd_Ed_Lowres_1p.pdf

List of references and additional resources (4/5)

Title	Link
6.2_Menstrual cups	https://www.sswm.info/humanitarian-crises/camps/hygiene-promotion-community-mobilisation/hygiene-promotion-community/menstrual-hygiene-management
7.1_Using compost	https://www.sswm.info/sswm-university-course/module-3-ecological-sanitation-and-natural-systems-wastewater-treatment-1/use-of-compost
7.2_Mulching	https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/conservation-soil-moisture/mulching
7.3_Natural pesticides	http://www.fourthway.co.uk/posters/pages/pesticide.html
7.4_Urine fertilisation	https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/application-of-stored-urine https://www.sswm.info/humanitarian-crises/prolonged-encampments/sanitation/use-andor-disposal/urine-fertilisation-(large-scale) https://www.sswm.info/content/urine-storage https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/fertiliser-from-urine-(struvite)
7.5_Natural fertilisers	http://www.fourthway.co.uk/posters/pages/planttea.html
7.6_Liquid manure	http://www.fourthway.co.uk/posters/pages/liquidmanure.html https://www.facebook.com/283460171679419/videos/2378762677956/
7.7_Gardening with charcoal	https://permaculturenews.org/2010/05/25/back-to-the-future-terra-preta-%E2%80%93-ancient-carbon-farming-system-for-earth-healing-in-the-21st-century/
7.8_Seed sowing	https://www.seedsavers.org/learn http://blog.seedsavers.org/blog/how-to-store-seeds
7.9_Crop planning	https://www.sswm.info/water-nutrient-cycle/water-sources/hardwares/conservation-soil-moisture/crop-selection
7.10_Planting pits	https://c.ymcdn.com/sites/echocommunity.site-ym.com/resource/collection/27A14B94-EFE8-4D8A-BB83-36A61F414E3B/TN_78_Zai_Pit_System.pdf https://www.sswm.info/content/planting-pits
7.11_Buried pot manual irrigation	https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/manual-irrigation
7.12_Bucket or bottle drip irrigation	https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/drip-irrigation https://www.sswm.info/water-nutrient-cycle/water-use/hardwares/optimisation-water-use-agriculture/subsurface-drip-irrigation
7.13_Keyhole garden	https://insteading.com/blog/keyhole-garden/ https://qcat.wocat.net/en/wocat/technologies/view/technologies_1722/
7.13.1_Banana circle	https://treeyopermacultureedu.wordpress.com/chapter-10-the-humid-tropics/banana-circle/

List of references and additional resources (5/5)

Title	Link
7.14_Vertical gardens	https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-blackwater-and-greywater-agriculture/greywater-towers https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-blackwater-and-greywater-agriculture/vertical-gardens
7.15_Permaculture Design	https://en.wikipedia.org/wiki/Permaculture https://permacultureprinciples.com/ https://permaculturenews.org/ https://treeyopermacultureedu.wordpress.com/
7.15.1_Permaculture "Mandala" garden	http://www.onegreenplanet.org/lifestyle/how-to-make-a-mandala-garden/ https://permaculturenews.org/2017/03/24/going-build-mandala-garden/ https://qcat.wocat.net/en/wocat/approaches/view/approaches_1953/
7.16_Agroforestry	https://www.permaculturenews.org/resources_files/farmers_handbook/volume_4/4_agroforestry.pdf https://permaculturenews.org/2011/10/21/why-food-forests/
7.16.1_Janeemo agroforestry	http://janeemo.webarchive.hutton.ac.uk/ http://www.juliankrubasik.com/janeemo.html www.kusamala.org/projects/janeemo/
7.17_Farmers Managed Natural Regeneration (FMNR)	https://en.wikipedia.org/wiki/Farmer-managed_natural_regeneration http://fmnrhub.com.au/ https://www.youtube.com/watch?v=afjVaehQRxg
8.1_Compost making	https://www.sswm.info/water-nutrient-cycle/reuse-and-recharge/hardwares/reuse-urine-and-faeces-agriculture/application-of-pit-humus-and-compost
8.2_Windrow composting	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Decentralized_Composting/Rothenberger_2006_en.pdf http://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management
8.3_Vermicomposting	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/E-Learning/Moocs/Solid_Waste/W4/Manual_On_Farm_Vermicomposting_Vermiculture.pdf http://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management
8.4_Anaerobic digestion	https://www.eawag.ch/fileadmin/Domain1/Abteilungen/sandec/publikationen/SWM/Anaerobic_Digestion/biowaste.pdf
8.5_Burying waste	http://www.bvsde.paho.org/bvsars/i/fulltext/manual/manual.html#manu
8.6_Waste incineration	https://mw-incinerator.info/en/401_operation.html

Citation (suggestion)

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