Swiss Water & Sanitation Consortium

Blue Schools

Linking WASH in schools with environmental education and practice

Concept Brief

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Photo frontpage (Helvetas Benin): **Safe drinking water at the school in North of Benin**

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Linking WASH in schools with environmental education and practice

Concept Brief

1st Edition

Schweizerische Eidgenossenschaft
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Swiss Agency for Development and Cooperation SDC

Introduction

Background

The Blue School concept was pioneered in 2007 by the International Rainwater Harvesting Alliance (IRHA) in 52 schools in 13 different countries in Asia, West Africa and Latin America and was further developed by the Swiss Agency for Development and Cooperation (SDC). A Blue School goes beyond activities related to Water, Sanitation and Hygiene (WASH). It promotes a school garden 'as a practical place to demonstrate the relationship between food production and an efficient management of water; as well as a demonstrative place for watershed and land management practices' (SDC factsheet). The concept builds on good practices of the WASH in School (WINS) community of practice as well as other sectors.

The SDC-funded Swiss Water & Sanitation Consortium (SWSC), composed of eight Swiss NGOs[1], has implemented different WASH projects in 16 countries since 2011. With the aim of contributing to the know-how of the sector, SWSC members have piloted innovative approaches, exchanged experiences and documented good practices. This includes the Blue Schools concept, implemented in more than 200 schools in Bangladesh, Benin, Ethiopia, Madagascar, and Nepal.

Why working with the youth to achieve SDG 6?

In September 2015, the UN General Assembly adopted the 2030 Agenda for Sustainable Development: Transforming our world. The Agenda is commonly known as the Sustainable Development Goals (SDG) and includes 17 areas for action. SDG 6 Water Supply and Sanitation is an important one that contributes to the realisation of many other SDGs.

Children are the leaders of tomorrow and key change agents in their communities. As changing behaviour of children is easier than changing those of adults, building a new environmentally-friendly generation is a promising path to contribute to the achievement of the SDG 6.

The Blue School concept contributes to all SDG 6 targets.

1 Swiss Water & Sanitation Consortium organizations: Caritas Switzerland, Fastenopfer, HEKS-EPER, HELVETAS Swiss Intercooperation, Solidar Suisse, Swissaid, Swiss Red Cross and Terre des hommes

2 Source: IRHA

Figure 1. **SDG 6 contribution to other SDGs**[2]

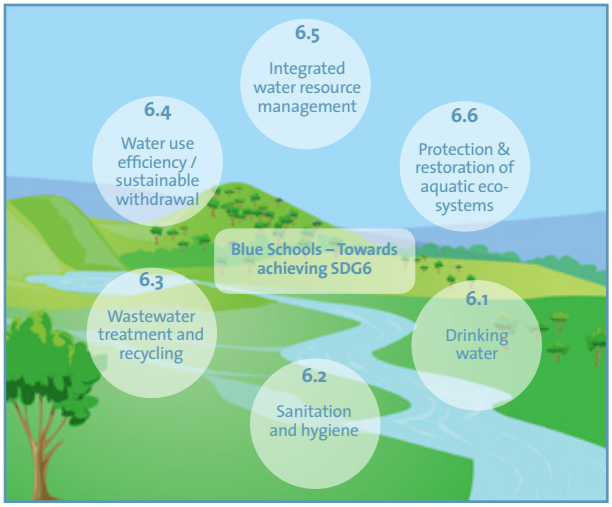

Figure 2. **The SDG 6 targets**

Students practicing handwashing in the North of Benin
(Photo: Helvetas Benin)

How was the Blue Schools Kit developed and why?

In 2016, the SWSC initiated a process to compile existing challenges, lessons learnt, and good practices from field teams that implemented Blue Schools. In general, most project teams introduced a school garden and tree planting in addition to the usual WASH activities. However, often there was too little focus on fostering the students' learning experience on the link between their health and the environment – and its preservation. Project teams, education authorities and school stakeholders expressed their need for more examples of practical exercises that could enrich the national curriculum as well as examples of environmentally-friendly technologies and practices that can be demonstrated in a school yard and replicated at home or in the community. These insights led to further develop the Blue School concept including support materials in the form of the "Blue Schools Kit".

The Blue Schools Kit is the result of a joint effort in 2017 and 2018 between field teams having implemented Blue Schools and WASH advisors from different organisations. The team consists of individual members from Caritas Switzerland, HELVETAS Swiss Intercooperation, Terre des hommes, the SWSC Management Unit as well as the Swiss Federal Institute for Aquatic Science and Research (Eawag), the International Rainwater Harvesting Alliance (IRHA) and international consultants. In July 2017, the SWSC hosted a four-day "Blue Schools Workshop" in Nairobi to jointly develop the Blue Schools Kit[3].

3 Participants of the workshop included field staff from HELVETAS Swiss Intercooperation in Benin, Nepal, and Madagascar, Fastenopfer in Madagascar, Caritas Switzerland in Ethiopia, Bangladesh and Kenya, COOPI in Ethiopia, Terre des hommes in Bangladesh and Swiss Red Cross in Nepal. A representative from IRHA also participated.

What is a Blue School?

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.

In a Blue School:

- Students have access to ***safe drinking water, use well-maintained latrines,*** maintain ***good hygiene practices*** and ***participate in gardening activities*** and solid ***waste separation and collection.***
- Students experience ***sustainable land and water management practices*** through the school garden and the other environmentally-friendly technologies or practices in the schoolyard or in nearby locations.
- Teachers enrich the theoretical lessons from the national curriculum on biology, chemistry, agriculture, etc. with practical exercises so that ***students can learn by doing.***
- Students are also introduced, in a visual and fun way, to ***new concepts*** such as watershed, water cycle and solid waste reduction, reuse and recycling.

The Blue School Kit is neither a new curriculum, nor intended to add to the current workload of teachers. By using safe and improved WASH facilities and experiencing good land, water and waste management practices, students are enabled to adopt healthy and environmentally-friendly behaviours in school and at home.

The following eight topics are covered in Blue Schools:

Becoming a Blue School is a ***pathway:*** Once the basic WASH requirements are fulfilled, a school can continue its pathway towards an environmentally-friendly learning experience. Depending on different factors including land and water availability, the existence of some facilities and the governmental and school priorities, the starting point can vary from one school to another.

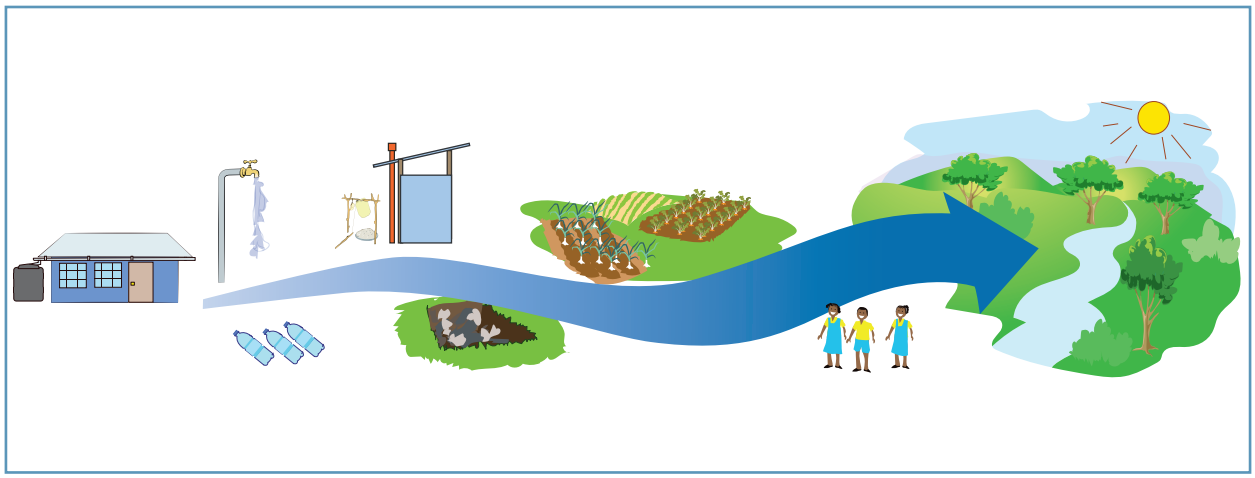

Figure 3. **Blue School Pathway**

Indicators, minimum standard and factors of success

The table below presents the recommended indicators and minimum standard for a school to qualify as a Blue School and the factors of success. It is based on recommendations of the United Nations Joint Monitoring Programme (JMP) for WASH in Schools (non-residential) led by WHO and UNICEF, as well as recommendations for gardening and solid waste management based on internationally recognised good practices. As each country has a unique process for factoring the SDG monitoring framework into its Education Management Information System (EMIS), it is recommended to adapt this table to the national standards.

Component	Indicators and minimum standard	Factors for success
Water	Drinking water from an improved source is available at the school when needed, accessible to all, and free from faecal and chemical contamination. Minimum quantity of water for drinking and handwashing: 5L/person/day.	There are mechanisms in place for Operation and Maintenance (O&M) of the water infrastructure, with clear roles and responsibilities. There are clear financing mechanisms for materials, consumables and services provision. In case on-site treatment is needed, a special container for storing and distributing treated water is recommended. Students and/or staff monitor the functionality status of the water infrastructure and treatment technology and are involved in the regular maintenance activities.
Sanitation	Improved sanitation facilities which are single sex and useable at the school, accessible and used by all[4], of sufficient quantity[5], & inspected for cleanliness[6]; appropriate facilities for menstrual hygiene management[7] are provided. Minimum quantity of water for sanitation[8] is available (depending on the sanitation system). There are facilities for girls for menstrual hygiene management (MHM) such as separate room with tap and/or water container and bins for disposal of sanitary products.	There are mechanisms in place for maintaining cleanliness of the sanitation facilities with clear roles and responsibilities, ideally displayed in a cleaning roster. There are clear financing mechanisms for materials, consumables and services provision. Students and/or staff inspect the cleanliness of the sanitation facilities and are involved in the regular maintenance activities.

4 Toilet design is appropriate for children with special needs.

5 Sufficient toilets are available – one per 25 girls and one for female staff; one toilet plus one urinal (or 50 cm of urinal wall) per 50 boys, and one for male staff.

6 Although subjective, JMP recommends the following measures of cleanliness:

Clean: All toilets: absence of strong smell or significant numbers of flies or mosquitos; no visible faeces on the floor, walls, seat (or pan) or around the facility.
Somewhat clean: Some smell and/or some sign of faecal matter in some of the toilets.
Not clean: Strong smell and/or presence of faecal matter in most toilets.

7 Requirements for MHM: water and private space for washing, bin with lid, & system for safe disposal of pads.

8 Minimum water for sanitation: pour flush toilet: 1.5–3.0L/person/day; conventional flush toilet: 10–20L/person/day; 1–2L/person/day for anal cleansing.

Hygiene	Functional handwashing facilities with soap or ash at each sanitation facility are accessible. Students wash their hands at critical times[9]. Students receive menstrual hygiene education; MHM products are provided for urgent needs.	There are mechanisms in place to ensure that behaviour change is sustained in the school. There are mechanisms in place to refurnish soap/ash and refill handwashing water containers (if needed). Students and/or staff monitor the functionality of the handwashing facilities and are involved in maintenance activities. There is an active student club (or similar group) guided by staff and/or parents, to organize Blue Schools activities in the school and community outreach activities.
Gardening	Students are engaged in small-scale gardening activities of at least three nutritious crops in any season, cultivated according to principles of low external input sustainable agriculture (LEISA) with efficient irrigation[10].	Schools include small-scale gardening among approved extracurricular activities (at least one hour per week). When relevant, teachers use the school garden to demonstrate school curriculum dealing with agriculture, biology, etc. School stakeholders as well as parents and students have clearly defined responsibilities for mentoring and maintenance of the school garden. The size of the garden is appropriate to water and land availability in the school. A minimum of around 3*3m plot (keyhole garden) is recommended.
Solid waste Management	Students participate in separation and collection of organic and non-organic waste. Organic waste is recycled. Plastic waste is not burnt but recycled or safely buried.	There are waste bins for separating waste in different fractions in the classrooms and in the schoolyard. Compost is produced and later used in the school garden. Students recognise the different types of waste and apply the concept of reduce, reuse, recycle.

9 In non-residential school, critical times are at minimum after defecation, before preparing food / eating.

10 At least 3 of the following LEISA techniques are used in the school garden: mulching, natural pesticides and fertilisers, crop diversification and rotation, fabrication and use of compost, rainwater harvesting.

Land & water management (Depending on the context)	Students participate in sustainable land and water management practices in the school yard and/or in nearby locations.	Rainwater is collected and stored for the school garden. Students practice water efficient irrigation and soil conservation techniques. Students take part in planting/watering/ maintaining trees in the schoolyard and/or nearby locations. The school organises environmentally-friendly activities and campaigns with the community.

Students nursing the plants in the vertical bag garden in Kenya
(Photo: Caritas Switzerland in Kenya)

Students demonstrating their keyhole garden in Bangladesh
(Photo: Terre des hommes Bangladesh)

The Blue Schools Kit

The Blue School Kit provides ideas to project staff, education authorities and school stakeholders on how to transform a school into a Blue School. More specifically, it contains a number of materials that have different target audiences and different purposes. It contains:

- ***A Concept Brief*** (this document), to share with parties interested to learn more about Blue Schools. The Concept Brief defines a Blue School and its different components and provides a road map on how best to engage government institutions, build ownership of the school stakeholders and ensure sustainability.
- ***A Catalogue of Technologies,*** 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.
- ***A Catalogue of Practical Exercises,*** aiming to inspire teachers with hand-on and low cost exercises to complement the theoretical lessons. The examples provided facilitate students' learning by doing and can be replicated in the students' home and in their communities.
- ***A Facilitator's Guide, for teachers and training of trainers,*** designed to provide a visual support to introduce the Blue Schools topics to students, as some topics might not be in the existing curriculum or might be overlooked, such as gender, menstrual hygiene management and transformation of solid waste into resources. For each topic, it suggests learning objectives, questions for discussion and examples of practical exercises as per the Catalogue of Practical Exercises.

The Catalogue of Practical Exercises and the Facilitator's Guide target students in upper primary school and/or secondary school, but the concept as such can be implemented with any age group.

Several recognised methodologies for hygiene and sanitation promotion in school exist, such as CHAST (Caritas Switzerland), Safe Water School Training Manual (Eawag), Fit for School (GIZ), the Three Stars Approach (UNICEF and GIZ) and others. The Blue School Kit does not prescribe any methodologies. Rather, it focuses on 'experiencing' by ensuring that an enabling environment for students is in place to transform the learning into practice.

As far as possible, the introduction of Blue Schools should be combined with sensitisation campaigns and interventions at the community level.

11 Images should be adapted to the local context and culture as appropriate.

Road map to implement Blue Schools

This road map is meant as a general guideline on how to initiate the process and the key enabling factors to consider. Overall, the support to provide to governmental institutions and to the school stakeholders for sustainable implementation of the Blue School concept requires a minimum of two years. Figure 4 below summarises the different steps recommended for a school to become a Blue School.

Preparatory phase

Implementing Blue Schools is a multi-sectorial process involving a range of stakeholders having different interests.

The first step is for project team to understand the institutional and regulatory framework. This helps identify the right structures and stakeholders that should be engaged. It also enables alignment with national plans and sector strategies and ensures compliance with and adherence to the rules and regulations, national standards and guidelines of the different sectors covered by Blue Schools (See green boxes in Figure 5).

The project team must also assess the national school curriculum in order to identify the Blue Schools topics already covered within the national curriculum and those topics that would be new. For that, it is recommended to initiate a dialogue with the education authorities responsible for school curriculum and teacher training. They are the best placed to recommend how the Blue Schools Kit can help enrich the lessons from the national curriculum.

Next, it is important to be clear on how a typical school is structured and affiliated within the local government system by identifying the school stakeholders[12] (see yellow boxes in Figure 5), their respective roles and responsibilities and their link to the local government institutions (i.e. the support they currently receive on the one hand and the reporting mechanisms on the other hand).

Other stakeholders in the areas such as local services providers should also be mapped, as they might play a key role for maintenance or delivery of other services in the school.

12 Schools stakeholders include the head teacher (called in some countries school director), all teachers, the board of management (called in some other countries parents teachers association), and the parents

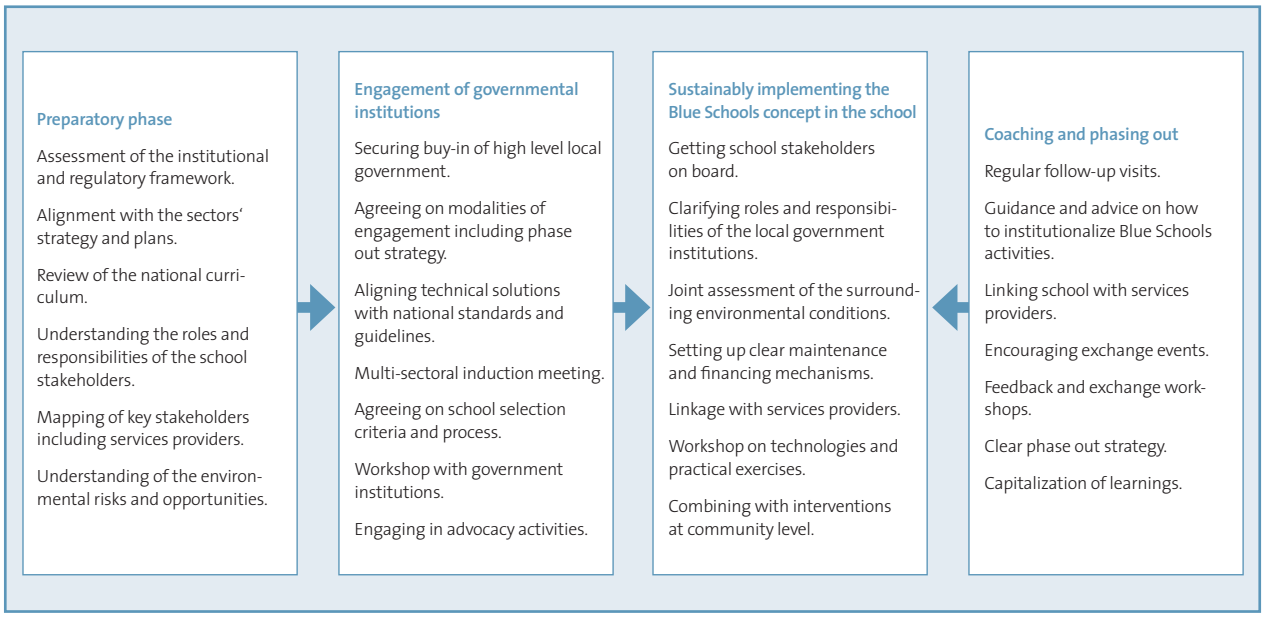

Figure 4. **Road map for Blue Schools implementation**

The project team needs to become familiar with the climatic patterns, water availability, soil conditions, topography, vegetation etc. and the associated environmental risks and opportunities. Consideration for these aspects – and how they may vary considerably among schools in the same region – is key to ascertain which Blue Schools technologies would be most appropriate in the specific context. This can also be discussed with the relevant government institutions.

Engagement of government institutions

The role that governmental institutions can play for a successful implementation of Blue Schools is country and context specific. As much as possible, government institutions should steer the process and be engaged in, among others, selecting the schools, facilitating the training of teachers, and carrying independent follow-up visits. Their engagement is key for sustainability and for replicating Blue Schools in the area or even in the country.

The Blue Schools topics cover different sectors, the project team should involve governmental institutions overseeing education, water, sanitation, natural resources management, agriculture, environment, youth affairs, etc. To secure buy-in, they should begin by engaging with high level government representatives, who can then commission relevant local government officers to examine the technical and implementation aspects.

Blue Schools implementation should also align with each sector's strategy and plans. All technical solutions must be designed according to national standards and guidelines.

The collaboration framework also needs to be clearly discussed and agreed at all levels. This includes:

- The 'project' scope and duration;
- Support to be provided by each party in terms of expertise and financing;
- Roles and responsibilities of local government institutions and how the project team can support;
- Respective tasks, the foreseen time allocation required and the lines of communication;
- Project team phase out (exit strategy).

The collaboration should be formalised in a Memorandum of Understanding (MoU).

To best engage all relevant sector institutions, it is recommended to hold a multi-sectoral induction meeting to introduce Blue Schools and jointly define selection criteria for the school as well as the steps for initiating Blue Schools activities. Based on these criteria, schools can be selected through an introduction and application process, or through a joint assessment. Water availability, land availability, motivation of the head teacher and the school capacity to implement Blue Schools are some examples of selection criteria.

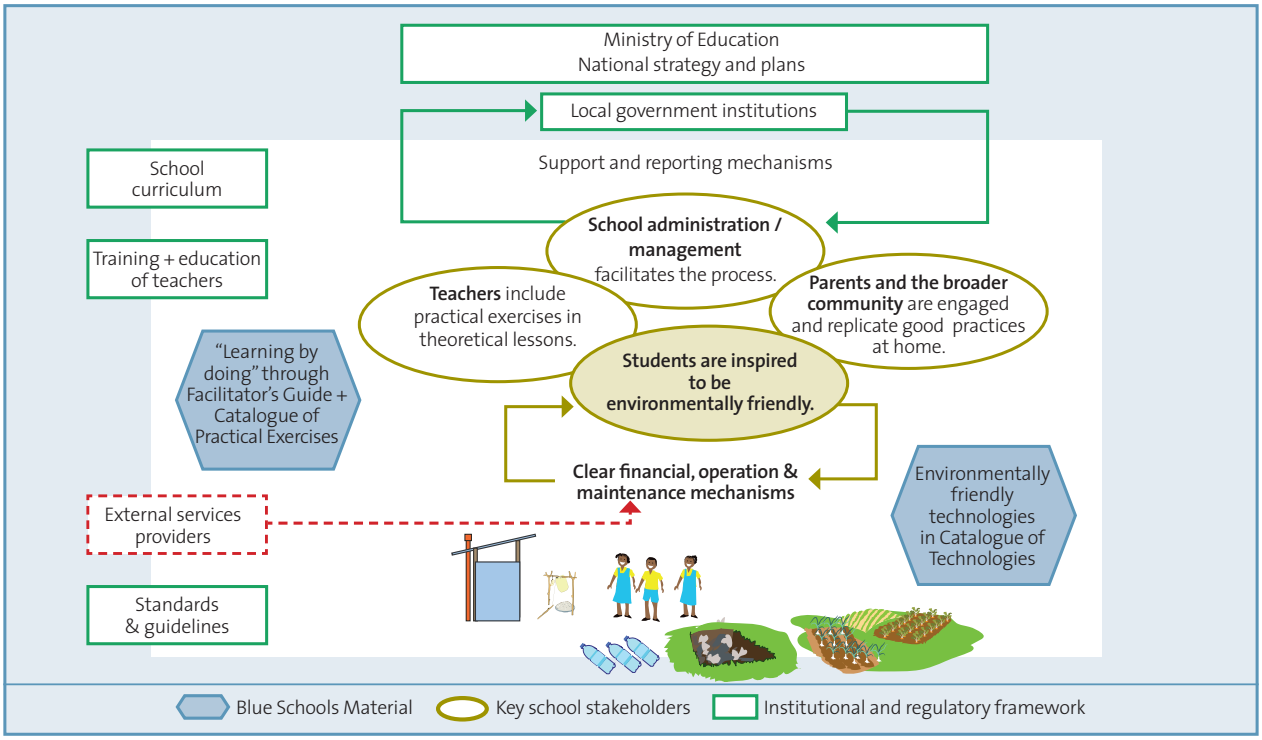

FIGURE 5. **INTEGRATING BLUE SCHOOLS IN THE NATIONAL EDUCATION FRAMEWORK**

"One student one tree" campaign in Madagascar
(Photo: Fastenopfer Madagascar)

Next, a workshop on technologies and practical exercises with government institutions (teacher training centres, extension workers or any other relevant stakeholders) can be organised to ensure anchorage at institutional level.

Ideally, the project team should also engage in advocacy activities at local and/or national levels on topics such as the development (or review process) of national standards or guidelines for schools, taking part in a national curriculum review process, adaptation of visual supports from the Blue Schools Kit to the local context and measures to bring Blue Schools (or some part of it) to scale. This can be in collaboration with other key sectors players having similar interest.

Sustainable implementation the Blue Schools

How to best mobilise a school and the relevant school stakeholders to engage in the process varies with the country and the context. In general, it is recommended to visit the selected schools to get school stakeholders[13] on board and clarify the project scope, the rules of engagement and the support they can expect during the project and beyond. The roles and responsibilities of local government institutions in terms of coaching the implementation of some activities, as well as long-term support should be clearly defined from the start to ensure that the activities introduced are sustained.

From there, the head teachers and other school stakeholders, the local government representatives and the project team should conduct an in-depth joint assessment of the environmental conditions, i.e. current sources of water and rainfall potential, existence and status of latrines, topography, soil type, etc. Based on this, looking at the Blue Schools Catalogue of Technologies, and considering local availability of consumables, materials, and possible external services providers, the school can decide on appropriate technologies to put in place.

From the start, it is essential to put in place operation and maintenance mechanisms with clear roles and responsibilities for the WASH facilities, school garden or other technologies and practices introduced in the school. The involvement of students through a school health club or any other students' groups in the monitoring of WASH facilities status (including waste management and cleanliness of the toilets) is important. However, it should not be used as a punishment and should not infringe on students' safety and free time outside of school. Teachers and other stakeholders must assume their responsibilities to safeguard children and ensure balanced routines. In parallel, financing mechanisms for materials, consumables and services provision need to be discussed and agreed upon between the school stakeholders. The local government institutions and the project team can support the school in linking them with the relevant services providers.

It is recommended to organise a workshop on technologies and practical exercises with teachers and relevant stakeholders to provide hands-on guidance on how to implement different low-cost technologies in the school yard and/or imme-

13 Key school stakeholders include: school administration, head teachers, teachers, school management (sometimes called parents teachers association), care takers, parents and, if relevant, some student representatives.

Girls and boys making reusable sanitary pads in Mid-Western region Nepal
(Photo: Swiss Red Cross Nepal / Nepal Red Cross Society)

diate surroundings (where possible). It is the occasion to promote an understanding of the benefit of practical exercises to enrich the theoretical lessons. Such an event is most fruitful if held with representatives of parents[14]. Ideally, this workshop should be organised by the local government institutions, with support from the project team as necessary. Depending on the specific context, efforts to engage education authorities and to train teachers may enhance advocacy for including some of the Blue Schools practical exercises in the official teacher training process.

Student outreach activities stand to influence their parents and the broader community. Ideally, the implementation of Blue Schools should be combined with interventions at community level for bigger impact.

Coaching and phasing out

Regular follow-up visits to the school with the relevant local government institutions should be organised to assess whether teachers use the practical exercises or need further support. The visits are an opportunity to provide additional guidance on how to sustain the mechanisms for O&M of WASH facilities and other practices or technologies and sustain behaviour change. The project team might need to provide further support to link up the school with relevant services providers.

Organising experience sharing events between schools, such as exchange visits, joint events for special days or competitions, creates a good platform for peer learning and exchange of challenges and ideas through healthy competitions.

It is also recommended to organise feedback and exchange workshops for teachers to discuss experiences, challenges and lessons learned in implementing and maintaining the WASH facilities, the school garden, the waste collection and separation or other Blue Schools technologies. These workshops are also a good opportunity for teachers to share experience in how they made use of the Blue Schools Kit in their school. Other platforms that can be used for experience sharing on Blue Schools include the regular meetings between head teachers of different schools in a similar area.

The project team should have a clear phase out strategy. As the process develops, the project team should let the local government institutions and the school head teachers to take a leading role in follow-up visits, providing direct advice to the school stakeholders and initiating the next actions. Local government institutions as well as school stakeholders (parents, teachers, administrators) should also be able to promote Blue Schools to other schools in their area but also to regional and national authorities. The support that school stakeholders can expect from government institutions should be clear from an early stage.

14 Involve parents, either via an existing parent 'association or by general invitation, during initial meetings, workshops, and on special days when technologies and practical exercises are demonstrated. Parents often have key decision making roles and could support sustainability of Blue Schools activities and replication at home and/or in the community.

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BLUE SCHOOLS

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CATALOGUE OF TECHNOLOGIES

1st Edition

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Introduction

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

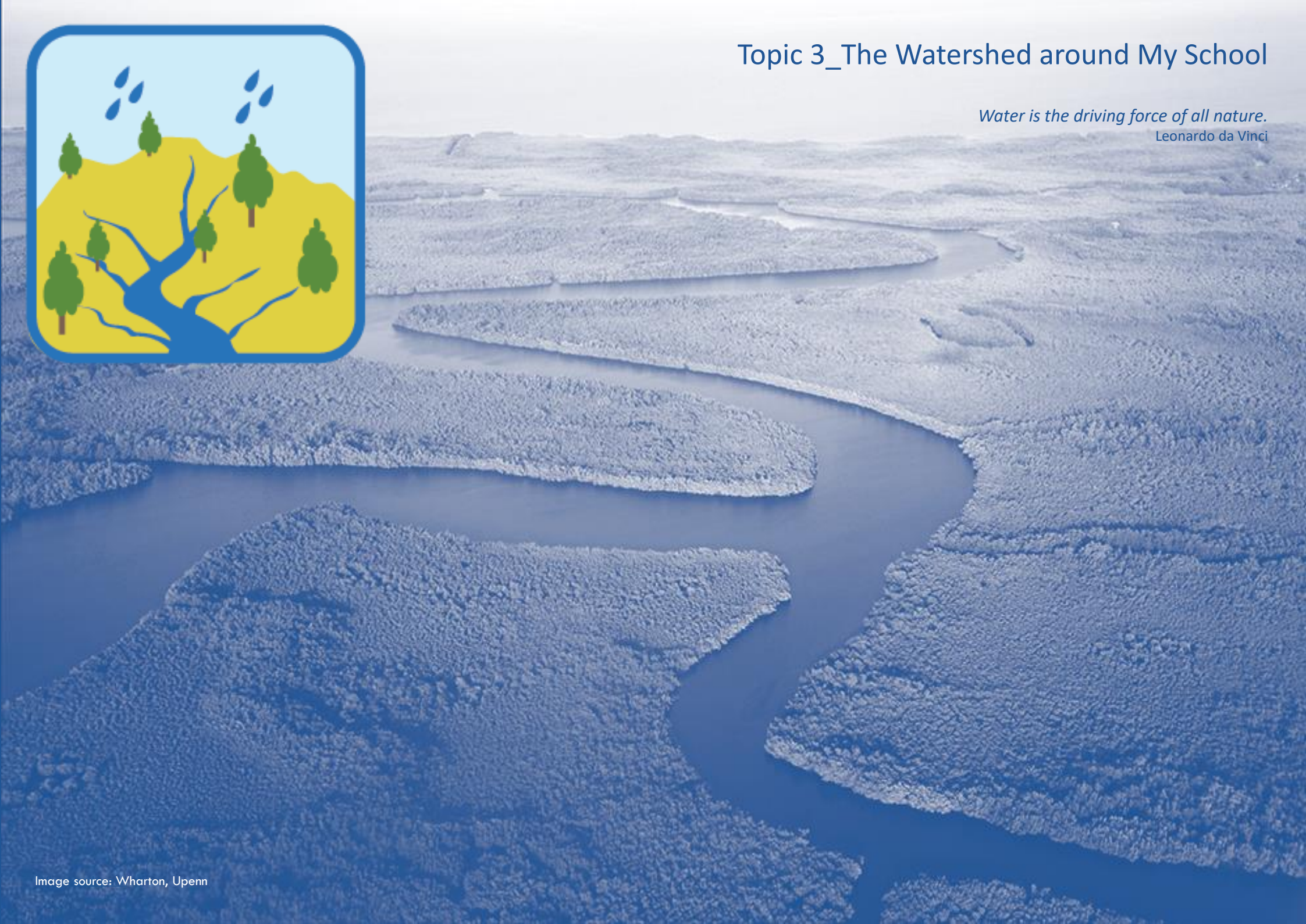

Image source: Wharton, Upenn

Erosion control

Water retention and infiltration

Flood management

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INTRODUCTION

The Watershed around My School

"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.

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

3.1_Planted hedgerows

THE VETIVER SYSTEM

EROSION CONTROL | MICROENTERPRISE | WATER INFILTRATION | WATER RETENTION

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

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

3.3_Radical terraces

DEFORESTATION | EROSION CONTROL | WATER INFILTRATION | WATER RETENTION

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

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

3.4_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

- 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

3.5_Sand dam

PRECIPITATION HARVESTING

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

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

3.6_Subsurface dam

PRECIPITATION HARVESTING

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

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

3.7_Field trenches

FLOOD MANAGEMENT | PRECIPITATION HARVESTING | WATER INFILTRATION | WATER RETENTION

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

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

3.8_Contour and eyebrow trenches

GROUND WATER AND FLOOD MANAGEMENT | EROSION CONTROL | SOIL MANAGEMENT

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

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/

3.9_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
- 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

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

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

- Rooftop harvesting (4.1)
- Parachute or tarp harvesters (4.2)
- Spring and water source protection (4.3)
- Protected hand dug well (4.4)
- Tube well or borehole (4.5)
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- Water storage tank: brick (4.9)
- Water storage tank: ferrocement (4.10)
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- Ceramic water filter (4.20)
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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.

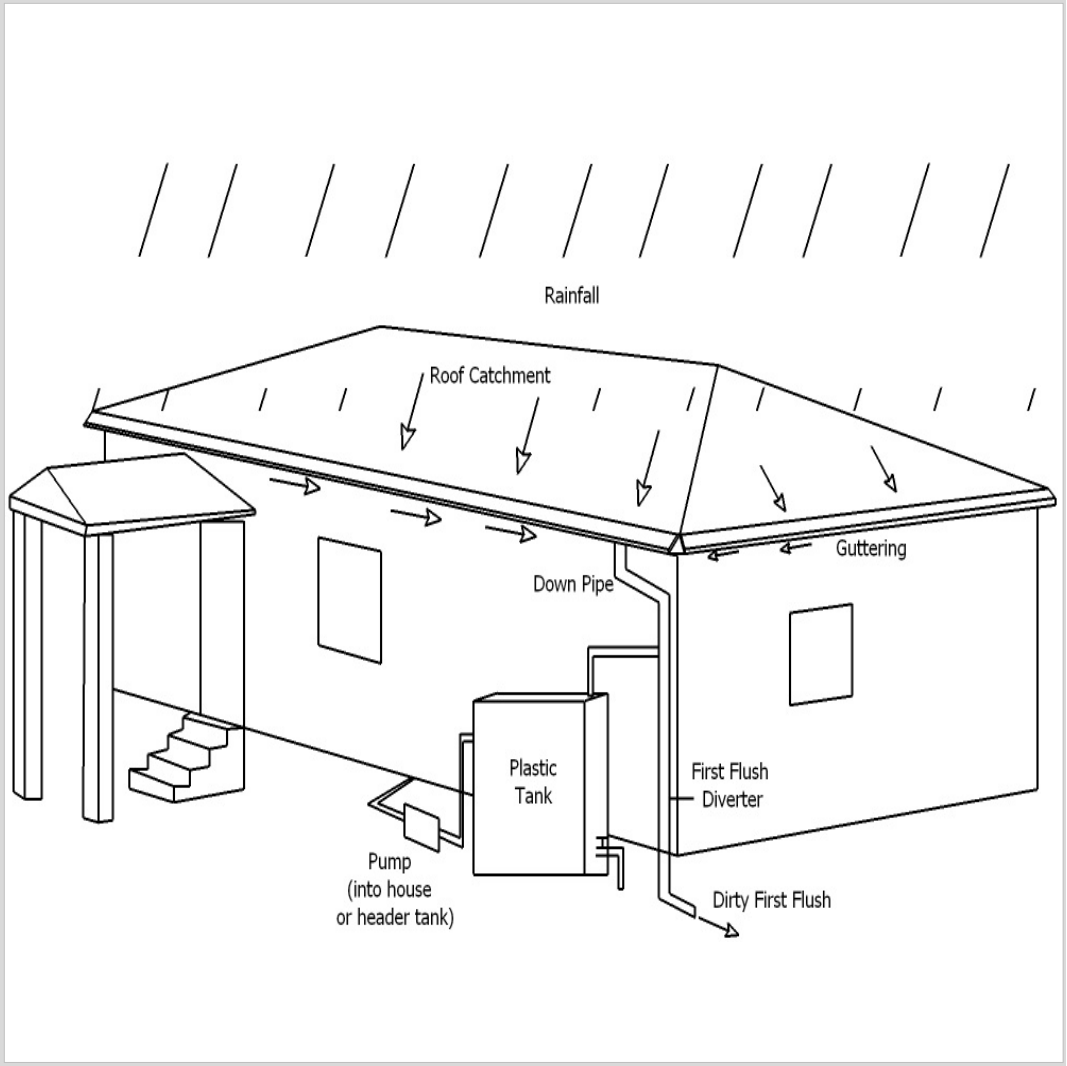
Unsafe drinking water may be contaminated by faeces and/or toxins and may also be unacceptable due to suspended solids. Its consumption can result in infectious diseases, such as gastroenteritis, cholera, and typhoid, among others. Contaminated water is estimated to result in more than half a million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



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

4.1_Rooftop harvesting

PRECIPITATION HARVESTING | WATER ACCESS | WATER STORAGE

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

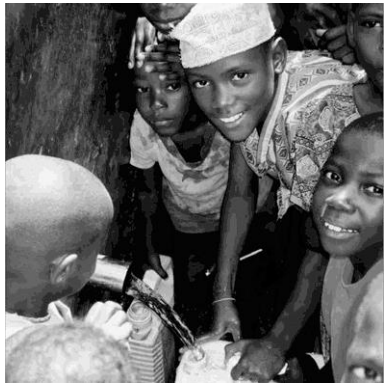
Parachute or Tarp *harvesting* can be used anywhere where access to water is difficult and rainfall is in excess of 300mm annually.

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

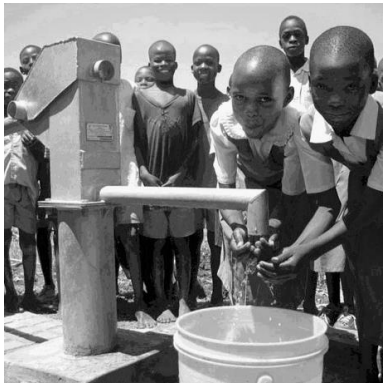
4.5_Tube well or borehole

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)

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

4.9_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
- 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

4.10_Water storage tank: ferrocement

WATER STORAGE

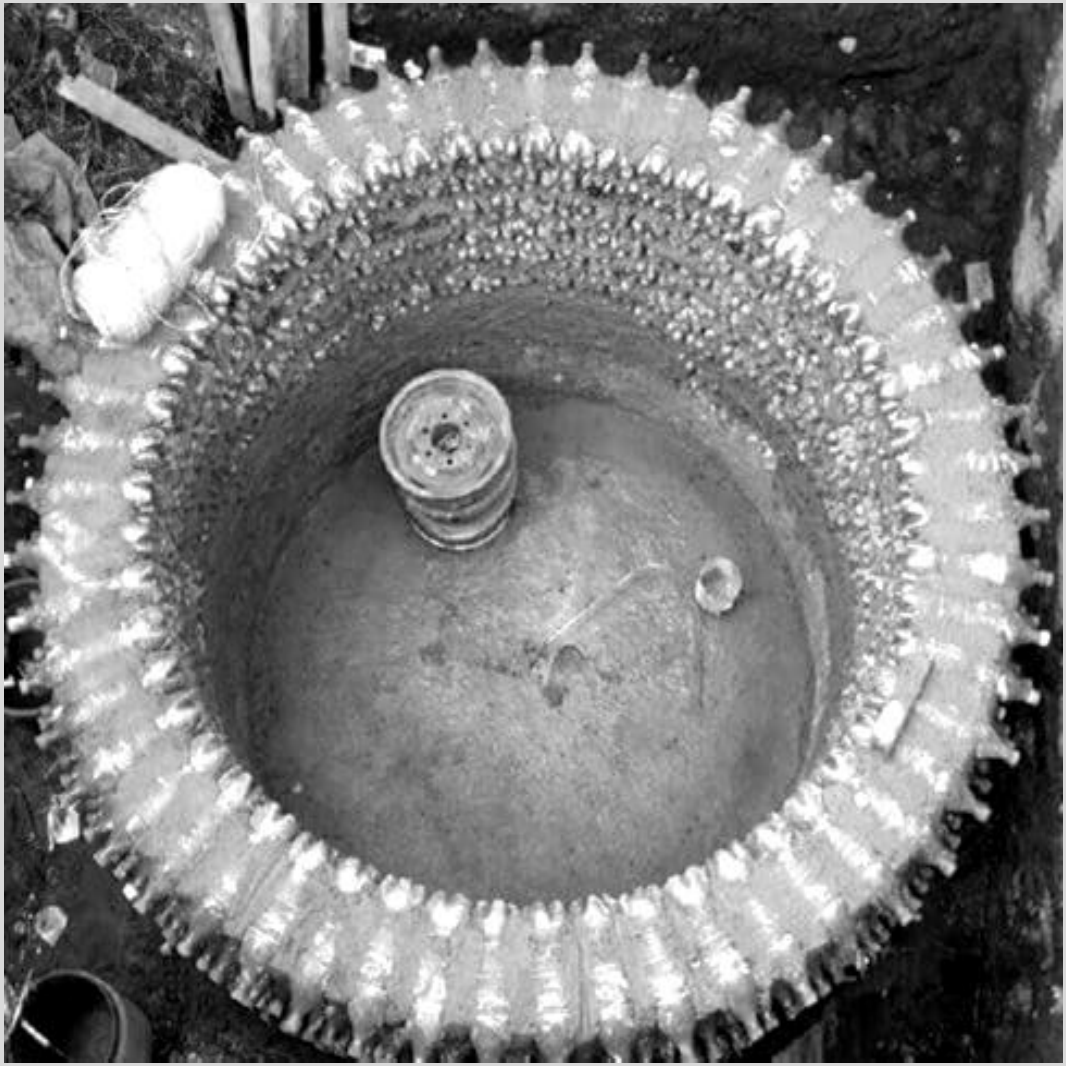
Outline Description of Technology
Even small 1000-2000 litres ferrocement tanks can be effective for the storing of water (or food). They can be constructed with various agricultural waste materials (e.g. dry leaves or grass) in combination with cement and cloth fibre. The larger 5000-10'000 litres pumpkin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

4.11_Water storage tank: plastic bottle

ECO TEC
WATER STORAGE

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

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

4.19_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 ≥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
- 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

4.20_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

- 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

4.21_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 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

4.22_Solar water disinfection (SODIS)

WATER TREATMENT

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

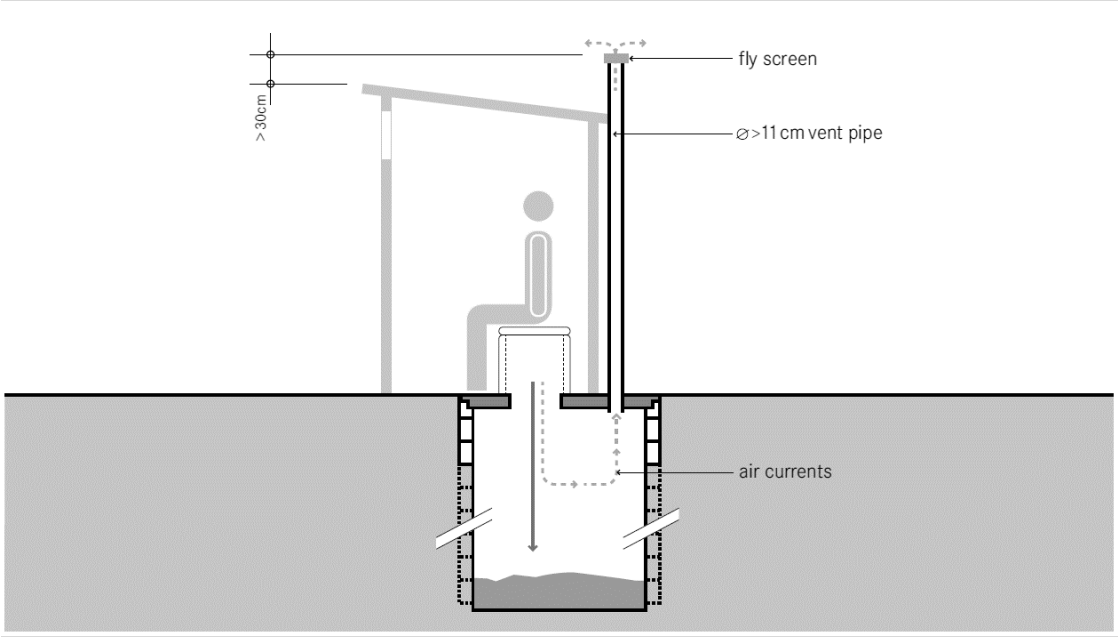
5.5_Soap making

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.

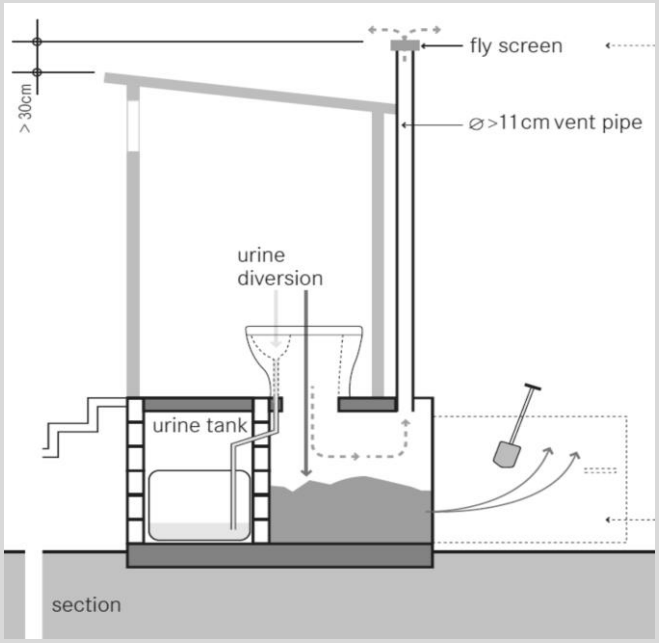
Cost Considerations

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

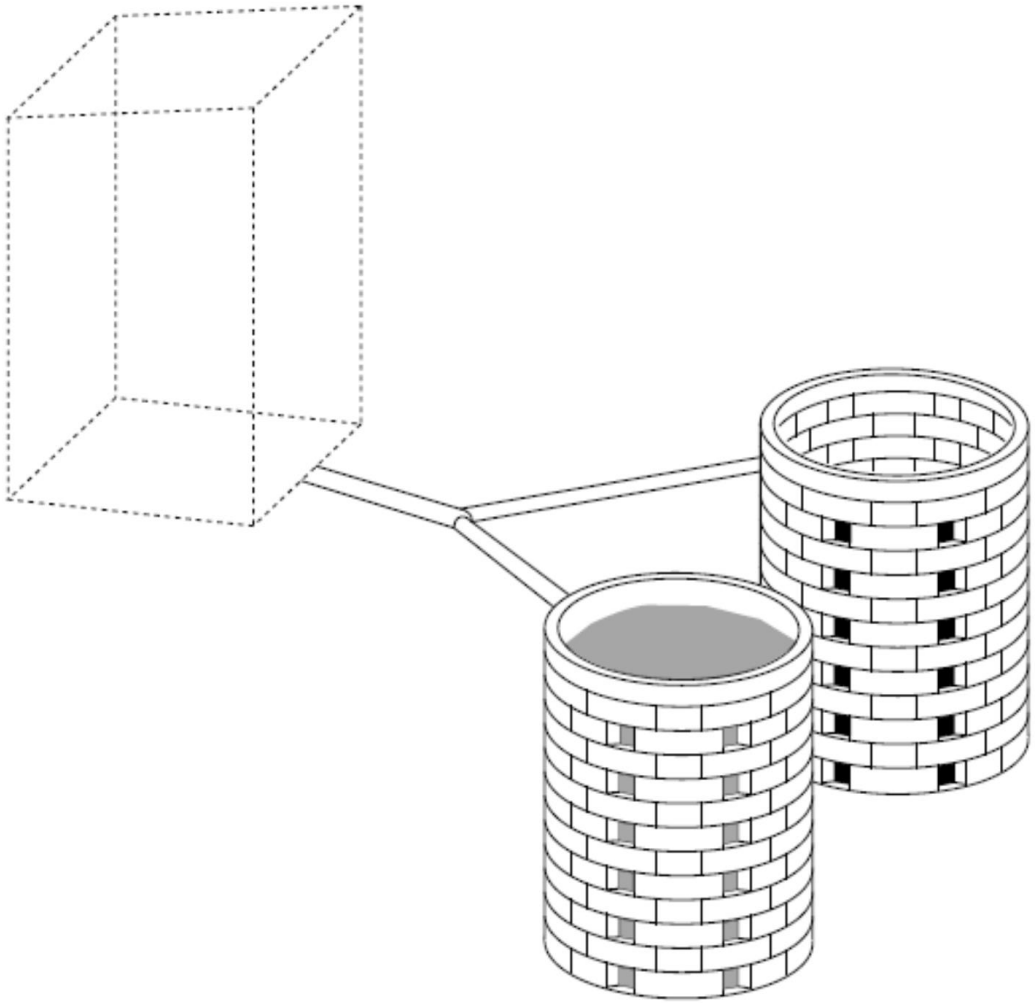
Outline Description of Technology
Urine diverting dry toilets (UDDTs) are used to collect and store urine and faeces separately. Faeces will only dehydrate when the vaults are well ventilated, watertight to prevent external moisture from entering, and when urine and anal cleansing water are diverted 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



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

5.8_Twin Pits for Pour Flush

SANITATION

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

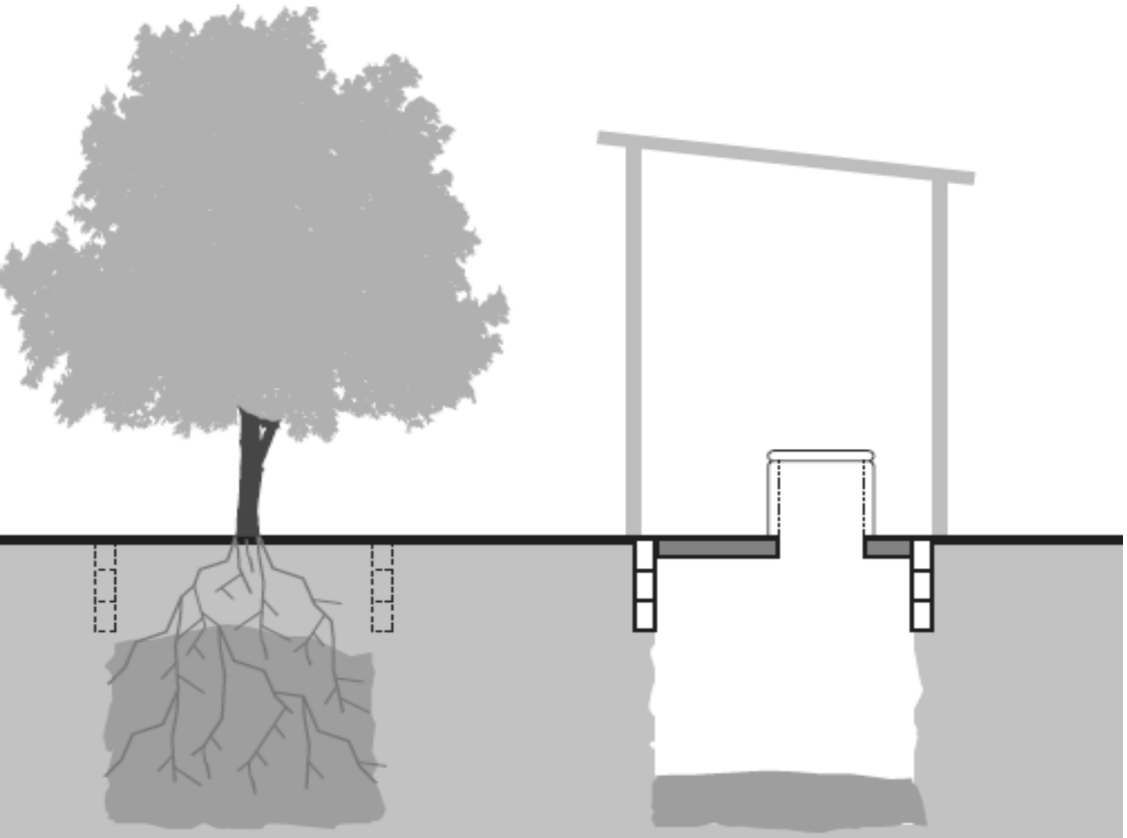
Twin Pits for Pour Flush is a very satisfactory and hygienic sanitation system. The pits require a longer retention time (two years is recommended) to degrade the material before it can be excavated safely. Therefore the pits should be of an adequate size to accommodate a volume of waste generated over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



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

5.9_Arborloo

SANITATION

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

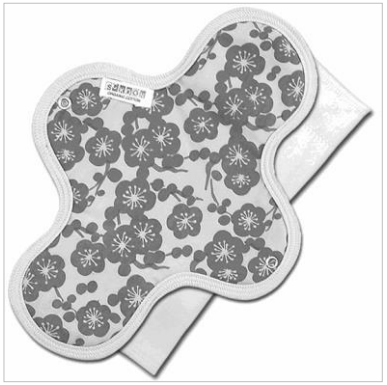
As children grow, changes in their bodies occur, accompanied by an evolution of their minds, feelings and understanding of psycho-social differences between males and females. Their needs also will evolve in many ways. This section of the Blue Schools Kit addresses in priority the young women's needs 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

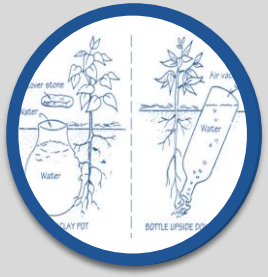
Image source: survivopedia

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

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

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
- 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

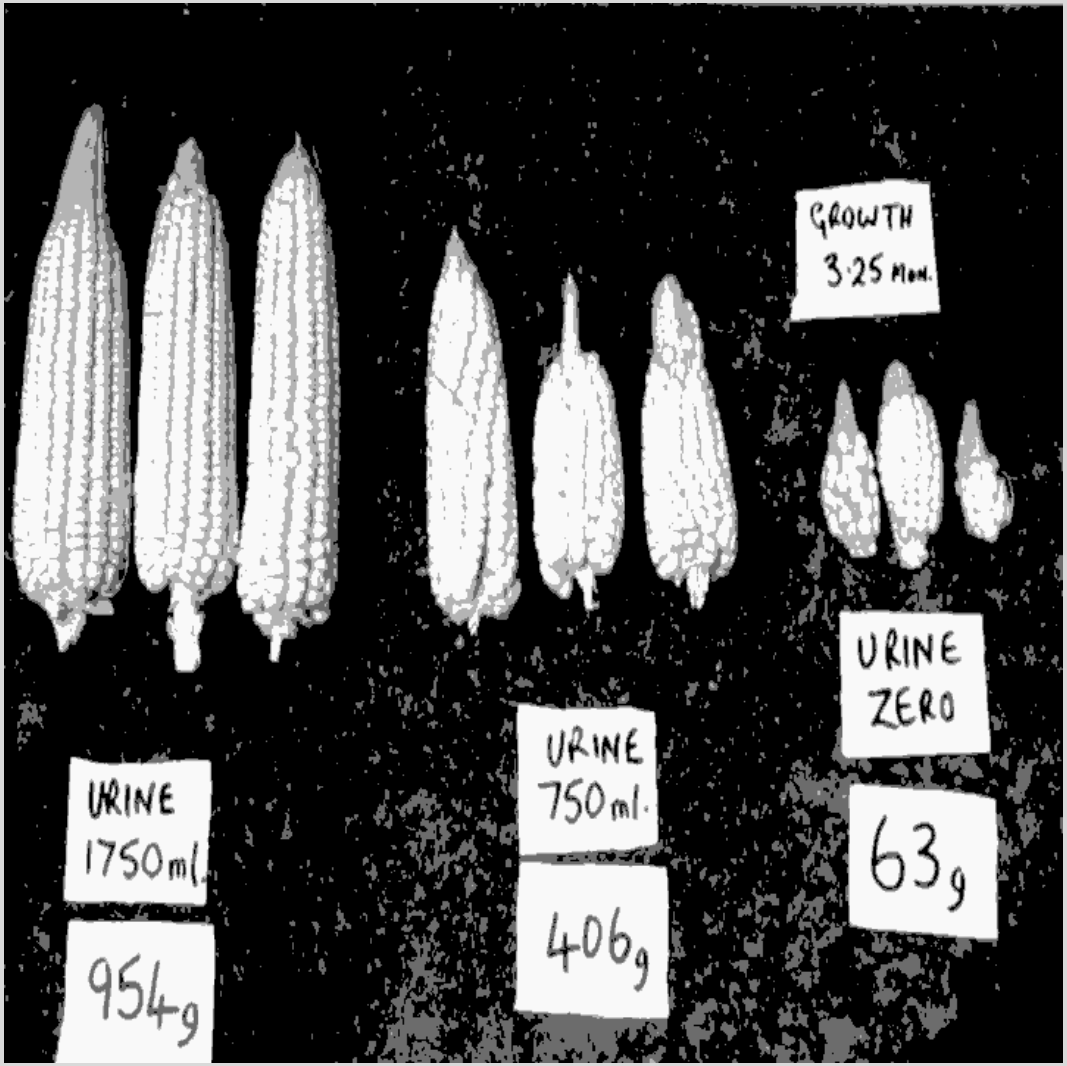
Outline Description of Technology
There are many ways to prepare natural pesticides, depending on local resources and on the problem one wants to treat. The recipe presented here uses Neem tree leaves, as it is quite widely available in many countries, and an efficient way to control various pests. For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



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

7.4_Urine fertilization

SOIL ENHANCEMENT

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

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)

Image source: Greendots.ch / Burkina Faso

7.8_Seed sowing

LIVELIHOOD | FOOD AUTONOMY

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

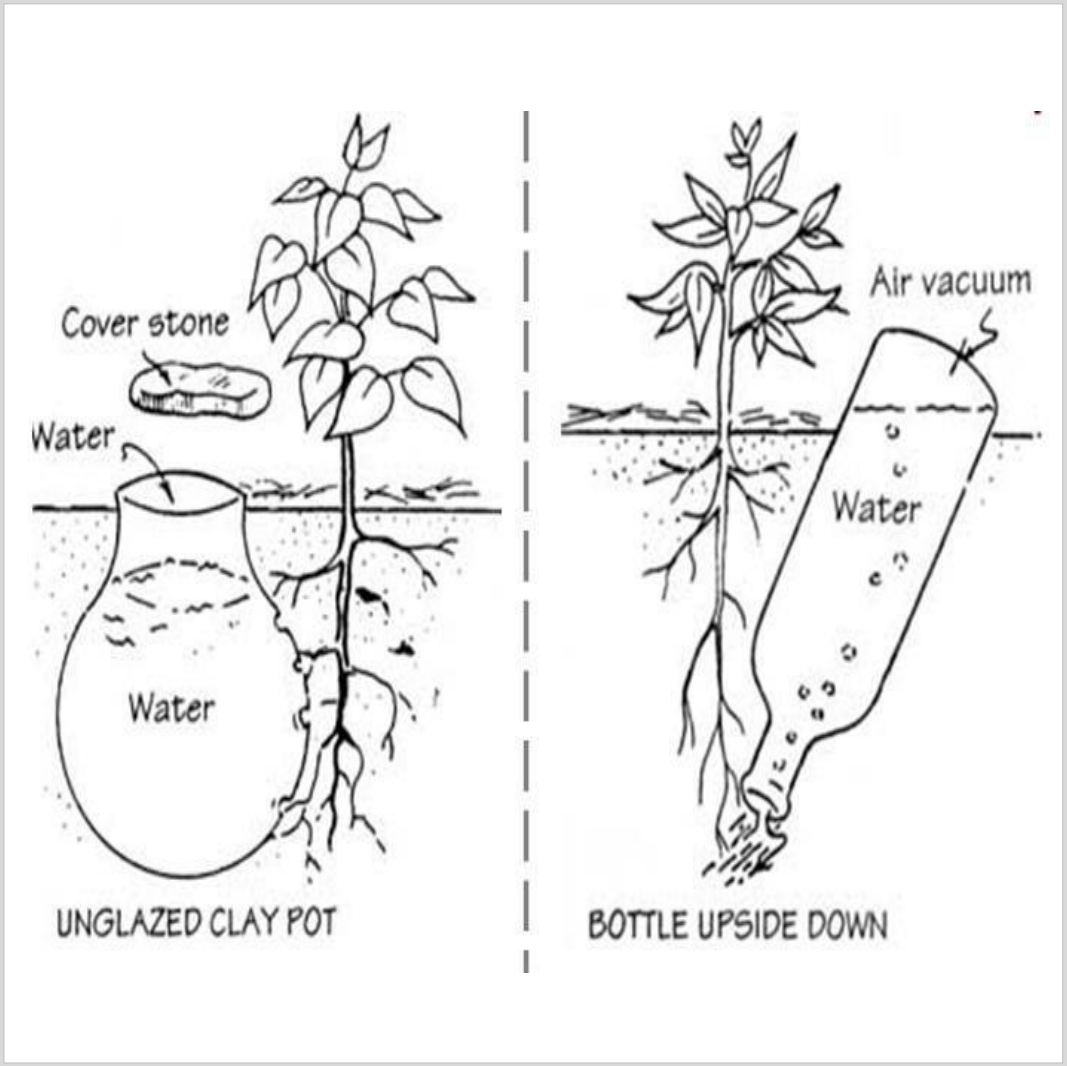
The method involves digging holes into the ground (ideally at the beginning of the dry season) in which plants like millet or sorghum can be sown later on at the start of the rainy season. The pits measure between 10 and 20cm in depth and 20 and 40cm in diameter and are spaced approximately 1m apart 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

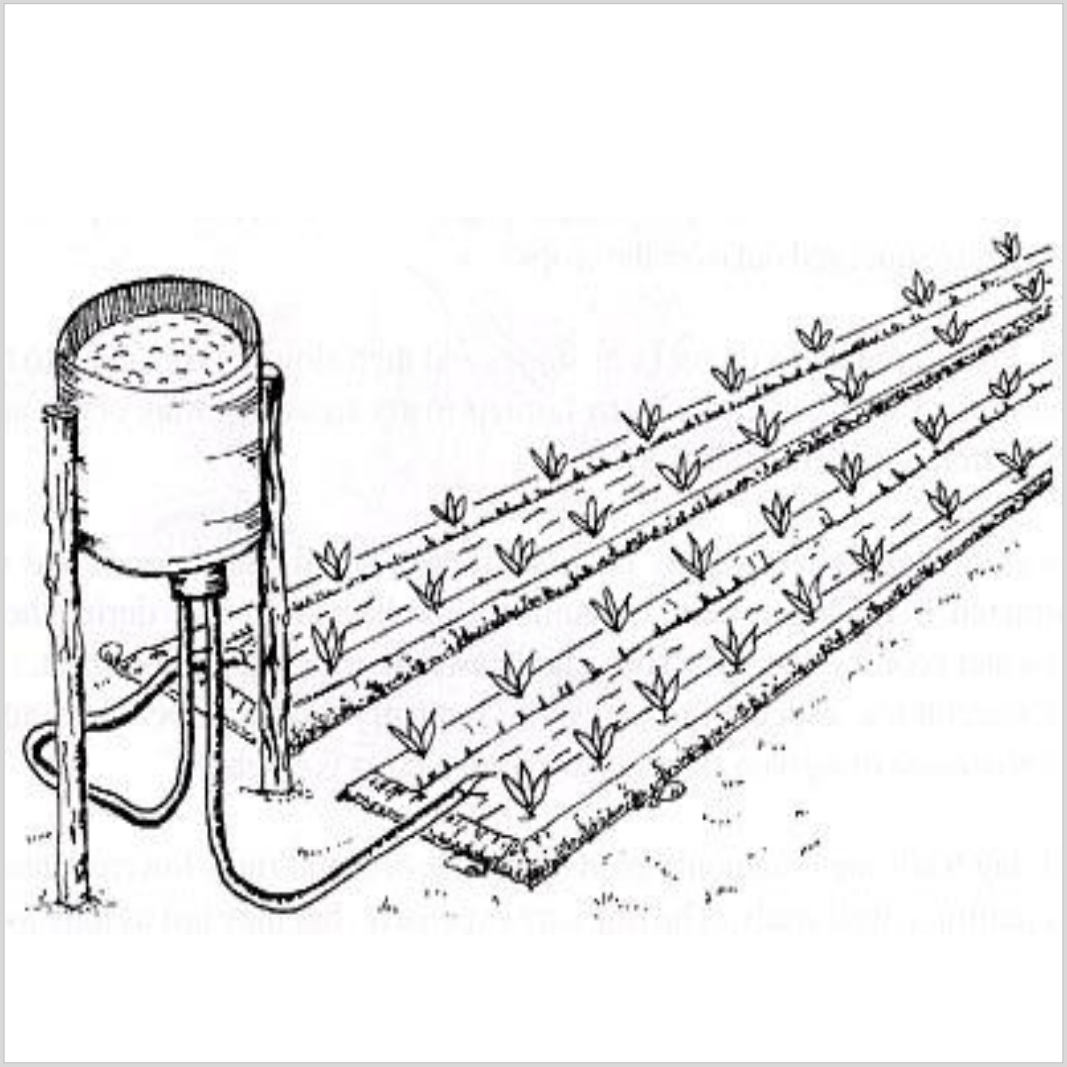
Minimal. The system simply requires a supply of clay pots, bottle or gourd type containers and labour.

Additional Resources

SSWM_Manual Irrigation

7.12_Bucket or bottle drip irrigation

WATER CONSERVATION



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

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

- 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_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.

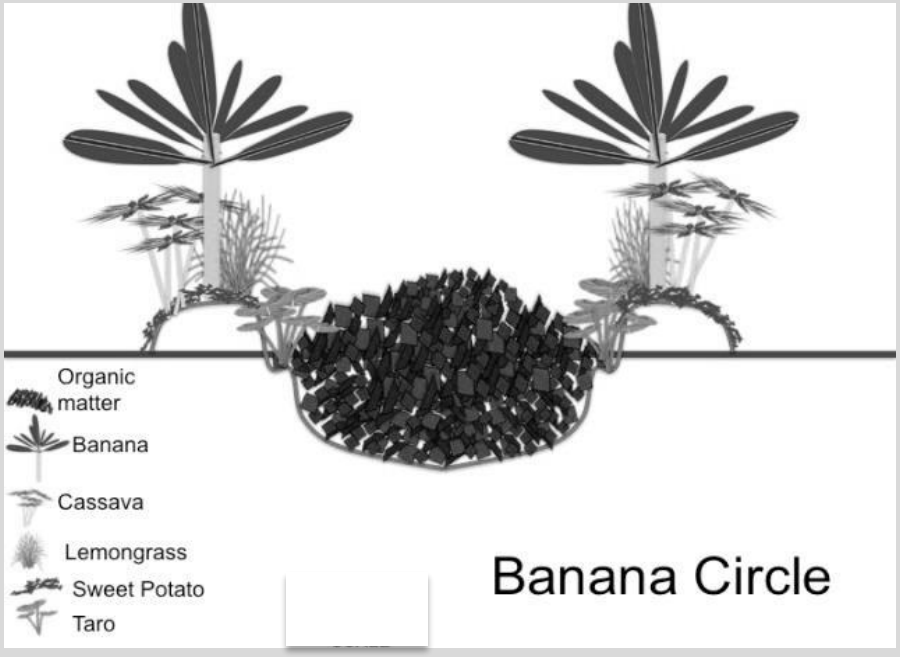
Additional Resources

Nifty Homestead WOCAT

7.13.1_Banana circle

MULTI-LAYER GARDEN

SOIL ENHANCEMENT | WATER CONSERVATION



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

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

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

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

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

DISADVANTAGES

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

Image source: By Claire Gregory - Own work, CC BY-SA 3.0

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

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

7.16.1_Janeemo agroforestry

DIET ENRICHMENT | MICRO ENTERPRISE | SUSTAINABLE FUEL

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

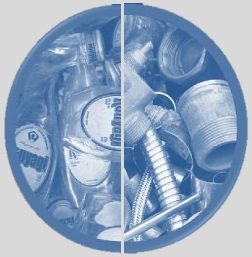
Resource recovery option
- Reuse the other side

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

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

8.2_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

8.3_Vermicomposting

ORGANIC WASTE

SOIL NUTRIENT CULTIVATION

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

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

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

DISADVANTAGES
- damages landscape
- none sustainable solution

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

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

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

8.6_Waste incineration

HAZARDOUS WASTE

SAFE WASTE DISPOSAL

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://treeyopermaculturedu.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

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Blue Schools

Linking WASH in schools with environmental education and practice

Facilitator's Guide

Support material for teachers

1st Edition

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http://waterconsortium.ch/blueschool/ [Access date]

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Introduction

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 Facilitator's Guide is designed to provide a visual support for teachers to introduce or strengthen the Blue Schools topics to students – including overlooked topics such as gender, menstrual hygiene management and transformation of solid waste into resources.

It follows the 8 topics of the Blue Schools Kit:

- 1. My Surrounding Environment
- 2. The Water Cycle
- 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, it suggests learning objectives, questions for discussion and examples of practical exercises. Images should be adapted to the local context and culture as appropriate.

The full description of the practical exercises, how to implement it and picture sources, as well as technical background sections on each topic are found in the Catalogue of Practical Exercises.

Users of this document are also encouraged to refer to the other materials of the Blue Schools Kit i.e. the Catalogue of Practical Exercises, the Concept Brief and the Catalogue of Technologies.

Schweizerische Eidgenossenschaft
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Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

1 My Surrounding Environment

KEY LEARNING OBJECTIVES

- **To understand the opportunities and resources that our surrounding environment offers**
- **To be aware of the fragility of our surrounding environment and learn how to protect/support it**

1 My Surrounding Environment

Important

- Observation and analysis
- Resources and limitations
- Land formation and water bodies
- Nature conservation

This topic introduces the concept of environment to the students. It encourages them to look beyond the surrounding of their school and analyse the landscape around them. This includes the topography, the soil characteristics and the vegetation, as well as the climate conditions such as temperature and rainfall and the impact of the climate on the landscape.

1 **22nd April:** Earth Day
5th June: World Environmental Day

List of activities

1.1 Transect walk
To familiarize students with their local environment and to encourage them to become keen observers of it.

1.2 Participatory mapping
To learn about, describe and share knowledge of the local environment through a community map-making exercise.

1.3 Participatory modelling
To help students to visualize how different parts of the environment relate to one another.

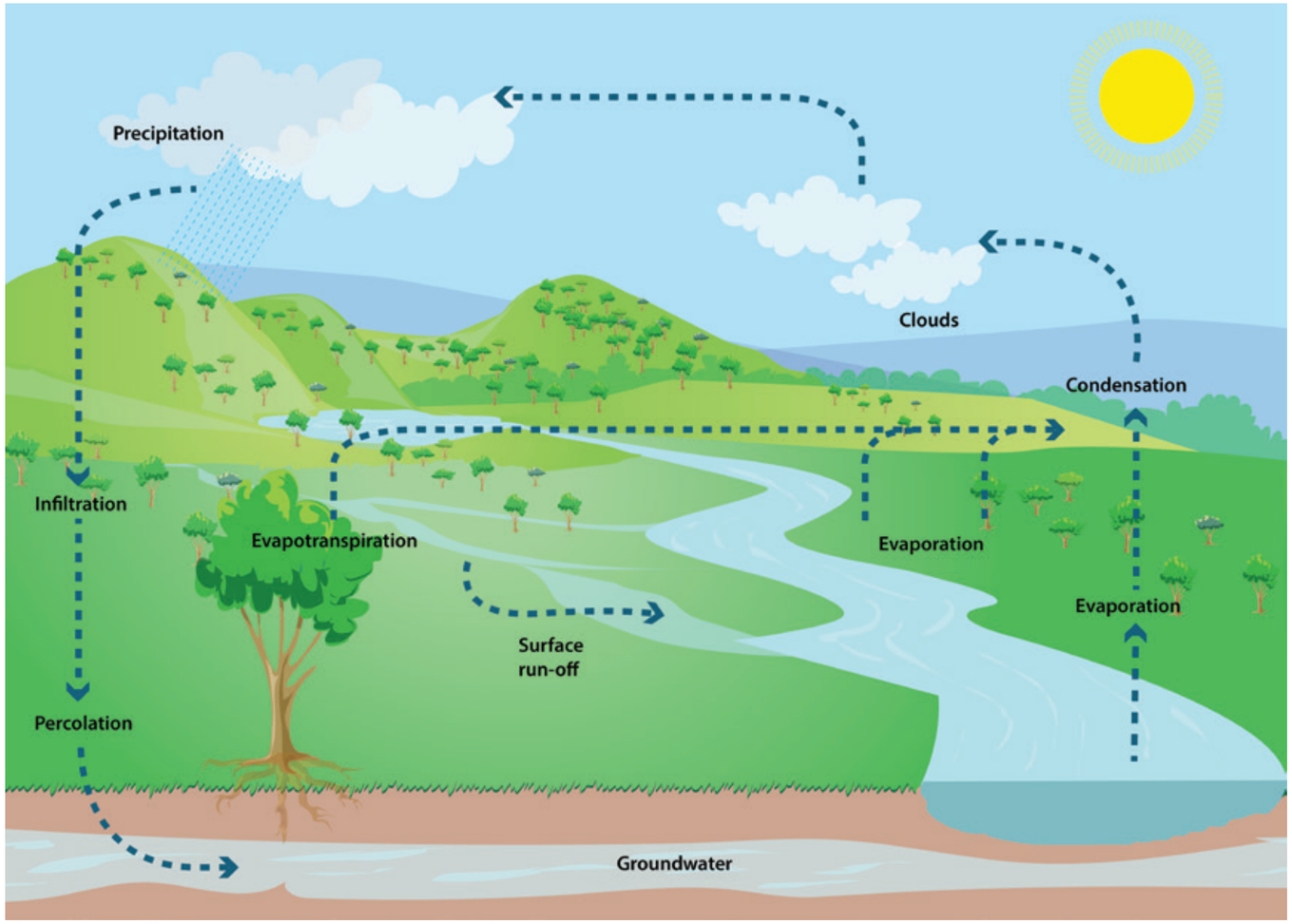
Questions for discussion

- How do you feel in your environment?
- What are the natural features surrounding you?
- How are they linked together?
- What are the resources and constraints present in your surroundings?
- How do human activities protect/ disturb the environment?
- How can we improve the quality of our environment?

2 The Water Cycle

KEY LEARNING OBJECTIVES

- **To realize that water is a limited resource coming from nature and that it is important that we protect and use it well**
- **To experience the different states of water and the four primary components of the water cycle**



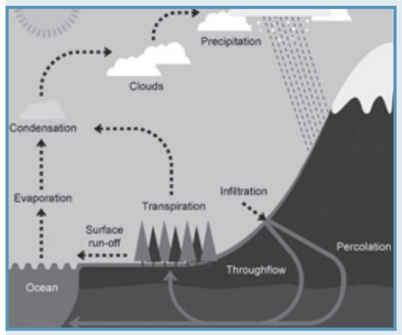
2 The Water Cycle

Important

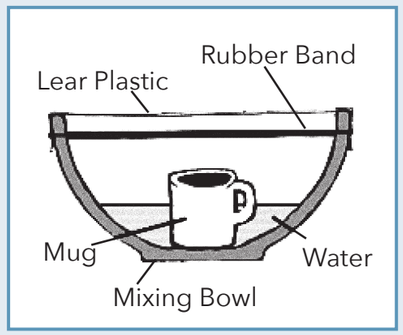
Cover all water cycle aspects:
- States of water: liquid, vapour and ice
- Evaporation, condensation, precipitation, percolation

This topic serves as an introduction to understand the water cycle, both as an abstract set of principles and as a set of phenomena that can be demonstrated and experienced. In this topic it is important that students learn how water behaves, where it is located in their environment, whether these supplies are renewable or non-renewable and how they are being affected by climate change and global warming.

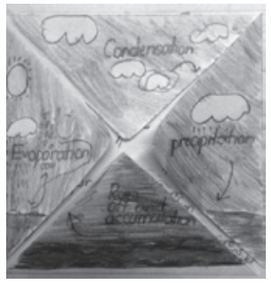
List of activities



2.1 What is the water cycle?
To teach students the principles of the water cycle.



2.2 Make a water cycle
To physically demonstrate the principles of the water cycle.



2.3 Water cycle model
To understand the key principles or states of water in the water cycle.

2.4 Water cycle wheel
To demonstrate how water moves through the cycle and is continuously changing it's state.

2.5 Comic strip
For students to demonstrate their knowledge about the water cycle.

2.6 Poem
To convey more poetic and evocative qualities about the water cycle.

... more activities

2.7 Water cycle dominoes
For students to demonstrate their understanding of the water cycle.

2.8 Evaporation in a jar
To see the principle of evaporative loss at work.

2.9 Cloud in a jar
To make vivid the process of condensation, that forms clouds.

2.10 Rain in a jar
To demonstrate the principle of precipitation.

2.11 Transpiration in a jar
To show students transpiration at work.

2.12 Global warming in a jar
For students to observe global warming phenomenon.

2.13 Water and nutrient cycle puzzle
To introduce the concept of nutrient cycles in the environment.

2.14 Plant in a bottle
To exemplify the concept of nutrient and water cycles.

Questions for discussion

- What different state of water do you see daily?
- What kind of water do you have in your environment? Salty? Fresh? Where?
- How is climate change / global warming affecting the water cycle in our country/region?
- How are these changes affecting the environment and the community?

3 The Watershed around My School

KEY LEARNING OBJECTIVES

- To understand what a watershed is, where water comes from and who are the different water users in the environment
- To recognize the impact of overuse, pollution and practices such as deforestation on the quantity and quality of water
- To find out what we can do to protect the watershed

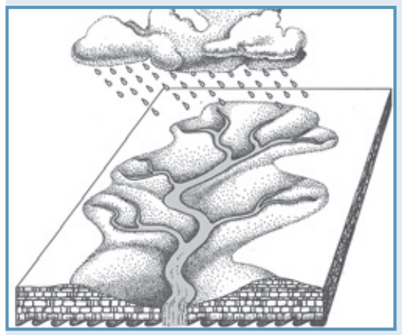
3 The Watershed around My School

Important

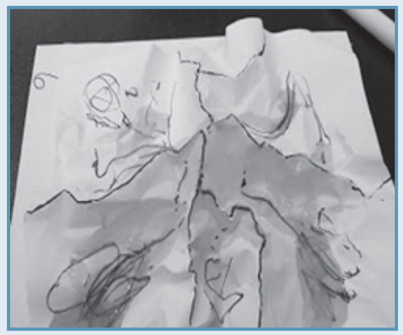
- Water sources and pathways
- Human impact
- Water resource management

This topic is about the importance of the watershed around the school and in which students live. They need to know where their Watershed is, where its boundaries are and how water moves through it.
A healthy watershed sustains us. It is important that they learn what kind of human behaviour supports the health of the Watershed and which actually damages it, such as deforestation, open defecation, and polluting the ground andsurface water sources.

List of activities



3.1 What is a watershed?
To teach students that a watershed is defined as the land area drained by a particular river or stream.



3.2 Crushed paper watershed
For students to demonstrate their understanding of the principles of a watershed and to 'see' it in action.

3.3 Picturing my watershed
For students to illustrate their understanding of how their own watershed looks like and how it behaves.

3.4 Drawing my watershed
To teach students how to find their own watershed from studying a topographic map.

Questions for discussion

- Where are the sources of fresh water in our surroundings?
- Why and how is our watershed important for our day-to-day life?
- How do our practices affect or damage our watershed?
- What factors can affect the water's quality and quantity
- What can we do to protect it?

4 My Drinking Water

KEY LEARNING OBJECTIVES

- To understand that clear water is not always safe to drink
- To experience and practice how to make water safe for drinking, by safe storage and water treatment at school and at home

4 My Drinking Water

Important

Cover all safe water aspects:
- Test water quality
- Treat water appropriately
- Store water appropriately

This topic introduces the importance of clean (not just clear) water and simple ways in which water can be purified using the processes occurring naturally in the Water Cycle. Water can be contaminated by bacteria, salts, chemicals and metals. Here are some experiments that demonstrate how bacteria can be eliminated from water.

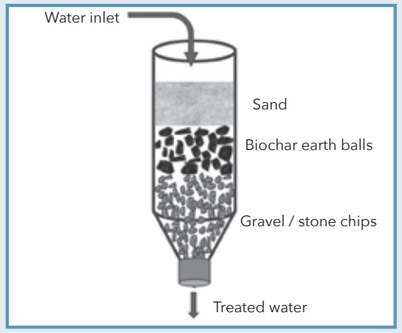
The process of eliminating salts and chemicals requires other kinds of technologies, some of them are listed in the Blue School Catalogue of Technologies.

1 **22nd March:** World Water Day

List of activities

4.1 Clear water isn't clean water
To show students that clear water is not always safe to drink.

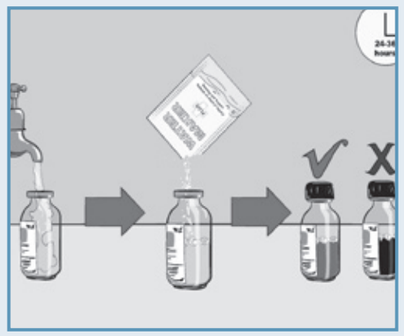
4.2 Safe storage and transportation
To show the basic principle of safe storage and transportation of water.



4.3 Water filter in a bottle
To show the basic principle of water filtration.

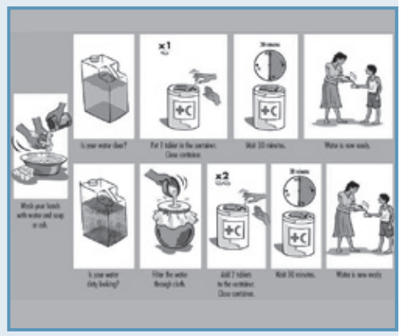
4.4 Mini desalination plant
To show students how the processes of condensation and evaporation desalinate water.

4.5 Solar water disinfecting
To demonstrate how to disinfect water using solar energy.



4.6 Water quality testing
To learn how water quality can be tested.

4.7 Treating water with Moringa seeds
To show students how to use Moringa seeds to reduce the turbidity of water.



4.8 Treating water with chlorine
To shows students how to apply chlorination tablets or solution to treat water.

Questions for discussion

- Where do you fetch water (borehole, river, dam, standpipe, well, etc.) ?
  Do you think it is safe water to drink? Why?
- List all the things you do with water at home, in the community, at school, etc. (drinking, swimming, washing, bathing, etc.).
  Do you need safe water for that?
- How do you transport water?
  Do you think this keeps water clean?
- Where do you store water?
  Do you think this keeps water clean?
- Why is water which looks clear or which has a good taste not always safe to drink?
- How does water get contaminated?
- What can you do to keep water safe at home?

5 Sanitation and Hygiene

KEY LEARNING OBJECTIVES

- **To understand how diseases are transmitted and what good and bad hygiene practices are**
- **To apply good hygiene practices that can help blocking the transmission route of diseases at school and at home**

5 Sanitation and Hygiene

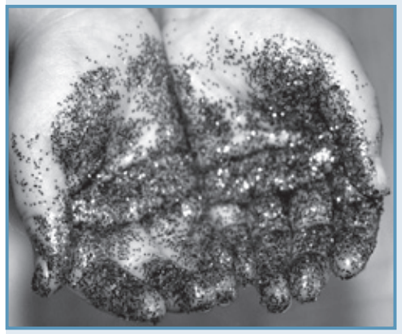
This topic aims to encourage students to cultivate good hygiene and sanitation practices to block the routes of disease transmissions.
These range from using a latrine, proper hand washing, cultivating good personal hygiene habits, good food hygiene habits, keeping the environment clean and becoming an example of these practices in the community.

Important

Cover all hygiene aspects:
- Sanitation
- Water hygiene
- Food hygiene
- Environmental hygiene
- Personal hygiene

1 **19th Nov.:** World Toilet Day
15th Oct.: Global Handwashing Day

List of activities



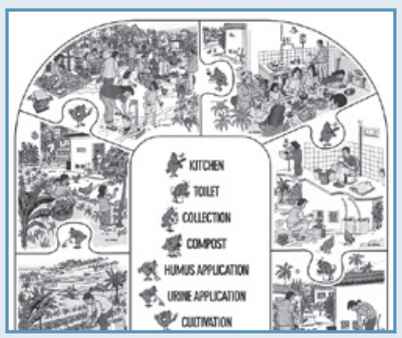
5.1 Glitter hands
To teach students that clean hands require effort, the use of soap and vigorous rubbing.

5.2 Germ transfer
To teach students about the spread of germs by vividly showing how germs can live on hands and the things they touch.

5.3 Hygiene matching game
To teach students the hygienic action that is linked to each body part.

5.4 Good habit bad habit
To reinforce students' understanding of both good and bad hygiene habits.

5.5 Hygiene charades
To help students get the motions of hygienic behaviour right by playing hygiene charades.



5.6 Eco sanitation puzzle
To teach students the steps in the 'Sanitation and Hygiene' cycle.

... more activities

5.7 Pile sorting of hygiene practices
To recognize what are good or bad hygiene practices.

5.8 Supervision of WASH facilities
To make students responsible for the maintenance of WASH facilities.

5.9 Soap making
To learn how to make soap using local materials.

5.10 Glass of water
To be triggered to stop open defecation.

5.11 Organising events
To show practices to parents and the broader community.

5.12 Visit to the community
To reach out to the broader community and show good practices.

5.13 Handwashing routine
To help forming habits of hand washing.

5.14 Demonstration of good practices
To show other good hygiene practices: latrine use, tooth brushing....

5.15 Construction of tippy tap
To learn how to construct a simple handwashing facility using local materials.

Questions for discussion

- What are the causes, symptoms and effects of diarrhoea?
- What are the different route of disease transmission?
- How can flies transmit diseases?
- What can we do to block these routes?
- Why is it important to use a latrine?
- What is a good latrine?
- When do we need to wash our hands?
- What can happen if we do not wash our hands?
- Why is it important to keep our environment clean?
- What do we need to do to keep our personal hygiene?

6 Growth and Change

KEY LEARNING OBJECTIVES

- **To understand the changes for both boys and girls in puberty: it is part of growing up and is a normal process**
- **For girls: To learn how to manage menstruation: body hygiene, types of pads available and their safe reuse and/or disposal**

6 Growth and Change

This topic encourages students to adopt good, fair and balanced attitudes about gender – including themes of access to education and societal roles. It also emphasises menstruation as a natural process; presenting information about puberty and adolescence and encouraging students to respect the physical changes evident in both sexes at this time in their lives. The exercises proposed seek to build agreement among students that both sexes should support good menstrual hygiene practices.

Important

Cover all growth and change aspects:
- Puberty and physical changes
- Gender roles and equality
- Respect and understanding
- Managing menstruation safely

1 **28th May:** Menstrual Hygiene Day

List of activities

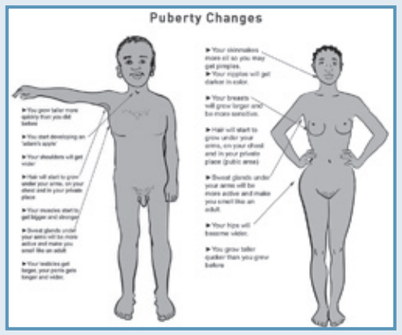
6.1 Handprint circle
To encourage students to demonstrate principles of equality and awareness.

6.2 Equality quiz
To reveal to students their understanding of the difference between fact and opinion around issues of gender.

6.3 Music equality game
To encourage students to demonstrate good behaviour around issues of equality.

6.4 Role reversal game
To have students take on roles typically associated with the opposite gender.

6.5 Knock down the myth
To distinguish facts from myths and to 'knock down' myths associated with menstruation.



6.6 As we grow up
To discuss the changes that occur during adolescence to boys and girls.

... more activities

6.7 My menstrual cycle
To enable girls to understand menstrual cycle stages

6.8 Keeping my menstrual cycle calendar
To enable girls to understand each of their menstrual cycle.

6.9 Reusable pad making workshop
To provide all students with skills for making reusable pads.

6.10 Disposal
To discuss how to safely and hygienically manage menstruation.

Questions for discussion

- How does our body change during puberty?
- What are de differences between boys and girls at puberty?
- Are those differences well accepted in our school? ...and in our community?
- How could we improve the situation?

7 From Soil to Food

KEY LEARNING OBJECTIVES

- To apprehend the crucial role of biodiversity and sustainable agriculture technique in our food growing systems
- To recognize the importance of trees in supporting the watershed and food production
- To observe soil composition and its connection with plants and water

7 From Soil to Food

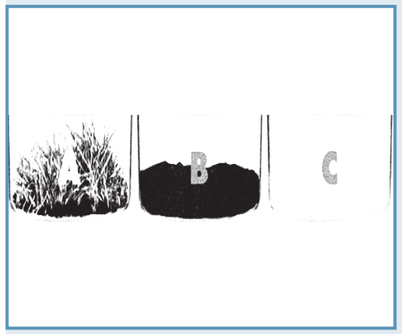
Important

- Make compost
- Use mulch
- Diversify & rotate crops
- Use natural fertilisers & pesticides

This topic encourages students to learn about growing food, and that growing food begins with healthy soil and sustainable water source. Students learn about ecosystem conditions keeping gardens alive and food growing abundantly. This includes learning how to maintain and/or improve soil quality and fertility as well as exploring the relationship between land and water, as they are essential for being able to grow food sustainably.

1 **11th June:** World Agriculture Day

List of activities



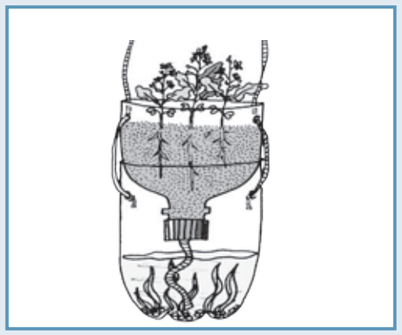
7.1 Evaporative loss
To help students learn about evaporative loss in the ground and how plants help to retain water in the soil.

7.2 Soil erosion
To visualise the process of soil erosion and demonstrate that organic ground cover protects soil from erosion and nutrient loss.

7.3 Deforestation
To convey that unsustainable tree cutting makes soil dry out, erode in the rain, and eventually causes a decrease in rainfall.

7.4 Soil shaking
To familiarize students with the composition of soil in their area, and the types of soil that are best for growing plants.

7.5 Decomposition column
To encourage students to understand the process of decomposition in the formation of compost.



7.6 Terra-aqua column
To familiarize students with the organic processes that take place between land and water—and how the balance affects their environment.

... more activities

7.7 Terra-decomposition-aqua column
To learn about organic processes taking place in the environment.

7.8 Plant a tree
To teach students about the importance of growing trees.

7.8.1 Plant Moringa Oleifera
To inform students about beneficial multipurpose plants.

7.9 Compost pit
To show students an easy way to make compost.

7.10 Keyhole garden
To show students a way to cultivate vegetables in an efficient and productive way.

Questions for discussion

- What is biodiversity?
- What are causes of soil erosion?
- What are the impacts of soil erosion?
- What are the characteristics of a healthy soil?
- Why is a healthy soil important?
- How does water interact with soil?
- Aside from water, what do plants need in order to grow?
- Describe some sustainable agriculture techniques and tell what makes them useful.
- How do you plant a tree?
- Why are trees important for the environment?

8 From Waste to Resources

KEY LEARNING OBJECTIVES

- **To understand the importance of waste management and how waste pollutes our environment when not properly handled**
- **To learn and experience sustainable waste management practices**

8 From Waste to Resources

This topic aims to encourage students to become conscious about the impacts related to bad waste management and about what can be done to avoid this. It encourages them to apply the 3R principles which are: Reducing the amount of waste generated by consuming less or differently, Reusing and Recycling waste. It helps them change their mind-set and look at waste as a resource, if the waste is segregated at source into different types of materials.

Important

Cover all waste aspects:
- Reduce
- Reuse
- Recycle
- Good waste management
- Environmental impact

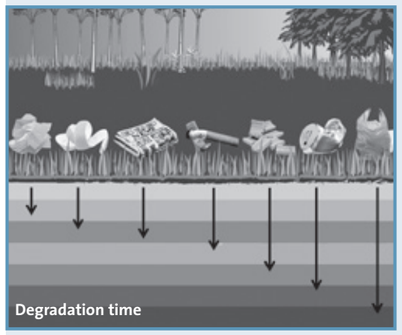
1 **18th March:** Global Recycling Day
In Sept.: World Cleanup Day

List of activities

8.1 Waste collection day
To show to students the impacts of dumping and throwing waste away.

8.2 Impacts of unmanaged waste
To familiarize students with the issues of not managing waste properly when openly burning or dumping it.

8.3 Visit of landfill/dumpsite
To show students what the end of life of waste is, its contamination risk and the importance of reducing waste generation



8.4 Waste degradation rate
To familiarize students with the long term impact of throwing waste away.

8.5 Waste assessment
To enable students to evaluate their waste production.

8.6 Waste bin from plastic bottles
To familiarize students with waste recycling and waste separation.

... more activities

8.7 Ecobricks – Building with plastic
To demonstrate students how to recycle plastic waste by producing a building material.

8.8 Recycling your own paper
To teach students how to make their own recycled paper.

8.9 Composting – Moisture test
To teach students how to control moisture content of a composting heap.

Questions for discussion

- What type of waste do you produce and how much?
- How would you describe the waste (weight , volume, wetness,...)?
- What do you do with your waste? Do you put it in bins, throw it away, burn it? Do you think it is appropriate to do so? Why?
- How could you produce less waste than what you are producing?
- How could you re-utilize/recycle the waste you produce?
- If you cannot recycle or reuse your waste, what can you do with waste to avoid environmental pollution?

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BLUE SCHOOLS

Linking WASH in schools with environmental education and practice

CATALOGUE OF PRACTICAL EXERCISES

1st Edition

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HELVETAS Swiss Intercooperation
Swiss Federal Institute of Aquatic Science and Technology (Eawag)
International Rainwater Harvesting Alliance (IRHA)

Introduction

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 Practical Exercises aims to inspire teachers with hand-on and low cost exercises to complement the lessons from the national curriculum. The examples provided facilitate students' learning by doing and can be replicated in the students' home and in their communities.

It provides examples of practical exercises for each topic of the Blue Schools Kit:
1. My Surrounding Environment
2. The Water Cycle
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, technical background sections are provided to facilitate understanding of basic key concepts. Each topic includes a selection of teaching, participatory or creative activities, discussions, demonstrations, games, and experiments, all requiring simple material at little to no cost. The practical exercises aim to help reaching the key learning objectives defined in each topic's first page. The level of difficulty for each exercise is indicated; depending on the class and age group, teachers can select the most appropriate activities and students can deepen their knowledge on these topics from year to year.

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 on the Swiss 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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With support from Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra
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Practical Exercises (by Topic)

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Topic 1_My Surrounding Environment

The environment is everything that isn't me.
Albert Einstein

Image source:: http://www.wordandspiritbristol.org.uk

This topic introduces the concept of environment to the students. It encourages them to look beyond the surrounding of their school and analyse the landscape around them. This includes the topography, the soil characteristics and the vegetation, as well as the climate conditions such as temperature and rainfall and the impact of the climate on the landscape. This aims to help students:

- To understand the opportunities and resources that our surrounding environment offers.
- To become aware of the fragility of our surrounding environment and learn how to protect/support it.

Topic 1_Technical Background

HUMANS RELATIONS WITH THEIR ENVIRONMENT

Broadly, the "Environment" is everything that is around us. It includes physical, chemical and other natural elements and forces. Living things constantly interact with—and adapt themselves to—conditions in their environment. Specifically, the **natural environment** encompasses all living and non-living things occurring naturally. It includes the interaction of all living species, climate, weather, and natural resources that affect human survival and economic activity.

The natural environment has resources: means that are available and supportive to our existence; as well as constraints: conditions that could make us vulnerable. There are landmarks with stories to tell, and it is important to support the youth to understand the environment in which they live and to accompany them to perceive challenges and solutions.

There are many ways to learn about the natural environment, to *examine*, analyse and better understand the landscape. At first it is important to describe the feeling that one has about the location: if one feels safe or insecure, comfortable or tense, if the area is open or closed, appealing or uninviting, noisy or quiet, mineral or vegetal, etc. These initial impressions make it possible to characterize how people *experience* their environment. Next it is interesting to become aware of what is visible around us and to describe our environment by breaking it down into distinct, physical elements: trees, soil, roads, buildings, inhabitants, natural resources and their use for services. These services include producing food and water, protecting against extreme climate related phenomena and landscape degradation, and providing leisure and cultural benefits. Finally, it is essential to observe the relations between the visible elements and how they interact with each other.

These three sequential levels of understanding make it possible to characterize our surroundings, to better perceive the underlying constraints as well as the potentials to live more in harmony with the natural environment. This includes learning to ask essential questions about our environment and taking measures for its preservation and protection.

Main reference

Definition adapted from Johnson, D. L.; et al., (1997). "Meanings of Environmental Terms". *Journal of Environmental Quality*. Cited in Wikipedia.

Other resources

https://www.aquaportail.com/definition-9038-environnement.html
http://www.vivacites-idf.org/

1.1_Transect walk

OUTDOOR ACTIVITY

LEVEL: SIMPLE

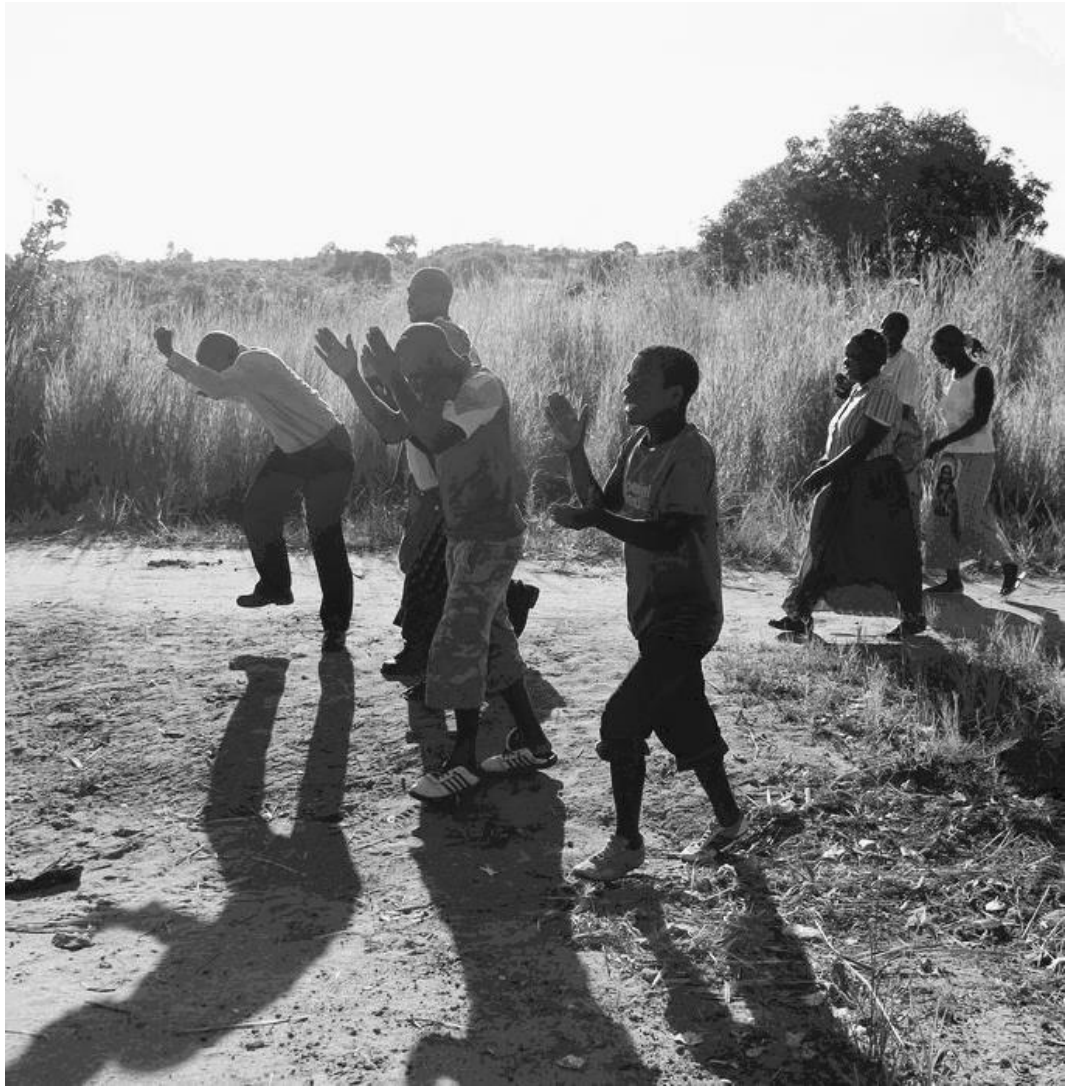
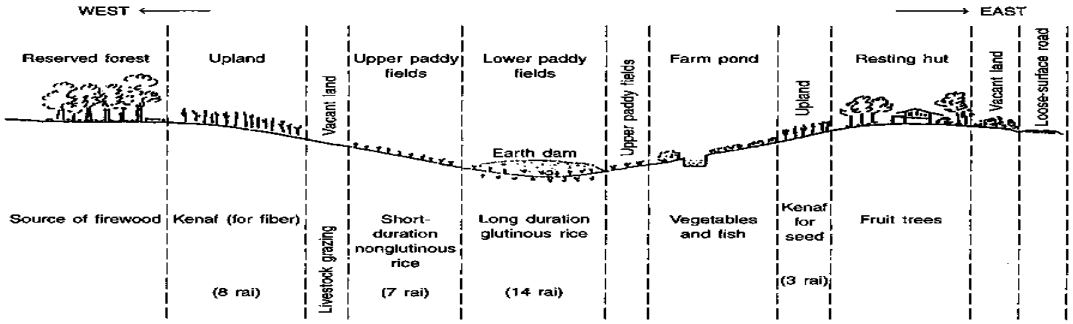


Image source: Flickr



Teaching Objective

The objective of a transect walk is to familiarize students with their local environment and to show them how to be keen observers. The students should make notes about their environment's characteristics, resources, and vulnerabilities, and observe whether these vulnerabilities have been caused by climate change and unsustainable human behaviour.

Exercise

A transect is a straight, direct line through a natural feature, through the community or through a project area. A transect walk is a systematic, purposeful walk along a defined path or transect. The purpose of this walk is to observe existing conditions and gain a more detailed insight into ones' surroundings and the challenges or vulnerabilities in the environment. The walk can be general in focus or specifically linked to a topic such as the watershed, hygiene and sanitation, or waste. Students observe the conditions through asking questions, through listening and looking closely, gathering information that can be incorporated into a transect diagram. Observations can be noted and shared in group discussion and as part of a mapping exercise (1.2).

Required Materials

notebooks or paper | pencils | camera (if available)

Additional Resources (hyperlinks)

- CLTS (focusing on sanitation) SSWM Geoparticipation World Bank Group

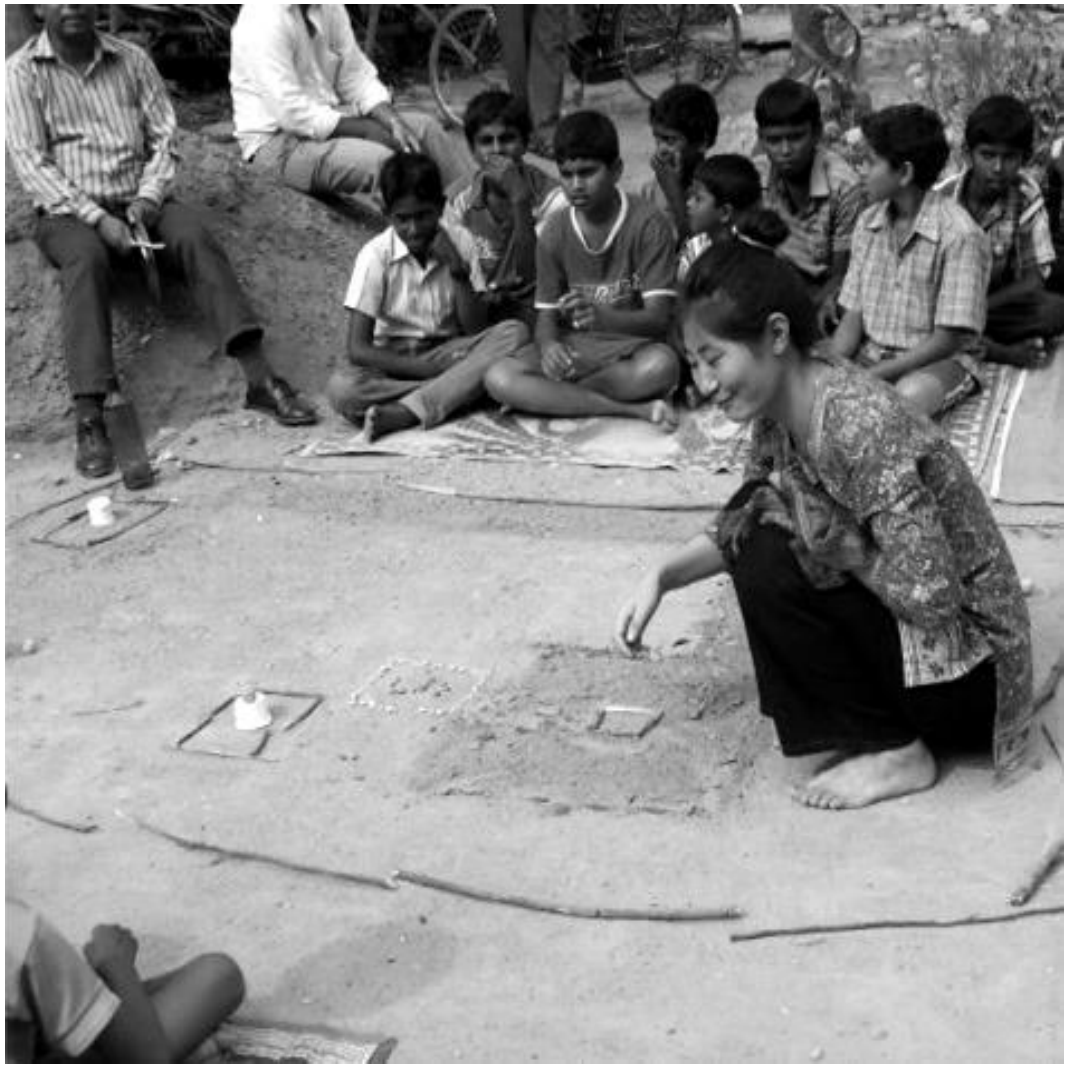


Image source: Social Work Christ University

1.2_Participatory mapping

PARTICIPATORY ACTIVITY
LEVEL: MEDIUM

Teaching Objective
The objective of this exercise is to make a large map of the environment, community or watershed in which the students live. The purpose of the map is to promote the sharing of knowledge about this region, and to support good decision making about the management of it's natural resources. The teacher or community leader assumes the role of facilitator.

Exercise
This mapmaking technique can provide a community with an important overview of the vulnerabilities and hotspots in their environment, in regard to the access of clean water, sustainable sanitation, food sources and land management. First, determine the size of the map and the materials that you will use to make it. The map can be made be with paper and writing or with locally available materials such as wet sand and earth with sticks and stones or seeds. Second, invite the group to draw the outline of the local area to be mapped in the exercise. Include, as appropriate, roads, towns, rivers and other water sources, forests and property boundaries. Aspects of the landscape can be represented by adding objects onto the map. Third, when the base map is complete, invite each individual to add detail that they consider important from their perspective. The detail should encompass problems that the community is facing, such as those related to water, sanitation and the health of the environment. Record where the problems are located, where are the hotspots of these problems, which are worst, who is responsible for causing these problems. Ask whether these problems are connected to each other, and how these problems influence one another. Keep modifying the map until everyone participating is happy with the result.

Required Materials
paper | pen or pencil | or any locally available materials as described above.

Additional Resources (hyperlinks)
SSWM

Image source: Participatory GIS:

1.3_Participatory modelling

PARTICIPATORY ACTIVITY

LEVEL: ADVANCED

Teaching Objective

The objective is similar to Exercise 1.2 but this method leads to the construction of a large scale 3-dimentional model. It is more complex to achieve but it is by far the most effective tool for a community to use to collect and capture local knowledge about ecosystems and human habitation, and to empower themselves to make good decisions about the future of their environment.

Exercise

This is a complex logistical exercise that requires planning and the collecting together a lot of materials. A base map needs to be prepared using digital contour data (GIS). It may be possible to get assistance from the Department of Land and Surveys, or its equivalent. Appropriate horizontal and vertical scales (the thickness of contours) need to be determined for the model. The scale is affected by resources and space available for construction. This is a model that should be preserved and used over a long period of time and so it is important that there is a safe place in the community where it can be kept. Contour data needs to be transferred from source maps to card and then cut out. Contour sheets then need to be glued together. Once the form of the landscape is complete, the model is covered with paper to smooth the surface, and painted to reflect the different elements in the environment, water bodies, land, forest, pasture and so on. Once the base model is complete, labeled pins can be positioned on the map to refer to natural and man-made elements in the environment, identifying areas affected by climate change and anything else the students and community deem to be relevant.

Required Materials

plywood sheets (model base) | foam core or card (contours) | GIS information | large sheets of carbon paper to transfer contour data onto foam core | paper | glue | paint | pins

Additional Resources (hyperlinks)

IAPAD PACC

Topic 2_The Water Cycle

We forget that the water cycle and the life cycle are one.
Jacques-Yves Cousteau

This topic is about encouraging students to learn about the water cycle, what it is, what its key properties or stages are, how students can see the water cycle at work in their own environment, and how the water cycle is affected by climate change and global warming. The exercises in this topic are selected to help students:

- To realize that water is a limited resource coming from nature and that it is important that we protect and use it well.
- To experience the different states of water and the four primary components of the water cycle.

Image source: WallpaperUp

Topic 2_Technical Background

THE WATER CYCLE

What water is and where you find it

When you look at Earth from space, perhaps its most noticeable feature is its water, covering 70% of the planet's surface. Deep blue oceans hold about 97% of Earth's water, and glistening white ice sheets and glaciers near the poles account for another 2%. Wisps of clouds swirl across the globe, holding water droplets and ice crystals, and even clear skies contain water in the form of vapour. Smaller amounts of water exist in rivers, lakes, and swamps and also hide beneath Earth's surface, buried between rock and soil. Whether stored as solid ice, liquid, or vapour, water exists almost everywhere on Earth's surface.

The steps of the water cycle

The never-ending movement of water between different states is called the water cycle. The sun's energy drives the evaporation of liquid water stored in oceans, seas, lakes, and rivers, providing almost 90% of the water vapour in the atmosphere. Much of the rest comes from transpiration, the release of water vapour from plants. Surprisingly, even a single large oak tree can give off as much as 40,000 gallons of water per year. Once evaporated or transpired, water molecules remain in the atmosphere for about ten days before falling back to the surface as precipitation. Most falls as rain, but some falls as snow or ice. This solid water collects on mountaintops and in glaciers and ice caps, providing a vast storage facility of freshwater. In fact, snowpack in Western states holds as much as 75% of the area's water supplies. Rain and melting snow and ice flow into rivers and oceans and infiltrate the ground, replenishing aquifers and seeping slowing back into bodies of open water. From there, the cycle continues, perpetually moving one of life's most important molecules around the planet.

HOW CLIMATE AFFECTS THE WATER CYCLE

Temperature, evaporation and transpiration

Changes in climate, or the long-standing patterns of weather seen in a given region, alter the water cycle. Temperature plays a particularly important role, as increased heat speeds up the cycle. Warmer temperatures lead to increased rates of evaporation, transpiration, and the amount of water vapour in the air. Over the past century, scientists have observed that temperatures have increased globally, and with this, atmospheric water vapour has also increased. Since what goes up must come down, at least with respect to the water cycle, increased water vapour leads to increased precipitation. The consequences of this on the ground, however, are difficult to predict. Precipitation does not always occur at the same place that evaporation happens, and factors such as geography and atmospheric circulation patterns play a large role in determining where the water eventually falls.

Consequences of increased Evaporation:

A faster water cycle can lead to two seemingly contradictory results: increased drought and increased precipitation and flooding. In some environments, especially those with limited open water, increased evaporation and transpiration dries out the ground, leaving less water to move to the atmosphere, fewer clouds, and less precipitation. Over the past century, the Sahel in Africa, the Mediterranean, southern Asia, and the southwest United States have all become drier. In other environments, particularly those with access to oceans or lakes that provide a more plentiful source of water, more evaporated water can lead to more precipitation. Eastern North and South America, northern Europe, and northern and central Asia have all become significantly wetter over the past century, a change that correlates with increased regional temperatures. And when precipitation occurs, it is more likely to be intense and heavy because the atmosphere contains more water. Rain and snowstorms may then lead to regional flooding. (Laura Holder for Clue Into Climate KQED)

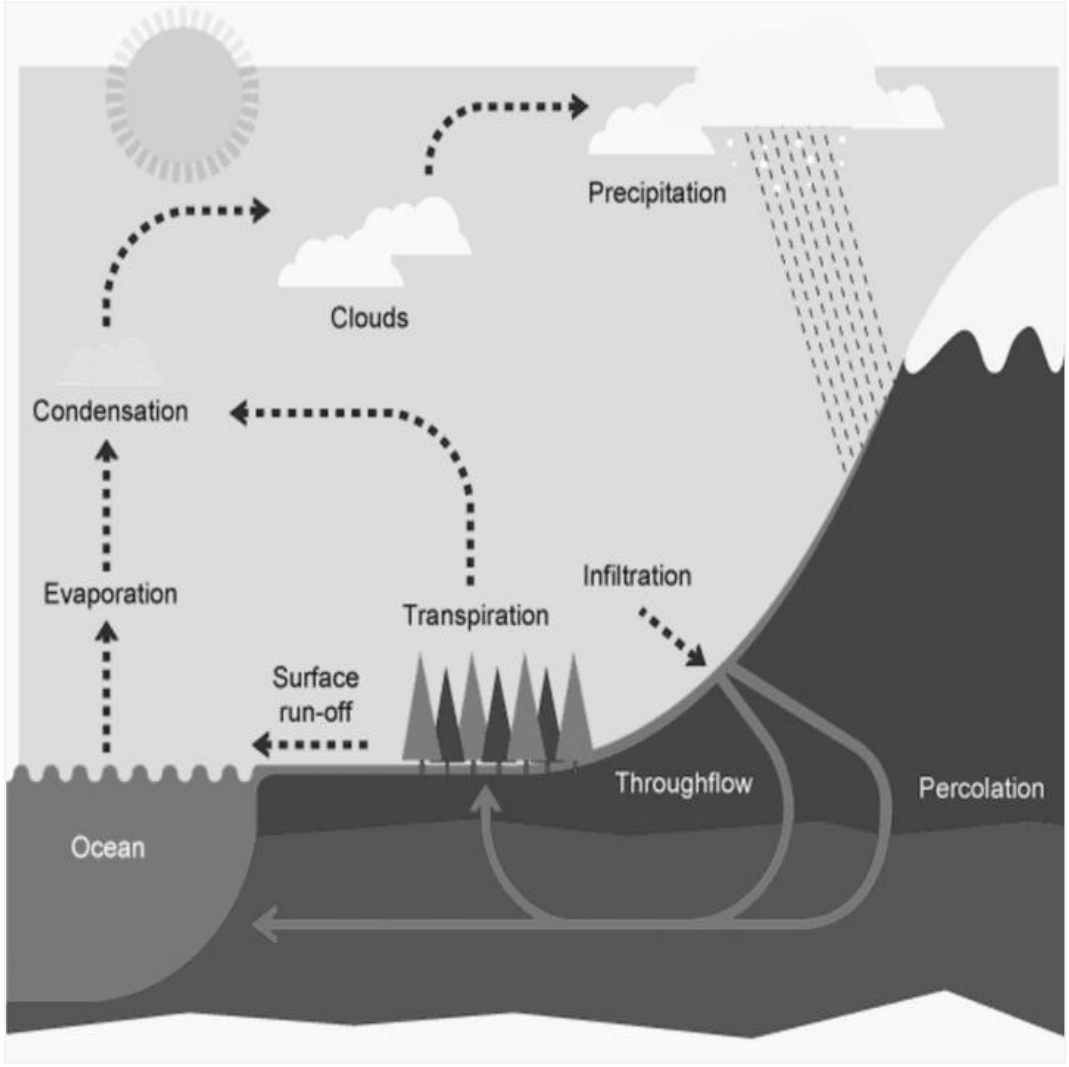


Image source: bbc.co.uk

2.1_What is the water cycle?

DISCUSSION
LEVEL: ADVANCED

Teaching Objective
The objective is to introduce students to the key properties of water cycle and to explain how these properties explain how the water on the earth is in a continuously changing state.

Exercise
ENERGY from the Sun heats the surface of the Earth. WATER evaporates from oceans, rivers, lakes, etc. Warm, MOIST air rises because it is less dense. CONDENSATION occurs when this water vapour comes into contact with a surface (in this case dust particles in the air) and is turned back into water droplets as it cools down and clouds are formed. PRECIPITATION occurs as these water droplets get bigger and heavier and they begin to fall as rain, snow and sleet, etc. When the precipitation reaches the earth's surface, some falls directly into the sea but other water falls on land: Some of the water falling on the land is INTERCEPTED by vegetation. Some water will reach bare ground. Some will EVAPORATE from the surface of leaves or be taken up by the plant roots, and some of this water will eventually return to the air as vapour through the process of TRANSPIRATION. This slows down or prevents some water flowing back to the river. Some water flows across the surface of the ground - surface RUN-OFF. This happens when the surface doesn't allow water to penetrate. Surface run-off is more likely to occur if the ground is SATURATED with water or when the rock is hard and IMPERMEABLE. This water moves quickly to the river. Some water INFILTRATES into the soil. This THROUGH FLOW moves more slowly back to the river than surface run-off. Some water PERCOLATES deeper into the ground and is slowly transferred back to the river or sea. STORES AND TRANSFERS: The movement of water between the major water stores; the ocean, ice caps, land and the atmosphere are called transfers. (bbc.co.uk)

Required Materials
none

Additional Resources (hyperlinks)
SSWM USGS_Downloadable Poster

2.1.2_Water cycle terms

DISCUSSION
LEVEL: ADVANCED

Condensation	The process where water vapor changes from a gas to liquid water.
Water Cycle	The movement of water between the atmosphere and Earth. It includes: Evaporation, Condensation, Precipitation, Surface Runoff, Transpiration and Perspiration.
Transpiration	When plants release water through pores in their leaves back into the atmosphere.
Groundwater	All the water that soaks into the ground, found under the Earth's surface.
Cloud	Millions of tiny water droplets or crystals. They form when water vapor in the air condenses to form liquid water or ice crystals. They can only form when dust particles and cool air are present**
Evaporation	The process where liquid water changes to a gas as water vapor.
Cool Air	Cool air is necessary for condensation to occur in the atmosphere and clouds to form.
Surface Runoff	Water that cannot be absorbed into the surface (the ground is too dense) but runs along it.
Water Vapour	When water is in the gas state.
Precipitation	Any form of water that falls from clouds and reaches Earth's surface. Rain, snow, sleet or hail.
Humidity	The amount of water vapor in the air warm air can hold more water vapor than cool air.
Relative Humidity	The percentage of water vapor in the air compared to the maximum amount of water that the air can hold at a particular temperature.
Dew Point	The temperature at which condensation begins.
Perspiration	When animals release water through pores in their skin back into the atmosphere. It is commonly known as sweat!

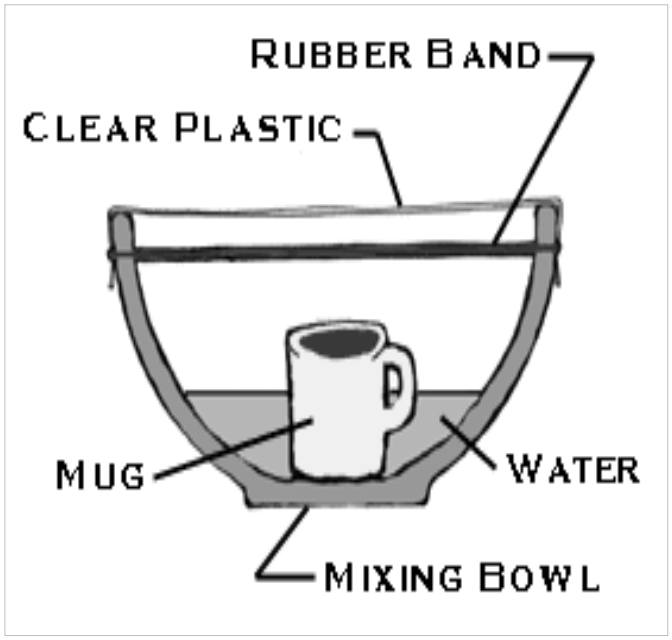


Image source: thewaterproject.org

2.2_Make a water cycle

EXPERIMENT
LEVEL: SIMPLE

Teaching Objective
The objective is to enable students to visualize the key processes taking place in the water cycle. Students should understand that water is always changing its state, from liquid to vapour and back again.

Exercise
This small, simple experiment demonstrates what happens at a much larger scale when the sun's heat causes water to evaporate from streams, lakes, rivers, and oceans. Water vapour rises, and eventually reaches cooler air and condenses into clouds. When the clouds are full of water, or saturated, they release some of the water as rain.

Put the bowl in a sunny place outside. Using the pitcher or bucket, pour water into the bowl until it is about ¼ full. Place the mug in the centre of the bowl. Be careful not to splash any water into it. Cover the top of the bowl tightly with the plastic wrap. Tie the string around the bowl to hold the plastic wrap in place. Watch the bowl to see what happens. The "mist" that forms on the plastic wrap will change into larger drops of water that will begin to drip. When this happens, continue watching for a few minutes, then carefully peel back the plastic. Is the mug still empty? Water from the "ocean" of water in the bowl evaporated. It condensed to form misty "clouds" on the plastic wrap. When the clouds became saturated it "rained" into the mug. (The Water Project)

Required Materials
a large metal or plastic bowl | a pitcher or bucket | a sheet of clear plastic wrap | a dry ceramic mug,| a long piece of string or large rubber band | water

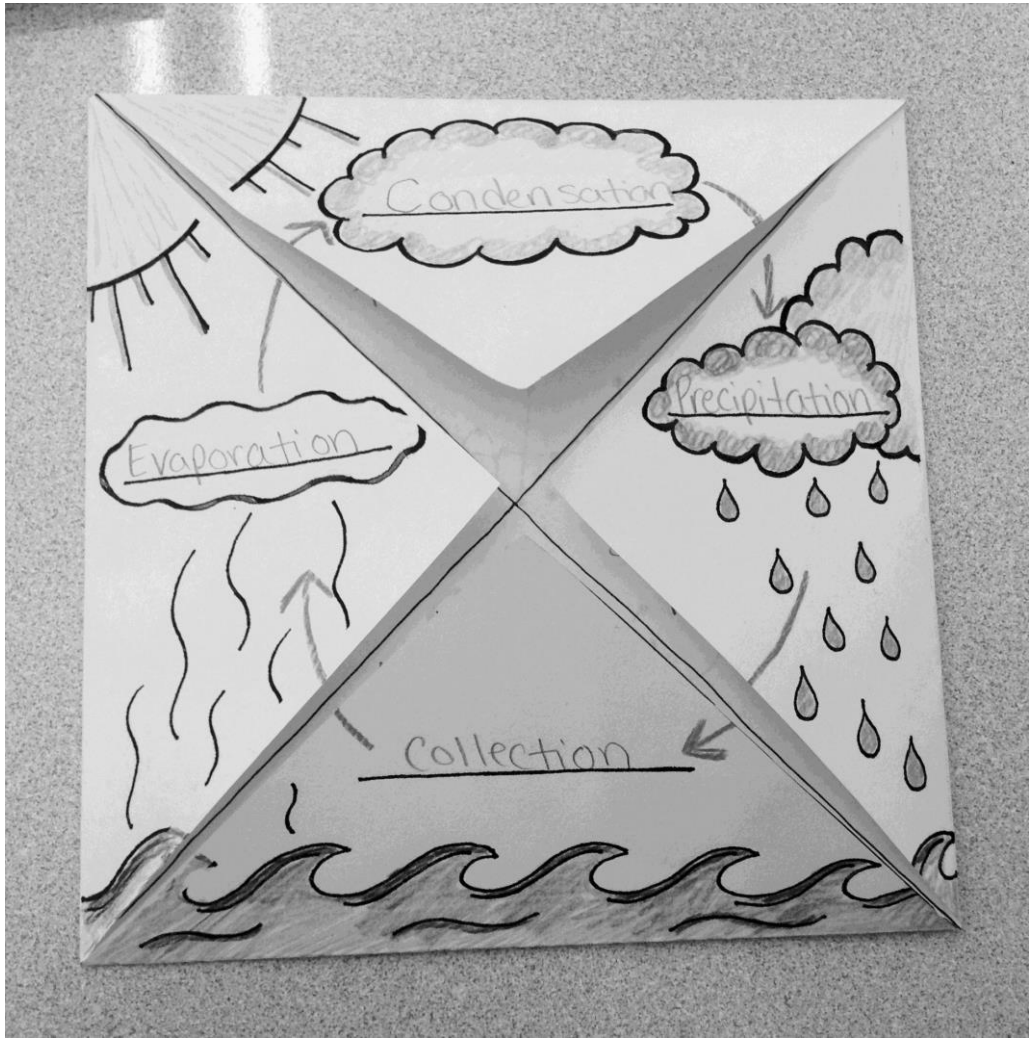


Image source: pinterest

2.3_Water cycle model

CREATIVE ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to have the students each demonstrate their understanding of the four key stages of the water cycle: Condensation, Precipitation, Collection, and Evaporation. This project is something they can take home with them and share with their family and siblings.

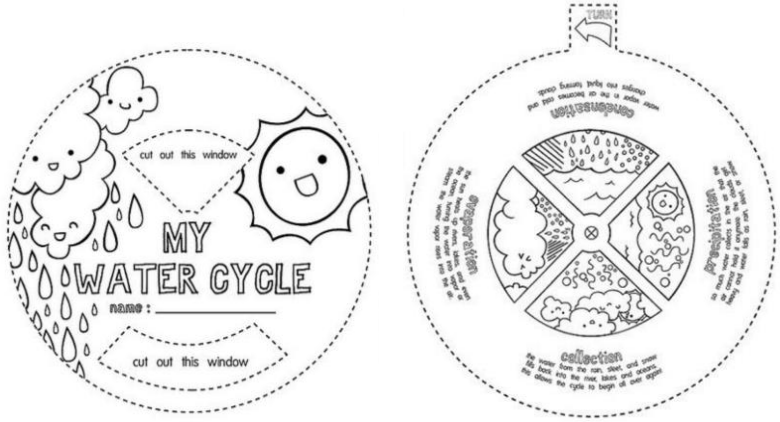
Exercise

Invite students, either individually or in teams, to make a simple paper model illustrating the water cycle. First, begin with a square piece of paper. Second, fold each corner to the centre to form a smaller square. Third, draw a picture of one of the fundamental properties of the water cycle onto each flap. Fourth, underneath each flap they can write the definition for that property.

Required Materials (hyperlinks)

square sheet of paper | pencils or crayons

Image source: pinterest



2.4_ Water cycle wheel

CREATIVE ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to have students demonstrate their understanding of the key processes of condensation, precipitation, collection, and evaporation and how and where these processes take place in their own environment.

Exercise

Invite students, either individually or in teams, to make a simple circular paper model illustrating the water cycle in their environment. Are there mountains or hills? Is there a river of lake? Do they see clouds? The model is made up of two circles fixed together in the centre with a pin, that allows the circles to be rotated. The bottom circle illustrates water droplets or moisture moving through the cycle. The top circle illustrates the environment or watershed. Holes cut into the top circle reveal the water moving through the environment.

Required Materials

2 sheets of paper | a pin | pencils or crayons

Additional Resources (hyperlinks)

Template

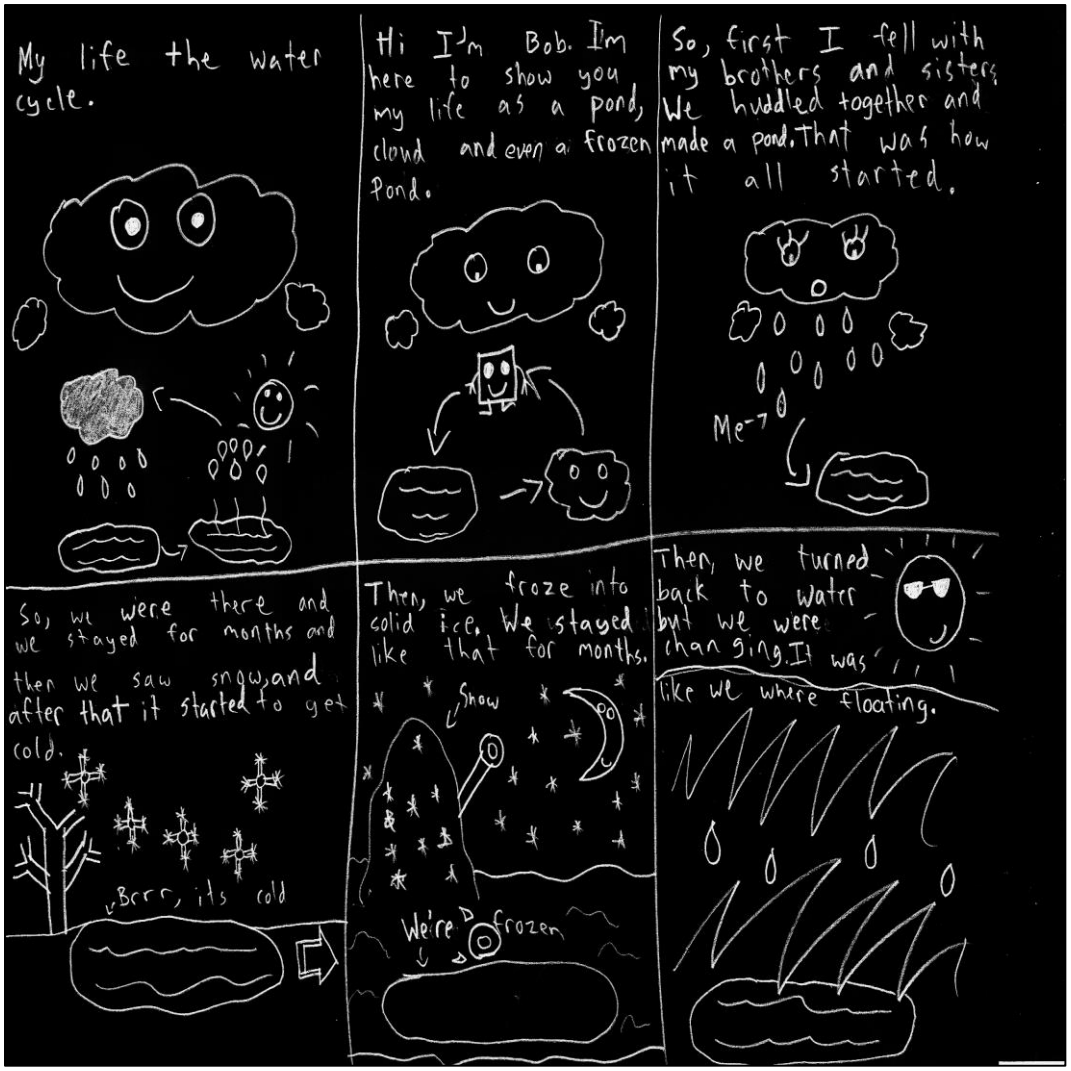


Image source: Wsd Blue and Gold

2.5_Comic strip

CREATIVE ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective is to have the students make water cycle processes vivid through a 'fun' or 'witty' comics. This activity gives students the opportunity to demonstrate their understanding of the water cycle through creative story telling.

Exercise

This activity can be in a number of ways; orally, as a story telling, by drawing the comic on a classroom blackboard, or by having the students each draw the comic or story on a piece of paper. Invite students to invent a comic or a story about the adventures of a raindrop. This activity can be done individually, in pairs, or in groups.

Required Materials

none or paper | pencils

Image source: University Corporation for Atmospheric Research

2.6_Poem

CREATIVE ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective is to have students demonstrate a deeper, less scientific understanding of the water cycle through the reading and writing of poetry. Poetry can convey subtleties, emotions, feelings and problems in ways that are not expressed through more practical or scientific language.

Exercise

Select a Poem about the water cycle and invite the students to learn it by heart. More advanced students can be invited to make up their own poem about the water cycle.

Required Materials

paper | pencils (no materials needed for the poetry reading)

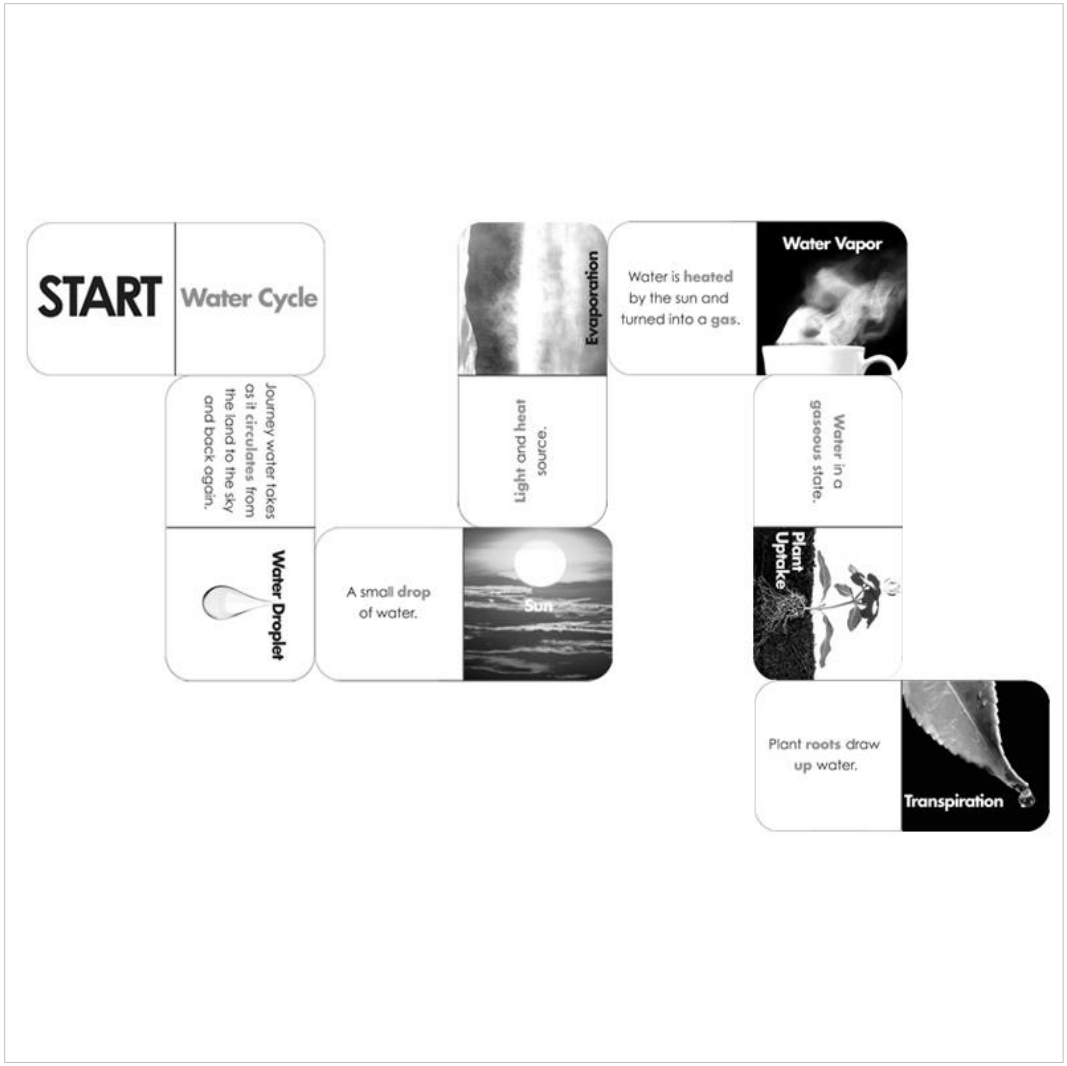


Image source: E is for Explore

2.7_Water cycle dominoes

GAME

LEVEL: ADVANCED

Teaching Objective

The objective of this activity is to enable the students to demonstrate their full understanding of how the water cycle behaves in their environment through the creation and playing of a game of dominoes. The faster and more energetically the game is played, typically the better the understanding of the students.

Exercise

This is a game can either be made in advance by a teacher or as part of the activity by the students themselves. 28 images and 28 statements paired with those images should be selected. The images can illustrate aspects or details of the students natural environment and the written descriptions paired with them should describe water cycle processes that would be taking place in the image. When playing the game, students need to match each image to its correct statement or description.

Required Materials

paper or cardstock | glue | pencils, crayons or pens

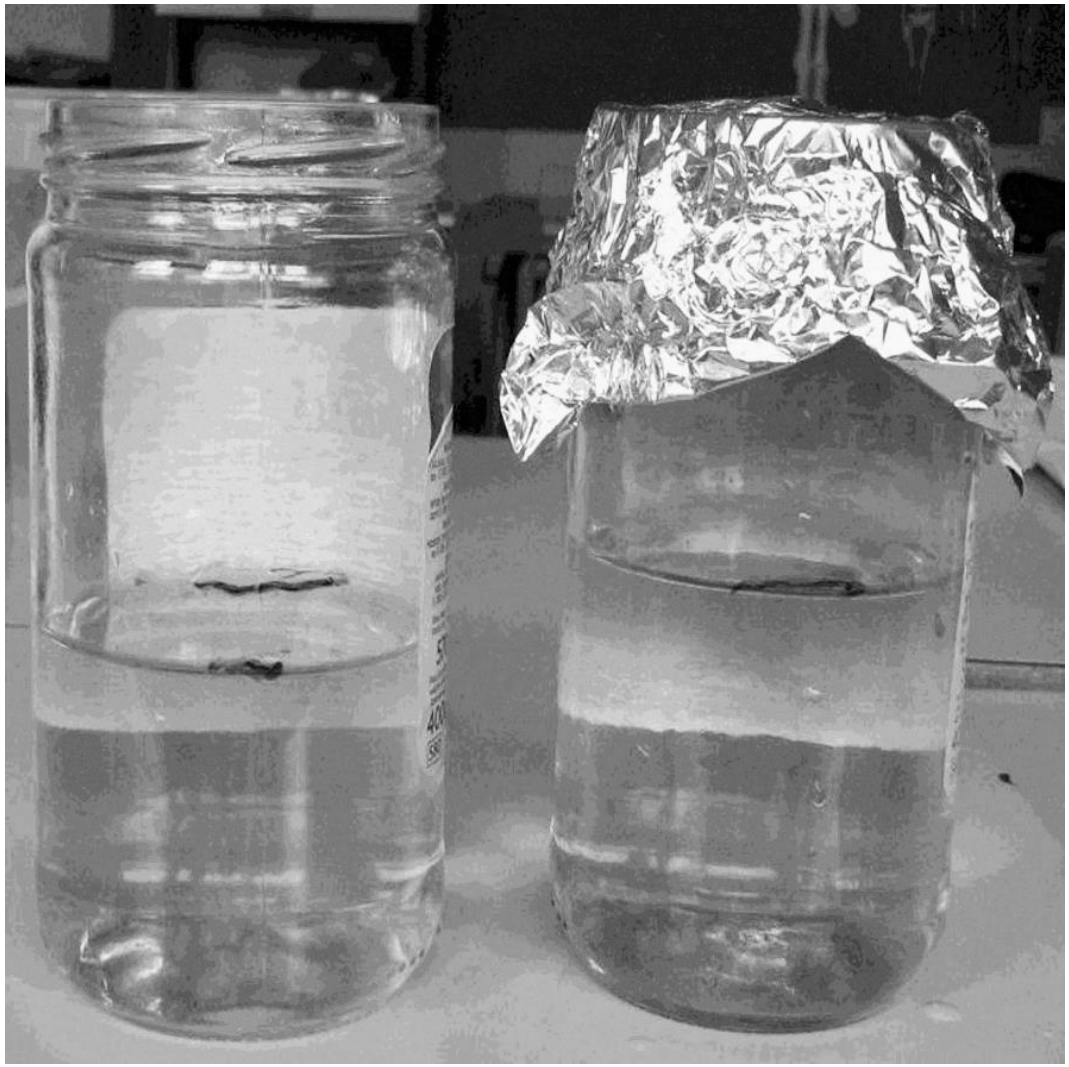


Image source: Elements of Science

2.8_Evaporation in a jar

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The objective of this exercise is to see the principle of evaporative loss at work. This experiment demonstrates that when water is left uncovered and exposed to the sun, it evaporates far more quickly that water that is covered. This is a way of illustrating the value of covered water tanks in hot climates.

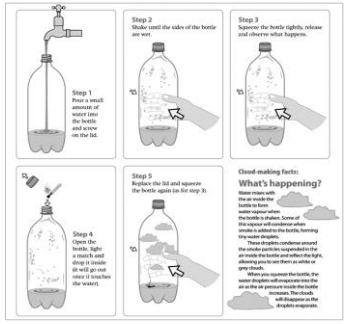
Exercise

Fill two identical glass jars with water. Leaving one of the jars uncovered, cover the other one with an improvised aluminium foil lid. Make the lid as secure as possible. Then, take the jars outside and place them both in an equally sunny spot. Draw a picture of the jars, noting the current water levels. Return to the experiment every day for the next week to observe and draw the current state of the water jars. You will observe that the water in the uncovered jar “disappears” more every day, while the water in the covered jar evaporates at a much slower rate because the evaporation process is blocked by the aluminium foil.

Required Materials

2 glass jars of the same size | water | aluminium foil | a marker pen

Image source: Herald Sun



2.9_Cloud in a jar

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The objective is to make vivid the process of condensation, that forms clouds and makes it possible for rain to fall, irrigating the land.

Exercise

Clouds are formed when rising moist air cools. The water molecules condense around particles of dust or smoke forming water droplets. In this experiment, you will create a mini cloud in a glass jar using hot water, a lit match, and ice.

A few minutes before beginning the demonstration, warm the jar by partially filling it with hot water. Leave the water in the jar until right before you are ready to use it. Put a handful of ice cubes into the plastic bag or a pouch made from plastic wrap. Keep the bag of ice handy so you have it ready during step 5 of the activity. At the beginning of the demo, swirl the warm water around the sides of the jar to clear any condensation. Then pour out that water and pour several cups of very hot or boiling water back into the jar. Light the match and drop it into the jar. The water will extinguish the flame and a small amount of smoke will rise from the surface of the water. Quickly place the bag or plastic pouch with the ice cubes over the top of the jar so that it hangs down into the jar slightly. Pull the sides of the plastic bag down over the mouth of the jar and secure with a rubber band or the jar lid.

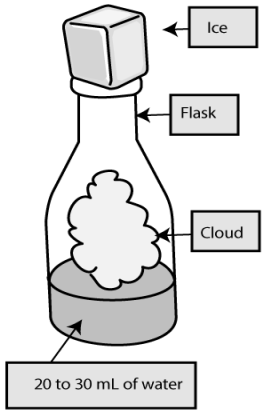
Required Materials

glass Jar (preferably a gallon) | garbage bag or plastic wrap | large rubber bank | match | ice cubes | very hot water.

Additional Resources (hyperlinks)

Science Illustrated The Water Project

Image source: Rusticremnants



2.10_Rain in a jar

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The objective is to demonstrate the principle of precipitation. Water vapour requires contact with a surface in order to condense and become liquid. In the jar that surface is the glass and in the air it is the dust.

Exercise

Boil Water until Steaming. Fill 1/3 of glass jar with steaming water. Cover mouth of jar with plate. Wait 2 minutes. Put some ice cubes on the plate and watch carefully to see what happens in the jar. You should be able to see little streams of water running down the sides of the jar just like the way rain runs down a windows when it is raining outside.

Required Materials (hyperlinks)

glass jar | plate | boiled water | ice cubes

Image source: Teach Beside Me

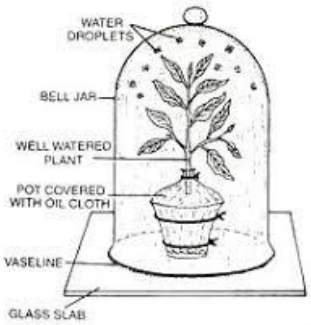


Fig. 11.31. Demonstration of transpiration by bell jar experiment.

2.11_Transpiration in a bag

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The objective is to show students transpiration at work and to convey that without plants emitting water vapour into the air the air becomes dry, rainfall decreases and the ground dries, making it hard to sustain plants.

Exercise

This shows at a small scale what happens when areas are deforested and why deforestation triggers the drying out of the air and land, a process also known as desertification.

Identify a plant and cover the while plant or part of it with a plastic bag or glass jar. Condensation will form on the surface of the bag or jar, revealing the transpiration process in the plant.

Required Materials

plant | a plastic bag and string or a bell jar

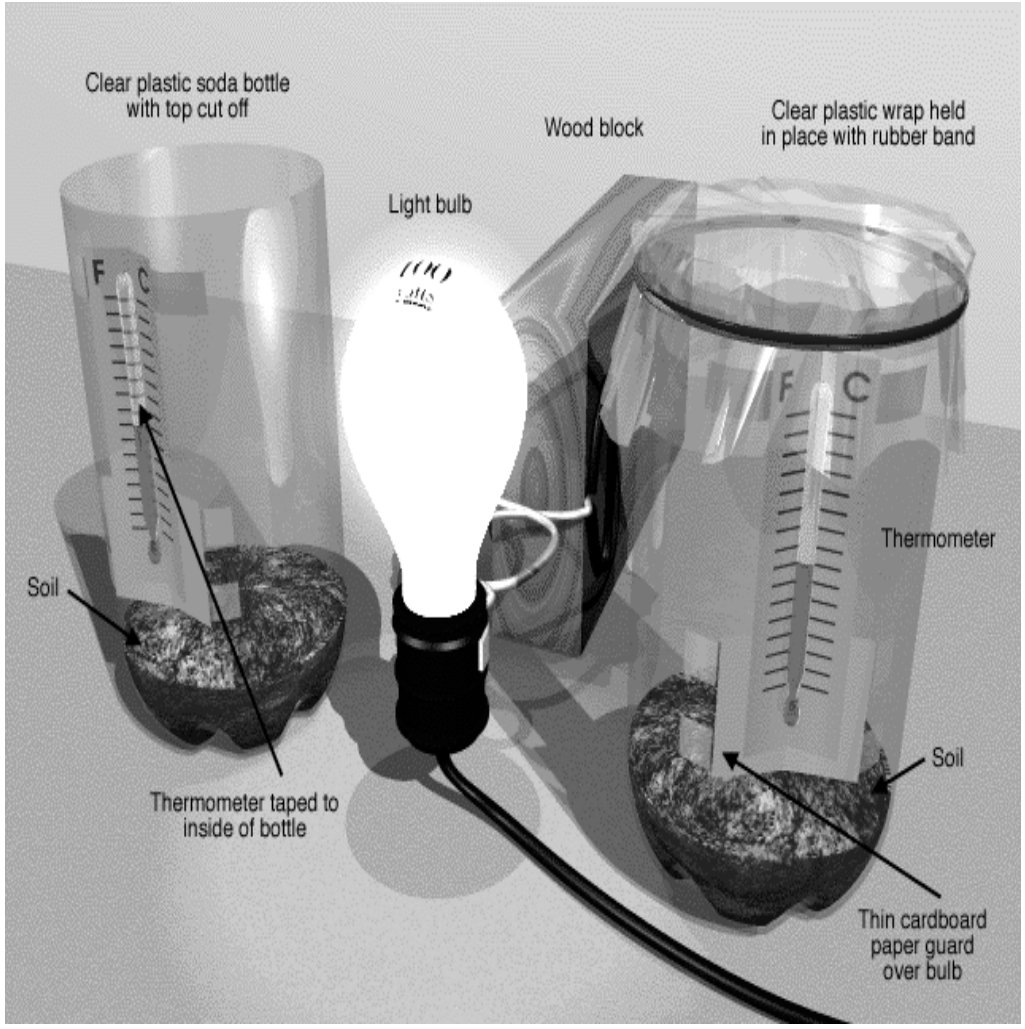


Image source: Bigelow Laboratory for Ocean Sciences

2.12_Global warming in a jar

EXPERIMENT

LEVEL:ADVANCED

Teaching Objective

The students will observe global warming using 2-liter plastic bottles, soil, and water to create a greenhouse effect. They will measure temperature changes as well as the effects of soil dampness. Key concepts include: how a greenhouse works, how the "greenhouse effect" keeps the earth warm for human habitation, and how Global warming is increasing the Earth's average temperature.

Exercise

To make the Greenhouses, cut half of the bottles near the shoulder (these are the experiment bottles) and the other half, about 4" from the bottom of the bottle (these are the control bottles). Let the bottles sit in direct sunlight for 30-50 minutes. Find a place where the bottles can remain undisturbed and be in direct sunlight for the duration of the experiment. Position a thermometer in each bottle. Make sure all thermometers are facing the same direction relative to the light source. To test the effect with damp soil, add the same amount of soil to the bottom or the experiment bottle and the control bottle. For testing the effect on water temperature, add the same amount of water to each bottle and make sure the bulb of the thermometer is the same amount into the water. For testing the effect on iced water, begin with about 3" of water in each bottle, marking the level of water with a marker on each bottle. Add 6-12 ice cubes to each bottle. In this experiment change in the water level is more important than the temperature difference. Continue the experiment until all the ice is melted.

Required Materials

2 clear plastic 2-liter bottles per team of students | plastic wrap or clear plastic bags to cover the "greenhouses" | string or rubber bands to hold the plastic in place | 2 thermometers per team | 2 2"x 2" pieces of thin cardboard | soil | ice cubes | water | plastic rulers | masking tape | utility knife or saw for cutting the plastic bottles | sunshine

Additional Resources (hyperlinks)

Bigelow Laboratory for Ocean Sciences The Water Project Yale

Image source: Aguasan

2.13_Water & nutrient cycle puzzle

GAME

LEVEL: MEDIUM TO ADVANCED

Teaching Objective

The objective of this exercise introduce the concept of nutrient cycles in the environment and how water plays a very important part in keeping nutrients in the right place.

Exercise

This puzzle concerns the role and complexity in the water cycle and nutrient cycle can be made downloaded from the link provided.

Required Materials

paper or cardstock | pencils | crayons or pens

Additional Resources (hyperlinks)

Aguasan

Image source: WikiHow

2.14_Plant in a bottle

EXPERIMENT

LEVEL: EASY

Teaching Objective

The objective of this exercise exemplify the concept of nutrient and water cycles and how in a closed system it allows plants to grow.

Exercise

1. Select your bottle. The bottle should be large enough to allow room for plants to grow. Clean it and allow the bottle to dry thoroughly before using it. The larger the opening, the easier it'll be to maintain the garden.
2. Turn the bottle right-side up. This will form the base of the bottle garden.
3. Place pebbles and sand on the base of the bottle. You can use a small spoon through the mouth of the bottle to add the pebbles and sand and move them around. This will provide a good drainage base for the plants. Wet the sand before putting it in place. Do not underestimate the importance of good drainage, as the bottle does not have drainage holes and wet substrate can lead to fungus issues.
4. Cover the sand and pebbles with soil. The soil should be good quality and pre-dampened. If you accidentally get soil on the sides of the bottle, obscuring the view, you can tie gauze or cotton to the end of a pencil and reach in to wipe off the soil.
5. Plant the garden. Choose seeds of small indoor plants. Place the seeds in the soil. Put the seeds in different spots to make it an interesting arrangement. Bottle gardening lends itself well to plants which require a good deal of humidity (e.g. tropical plants) because the bottle will trap moisture.
6. Watch the plants grow. Tend to them as they mature. The plants will need air and moisture. Be sure to perforate the lid or cap of the bottle or jar, or don't put it on at all. Only water when no condensation is observed on the glass.

Required Materials

bottle with lid | pebbles and sand | soil | seeds of small indoor plants | water

Additional Resources (hyperlinks)

WikiHow

Topic 3_The Watershed around My School

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

The topic is about encouraging students to learn about the watershed in which they live. Through discussions and activities the students can understand what a watershed is, why it is important to them, how a watershed can change over time and be affected by climate change and how unsustainable human behaviour can damage the watershed.

The exercises in this topic are selected to help students :

- To understand what a watershed is, where water comes from and who are the different water users in my environment.
- To recognize the impact of overuse, pollution and practices such as deforestation on the quantity and the quality of my water.
- To find out what we can to do to protect our watershed.

Topic 3_Technical Background

What is a watershed? If you are standing on ground right now, just look down. You're standing, and everyone is standing, in a watershed. A watershed is the area of land where all of the water that falls in it and drains off of it goes to a common outlet. Watersheds can be as small as a footprint or large enough to encompass all the land that drains water into rivers that drain into a bay where it enters the ocean.

A WATERSHED IS A PRECIPITATION COLLECTOR
Most of the precipitation that falls within the drainage area of a stream, collects in the stream and eventually flows downstream. Imagine that the whole basin is covered with a big (and strong) plastic sheet. Then if it rained one inch, all of that rain would fall on the plastic, run downslope into gullies and small creeks and then drain into main stream. Ignoring evaporation and any other losses, then all of the water that fell as rainfall would eventually flow by to the outflow point of the watershed.

NOT ALL PRECIPITATION THAT FALLS IN A WATERSHED FLOWS OUT To picture a watershed as a plastic-covered area of land that collects precipitation is overly simplistic and not at all like a real-world watershed. There are many factors that determine how much water flows in a stream (these factors are universal in nature and not particular to a single stream):

Precipitation: The greatest factor controlling stream flow, by far, is the amount of precipitation that falls in the watershed as rain or snow. However, not all precipitation that falls in a watershed flows out, and a stream will often continue to flow where there is no direct runoff from recent precipitation.

Infiltration: When rain falls on dry ground, some of the water soaks in, or infiltrates the soil. Some water that infiltrates will remain in the shallow soil layer, where it will gradually move downhill, through the soil, and eventually enters the stream by seepage into the stream bank. Some of the water may infiltrate much deeper, recharging groundwater aquifers. Water may travel long distances or remain in storage for long periods before returning to the surface. The amount of water that will soak in over time depends on several characteristics of the watershed:

Soil characteristics: Clayey and rocky soils absorb less water at a slower rate than sandy soils. Soils absorbing less water results in more runoff overland into streams.

Soil saturation: Like a wet sponge, soil already saturated from previous rainfall can't absorb much more, thus more rainfall will become surface runoff.

Land cover: Some land covers have a great impact on infiltration and rainfall runoff. Impervious surfaces, such as parking lots, roads, and developments, act as a "fast lane" for rainfall - right into storm drains that drain directly into streams. Flooding becomes more prevalent as the area of impervious surfaces increase.

Slope of the land: Water falling on steeply-sloped land runs off more quickly than water falling on flat land.

Evaporation: Water from rainfall returns to the atmosphere largely through evaporation. The amount of evaporation depends on temperature, solar radiation, wind, atmospheric pressure, and other factors.

Transpiration: The root systems of plants absorb water from the surrounding soil in various amounts. Most of this water moves through the plant and escapes into the atmosphere through the leaves. Transpiration is controlled by the same factors as evaporation, and by the characteristics and density of the vegetation. Vegetation slows runoff and allows water to seep into the ground.

INTEGRATED WATER RESOURCES MANAGEMENT
Promoted across the world, this concept aims to promote changes in practices which are considered fundamental to improved water resource management. There are three interrelated principles:

1. Ensuring equal access for all users (particularly marginalised and poorer user groups) to an adequate quantity and quality of water necessary to sustain human well being (principle of social equity);
2. Bringing the greatest benefit to the greatest number of water users possible with the available financial and water resources (principle of economic efficiency);
3. Requiring that adequate allocation is made to sustain aquatic ecosystems and their natural functioning (principle of ecological sustainability).

Reference: (USGS)
https://en.wikipedia.org/wiki/Integrated_water_resources_management

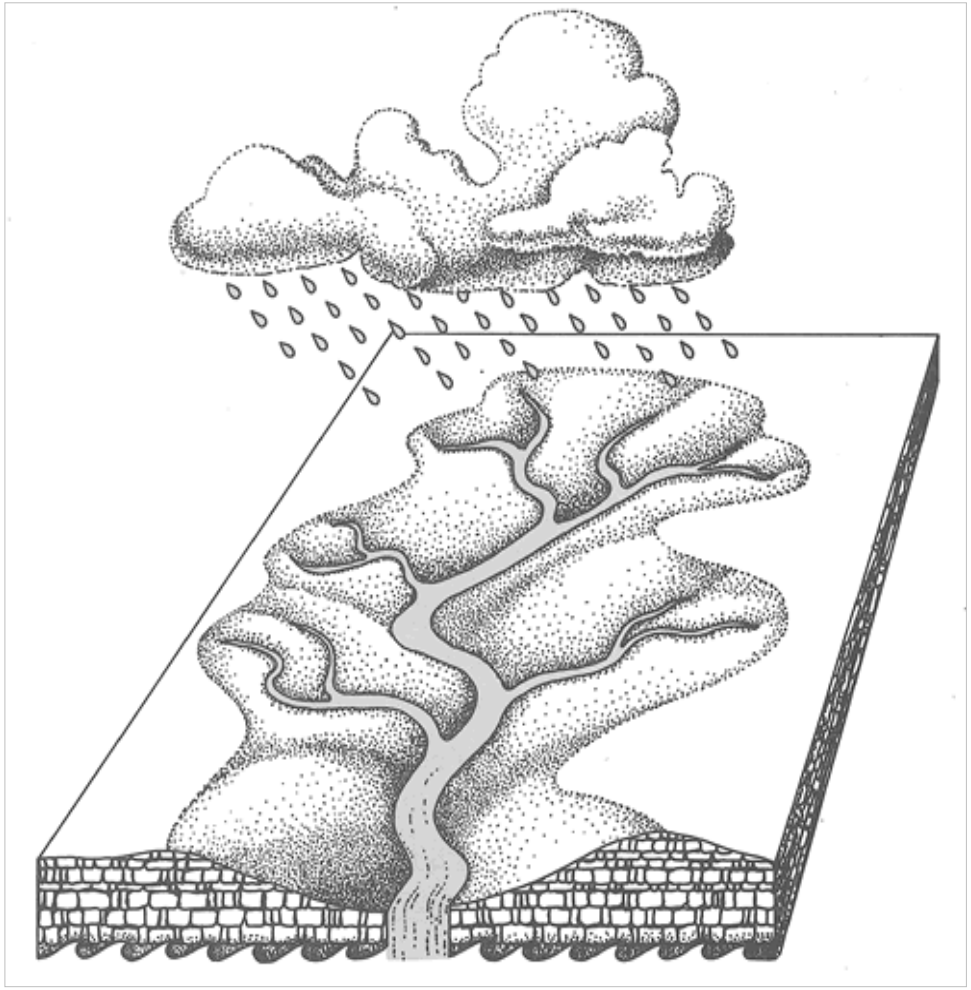


Image source: Soundbook Online

3.1_What is a watershed?

DISCUSSION

LEVEL: SIMPLE TO ADVANCED

Teaching Objective

The purpose of this exercise is to teach students that a watershed is defined as the land area drained by a particular river or stream, how to find the limits of the watershed in which they live and how certain practices like deforestation negatively affect the watershed.

Exercise

Conduct a discussion around the following concepts: Imagine a watershed as an enormous bowl. As water falls onto the bowl's rim, it either flows down the inside of the bowl or down the outside of the bowl. The rim of the bowl or the watershed boundary is sometimes referred to as the ridgeline or watershed divide. This ridge line separates one watershed from another. (Watershed Delineation). All human beings live in a watershed. A watershed is an area of land that drains into a body of water. When rain falls it lands on trees, grass, homes, roads, farms, gardens, schools and more. Natural surfaces absorb that water, but paved surfaces, buildings, and landscaped plots send most of the water flowing over land, downhill to nearby streams. We call that water runoff, and it carries with it anything that's on the land – soil, fertilizer, feces trash and more. Forests transport large quantities of water into the atmosphere via plant transpiration. This replenishes the clouds and instigates rain that maintains the forests. When deforestation occurs, precious rain is lost from the area, flowing away as river water and causing permanent drying. Without trees, eventually the land will become a desert. (USGS)

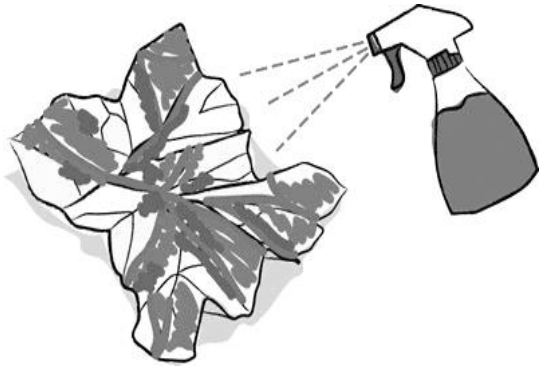
Required Materials

none

Additional Resources (hyperlinks)

USGS

Image source: https://ttfwatershed.org



3.2_Crushed paper watershed

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this exercise is to allow students to understand the principle attributes that define a watershed.

Exercise

First introduce the students to the following definitions and concepts: What is a watershed? A watershed is an area of land that drains into a body of water. When rain falls it lands on trees, grass, homes, roads, farms, gardens, schools and more. Natural surfaces absorb that water, but paved surfaces, buildings, and landscaped plots send most of the water flowing over land, downhill to nearby streams. We call that water runoff, and it carries with it anything that's on the land – soil, fertilizer, faeces trash and more. Then, invite the students to make a simple model of a watershed by crumpling two pieces of paper, flattening them out slightly and then marking onto the top sheet, the high points of the model's topography with water soluble markers. The high points on the model define the watershed boundary. The low points define the rivers and water basins. Once the high points) and low points are marked, spray the model with water and watch water run down the slopes and soak in to the paper.

Required Materials

2 pieces of plain A4 scrap paper | pray bottle | water | water-based markers (blue, brown, and black)

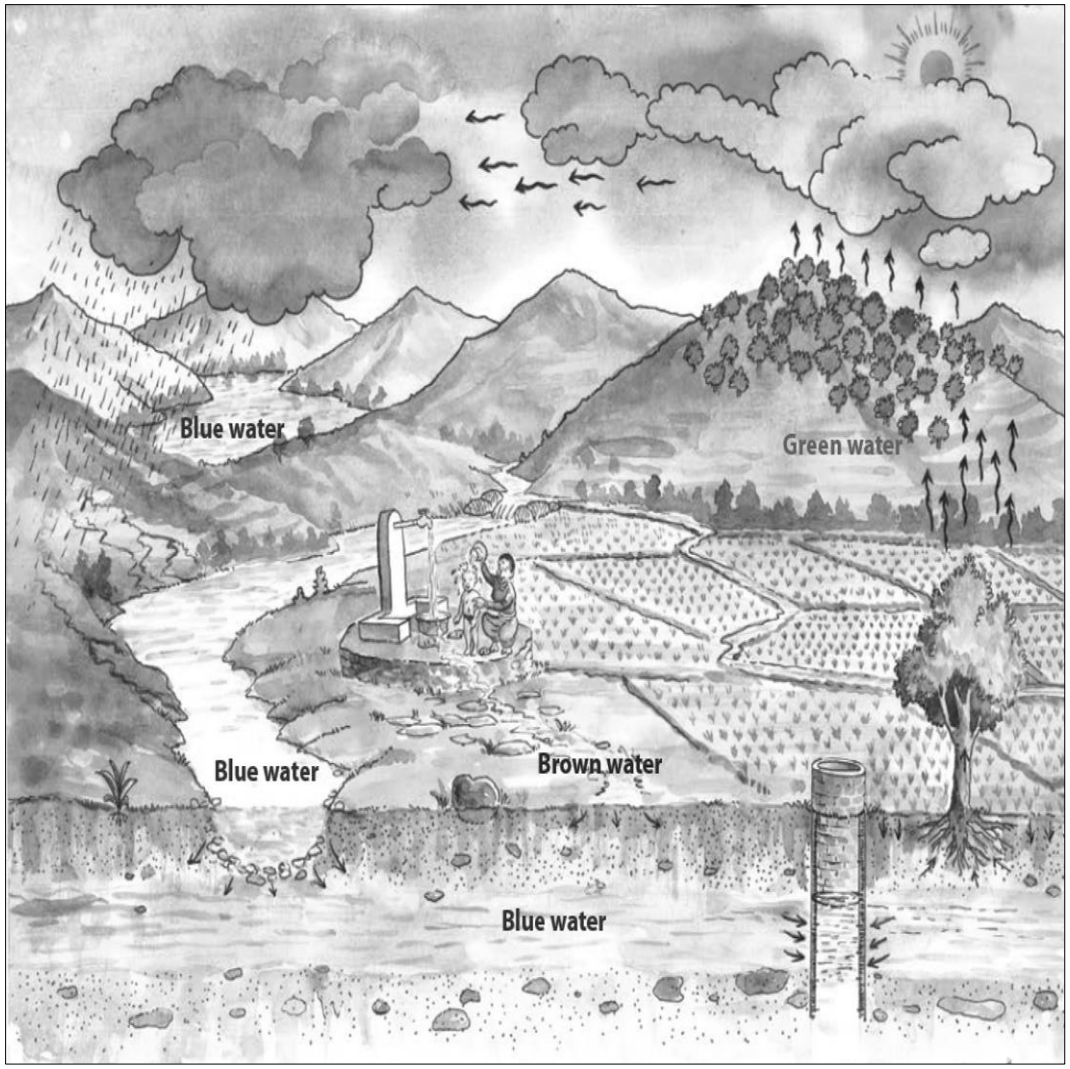


Image source: Helvetas Nepal

3.3_Picturing my watershed

CREATIVE ACTIVITY

LEVEL: SIMPLE TO ADVANCED

Teaching Objective

The purpose of this exercise is to use creative processes of drawing or painting to describe the watershed they are living in, in order that the student becomes even more familiar with it. The pictures can emphasize the features of the watershed, human interventions in it, and the things they love and find difficult about living in it.

Exercise

Students can work individually or in groups to draw or paint their watershed. This activity can be directed to focus on specific or more general aspects, on the natural and the man-made elements affecting it.

Required Materials

paper | pencils | coloured pencils or paints

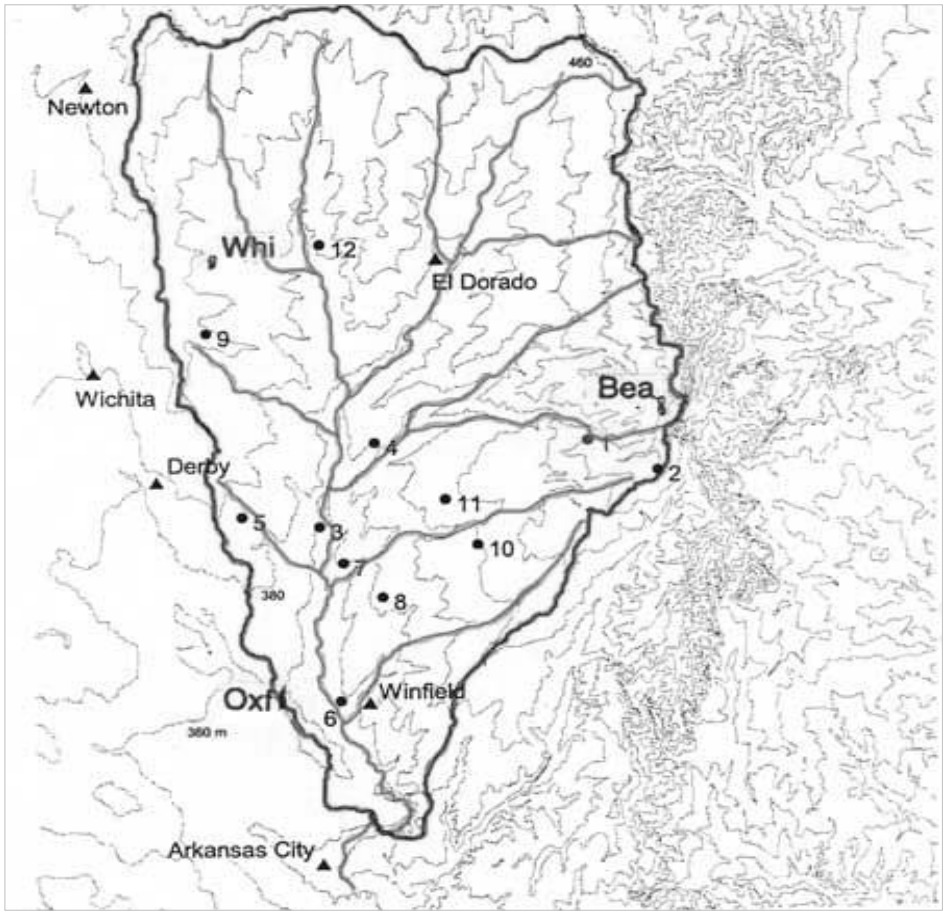
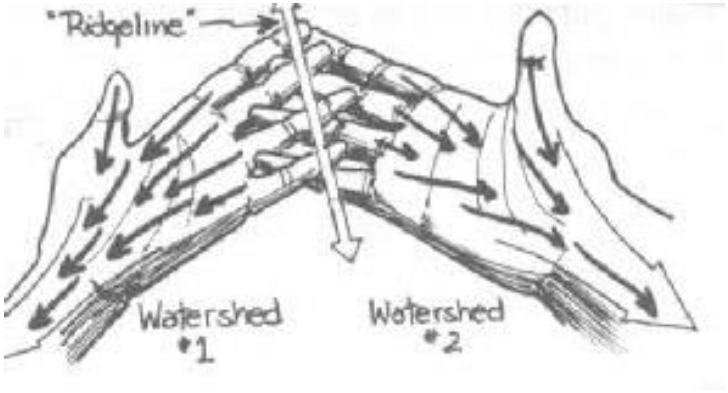


Image source: Globe.gov



3.4_Drawing my watershed

EXPERIMENT

LEVEL: MEDIUM TO ADVANCED

Teaching Objective

The purpose of this exercise is to teach students how to find their own watershed from studying a topographic map.

Exercise

Use a topographic map to locate the river, lake, stream, wetland, or other water bodies of interest. Trace the watercourse from its source to its mouth, including the tributaries. This step determines the general beginning and ending boundaries. Examine contour lines on the topographic map that are near the watercourse. Contour lines spaced far apart indicate that the landscape is more level and gently sloping. Contour lines spaced very close together indicate stepper areas. Check the slope of the landscape by locating two adjacent contour lines and determine their respective elevations. A depressed area (valley, ravine, swale) is represented by a series of contour lines "pointing" towards the highest elevation. A higher area (ridge, hill) is represented by a series of contour lines "pointing" towards the lowest elevation. Determine the direction of drainage in the area of the water body by drawing arrows perpendicular to a series of contour lines that decrease in elevation. Storm water runoff seeks the path of least resistance as it travels downslope. Mark the break points surrounding the water body. The "break points" are the highest elevations where half of the runoff would drain towards one body of water, and the other half would drain towards another body of water. Imagine a drop of rain falling on the surface of the map. Imagine the water flowing down the slopes as it crosses contour lines at right angles. Follow its path to the nearest stream that flows to the water body you are studying.

Required Materials

Paper | pencils | topographic map

Additional Resources (hyperlinks)

Watershed Delineation

Topic 4_My Drinking Water

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

This topic is about encouraging students to understand the importance of clean drinking water. The exercises in this topic are selected to help students:

- To understand that clear water is not always safe to drink.
- To experience and practice how to make water safe for drinking, by safe storage and water treatment at school and at home.

Image source: Water for Africa

Topic 4_Technical Background

SAFE WATER

Water is essential to life. More than 90% of deaths from diarrheal diseases in the developing countries occur in children under five years old (WHO/Unicef). Malnutrition also reduces children's resistance to infectious diseases. Access to safe drinking water is then a top priority to reduce child mortality today.

This section aims to make students realise the importance to drink safe water for their health and give them practical tools on how to make sure the water they drink is safe.

It focuses on:

- Introducing the concept of water quality, and that clear water is not necessarily clean water;
- The difference in water quality depending on the source of water;
- The importance of transport and storage;
- How to treat water at the school and at home.

WATER PURIFICATION

There are five steps to basic water purification: aeration, coagulation, sedimentation, filtration, and disinfection. Aeration adds air to the water. It allows gases trapped in the water to escape and adds oxygen to the water. Coagulation is the process which allows dirt and other suspended solid particles to chemically 'stick together' into flocks (clumps of alum and sediment). During this step, the water is also clarified, or made clear and colourless. Sedimentation is the process that occurs when gravity pulls the particles of flocks to the bottom of the container. So as the water sits undisturbed, most of the flocks settles, preparing the water for the next step. Filtration is the process where remaining solid particles and flocks are separated and removed from the water. Disinfection is the final step, in which water is treated with solar energy or chemicals (chlorine) to remove bacteria and other micro-organisms. These unseen bacteria can cause severe sickness and even death in humans. Toxic chemicals and heavy metals may require further steps to make the water safe to drink. (Home Science Tools)

Image source: Pinsdaddy.com

4.1_Clear water isn't clean water

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this exercise is to demonstrate to students that clear water is not always safe to drink. Clear water may contain many things invisible to the eye that can make us ill; such as effluent from human and animal excreta, and fertilizers and chemicals used to grow food.

Exercise

Bring four water bottles full of safe drinking water where one bottle has dissolved salt, one has dissolved sugar, one has cinnamon or other spice (to visibly discolour the water) and one bottle without any additive. Have participants choose which water they would like to drink. Have them take a large sip in a cup. Make sure they are facing the group so that the group may view their reaction to the taste. Participants can take turns, but make sure to rearrange the water bottles between each taste test in order to preserve the surprise. Shake water bottles as necessary. Next, ask group members what they have learned from this activity. Which water bottles look clean? Is a clean-looking one always actually pure? How does this translate to our lives? This activity should get people thinking about the water they drink in their own households. (Peace Corps)

Required Materials

4 plastic water bottles | water | salt | sugar | cinnamon (or other visible spice)

4.2_Safe storage and transportation

Image source: CHAST

DISCUSSION
LEVEL: SIMPLE

Teaching Objective
The objective of this activity is for student to understand the importance of transportation and safe storage to keep water safe to drink.

Exercise
Show students different ways to transport and store water, an discuss which one are safe and which are not. Explain the risks of unsafe practices, and how to improve the process, for example by keeping the storage containers clean and closed by a lid.

There are a few important points:

- Treated water should be stored in plastic, ceramic, or metal containers especially when using treatment options that do not leave residual protection. The following characteristics of containers serve as physical barriers to recontamination (CDC & U.S. AID 2009);
- A medium sized, easy to clean opening with a lid or cover that discourages users from placing potentially contaminated items such as hands, cups, or ladles into the stored water;
- A spigot or small opening to allow easy and safe access to the water without requiring the insertion of hands or objects into the container;
- A size appropriate for the household water treatment method, with permanently attached instructions for using the treatment method and for cleaning the container.

Required Materials
Pictures or drawings of different types of storage vessel

Main reference (hyperlinks)
SSWM
Additional resource (hyperlinks)
CHAST, Caritas Switzerland

4.3_Water filter in a bottle

EXPERIMENT

LEVEL: SIMPLE

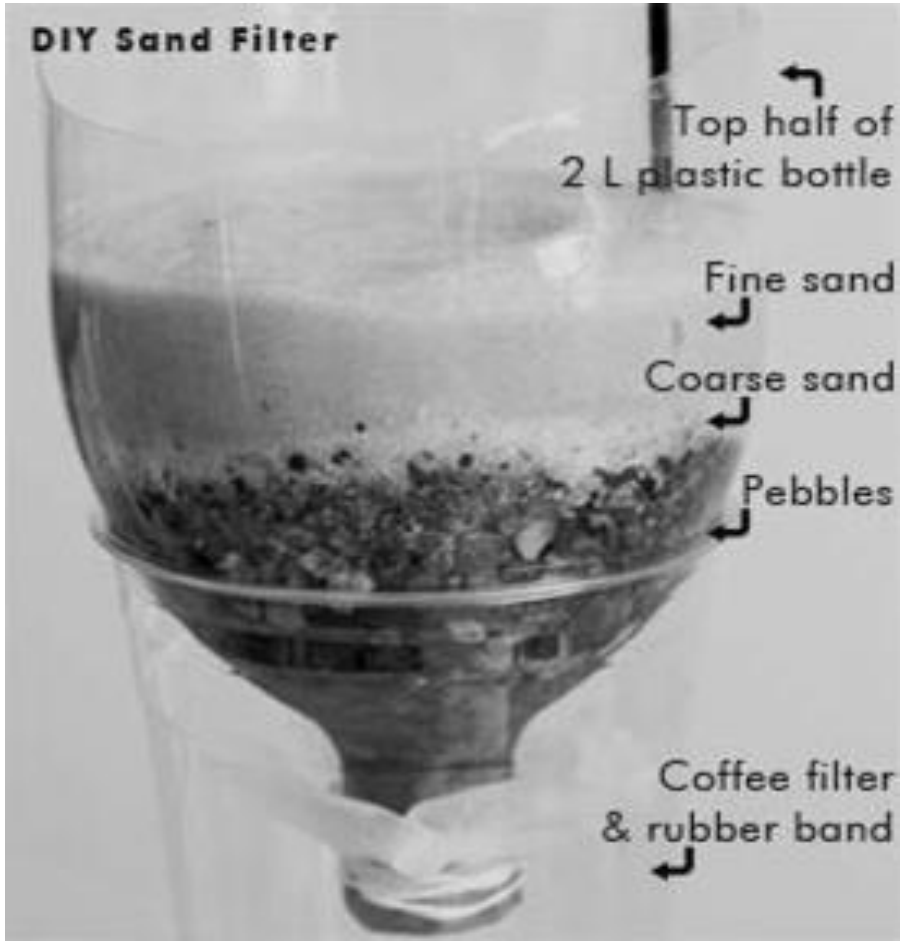
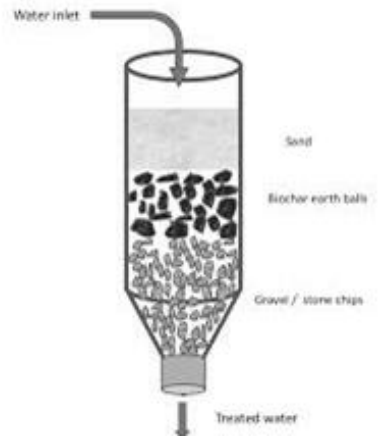


Image source: Home Science Tools



Teaching Objective

The purpose of this demonstration is to show the basic principles of water filtration at work.

Exercise

Remove the bottom of a plastic soda bottle. Cover the cap end of a plastic bottle with a coffee filter and secure with a rubber band. Add the gravel (or small pebbles). Add the course sand and than add the fine sand. Set the bottle up side down on the bottom of the bottle that was cut off or in a glass jar. Pour in the dirty water and watch what happens. Activated charcoal can be added to the filter between the gravel layer and the course sand layer if available.

Required Materials

soda bottle with lid | 2 cups of fine sand | 1 cup of coarse sand | 1 cup of small pebbles | filter paper or coffee filter | rubber band | spoon | half a litre of dirty water

Additional Resources (hyperlinks)

How to make a water filter_Wikihow

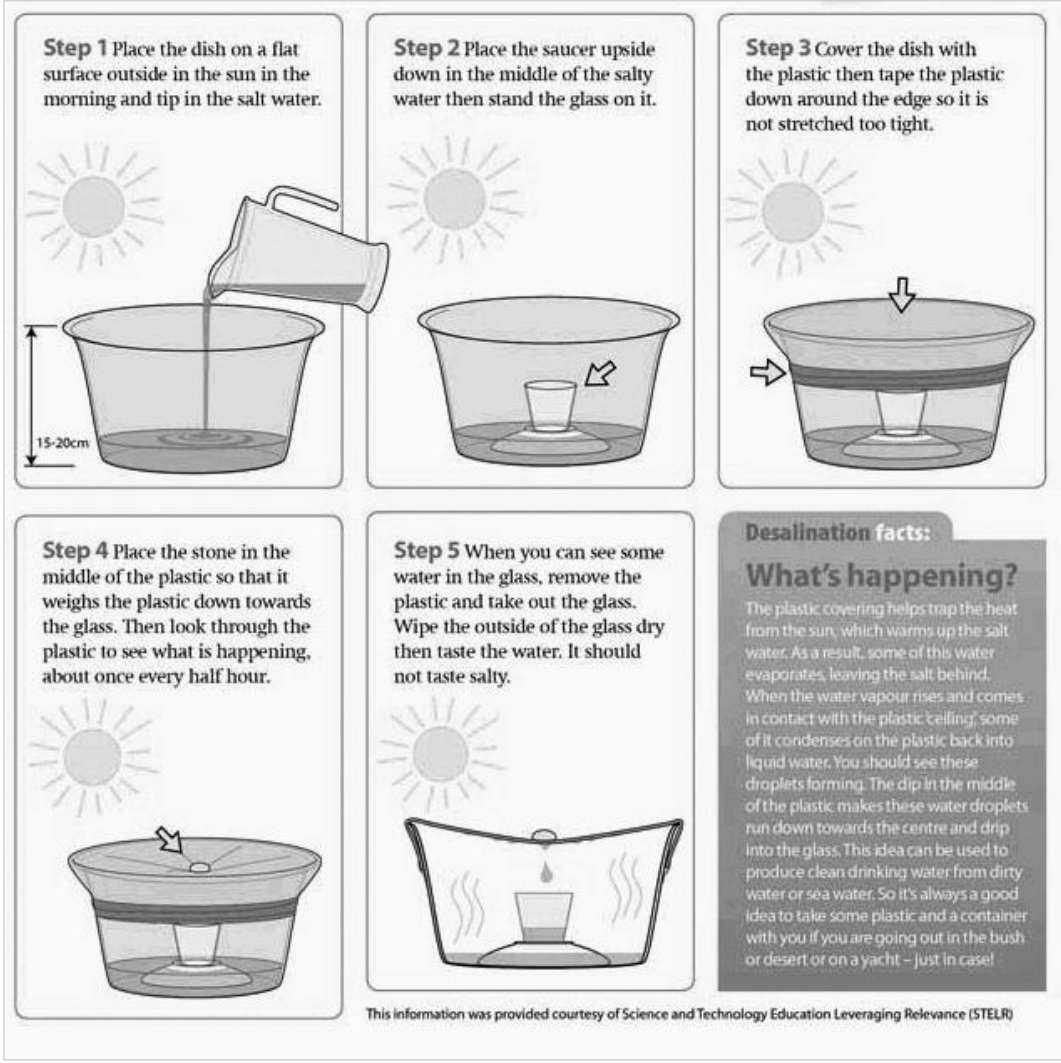


Image source: Science illustrated

4.4_Mini desalination plant

EXPERIMENT

LEVEL: MEDIUM

Teaching Objective

The purpose of this experiment is to allow students to understand the principle of desalination and water purification

Exercise

Place the dish on a flat surface, outside in the morning sun and add the salt water. Place the saucer upside down in the middle of the bowl and stand the glass on it. Cover the dish with plastic and tape it down so that the surface is tight. Place a stone in the middle of the plastic and observe what is happening every 30 minutes. When you can see water collecting in the glass, remove the plastic and glass and taste the water.

Remark

Many natural waters are low in many minerals or soft (low in divalent ions). That water may contain desirable substances has received less attention in guidelines and regulations, but an increased awareness of the biological value of water has occurred in the past several decades. Demineralised water is defined as water almost or completely free of dissolved minerals as a result of distillation. It has been adequately demonstrated that consuming water of low mineral content has a negative effect on homeostasis mechanisms, compromising the mineral and water metabolism in the body.

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Required Materials

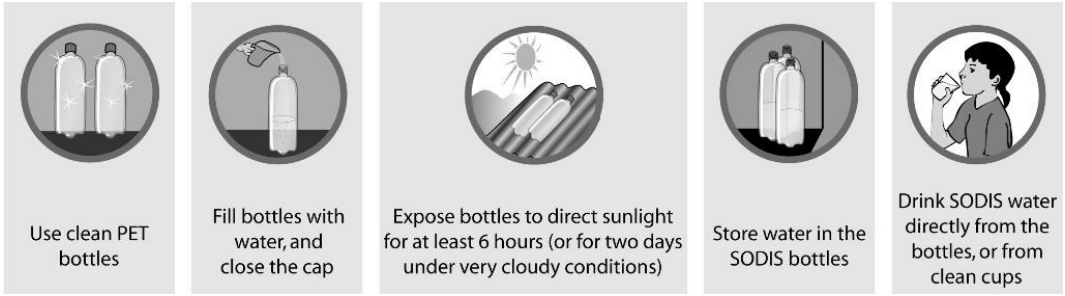
flat bottomed glass dish | drinking glass | saucer | 2 cups of sea water or water with salt dissolved in it | plastic film | masking tape or rubber band | stone

4.5_Solar water disinfection

EXPERIMENT

LEVEL: SIMPLE

Image source: SODIS Eawag Fundacion SODIS



Teaching Objective

The purpose of this experiment is to demonstrate how to disinfect water using solar energy

SODIS is a water treatment method which uses solar energy to improve the microbiological water quality. It is used at household level to treat small quantities of drinking water. The treatment process is a simple technology using solar radiation to inactivate and destroy pathogenic microorganisms present in the water. The treatment basically consists in filling transparent containers with water and exposing them to full sunlight for about six hours.

Exercise

Using clean PET bottles, fill with water and close the cap. Expose the bottles to direct sunlight for at least 6 hours (or for two days under cloudy conditions). Store the water and drink from clean cups. This method does not work under conditions of continuous rainfall. During the rainy season harvested rain is the best option.

Required Materials

PET water bottles | water

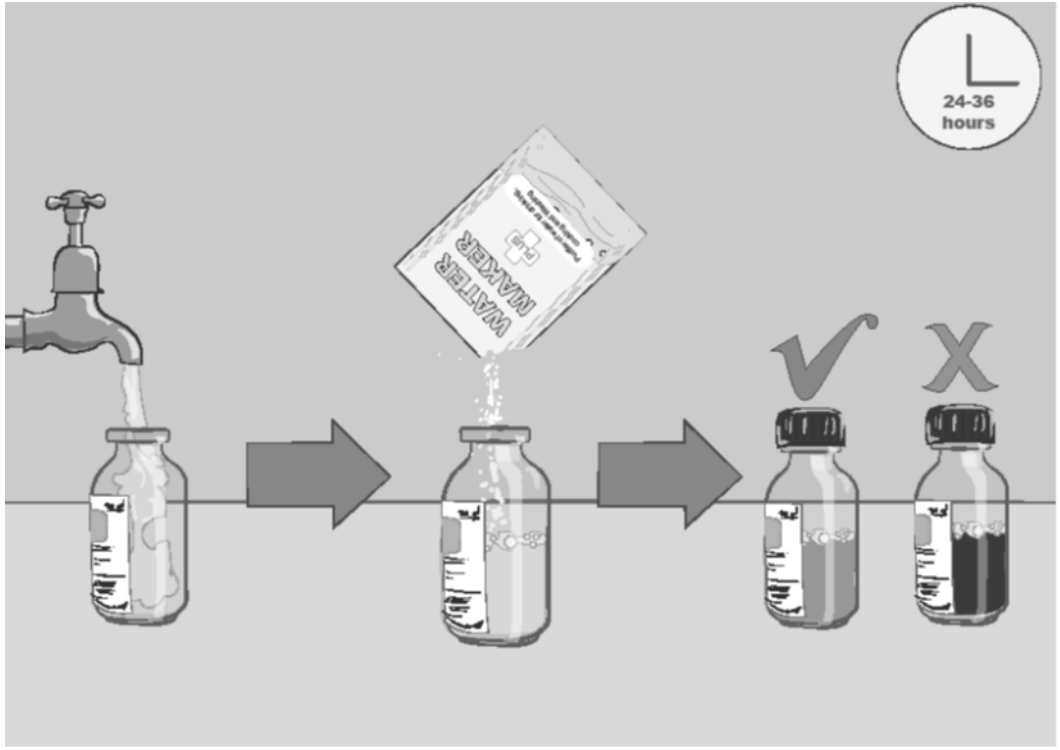


Image source: School Health Club Poster, Caritas Switzerland, 2017

4.6_Water quality testing

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is for student to learn how water can be tested and realize that transparent water does not mean safe for drinking.

Exercise

To know if water is safe, it should be tested. A simple test that can be done is the H2S method. The H2S method comes with little glass bottles containing a reddish powder. To test the water, fill the water sample in the bottle, gently shake it and keep the bottle at ambient temperature for 24-48 hours. If the water stays reddish, it is safe to drink. If it turns black, it is contaminated with fecal bacteria and unsafe to drink. To make the exercise more fun, take two samples at a time to compare, for example a sample of treated drinking water and a sample of untreated water from the river.

Required Materials

The H2S test kits can be purchased from a chemist.

Additional Resource (hyperlinks)

SSWM

India Water Portal

Image source: http://holland-water.nl/moringa-seeds-engels/?lang=en/

4.7_Treating water with Moringa seeds

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

This exercise shows students how to use Moringa seeds to reduce the turbidity of water. (See also exercise 7.8 Planting Moringa). Moringa seeds can be used to increase water's quality, mainly by reducing the turbidity. There are indications that they could also act as an anti-microbial agent (but this is still being researched).

Exercise

- Collect mature *Moringa oleifera* seed pods and remove seeds from pods.
- Remove seed coat to obtain clean seed kernels; discard discoloured seeds.
- Determine quantity of kernels needed based on amount and turbidity of water; in general 1 seed kernel will treat 1 litre of water.
- Crush appropriate number of seed kernels (using grinder, mortar & pestle, etc.) to obtain a fine powder and sift the powder through a screen or small mesh.
- Mix seed powder with a small amount of clean water to form a paste.
- Mix the paste and 250 ml (1 cup) of clean water into a bottle and shake for 1 minute to activate the coagulant properties and form a solution.
- Filter this solution through a muslin cloth or fine mesh screen (to remove insoluble materials) and into the water to be treated.
- Stir treated water rapidly for at least 1 minute then slowly (15–20 rotations per minute) for 5–10 minutes.
- Let the treated water sit without disturbing for at least 1–2 hours.
- When the particles and contaminates have settled to the bottom, the clean water can be carefully poured off.
- This clean can then be filtered or sterilized to make it completely safe for drinking.
    - Sand Water filters
    - Solar Sterilization
    - Chlorination: 1–2 drops per litre
    - Boiling: minimum of 5 minutes

Main source (hyperlinks): Ecocommunity.org

Other resource (hyperlinks): CAWST

Required Materials

Moringa seeds | grinder or mortar | 1 bowl and a bottle | small mesh

4.8_Treating water with chlorine

EXPERIMENT

LEVEL: SIMPLE

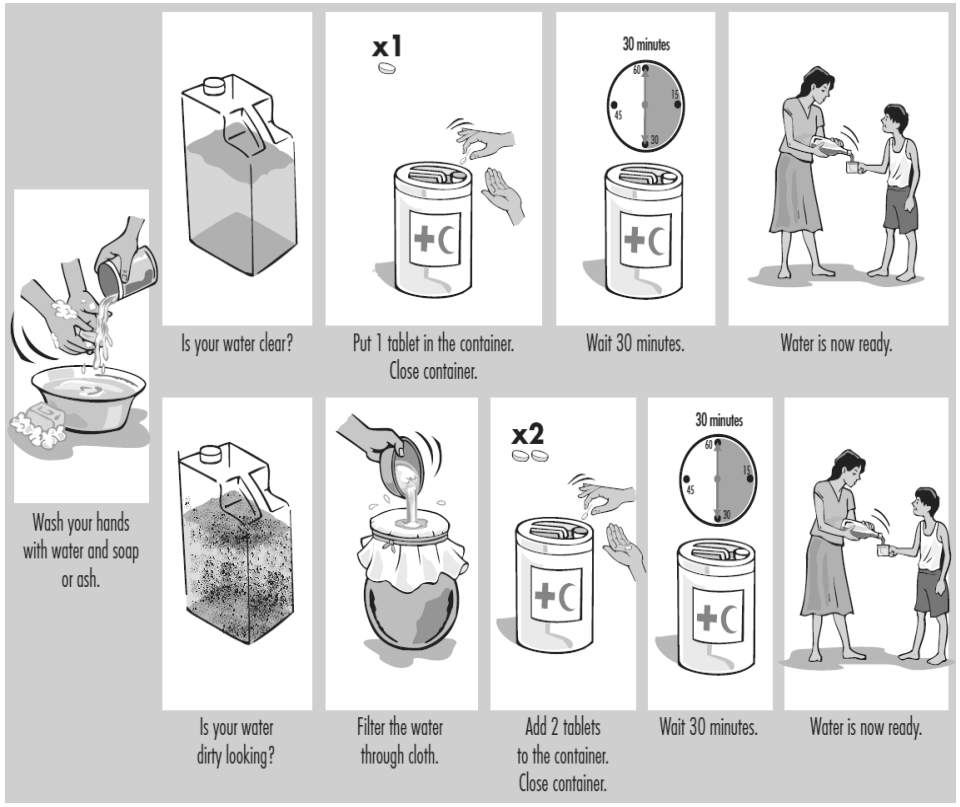


Image source: : http://www.ifrc.org

Teaching Objective

This exercise shows students how to apply chlorination tablets or solution. Chlorination is one of many methods that can be used to disinfect water. This method was first used over a century ago, and is still used today. It is a chemical disinfection method that uses various types of chlorine or chlorine-containing substances for the oxidation and disinfection of what will be the potable water source.

The main purpose of chlorination is to disinfect water, but it also has many other benefits. Unlike some of the other disinfection methods like ozonation and ultraviolet radiation, chlorination is able to provide a residual to reduce the chance of pathogen regrowth in water storage tanks or within the water distribution system. In addition to destroying harmful microorganisms, chlorination also reduces the amount of iron, manganese and hydrogen sulphide in water. Chemical disinfection using chlorine has the benefits of being relatively quick, simple, and cheap and to provide some protection against recontamination.

Exercise

The correct amount of chlorine solution must be used. If the concentration of chlorine is inadequate the solution may fail to destroy all the harmful micro-organisms and if in excess, health may be adversely affected. Only an appropriate amount of chlorine can destroy most of harmful micro-organisms and provide a safe amount of residual chlorine. Please follow the instructions given on the product used.

Use water purification and disinfection tablets. Water purification tablets are made of either chlorine dioxide or iodine, and kill bacteria and viruses in water. To use these tablets, fill a pitcher or jar with water and add enough tablets to treat the water. One tablet typically treats 1 litre of water. These tablets generally need anywhere from 30 minutes to four hours to work.

Main source (hyperlinks)

www.sswm.info

Required Materials

Chlorination tables or drops

Topic 5_Sanitation and Hygiene

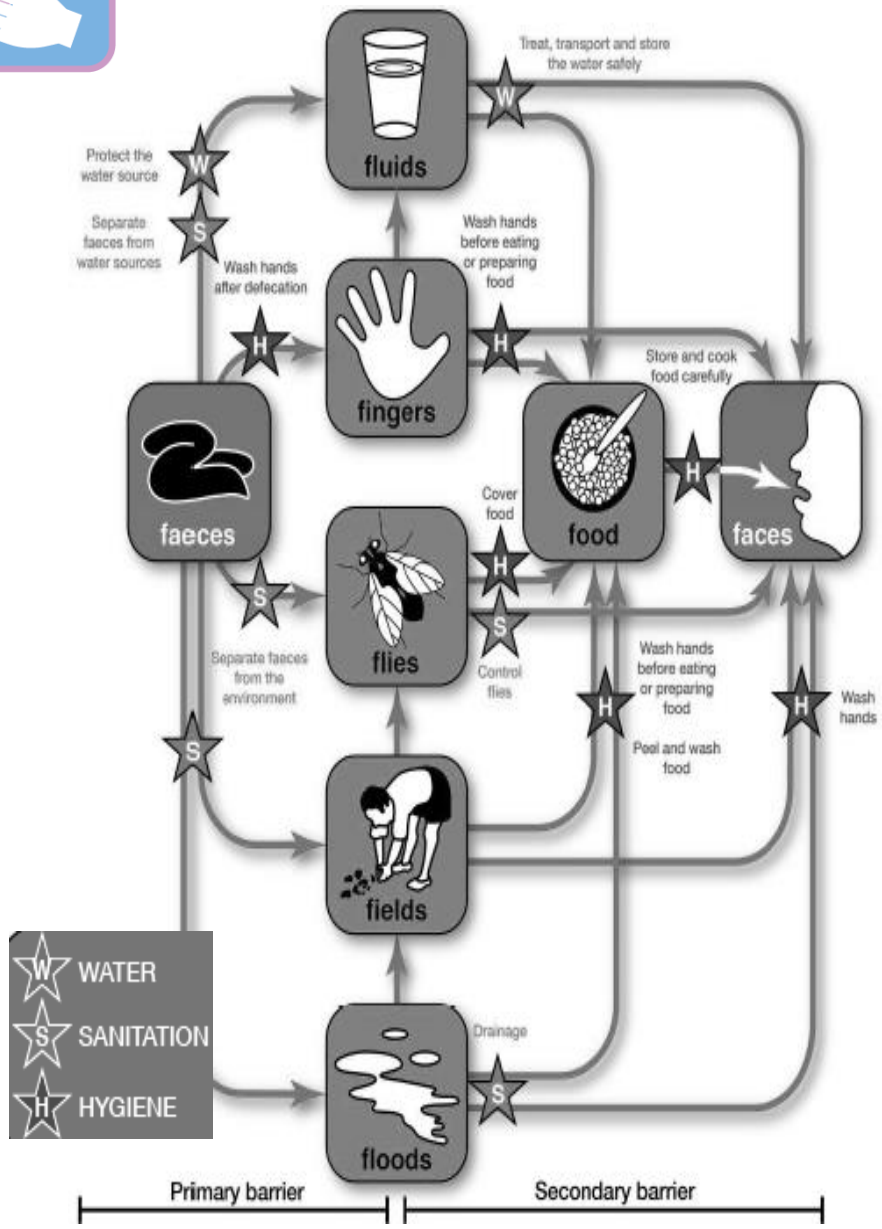
Hygiene is two thirds of health.
Lebanese Proverb

This topic encourages students to establish a connection between their health and well-being and good hygiene and adequate sanitation. The exercises in this topic are selected to help students:

- To understand how diseases are transmitted and what good and bad hygiene practices are.
- To apply good hygiene practices that can help blocking the transmission route of diseases at school and at home.

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

Topic 5_Technical Background



The 'F' Diagram
Image source: Scott, WEDC

HYGIENE AND SANITATION

Definitions and differences between hygiene and sanitation
Hygiene generally refers to the cleanliness of the human body and respective practices, such as washing hands, nail trimming and showering. Beyond that, hygiene also refers to practices that guarantee hygienic conditions of a surrounding environment, such as cleaning and waste management. **Sanitation** is synonymous with the infrastructures that allow human beings to satisfy personal and public hygiene. Properly constructed and maintained "improved" toilets hygienically separate human excreta from human contact in the environment. This prevents human contact with waste and bacteria in the environment that can cause (lethal) diseases. Importantly, "safely-managed sanitation" includes the onsite treatment and disposal or reuse of human excreta, or conveyance to an offsite facility for treatment and disposal/reuse.

Why are water, hygiene and sanitation so important?
As seen in the 'F' diagram, water, sanitation and hygiene interventions act as barriers to stop the transmission of disease; these can be primary (preventing the initial contact with the faeces) or secondary (preventing it being ingested by a new person), This section of the Blue Schools Kit focuses on the promotion of knowledge about how diseases spread and how to limit this through sound hygiene practices and sanitation infrastructure.

This topic introduces, through a variety of exercises—including practical demonstrations—the effects of good hygiene practices for personal health and how to integrate them into daily routines. It aims to cover most aspects of hygiene and sanitation, including:

- The correct use and maintenance of toilet facilities at school and at home, including how to safely confine faeces and to avoid faecal-oral contamination from flies, food, fluids, floods, fingers and domestic animals;
- How to correctly wash hands with soap or ash at critical moments, and important elements and adequate performance of personal hygiene (tooth brushing, face washing, wearing shoes, nail trimming etc.);
- Covering food to protect it from contamination from flies or other sources;
- The importance to keep the surrounding environment clean, collecting (and separating waste) - further covered in topic 8.

Image source: Philip Cohen

5.1_Glitter hands

GAME

LEVEL: SIMPLE

Teaching Objective

Through this game you can teach children that clean hands require effort, the use of soap and vigorous rubbing. Simply getting their hands wet and wiping them on their clothes will not remove the glitter (or germs).

Exercise

Some students only rinse their hands quickly under water, if they wash at all. Hands, in fact, should be scrubbed with soap for at least 15 to 20 seconds. Sprinkle glitter on the children's hands and challenge them to wash off the glitter with soap and water. Because glitter is naturally sticky, it may take up to 30 seconds to scrub the glitter away. Then indicate that they should scrub off germs like the glitter each time that that hand washing occurs.

Required Materials

glitter | water | soap

Image source: Love to know

5.2_Germ transfer

GAME

LEVEL: SIMPLE

Teaching Objective

This exercise is a playful way to communicate to the students how easily germs are spread. Just because they cannot see the germs on their hands it doesn't mean they are not there. The paint stands in for germs and makes them visible.

Exercise

Teach students about the spread of germs by showing how germs can live on hands and the things they touch. Pretend to sneeze, and when you do, cover your hands in a washable paint. Then go about your business, touching things around the room. The students will see the transfer of germs. After the exercise, invite the students to find and tally all the surfaces where germs now live from your transferring them around the room, and then invite them to clean the marks off the surfaces.

Required Materials

Colour washable paints

Image source: Board Maker Online

5.3_Hygiene matching game

GAME

LEVEL: SIMPLE

Teaching Objective

This exercise shows children the cleaning activity that corresponds to each body part.

Exercise

Develop a matching game that teaches students the various tools for personal hygiene appropriate for use in your community and which body part to use them on. On one set of cards, draw pictures of soap, a toothbrush, fingernail clippers or mouthwash. Then create another set of cards that shows hands, teeth, nails and mouth or the name of the instrument. Flip all of the cards over and have the students try to match the tool to the body part.

Required Materials

paper or cardstock | crayons | scissors

5.4_Good habit - bad habit

GAME

LEVEL: SIMPLE

Teaching Objective

This exercise encourages students to show their understanding of good and bad hygiene habits.

Exercise

On pieces of paper, write 10 good hygiene habits; such as: brushing teeth each night, washing for 20 seconds or covering the mouth when coughing. On 10 more pieces of paper, write down the bad habits. Fold all of the pieces of paper and place them in a hat. The children can draw out one at a time and decide whether it's a good hygiene habit or a bad hygiene habit

Required Materials

paper | pencil | hat or container

5.5_Hygiene charades

GAME

LEVEL: SIMPLE

Teaching Objective

The objective of this game is to have students familiar with all actions and gestures required for good hygiene.

Exercise

Help students get the motions of hygienic behaviour right by playing hygiene charades. One child picks an action for hygiene, such as brushing teeth, coughing into a sleeve or taking a shower. Each student acts out the hygiene habit without using any words. The other students guess what action is being portrayed and then you talk about the proper way to do each hygiene habit.

Required Materials

none

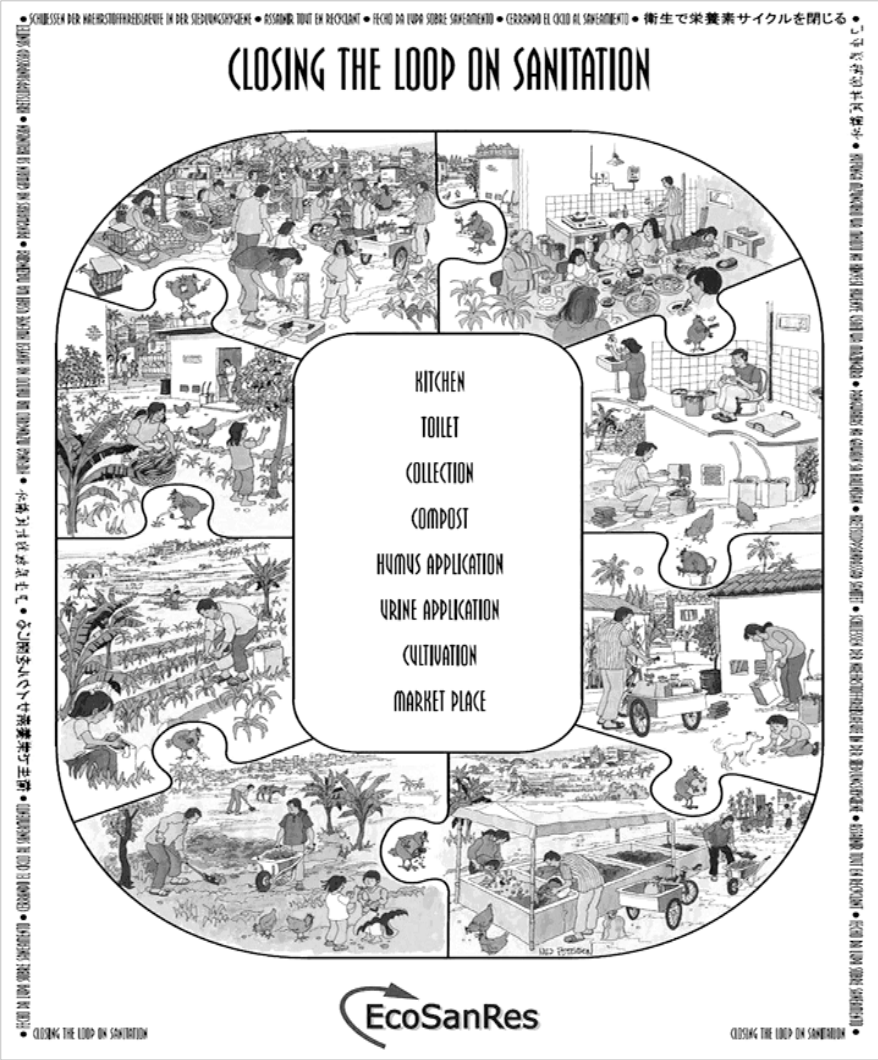


Image source: EcoSanRes

5.6_Eco sanitation puzzle

GAME

LEVEL: ADVANCED

Teaching Objective

This exercise introduces students to the steps of safely managed sanitation.

Exercise

Ask students about what happens to excreta after using the toilet.

During the discussion, describe sanitation as a multi-step process in which human excreta and wastewater are managed from the point of generation to the point of use or disposal. 'resources'.

Explain that onsite sanitation systems, where excreta is collected in pits or septic tanks, requires the safe emptying of solids (sludge) and conveyance to treatment sites or safe burial depending on the system design. Sewerage systems use flush water to move excreta to treatment stations.

Talk about the different steps in the safely managed sanitation chain: type of toilet, collection/storage, evacuation, transport, treatment and disposal / reuse. Although considered *wastes*, some sanitation systems, such as EcoSan and small scale treatment plants, recover products as *resources*; for examples as fertilizers, cooking gas, and compost.

Download the poster/puzzle from the Ecosan Database or make a puzzle with a drawing for each step in a safely managed sanitation system based on the predominant system in your community.

Required Materials

card stock | pencils or crayons.

Additional Resources (hyperlinks)

EcoSanRes

Eawag Compendium of Sanitation Systems and Technologies

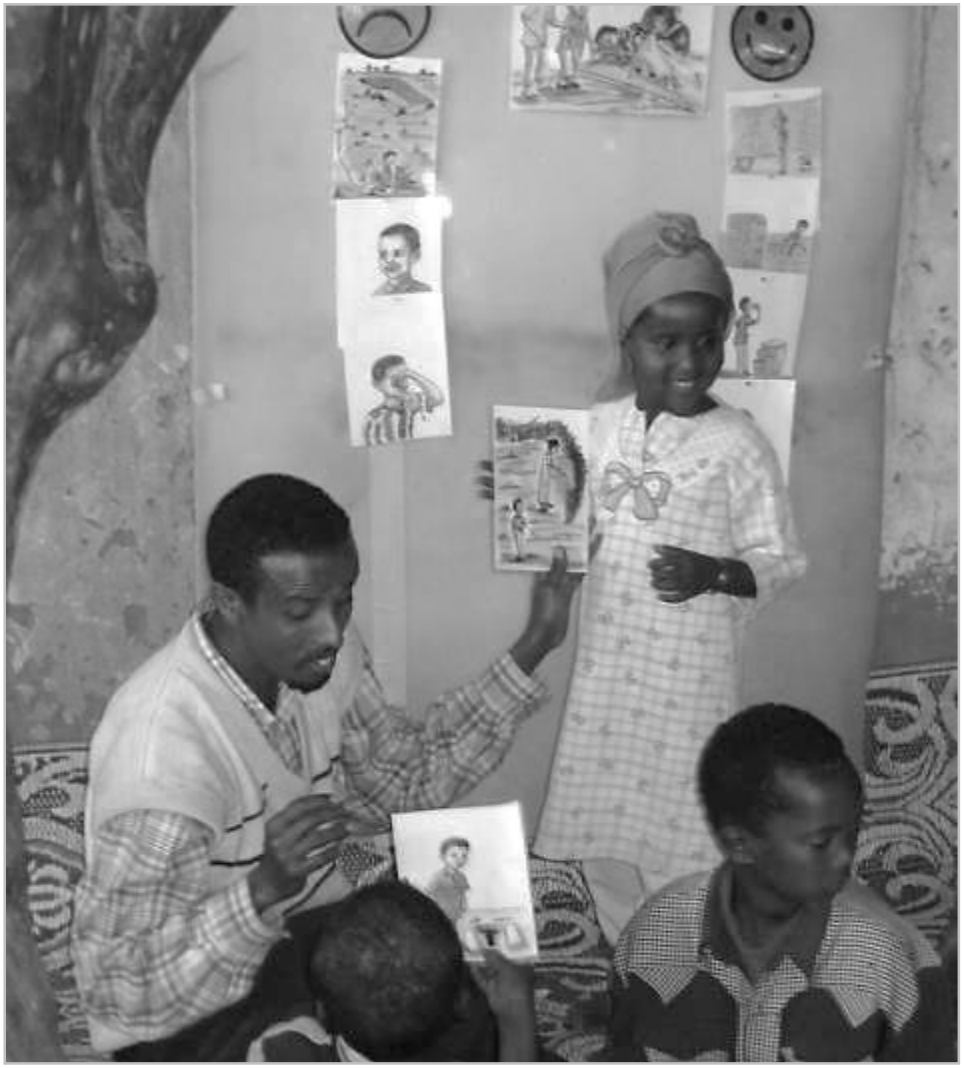


Image source: CHAST

5.7_Pile sorting of hygiene practices

GAME

LEVEL: SIMPLE

Teaching Objective

The objective of this exercise is for student to analyse different practices of daily life, discuss whether it is a good or bad practices and understand why, using pre-drawn cards or drawings.

Exercise

Use cards demonstrating daily good and bad practices or even ask students to draw some. Draw a happy smiley and a sad smiley. Ask students to discuss between themselves if the practice is good or bad and ask them why.

Additional Resources

CHAST, Caritas Switzerland

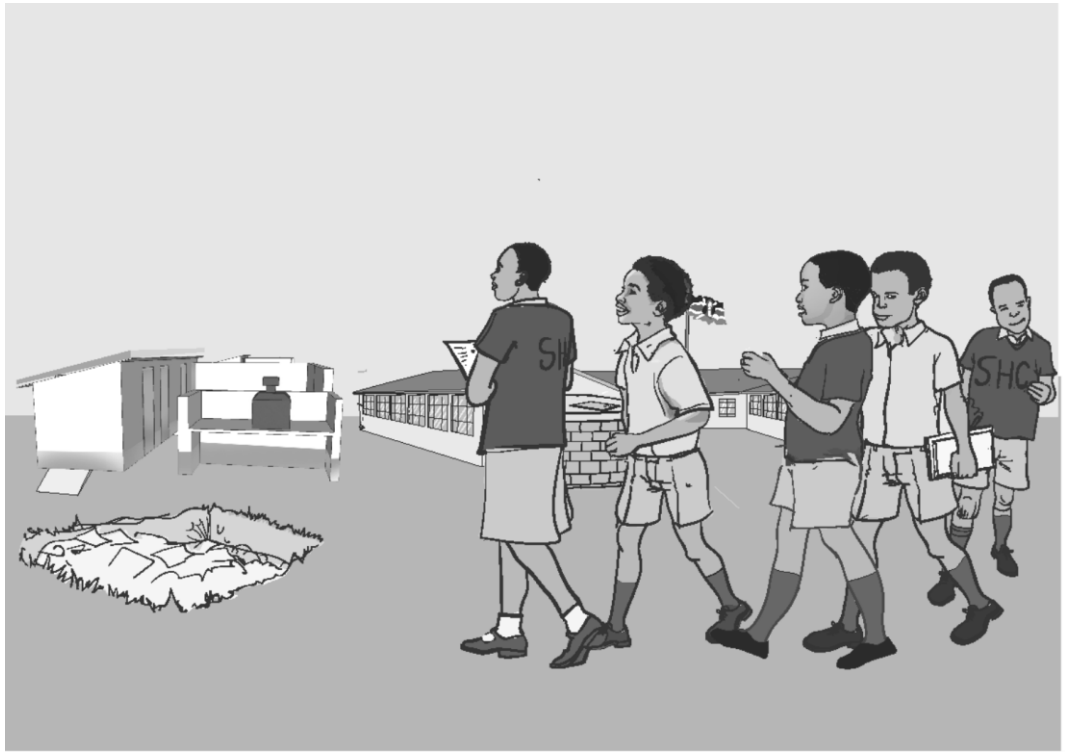


Image source: School Health Club Poster, Caritas Switzerland, 2017

5.8_Supervision of WASH facilities

OUTDOOR ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to make students responsible and play a more active role in the maintenance of WASH facilities.

Exercise

Some selected students, volunteers or members of the school health club or equivalent if existent, can monitor the status and cleanliness of the WASH facilities in the school with the help of a checklist. Together with a teacher, they can then discuss how to further improve the WASH conditions in their school. This should be done on a regular basis, and should be institutionalized in a cleaning roster.

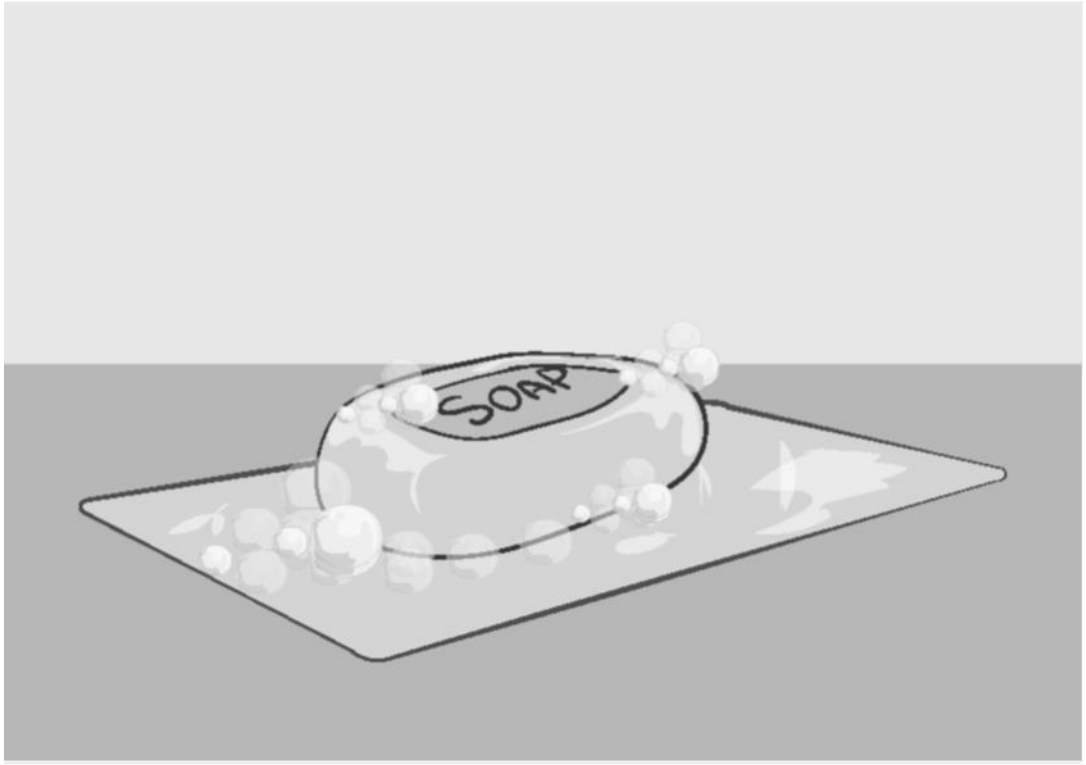


Image source: School Health Club Poster, Caritas Switzerland, 2017

5.9_Soap making

EXPERIMENT

LEVEL: ADVANCED

Teaching Objective

The objective of this activity is for student to learn how to make soap using local materials.

Exercise

A teacher can look for someone in the community who knows how to make soap from local materials to come and teach its members on how to prepare soap. The soap can be used for hand washing in the school. It can be used as a bar or liquid soap filled in a small plastic bottle with a hole in the top. Extra soap can be sold to generate funds for other WASH items such as tissues or sanitary pads. In case making soap is too complicated or if the required materials are not accessible locally, teachers can consider using ashes instead of soap.

Materials needed:

There are 3 key ingredients in soap: oil or fat, lye and water.

1. Oil or fat — beeswax, aloe butter, coconut oil, coffee bean oil, moringa oil, animal fat, palm oil, and shea butter
2. Lye — sodium hydroxide (NaOH) or potassium hydroxide (KOH)
3. Water — bottled, filtered or distilled water

Additional Resources

CAWST

Wikihow – handmade soap

Image source: CLTS handbook

5.10_Glass of water

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this experiment is to realize that open defecation leads to everyone eating each other faeces. By triggering a sense of disgust and shame, students will be urged to change behaviour.

Exercise

Ask for a glass or a bottle of drinking water. When it is brought, offer it to students and ask if they want to drink it. Most likely, they will say yes.
In the meantime, bring some faeces in the middle so that all student can see it. Pull a hair from your head or take a small stick or a blade of grass and then touch the faeces with it so that all can see, and dip the hair in the glass of water. Ask if they can see any thing in the glass of water. Next, offer the glass of water to a student and ask if he wants to drink it. Immediately he/she will refuse. Pass the glass on to others and ask if they could drink. No one will want to drink that water. Ask why they refuse it. They will answer that it contains 'shit'.
Now ask how many legs a fly has. Inform them it has six legs and they are all serrated. Ask them what happens when flies sit on their food and plate: what are they bringing with them from places where open defecation is practiced? Finally ask them what they are eating with their food. When a student says that they are eating one another's shit, bring them to the front to tell everyone. Do not say it before they do. It has to be what they have said as a result of their analysis, not what you have come to tell them.

Materials needed:

- A glass or a bottle of water
- Fresh faeces collected from the surrounding environment

Resource (hyperlinks)

CLTS handbook

Image source: School Health Club Poster, Caritas Switzerland, 2017

5.11_Organizing events

PARTICIPATORY ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of these events is to reach out to parents and the broader community and demonstrate good hygiene and sanitation practices.

Exercise

Some selected students, volunteers or members of the school health club or equivalent if existent, can develop songs, dramas, poems or a quiz on H&S and present them to the other students, before, during or after classes to sensitize them on good hygiene practices.

The songs, dramas and poems can also be performed during:

- Celebrations of global WASH days*;
- Parents' days;
- Interclass or interschool competitions;
- Visits to the adjacent villages.

Important global WASH days:
22/03: World Water Day
28/05: Menstrual Hygiene Day
15/10: Global Hand Washing day
19/11: World Toilet Day

Image source: School Health Club Poster, Caritas Switzerland, 2017

5.12_Visit to the community

PARTICIPATORY ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to reach out to parents and the broader community and demonstrate good hygiene and sanitation practices.

Exercise

Some selected students, volunteers or members of the school health club or equivalent if existent, can visit adjacent villages to pass hygiene messages to the community, as well as to children who do not come to school. They can use dramas, songs, poems and practical demonstrations such as proper hand washing, collection of waste or to demonstrate the construction of a tippy-tap and how it is used.

Image source: School Health Club Poster, Caritas Switzerland, 2017

5.13_Handwashing routine

DISCUSSION

LEVEL: SIMPLE

Teaching Objective

The purpose of this discussion is to institutionalize the practices of hand washing at key moments during the school day.

Exercise

Teachers, with their class, can introduce systematic handwashing, before eating and/or after the break, with all students. Another way to institutionalize handwashing is by starting every day by a word related to good hand washing practices and carrying out, with the students, systematic monitoring of the WASH facilities.

Image source: CHAST

5.14_Demonstration of good practices

DISCUSSION

LEVEL: SIMPLE

Teaching Objective

Good hygiene practices is more than only hand washing. The objective of this activity is to demonstrate other good hygiene practices such as latrine use, tooth brushing, and face washing exercise for students to practice at school but also at home.

Required material

Tooth brush or wood stick, soap, water, piece of clothes for dying.

Additional Resources (hyperlinks)

CHAST, Caritas Switzerland

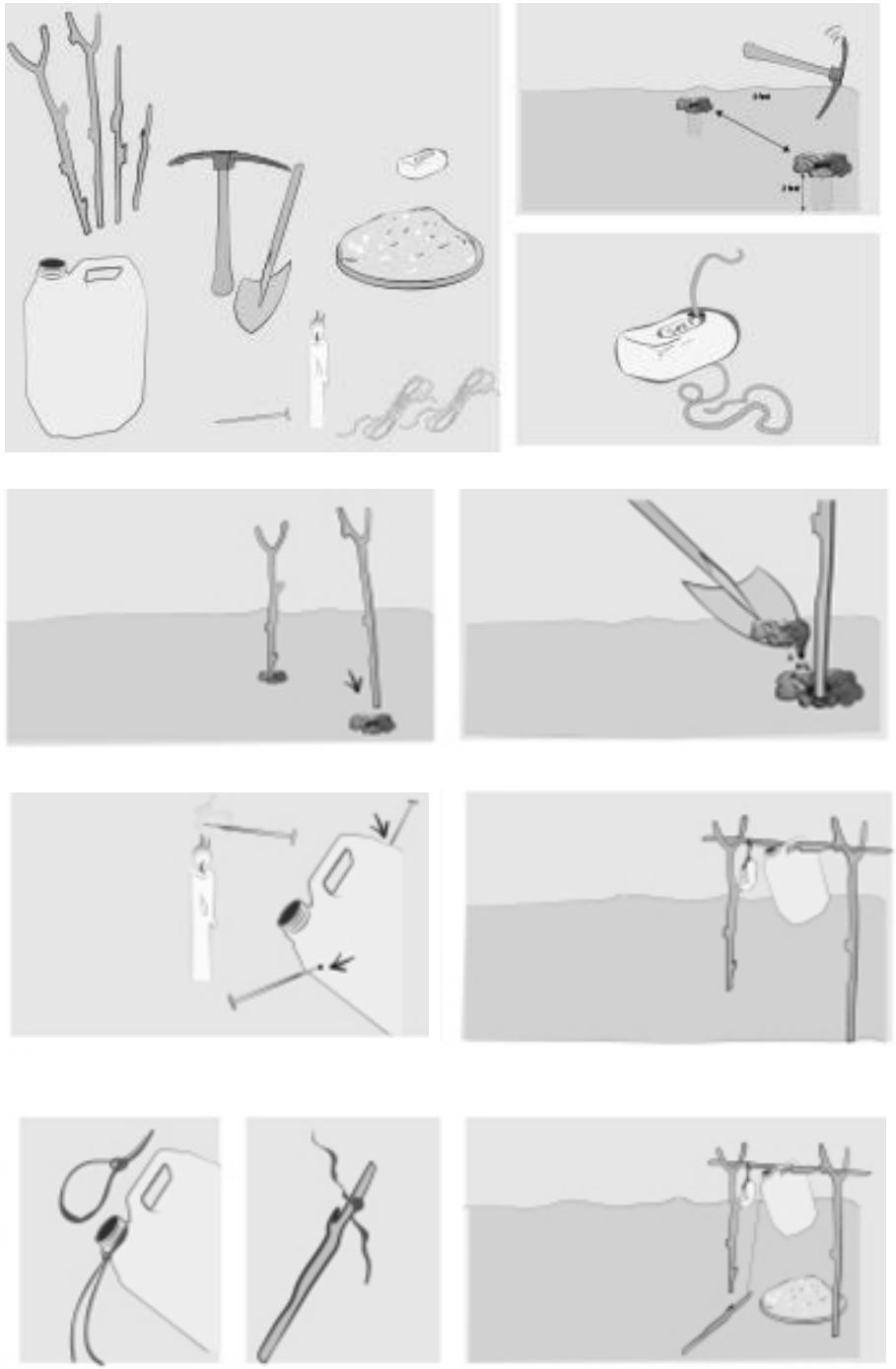


Image source: School Health Club Poster, Caritas Switzerland, 2017

5.15_Construction of tippy tap

OUTDOOR ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is for students to learn how to construct a simple handwashing facility using local materials, and to replicate it at home.

Exercise

Students can learn how to construct it in school and afterwards teach their families.

Materials needed to build a tippy-tap:

- Two pieces of 2 meters forked sticks;
- Two pieces of 1m straight sticks ;
- One water container;
- One nail;
- One candle/matches;
- Two strings.

Additional Resources (hyperlinks)

Tippytap.org

WASHplus

Topic 6_Growth and Change

To call women the weaker sex is libel
Mahatma Gandhi

This topic is about encouraging students to be respectful about gender differences, particularly during puberty and adolescence, to respect gender equality between the sexes, the importance of avoiding gender stereotyping and learning that all children have an equal right to education. The exercises in this topic are selected to help students:

- To understand the changes for both boys and girls in puberty: it is part of growing up and is a normal process.
- For girls: to learn how to manage menstruation: body hygiene, types of pads available and their disposal.

Image source: https://menengage.org

MENSTRUAL HYGIENE MANAGEMENT

Respecting gender based specificities and needs

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.

Menstruation

Menstruation is a natural process. However, in most parts of the world, it remains a taboo and is rarely discussed, even with family members. Many cultures have beliefs, myths and taboos relating to menstruation. Almost always, there are social norms or unwritten rules and practices about managing menstruation and interacting with menstruating women. Some of these are helpful but others have potentially harmful implications (SWSS).

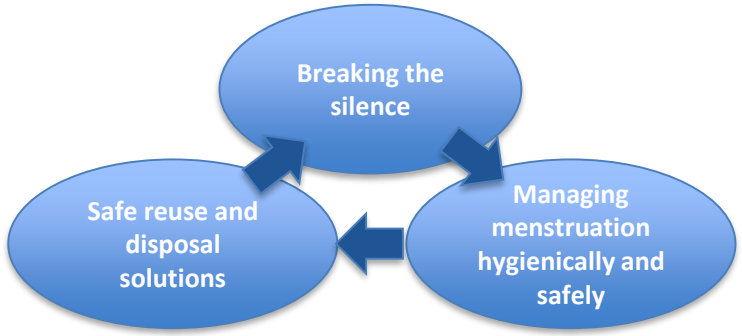
MHM in schools

Many schools do not support adolescent girls or female teachers in managing menstrual hygiene with dignity. Inadequate water and sanitation facilities make managing menstruation very difficult, and poor sanitary protection materials can result in blood-stained clothes causing stress and embarrassment. Teachers (and male members of staff in particular) can be unaware of girls' needs, in some cases refusing to let them visit the latrine. As a result, girls have been reported to miss school during their menstrual periods or even drop out completely.

Nonetheless, schools make a good entry point to talk about menstrual hygiene, to be included or to strengthen the existing curriculum. Students trust their teachers and listen to their advice. Teachers also have more factual and scientific knowledge to break taboos and bring about the fact that menstruation is a normal process in life.

A sound approach of MHM

The Water Supply and Sanitation Collaborative Council (WSSCC) developed a framework for Menstrual Hygiene Management that includes three interlinked dimensions of managing menstruation hygienically:



1. **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.

2. **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.

3. **Safe reuse and disposal solutions** – ensuring mechanisms for safe reuse, collection and disposal of menstrual waste in an environmentally safe manner. Disposal can actually involve a number of steps in the waste disposal chain, particularly when a girl is in a school where sanitary materials are collected for disposal.

In schools (and other public places), the waste chain includes:

- A discrete, washable container with lid, where sanitary materials can be temporarily stored in.
- Collection, transfer and empting of the containers.
- Final destruction of the sanitary materials through burying, incineration or other method.

MAIN SOURCE: *Esther Lowe-de Vreede, Caritas Switzerland*

Image source: Dreams time

6.1_Handprint circle

CREATIVE ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The purpose of this activity is to encourage students to demonstrate principles of equality and awareness of how to get along with students different from themselves.

Exercise

Children can trace and cut out a handprint in a colour of their choosing that can be used to create a classroom display, such as a handprint wreath that combines all their classmates' hands in one wreath of equality. Children can also make stick or paper bag puppets to tell stories of how they can get along with and show respect for someone who is different.

Required Materials

construction paper | scissors | crayons or paint

6.2_Equality quiz

GAME

LEVEL: SIMPLE

Teaching Objective

The purpose of this game is to encourage students to demonstrate their understanding of the difference between fact and opinion around issues of gender.

Exercise

A game structured like a fact and opinion quiz gives children practice at recognizing truth and falsehood in the conscious and unconscious assumptions they make about others. Make cards that display statements such as, “Girls are smarter than boys,” “Girls and Boys should both be educated”, “Girls should fetch Water,” or “All boys are good at sports.” Divide the students into teams and take turns drawing cards and reading them aloud. The other team has 15 seconds to decide if the statement is fact or opinion and tell why for a point. Play as time allows. The team with the highest score at the end wins.

Required Materials

cardstock or paper | pencils or pens

Image source: Clover foundation

6.3_Music equality game

GAME

LEVEL: SIMPLE

Teaching Objective

The purpose of this game is to encourage students to demonstrate good behaviours around issues of equality.

Exercise

Students can quickly focus in on the differences between themselves and others, resulting in a sense of shame or overzealous pride, depending on how they view their own traits. A game of musical diversity can get them thinking more about their similarities. Play some music and allow the students to wander or dance around freely. When the music stops, they have 30 to 60 seconds to grab a partner and find one thing that they have in common.

Required Materials

musical Instrument (or singing) | chairs (or sitting on ground)

Image source: bbc

6.4_Role reversal game

GAME

LEVEL: SIMPLE

Teaching Objective

The purpose of this game is to get the children to take on roles typically associated with the opposite gender. Invite boys to act out carrying water, cooking or looking after children. Invite girls to demonstrate their abilities to do activities that the boys do.

Exercise

Choose 6 students, 3 girls and 3 boys and pair them. Assign an activity that they are each familiar with doing in their daily lives. Have them act out this activity in class. Then ask them to switch activities with their partner and show their ability or willingness to do it. A race could be set up between the girl and boy pair both carrying water to see who spills the least.

Finally, have students share their experiences of the exercise during a class discussion.

Required Materials

none

6.5_Knock down the myth

GAME

LEVEL: SIMPLE TO ADVANCED

Image source: Unicef

Teaching Objective

The purpose of this game is literally to 'knock down' myths surrounding girls and gender discrimination.

Exercise

In this game, taboos against girls are written on pieces of paper. The paper is placed into a plastic bottle and the bottles are placed in the middle of a circle of students. The aim is to use a ball to knock the bottle down and 'knock down the myth'

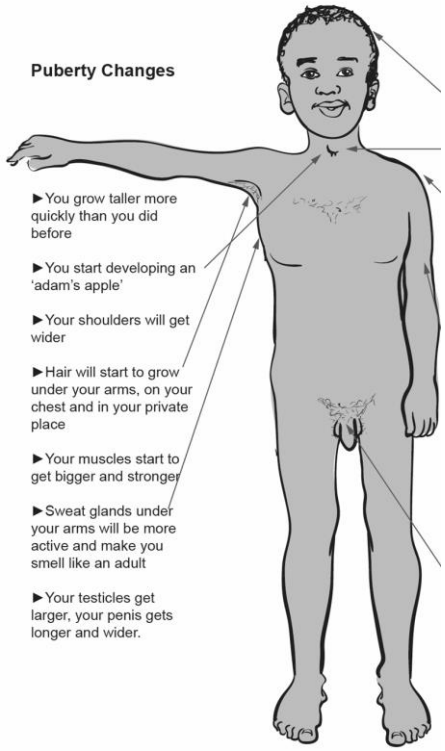
After the game, ask students to share what they have learned.

Required Materials

paper | pencils | plastic bottles | ball

Additional Resources (hyperlinks)

Unicef



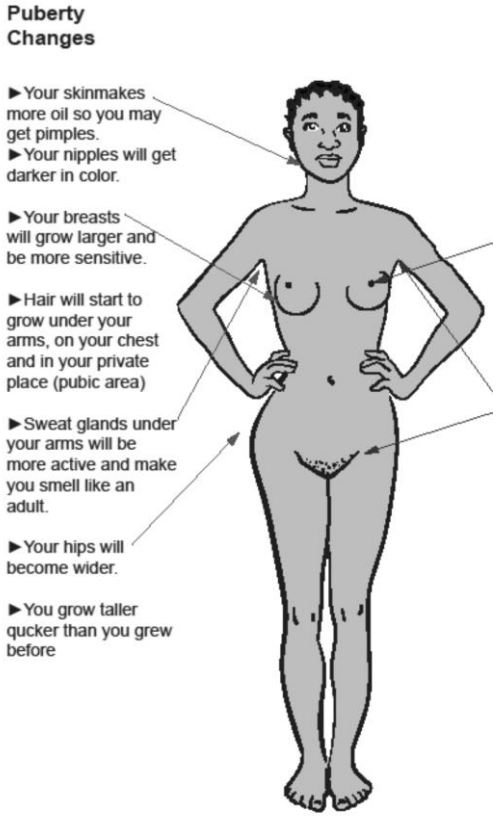


Image source: CHAST

6.6_As we grow up

DISCUSSION
LEVEL: ADVANCED

Teaching Objective
The purpose of this session is to discuss the changes that occur during adolescence to boys & girls and to describe the functional difference of the reproductive organs of boys and girls

Exercise
Define adolescence and when it starts.
Discuss both the physical and emotional changes that occur in boys & girls.
Discuss the changes that are similar and those that are different, comparing boys & girls. Highlight that the first wet dream for boys is called semenarche and the first period for girls is called menarche.
Draw the reproductive organs and discuss their functions.

Required Materials
Chalk | blackboard

Additional Resources (hyperlinks)
WSSCC
CHAST, Caritas Switzerland

6.7_My menstrual cycle

DISCUSSION
LEVEL: ADVANCED

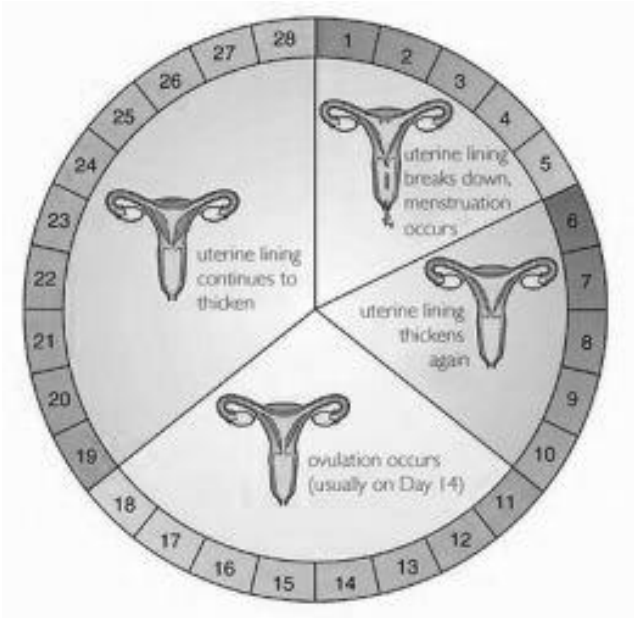


Image source: CHAST

Teaching Objective
The purpose of this discussion is to enable the girls to understand the different stages of the menstrual cycle.

Exercise
The teacher introduces the fact that every girl's cycle is different.

The teacher can draw the uterus and guide the students to discuss what happens at each stage of the menstrual cycle:

- The fact that the uterus is connected to the ovaries by fallopian tubes. Girls receive their first period (menarche) when an egg in one of the ovaries matures. This can happen between the ages of 8 and 19 years.
- Typically, one egg matures every cycle. Once mature, the egg is released from the ovary and passes through the fallopian tube. As the egg passes through the tube, the lining of the uterus thickens.

Required Materials
Chalk | Blackboard | Menstrual wheel (download)

Additional Resources (hyperlinks)
WSSCC

6.8_Keeping my menstrual cycle calendar

DISCUSSION

LEVEL: ADVANCED

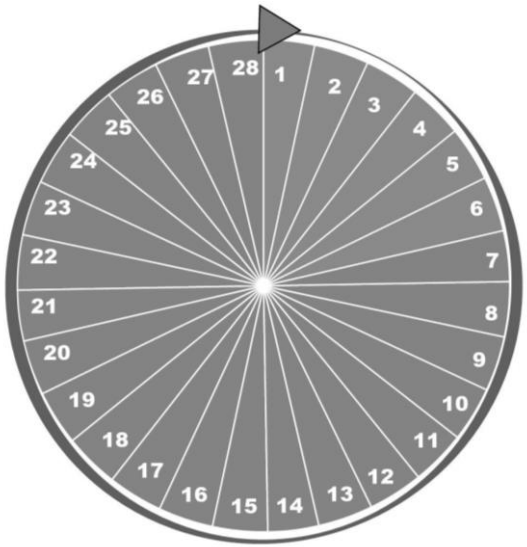


Image source: CHAST

Teaching Objective

The purpose of this discussion is to enable the girls to understand that each girl's cycle is unique. Every girl needs to know the length of their cycle including how many days in each cycle she gets her period. This is not for family planning purposes (e.g. counting safe days) rather so that she is able to have menstrual material ready for use in good time. This is also important so that they monitor how their cycle changes and are able to note when they need to see a doctor e.g. if they do not get periods for multiple cycles or if their cycle changes dramatically e.g. very heavy bleeding, very painful cramps etc.

Exercise

Ask the girls to keep a calendar. They need to record for at least 6 months, taking note of the first & last days of each cycle. The teacher can use the example of a 28 day cycle to explain, but after 6 months, each girl will know how long her cycle is on average.

Required Materials

Calendars and pens

Additional Resources (hyperlinks)

CHAST, Caritas Switzerland

6.9_Reusable pad making workshop

PARTICIPATORY ACTIVITY

LEVEL: MEDIUM

Image source: Perals from Africa

Teaching Objective

The purpose of this activity is to engage both male and female students in the importance of menstrual hygiene management and provide all students with the skill of being able to make reusable pads.

Exercise

Organize a student workshop for making reusable pads. Guidelines and detailed instructions can be found in the links provided below.

Required Materials

fabric | scissors | threads | sewing machines (ideal but not mandatory)

Additional Resources (hyperlinks)

SSWM Unicef Wikihow.com

Image source: Menstrupedia

6.10_Disposal

DISCUSSION
LEVEL: MEDIUM

Teaching Objective
The purpose of this discussion is to discuss how to safely & hygienically dispose menstrual waste i.e. soiled menstrual material

Exercise
1. The teacher can ask the girls to draw a map of the school & draw where they have seen or think soiled menstrual material being disposed off.
2. The teacher leads a discussion on the importance of disposing safely & hygienically e.g. to keep the environment clean.
3. The teacher and the girls go to the toilets and the teacher demonstrates how to use the disposal facilities available e.g. bins.

Additional Resources (hyperlinks)
Menstrupedia

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

This topic is about encouraging students to understand the processes associated with growing food, the importance of retaining and replanting trees, and the need for healthy soil, what causes it to become degraded, and what are the methods for returning nutrients to it. The exercises in this topic are selected to help students:

- To apprehend he crucial role of biodiversity and sustainable agriculture technique sin our food growing systems.
- To recognize the importance of trees in supporting the watershed and food production.
- To observe soil composition and its connection with plants and water.

Image source: [illegible]

Topic 7_Technical Background

As the human population has expanded, more and more land has been cleared for agriculture and other pursuits that degrade the soil and make erosion more likely to occur. This in turn has a detrimental effect on biodiversity—the ability of plants, animals, insects and humans to work together for healthy soil.

AGRICULTURE

When agriculture fields replace natural vegetation, topsoil is exposed and can dry out. The diversity and quantity of microorganisms that help to keep the soil fertile can decrease, and nutrients may wash out. Soil can be blown away by the winds or washed away by rains.

DEFORESTATION

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.

OVERGRAZING

The conversion of natural ecosystems to pasture land doesn't damage the land initially as much as crop production, but this change in usage can lead to high rates of erosion and loss of topsoil and nutrients. Overgrazing can reduce ground cover, enabling erosion and compaction of the land by wind and rain.. This reduces the ability for plants to grow and water to penetrate, which harms soil microbes and results in serious erosion of the land.

USE OF AGROCHEMICALS

Pesticides and other chemicals used on crop plants have helped farmers to increase yields. Scientists have found that overuse of some of these chemicals changes soil composition and disrupts the balance of microorganisms in the soil. This stimulates the growth of harmful bacteria at the expense of beneficial kinds.

The loss of fertile soil makes land less productive for agriculture, creates new deserts, pollutes waterways and can alter how water flows through the landscape, potentially making flooding more common.

DESERTIFICATION

Desertification can be characterized by the droughts and arid conditions the landscape endures as a result of human exploitation of fragile ecosystems. Effects include land degradation, soil erosion and sterility, and a loss of biodiversity, with huge economic costs for nations where deserts are growing.

LOSS OF ARABLE LAND

Arable land is any land that can be used to grow crops. Many of the practices used in growing those crops can lead to the loss of topsoil and destruction of soil characteristics that make agriculture possible.

CLOGGED AND POLLUTED WATERWAYS

Soil eroded from the land, along with pesticides and fertilizers applied to fields, washes into streams and waterways. This sedimentation and pollution can damage freshwater and marine habitats and the local communities that depend on them.

INCREASED FLOODING

Land is often transformed from a forest or other natural landscape, such as floodplains and wetlands, into a crop field or pasture. The converted land is less able to soak up water, making flooding more common. There are methods to improve soil water holding capacity as well as restoration and maintenance of wetlands. (worldwildlife.org).

Topic 7_Technical Background

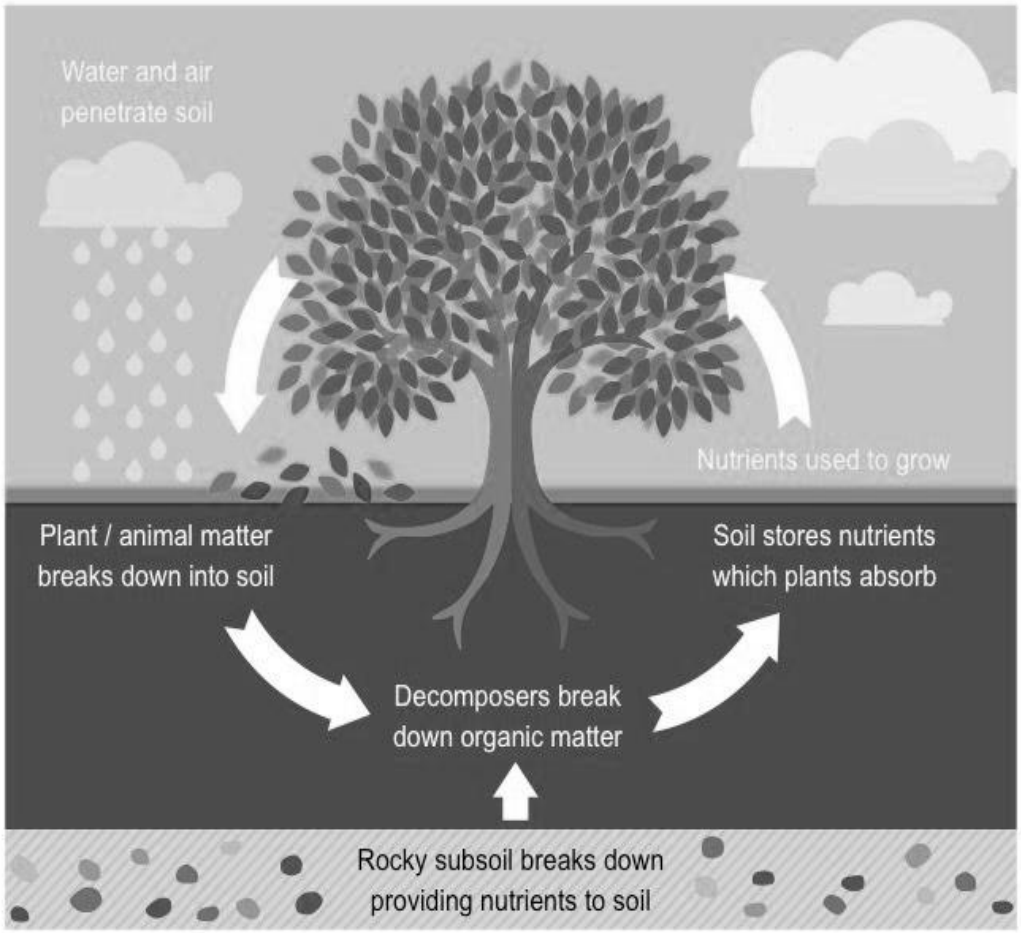


Image source: http://ib.bioninja.com.au

THE NUTRIENT CYCLE

Alongside the water cycle, another cycle is fundamental to life. It is called the Nutrient Cycle. Nutrient cycling is one of the most important processes that occur in an ecosystem. The Nutrient Cycle describes the use, movement, and recycling of nutrients in the environment.

Global and local cycles

The biosphere is a network of continually recycling materials. There are two main types of cycles: global cycles and local cycles. Elements such as carbon, nitrogen, oxygen, and hydrogen are recycled through abiotic environments including the atmosphere, water, and soil. Since the atmosphere is the main abiotic environment from which these elements are harvested, their cycles are of a global nature. These elements may travel over large distances before they are taken up by biological organisms. The soil is the main abiotic environment for the recycling of elements such as phosphorus, calcium, and potassium. As such, their movement is typically over a local region.

Why are nutrients so important?

Just like we need to eat to have energy for our daily activities, aside from water, plants depend on the availability of nutrients in order to grow. Valuable elements such as carbon, oxygen, hydrogen, phosphorus, and nitrogen are essential to life and must be recycled in order for organisms to exist.

Composting within agricultural systems capitalises upon the natural services of nutrient recycling in ecosystems. Bacteria, fungi, insects, earthworms, bugs and other creatures dig and digest the compost into fertile soil. The minerals and nutrients in the soil is recycled back into the production of crops.

Image source: www.greendots.ch, Burkina Faso

Topic 7_Technical Background

"You never feed the plants. You feed the soil creatures."
Geoff Lawton
Permaculture Research Institute Australia

SOIL

Soil is the earth's fragile skin that anchors all life on Earth. It is comprised of countless species that create a dynamic and complex ecosystem and is among the most precious resources to humans. Increased demand for agriculture commodities generates incentives to convert forests and grasslands to farm fields and pastures. The transition to agriculture from natural vegetation often cannot hold onto the soil and many of these plants, such as coffee, cotton, palm oil, soybean and wheat, can actually increase soil erosion beyond the soil's ability to maintain itself.

Half of the topsoil on the planet has been lost in the last 150 years. In addition to erosion, soil quality is affected by other aspects of agriculture. These impacts include compaction, loss of soil structure, nutrient degradation, and soil salinity. These are very real and at times severe issues.

The effects of soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which can worsen flooding. Sustainable land use can help to reduce the impacts of agriculture and livestock, preventing soil degradation and erosion and the loss of valuable land to desertification.

The health of soil is a primary concern to farmers and the global community whose livelihoods depend on well managed agriculture that starts with the dirt beneath our feet. While there are many challenges to maintaining healthy soil, there are also solutions and a dedicated group of people, including WWF, who work to innovate and maintain the fragile skin from which biodiversity springs. (worldwildlife.org)

It's the microbes and the bacteria that do all the main work in fostering soil fertility. The only effort required is to apply some regular soil mulch and good compost and then allow time to have nature break it all down.

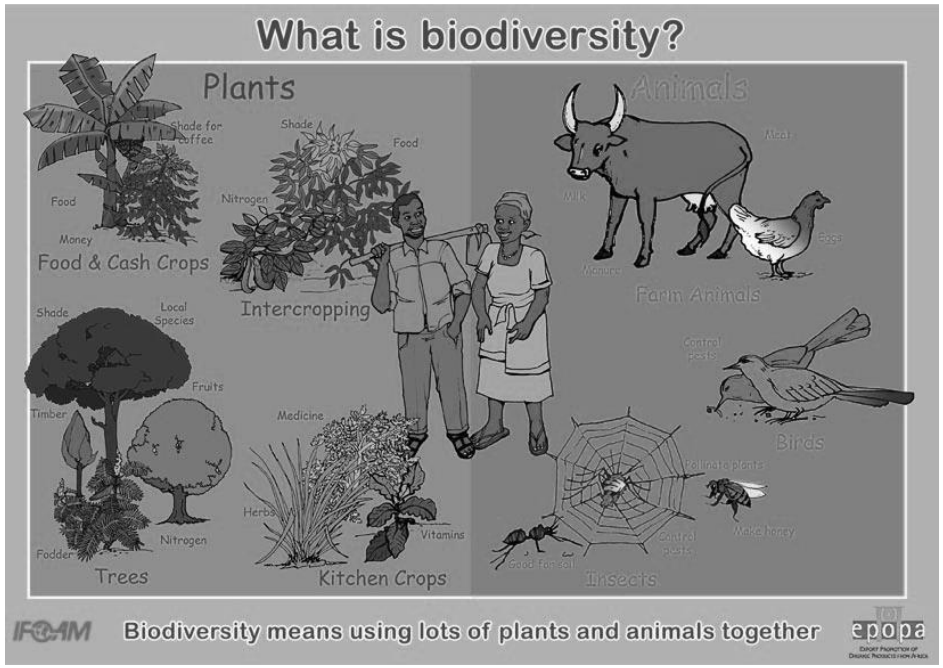
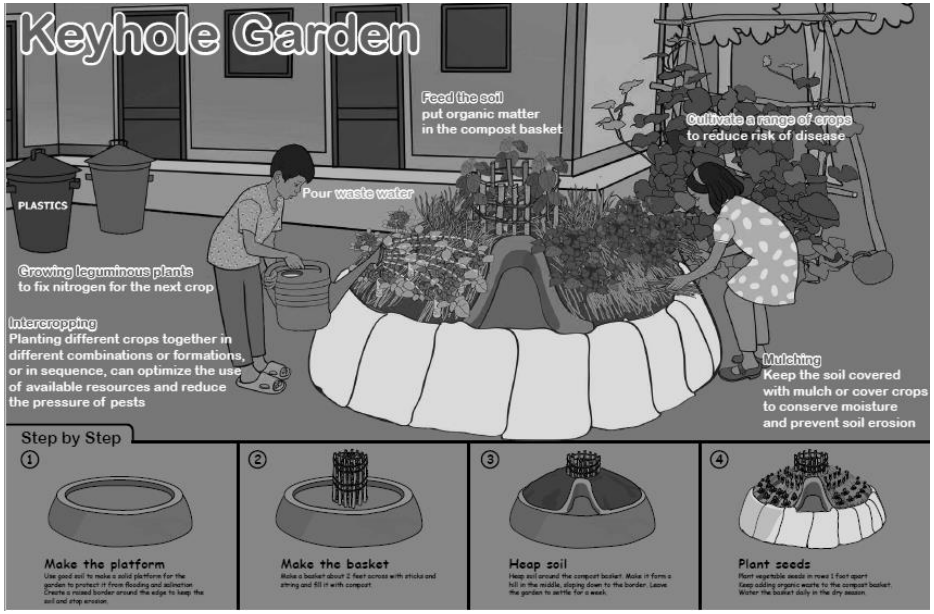


Image source: www.fourthway.co.uk



LOW EXTERNAL INPUT SUSTAINABLE AGRICULTURE (LEISA) and ORGANIC AGRICULTURE

The problems stated in the previous slides are important. But there are solutions to progressively restore degraded landscapes. Despite the remaining challenges, adopting sustainable practices for food production is possible and has proven effective and productive in many different countries and settings all over the world.

LEISA and organic agriculture are both examples of those new paradigms for agriculture, food production and farming systems. They represent not only a viable alternative to industrial agriculture, but maybe also a real hope, if not the only hope, for a positive and abundant future for humanity on this planet. Today, one important approach for implementing organic agriculture principles is permaculture design.

LEISA and permaculture, although not entirely the same, share common key strategies:

- The maximum use or sharing of local resources available on the homestead and the community (tangible assets, vegetation, animals, manual labour, knowledge, etc.);
- The aim to reduce as much as possible dependence toward external resources (such as energy, water, seeds and agro-chemicals) for health, ecological and economical reasons;
- The will to reduce waste;
- The importance of observing, assessing the needs, planning ahead and designing the food production systems to maximize their efficiency and minimize their environmental impacts;
- The importance of interacting with and accepting feed-back from the system, as a guidance to operate necessary changes;
- The utmost respect for the surrounding natural ecosystems (forests, watersheds, etc.) which support all life on Earth, including ours as humans.

FURTHER RESOURCES

Farming Matters, magazine on agro-ecology and LEISA:
REIJNTIES, c.., et al, Farming for the future: an introduction to LEISA, 1992
HOLMGREN, D., Permaculture: principles and pathways beyond sustainability", 2002
MOLLISON, B., Permaculture: a designer's manual, 1988

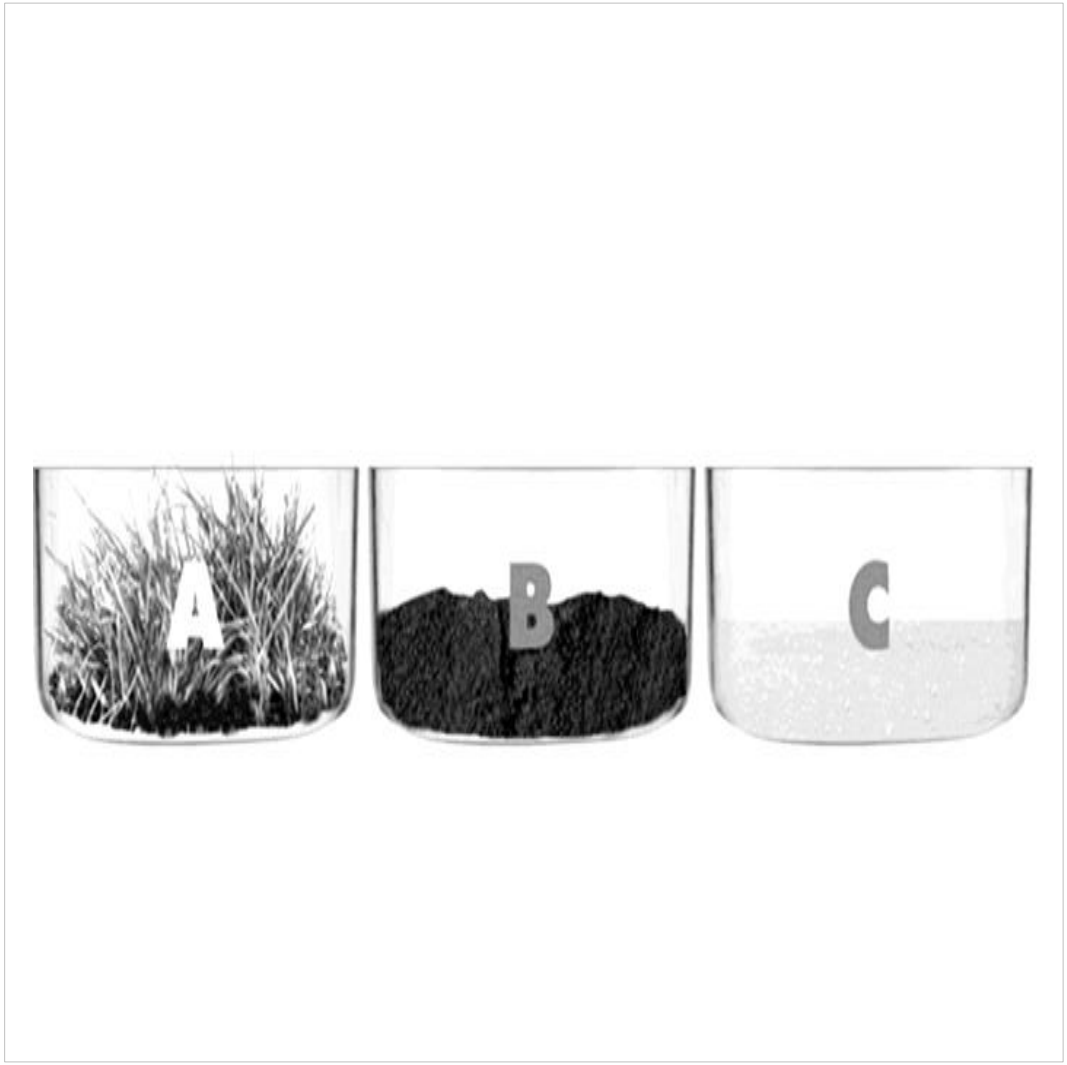


Image source: Farmcreditknowledgecenter

7.1_Evaporative loss

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this experiment is to encourage students to understand the principle of evaporative loss and how plants in the soil help to retain water in the soil.

Exercise

Select 3 open topped glass containers. Fill the first container with soil with grass, weeds, or plants (fill with water to top of soil without drowning plants). Fill the second container with soil and add the same amount of water as added to the first container. Fill the third container with an equal amount of water. Weigh each container and then place the containers in a sunny spot. Weigh each container once a day and examine any changes. Use a ruler and measure the water line along the side of each container. Use tape or a marker to show where the water line is and to compare day to day changes. Watch for at least one week. Additionally, students can also try to fill a fourth container (B') with a mix of 50% top soil 50% compost and compare the difference with the B container to show the water holding capacity of an organically rich soil.

Required Materials

3 glass containers | water | soil | grass | a scale

Image source: Farmcreditknowledgecenter

7.2_Soil erosion

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this experiment is to make the process of soil erosion visible to students and demonstrate that the less ground cover there is and the more exposed the soil, the worse the soil erosion and nutrient loss is.

Exercise

Start by cutting the top off of the milk jug or other container (be sure to leave the spout part of the bottle attached). Do this for all three containers. Fasten all three containers to your board. Fill all three with soil to just below the level of the spout. Plant grass seed or put your established plants in one of the containers. Cover a second one with the ground cover. Leave the third bare…they should look similar to this when you are done. To demonstrate soil erosion, make sure they are on a slightly elevated surface. You can either place clear containers under each of the spouts, or you can have a student hold the container as you go through the exercise. Measure out 2 cups of water (this may need to be adjusted depending on the size of the containers holding the soil). Put the water in the watering can, and then "water" the container with the bare soil. Measure out another 2 cups of water and repeat the process by "watering" the container with ground cover. Measure out a final 2 cups and "water" the container with the plants. Then discuss with students the difference in the "run off" from each of the three containers, emphasizing the loss of nutrients increases with the loss of ground cover and plants.

After this experiment, take a walk in the area surrounding your school and spot signs of erosion. Discuss the extent, the causes and the possible solutions of soil erosion occurring around you.

Required Materials

3 different large plastic containers with lids | a board or other flat surface large enough to hold all three containers | soil | grass seed or already established plants | leaves, twigs and other ground cover | three clear containers that can hold water | a measuring cup | a small watering can ideally with a sprinkler head

Natural Factors Affecting Soil Erosion

- *Heavy rains on weak soil: rain drops loosen soil particles and water transports them down hill*
- *Vegetation depleted by drought: rain drops are free to hit the soil, causing erosion during rainfall; winds blow away the fine particles during droughts*
- *Steep slopes: gravity "pulls harder;" water flows faster; soil creeps, slips, or slumps downhill*
- *Sudden climate change*
- *Rainfall: erosion increases unexpectedly rapidly as rainstorms become more severe*
- *Drought: water dries up and the soil becomes a play ball of winds; soil biota die; a sudden rain causes enormous damage*
- *Changing winds: areas previously sheltered become exposed*

Human-induced Factors

- *Changing the land by cutting down trees and deforesting it. The land loses its cover, then its soil biota, porosity, and moisture. Healthy top soil runs away and plants won't grow well.*
- *Intensive farming: the plough, excessive fertilizer, and irrigation damage the land often permanently*
- *Unsustainable management of waste, leading to contamination of the ground.*
- *housing development: soil is bared; massive earthworks to landscape the subdivision; soil is on the loose*
- *road construction: roads are cut; massive earthworks, leaving scars behind; not enough attention paid to rainwater flow and maintenance of roadsides*

7.2.1 _Soil erosion supplement

DISCUSSION

LEVEL: SIMPLE

Teaching objectives

The purpose of this discussion is to convey to the students what soil erosion is, so that they understand that while it is a natural process it is now happening at alarming rates, because of the way human beings are using their environment unsustainably.

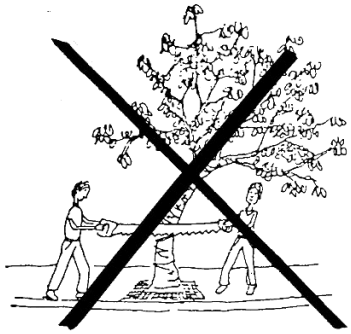
Exercise

Explain to the students how ocean waves, rivers, wind, rainwater, and ice, shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers. Soil is formed in the break own of organic and inorganic materials, sediments of sand, and smaller particles, sometimes containing the remains of organisms. Soil erosion is a natural process that occurs on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year. Soil erosion and degradation are now so severe worldwide that our ability to grow food is being threatened. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of topsoil. The loss of soil from farmland may be reflected in reduced crop production potential, lower surface water quality, and damaged drainage networks. The rate and magnitude of soil erosion by water is controlled by these factors: rainfall intensity and runoff, soil erodibility, slope gradient and length, and vegetation. (Benchmarks for Science Literacy)

Required Materials

none

Image source: http://www.astorialic.org/ | wisegeek.com



7.3_Deforestation

DISCUSSION

LEVEL: SIMPLE

Teaching Objective

The purpose of this discussion is to convey to the students the fact that deforestation, the unsustainable cutting down of trees, makes soil dry out, erode in the rain – and eventually causes decrease in rainfall.

Exercise

Conduct a discussion with the students based around the following facts: Deforestation is when forests are destroyed by cutting of trees and not replanted. Sometimes deforestation happens when people change the land into farms, pasture land and cities. A lot of deforestation is caused by the removal of all the trees from a forest for wood or fuel. An estimated 18 million acres (7.3 million hectares) of forest, which is roughly the size of the country of Panama, are lost each year, according to the United Nations' Food and Agriculture Organization. The loss of trees, which anchor the soil with their roots, causes widespread erosion throughout the tropics. Only a minority of areas have good soils, which after clearing are quickly washed away by the heavy rains. When forests are cleared or burnt, stored carbon is released into the atmosphere, mainly as carbon dioxide. Deforestation accounts for around 18% of all global greenhouse gas emissions due to human activities. It is a major contributor to global warming. Forests are vital for life, home to millions of species, they protect soil from erosion, produce oxygen, store carbon dioxide, and help control climate. ... Deforestation by humans is causing all of these necessary functions to be lessened, and hence damaging the atmosphere even further. (FAO)

Encourage students to imagine solutions that limit tree cutting and deforestation, i.e. on appropriate tree species to plant, agro-forestry or simple traditional techniques such as tree trimming (both pollarding or coppicing).

Required Materials

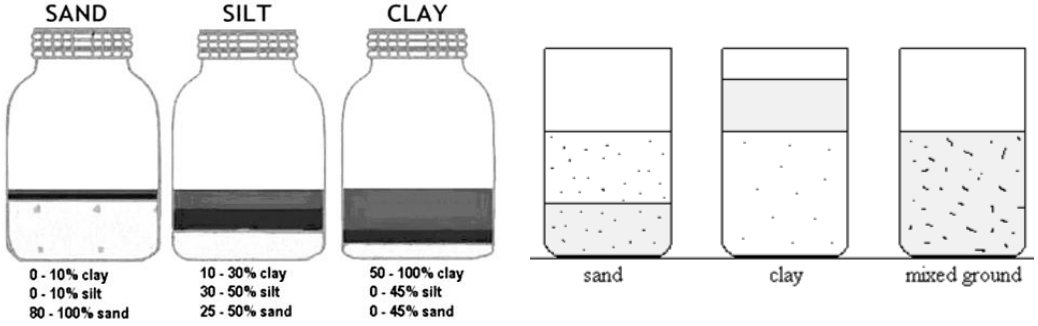
none

7.4_Soil shaking

EXPERIMENT

LEVEL: SIMPLE

Image source: pinterest



Teaching Objective

The purpose of this experiment is to familiarize students with the composition of soil in their area, and the types of soil that are best for growing plants.

Exercise

Collect a local soil sample. Fill a large clear glass jar halfway with the soil sample. Fill the remaining half of the jar with water, leaving 1" of air. Attach the lid and then shake the jar vigorously until the lumps of soil have broken up. Put the jar in a place where it can rest undisturbed overnight. After 24 hours, the jar's contents will have settled into distinct layers, SILT, CLAY and SAND. By examining the relative proportions of these layers you can gain a sense of the type of soil in your environment. Repeat this experiment with soils from different areas of varying quality (including soil from a garden where healthy plants are growing).

Remark

Except in naturally occurring soils, such as in untouched forests, it is very rare, if not impossible, to find a "perfect combination" of silt, clay, sand and organic matters. But most of the time, you can improve the soil's structure by adding compost (and mulch) where you want to grow a garden.

Required Materials

glass jar with lid | water | local soil sample

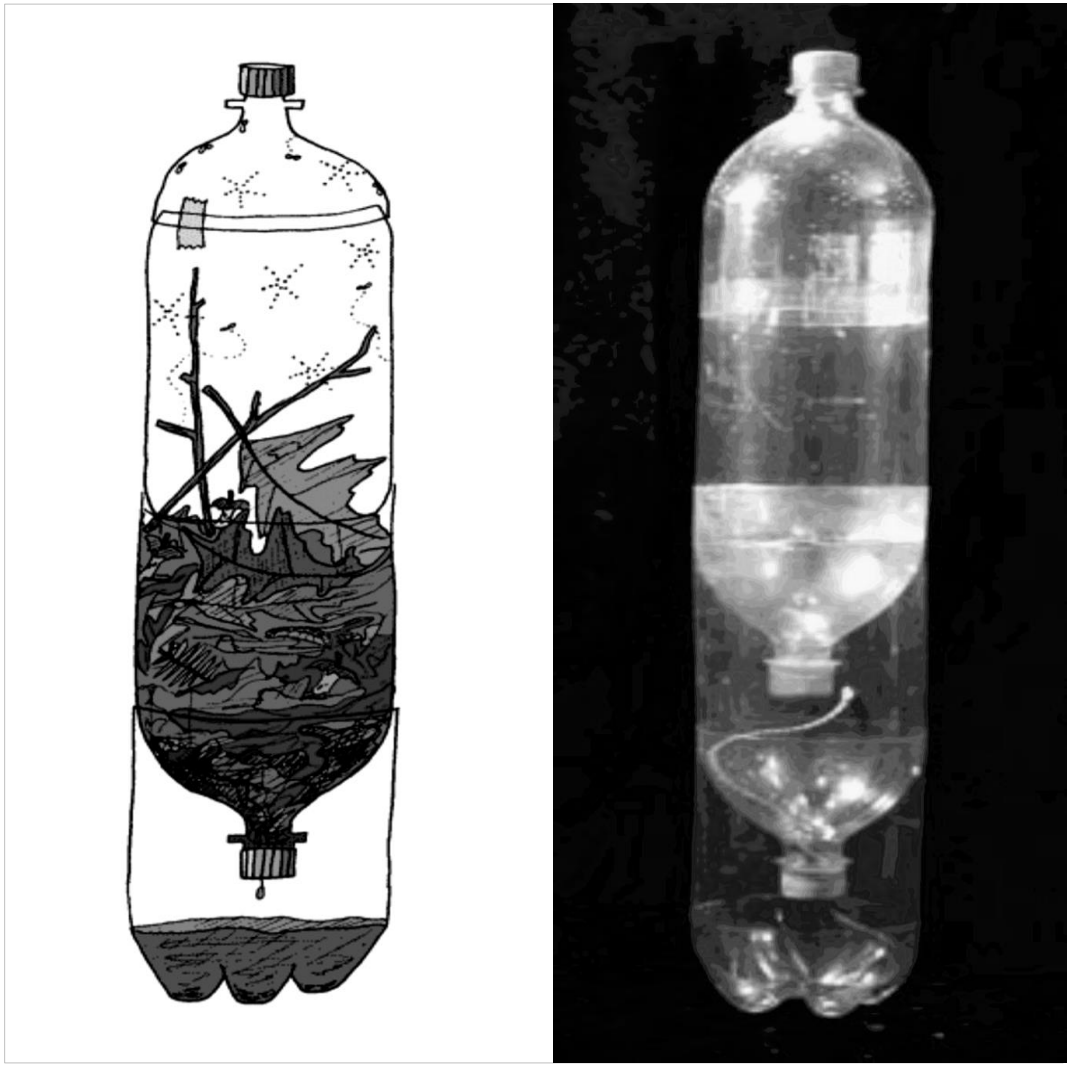


Image source: Bottle Biology

7.5_Decomposition column

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this experiment is to encourage students to understand the process of decomposition in the formation of compost, as well as the problem of non-biodegradable materials such as plastic in the environment

Exercise

Invite the students, either individually or as a group, to construct a decomposition bottle. The decomposition column can be thought of as a miniature compost pile or landfill, or as leaf litter on a forest floor. Through the sides of the bottle students can observe different substances decomposing and explore how moisture, air, temperature and light affect the process. Many landfills seal garbage in the earth, excluding air and moisture. How might this affect decomposition? Will a foam cup ever rot? What happens to a piece of fruit, or tea bag? Do banana peels decompose more quickly or slowly than leaves? Does adding layers of soil to the column affect the decomposition process? What happens to plastic? Invite the students to choose what they would like to see decomposing.

Main source (hyperlinks)

Bottle biology

Required Materials

2 PET bottles | scissors | organic materials from local environment

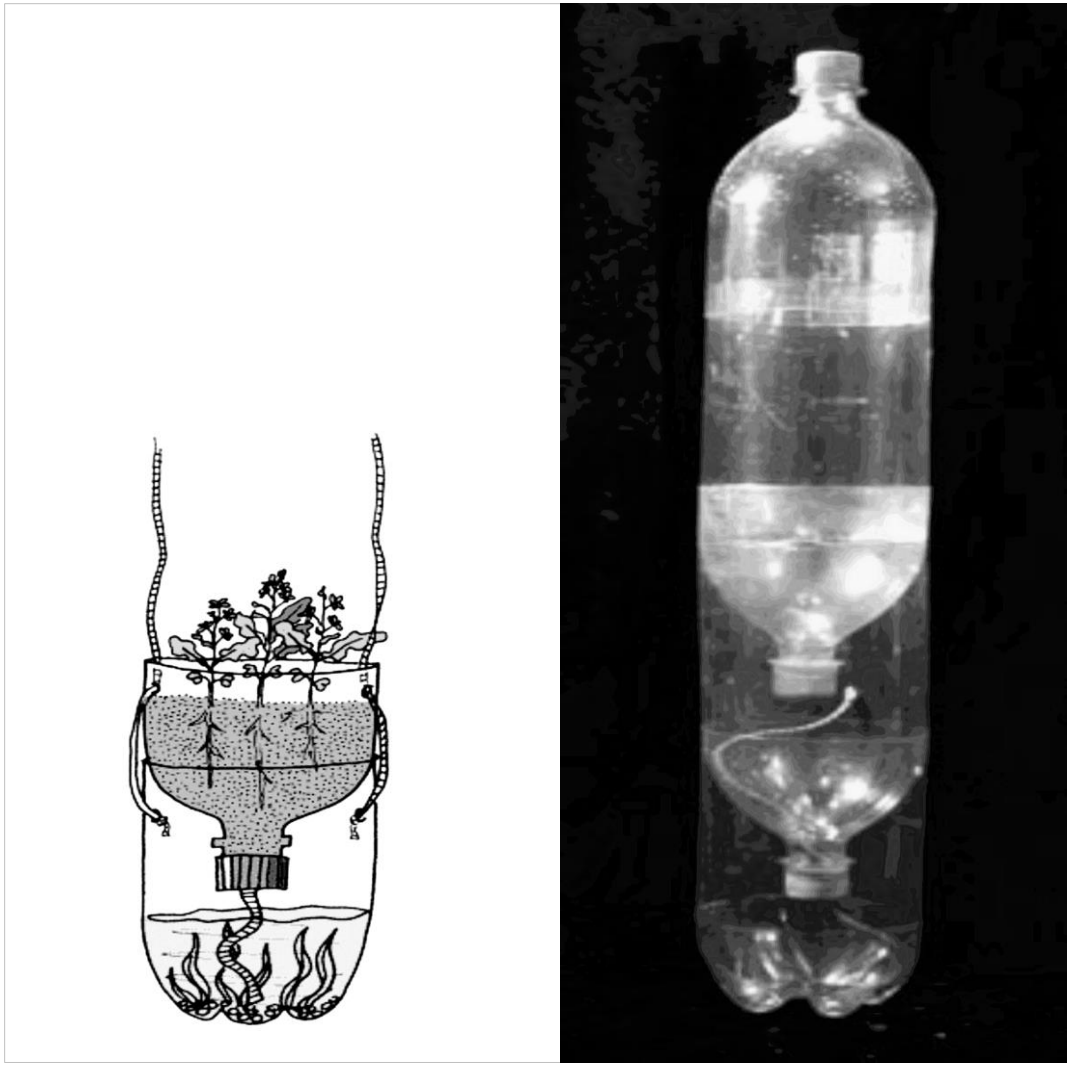


Image source: Bottle Biology

7.6_Terra-Aqua column

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this experiment is to familiarize students with the organic processes that take place between land and water—and how the balance affects their environment. The Terra-Aqua Column provides a student with a model to explore the link between land and water.

Exercise

Water is the common substance that falls from the atmosphere, flows through our bodies, runs through the soil beneath our feet, collects in puddles and lakes, then vaporizes back into the atmosphere in a never-ending cycle. Water, as it cycles between land, ocean and atmosphere, forms the major link between the terrestrial world (anything living on the earth) and the aquatic world (anything living on or in the water). Water drips off rooftops, flows over roads, percolates through the soils of fields and forests and eventually finds its way into rivers, lakes and oceans. During its journey, water will pick up leaf litter, soil, nutrients, agricultural chemicals, road salts and gasoline from cars, all of which have profound impacts on life in aquatic systems. Water can also be filtered or purified as it percolates through soil. The Terra-Aqua Column provides a student with a model to explore the link between land and water. The model has three basic components: soil, water and plants. By varying the treatment of just one of these components you can explore how one variable can affect the whole system. How does salt affect the growth of plants ? How does adding fertilizer to the soil affect algal growth in the water chamber ? What type of soil best purifies water ? Experimentation with the Terra-Aqua Column is practically unlimited. A student can be invited to define a question, and then design an experiment to explore it.

Main source (hyperlinks)

Bottle biology

Required Materials

PET bottle | string | soil and organic materials | water

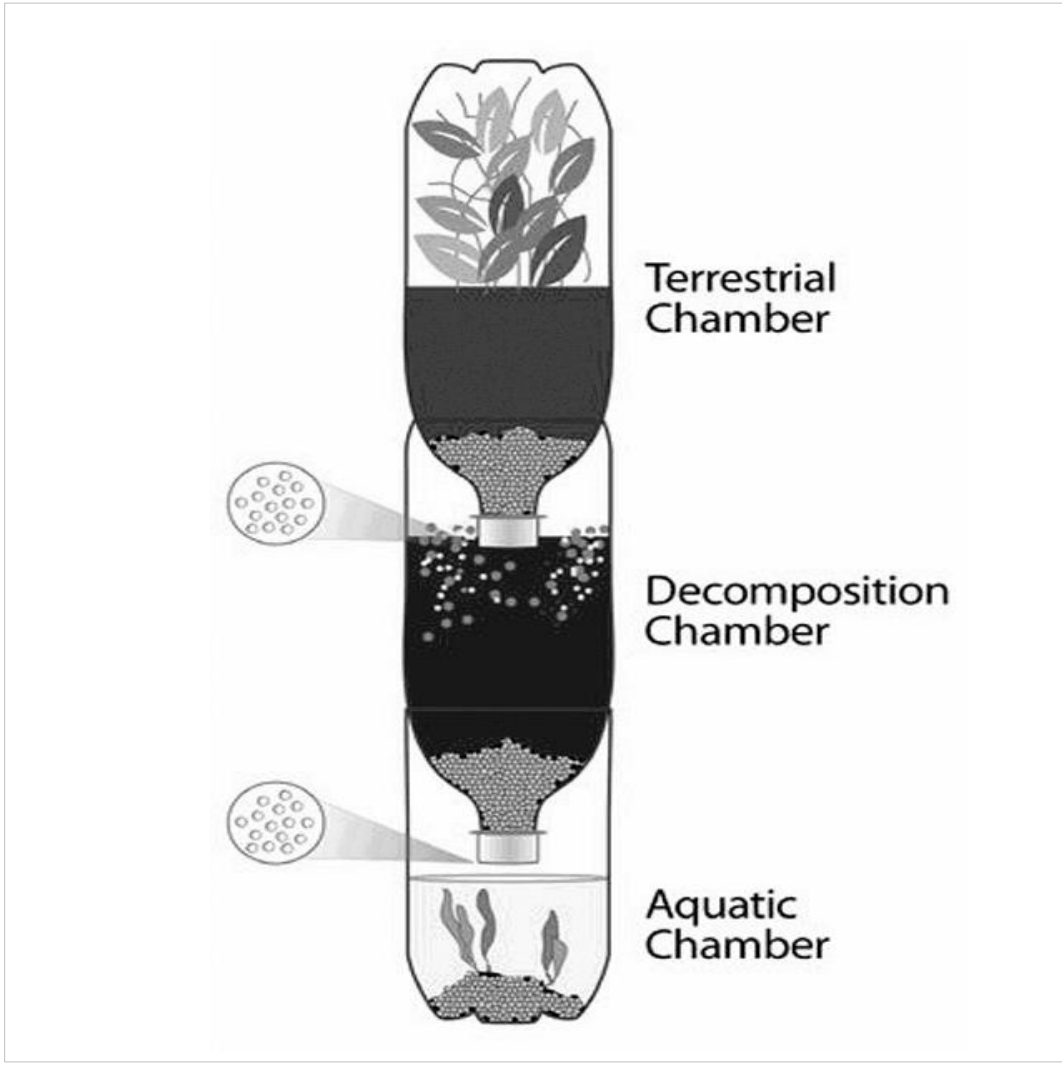


Image source: Bottle Biology

7.7_Terra-Decomposition-Aqua column

EXPERIMENT

LEVEL: SIMPLE

Teaching Objective

The purpose of this experiment is to encourage students to learn about the organic processes taking place in their environment: on the soil surface, within decomposing leaf litter, and in a freshwater habitat.

Exercise

An eco-column is a self-sustaining ecosystem on a small scale, made of plastic soda bottles. This eco-column has 3 chambers: the terrestrial chamber, the decomposition chamber, and the aquatic chamber. The terrestrial layer represents the land habitat including plants and insects (if desired). The bottle caps are perforated to allow fluid to move from one chamber to another. The decomposition chamber represents a leaf litter habitat, much like a compost pile. The aquatic chamber is a mini freshwater habitat for aquatic plants and even small fish. All three of these chambers make a "mini-ecosystem" within a classroom setting. A student can see the interactions between the chambers as the student waters the plants that grow in the terrestrial chamber and observe how the water travels through the decomposition layer all the way to the aquatic habitat below.

Main source (hyperlinks)

Bottle biology

Required Materials

3 PET bottles, scissors | soils and organic materials from local environment | water and aquatic materials for aquatic chamber

Image source: www.permaculture.co.uk

7.8_Plant a tree

OUTDOOR ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The purpose of this activity is to teach students about the importance of growing trees and regenerating the landscape; and how to plant and care for trees.

Exercise

Pick out a tree. Very young trees are usually sold bare-root. Bare-root means that they will look like sticks with a bit of root at one end. They can only be planted when they are dormant. The roots of very young trees must be soaked in a bucket of water for a few hours before planting. Larger trees are usually sold balled-and-burlapped. This means that the roots are enclosed in dirt and wrapped in burlap and twine or wire. These trees can be planted at any time. Pick a suitable spot in your yard to plant your tree. Be sure that the tree has the amount of sunlight that it needs to grow. Dig a hole and set aside the soil, sod clumps, and rocks. You want the hole large enough that the roots fit in without being crowded. For bare-root trees, the hole should be a few inches deeper than the length of the root and wider than the spread of the root. For the ball-and-burlapped tree, you will want to measure the height of the root ball and the depth of the hole before planting it. Remove the twine or wire before putting in the hole. Put the tree in the hole and fill it 2/3 of the way with the dirt. Fill the rest of the hole with water. Once it has settled, fill the rest of the hole with dirt. Make a saucer-like circle around the tree using the leftover rocks and dirt clumps. Water thoroughly and then mulch. Stake the tree so that it does not get knocked over by strong winds, lawn mowers, and other hazards. Water thoroughly once a week in dry weather. (Family education)

Remark

Conduct a thorough research on appropriate trees to grow. A native tree is the safest choice; however: in some areas alien species can be highly beneficial (for example, leguminous trees with nitrogen fixing capacities can play a long-term role in fostering soil fertility). Be aware, however, that some alien species (such as Eucalyptus trees) can reduce soil fertility—detrimental to other flora.

Required Materials

One tree (native to your region) | shovel | bucket of water | measuring tape

Image source: https://www.facebook.com/MoringaMission/

7.8.1_Plant *Moringa Oleifera*

OUTDOOR ACTIVITY
LEVEL: SIMPLE

Teaching Objective
The purpose of this experiment is to inform students about beneficial multipurpose plants that can easily be grown and propagated, using the example of Moringa.

Exercise
Moringa oleifera grows in dry to moist tropical or subtropical clime. It grows in any soil type, but heavy clay and waterlogged. Commonly known in various names such as Horseradish tree, Moringa, Drumstick tree, *Moringa oleifera* is deciduous, fast growing, and resistant to drought. It reaches a height of up to 12 m and trunk diameter of up to 45 cm upon maturity, but is tolerant to heavy pruning (good for hedges). The leaves are the most nutritious plant part; they are sometimes used to combat malnutrition. It is often cooked and consumed as vegetable, or dried and crushed into a powder then added into soups and sauces. Leaves can also be given to livestock as a complement to their fodder (including small animals such as chicken). Moringa is also planted as windbreaks and to prevent soil erosion. The seeds can be used to improve water quality (by coagulation; see exercise 4.8). Besides, Moringa is also used for its medicinal properties.
Moringa can easily be propagated by seeds, that are collected from existing trees' mature pods. You can plant the seeds in small containers in a mix of 50% sand and 50% compost, or alternatively, in locally available top soil; maximum 2cm depth. Watering regularly will be important. The seeds should germinate after two weeks, and the seedlings can be transplanted in the ground when they have reached 30cm at least. If seeds are not easily available, Moringa can be grown from cuttings as well.

Remark
Moringa is often presented as a miracle tree, as indeed the benefits of it are multiple. However, in order to build resilient food production systems, it is important to grow diverse crops and trees and avoid extended monocultures.

Main source (hyperlinks)
PFAF (Plants For A Future)

Other resources (hyperlinks)
NCBI, FAO, CAWSR

Required Materials
Moringa seeds or seedlings | compost | appropriate space | water

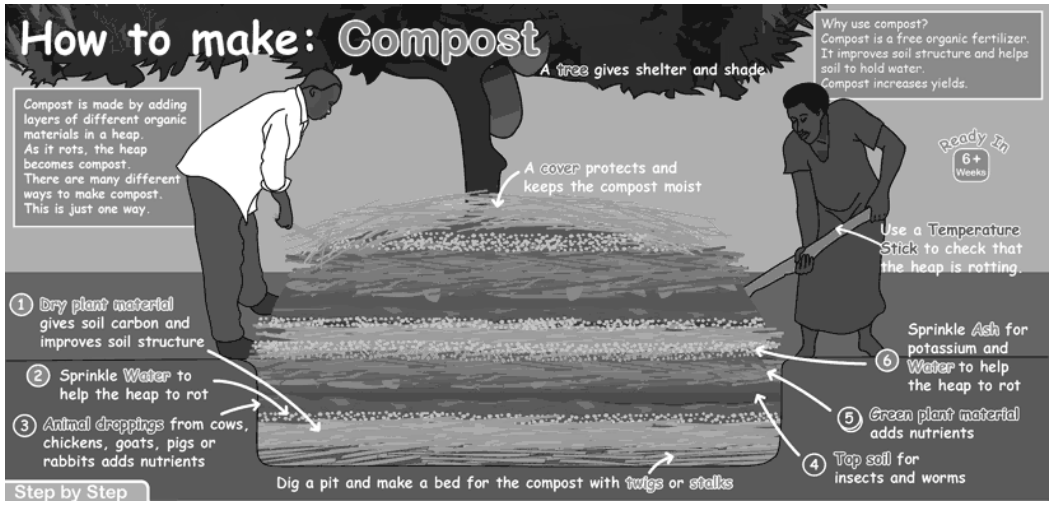


Image source: www.fourthway.co.uk

7.9_Compost pit

OUTDOOR ACTIVITY

LEVEL: SIMPLE

Teaching Objective

There are many ways to make compost. This exercise's objectives are to show students one easy way to make it and explain its importance for enhancing or keeping fertility in cultivated lands.

Exercise

To make compost, you will need to follow the following steps:

- Dig a pit, 20-30 cm deep and approximately 1mX1m in size.
- Build the compost layers alternating dry plant material, wood ash, animal dropping, top soil and green plant material. As a rule of thumb, the ratio 50% green and 50% brown material usually works well. Mostly, avoid putting more green than brown material.
- Water well as you go, to keep the dry layers moist and activate the composting process.
- If you can find compost worms, add them to the bottom layers of the heap, as they tend to work their way up. In that case do not add wood ash!.
- After three weeks, turn the compost around, and leave it for approximately another 3 weeks.
- When the compost is ready (dark brown crumble, smelling nice), apply to crops or sieve it and use for potting.

Remark

Make sure the compost heap is placed under a tree to protect it from direct sunlight and rain, as much as possible. Another tip is: if the compost smells bad, there is something wrong. The compost is probably saturated with nitrogen: in that case, add more dry vegetal material. You can use a temperature stick to make sure the heat goes up in the compost heap, which indicates that the composting process is happening. If it doesn't, add a little water and green material to the heap.

Main source (hyperlinks)

fourthway.co.uk

Other method (hyperlinks): The 18 days compost recipe

Required Materials

Appropriate tools to dig (spades, or other) | brown (dry) vegetal material | green (wet) vegetal material | animal droppings, manure, wood ash

Image source: Terre des hommes (Bangladesh)

7.10_ Keyhole Garden

OUTDOOR ACTIVITY

LEVEL: ADVANCED

Teaching Objective

The purpose of this activity is to how students a way to cultivate vegetables in an efficient and productive way, even when only a small space is available. Ideally, this garden should be built near the kitchen to facilitate its use and maintenance.

Exercise

To build a keyhole garden, you will need to follow the following steps:

- Measure and mark the circle for the central compost basket (roughly 50cm radius).
- Measure and mark the circle for the garden (150 cm), with the V shape access to the compost basket.
- Build the compost basket and start filling it up with dry material, green material, wood ash and manure. Sprinkle water on the dry layers.
- Build the garden's border with stones or bricks (or anything else available, like logs or banana stems).
- Mix and add the soils as you build the garden's walls (with top soil, well rotted compost and manure, and straw or dry vegetal matter). Heap the soil toward the compost basket, creating a little mound (this facilitate the plants' access to the nutrients in the basket, and increases the surface available for cultivation).
- Cover the compost basket to protect from sunlight or excess water during rainy season.
- Leave the garden to rest and settle for a week before planting seeds or seedlings.

Remark

It is important to build these garden following the main basic principles, such as the size of the garden (3m across is a maximum), make the central compost basket the right size, and using the material locally available.

Main source (hyperlinks)

Send a Cow UK - The Bangladeshi version can be seen here

Required Materials

A 3x3m space | bricks, or stones, or etc. | top soil, compost, well rotted manure, wood ash | straw | pegs (sturdy and bendy) | natural string |

Topic 8_From Waste to Resources

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

This topic encourages students to become conscious about the impact related to poor waste management and about what can be done to avoid it.
It introduces activities that promotes waste as a resource by applying the 3R principles: Reducing the amount of waste generated by consuming less or differently, Reusing and Recycling waste. The exercises in this topic are selected to help enable students:

- To understand the importance of waste management and how waste pollutes our environment when not properly handled.
- To learn and experience sustainable waste management practices.

Image source: https://cente

WASTE, ENVIRONMENTAL IMPACT AND REMEDYING STRATEGIES

Waste definition

Waste is a generic term that refers to something which is no longer used and is discarded. It is estimated that the world population now generates 1.9 billion tons of garbage each year, of which 30% remains uncollected and is mostly openly burned or dumped somewhere. For the collected fraction, 70% is disposed in landfills and dumpsites.

Environmental impact

Burning and dumping mixed waste are common practices that have a huge impact on human health and the environment.

Burning threat: Even if sometimes not visible, the smoke from burning waste can enter lungs through nose and mouth and the tiny particles can poison the blood, cause respiratory diseases and cancer. Burning waste is even more dangerous when it contains plastic waste as this releases harmful pollutants.

Dumping threat: Dumping waste leads to visible plastic accumulation in nature, environmental pollution of soil and water, and is also responsible for spreading of diseases as it encourages breeding of mosquitoes among other disease vectors.

The 3R principles

Waste is produced whenever we stop using a product and discard it. The best way to minimize the environmental threat of inadequate waste management is to minimize the waste amount that needs management by following the 3R principle of "reduce, reuse and recycle".

Reduce means avoiding waste production by considering what you buy and consume products that create less waste.

Reuse involves a repeated use of a product before you then finally discard it.

Recycle means to make use of the discarded object and transform to a resource for re-processing to new products or to recover energy from it.

If we take the example of a plastic bag used to carry things, *Reduce* would mean to use only 1 plastic bag for all the things we buy instead of one plastic bag for each item. *Reuse* would mean to utilize the same plastic bag for next time we go shopping. *Recycle* would mean to use it for another purpose, for example to produce an eco-brick (see exercise 8.6).

Waste heterogeneity

Even if we commonly see waste as a single entity, waste is made of different materials such as: plastic, paper, glass and organic waste. Different waste management strategies can be applied for these different materials to enhance their reuse, recovery and recycling. Being aware of the waste composition is a key step to change our view that it is a potential resource instead of something we want to get rid of.

HOW TO IMPROVE WASTE MANAGEMENT IN SCHOOL

The severe threats to human health and environmental pollution from open burning and inappropriate management of waste highlights the necessity to safely manage waste at schools and increase knowledge and awareness of students regarding risks but also to show pathways for improvement.

Tasks for a good waste management at the school:

- Understand the issues of inappropriate waste management (8.1 – 8.4)
- Identify waste streams and quantities (8.5)
- Separate the waste materials at source into different waste bins : organic waste, plastic, paper, metal (8.5 – 8.6)
- Check the Practical Exercises and the Catalogue of Technologies for Topic 8 to see what you can do with each fraction (8.6 – 8.9)

Image source: EVAgua

8.1_Waste collection day

OUTDOOR ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to show to students the impacts of dumping and throwing waste away.

Exercise

Organize a Waste Collection Day at a water body (river, stream, lake), green area, or any place where students like to play in their free time.

At the end of the day, the amount of waste collected (number of plastic bags filled or the total weight) is reported in a notebook.

Questions are asked to the students on:

1. What are the most predominant waste types collected (plastic/ metal/ glass/ paper/ organic)?
2. Where do they think the waste comes from?
3. What could be done to avoid that waste is dumped into the environment?

Required Materials

plastic bag for waste collection| gloves | notebook | pencils | (scale)

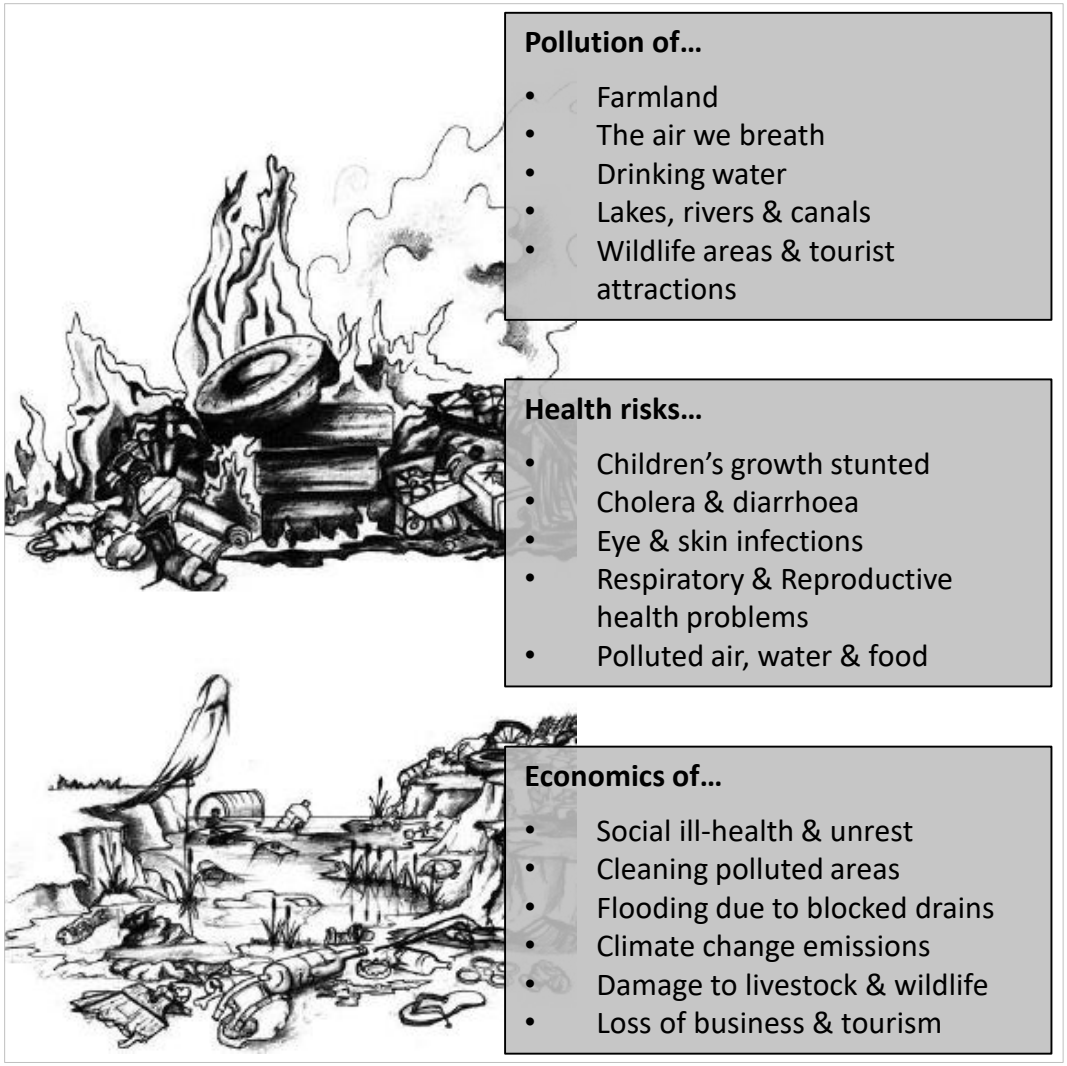


Image source: Wasteaid

8.2_Impacts of unmanaged waste

DISCUSSION
LEVEL: MEDIUM

Teaching Objective
The objective of this activity is to familiarize students with the issues of not managing waste properly when openly burning or dumping it.

Exercise
Based on the information provided in the boxes and in the Technical Background of this topic, discuss the issues of burning mixed waste with plastic and dumping waste with students.
The discussion can start by asking students if they have already burned or seen somebody burning mixed waste (with plastic) and if they think it is a good practice or not, and why. The same questions can be asked for the issue of dumping waste. Once they have shared their own experiences, provide them the information given on environmental and health threat. Discuss it with them and define what could be done to avoid these problems.

OPTION: Ask students to represent these threats in a drawing.

Required Materials
none | (pencils and paper)

Additional Resources (hyperlinks)
Wasteaid Toolkit

Image source: Eawag

8.3_Visit of landfill/dumpsite

OUTDOOR ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to show students what the end of life of waste is, its contamination risk and the importance of reducing waste generation.

Exercise

Organize a visit to the closest dumpsite or landfill. Before reaching the site, ask students where they think their waste ends and to describe what a landfill/dumpsite looks like. At the site, give students information provided in the Technical Background regarding annual amount of waste generated and dumped.

At the end of the day, collect impressions on what they think about the visit, what was the most impacting thing they saw, and what they would suggest to do to improve the situation.

Required Materials

appropriate shoes | local authorization to visit the sites | (transport)

Material	Degradation time
Paper	2-4 Weeks
Cardboard box	2 months
Cotton gloves	1–5 months
Painted wooden sticks	13 years
Plastic bag	10–20 years
Tin can	50 years
Disposable diapers	50–100 years
Soft plastic (bottle)	100 years
Hard plastic (bottle cap)	400 years
Aluminum cans	200 years
Glass bottles	Undetermined

Image source: Cmore

8.4_Waste degradation rate

DISCUSSION
LEVEL: ADVANCED

Teaching Objective
The objective of this activity is to familiarize students with the long term impact of throwing waste away.

Exercise
Biodegradation is a biochemical process in which materials are dissolved by bacteria and microorganisms. In nature, different materials degrade at different speeds, depending on their structure and composition. Main materials and corresponding degradation time are shown in the table.
Make cards for each material and for each degradation time separately and put them in two separate piles. Shuffle each pile and lay them out on a desk. Ask students to pair the material card with its correct corresponding degradation time card. Students should explain their choices. Once all material cards have been assigned to a degradation time, share the correct answers and ask them to make a drawing representing what they have just learned.

Required Materials
Pencils | paper | scissors

Image source: Waste Authority

8.5_Waste assessment

EXPERIMENT
LEVEL: ADVANCED

Teaching Objective
The objective of this activity is to enable students to evaluate their waste production.

Exercise
Collect the waste produced in one week from the waste bin of at least 5 classrooms. Note the number of students and teacher for each classroom. Weigh each bin and report it. Empty the waste onto a plastic sheet. Weigh the emptied bins to know the net amount of waste collected. Ask students to wear gloves and separate the waste in 5 piles of different materials: organic waste (food, fruit and vegetables leftovers), paper waste (used paper and cardboard), plastic waste (PET bottles, packaging,…), metal pieces and glass. Weigh each fraction by putting it into a basket and measuring it on a scale. Subtract the empty basket weight to calculate the net amount of waste generated for each fraction. Ask students to report the measurements in their notebook and calculate the percentage of each fraction over the total waste analysed. Rank the fraction according to their percentage. With the assessed number of students and teachers per classroom, calculate the waste generation per person. If there is a canteen, do the same exercise considering only the bins located in the kitchen and in the canteen. Evaluate how many meals are served per week to assess the waste generation rate per meal. At the end of the activity, questions are asked to students on:

1. What are the most predominant generated waste fractions (plastic/ metal/ paper/ organic)?
2. What could be done to reduce these amounts?

OPTION: Once the amount of waste generated per capita during 1 week is known, ask students to calculate how much time would be needed to fill up the classroom volume with waste, considering a waste density of approx. 600 kg/m^3.

Required Materials
Big plastic bags for waste collection | basket | gloves | plastic sheet (2X2m) | notebook | pencils | scale

Additional Resources (hyperlinks)
Wastewise Toolkit

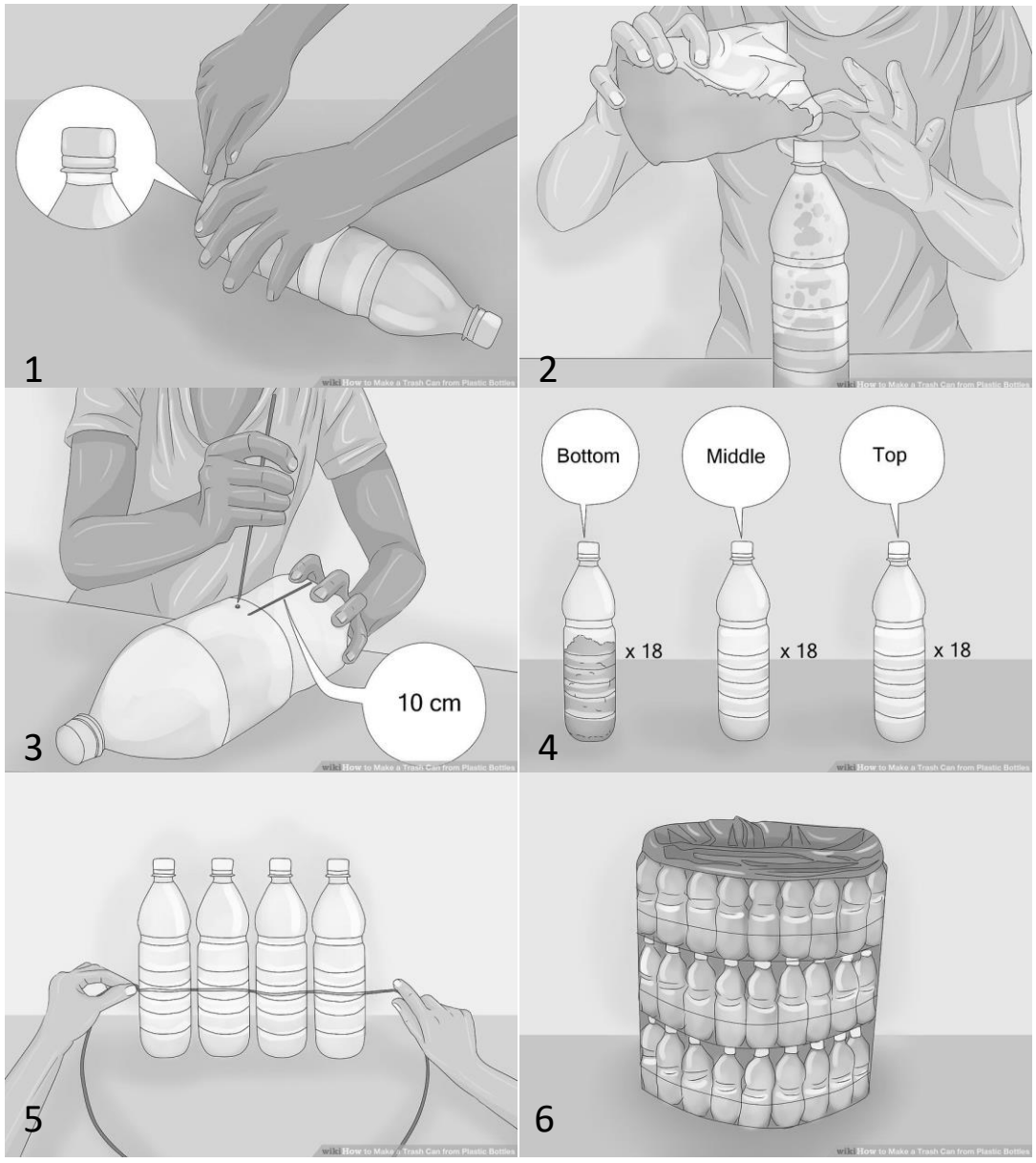


Image source: wikiHow

8.6_Waste bins from plastic bottles

OUTDOOR ACTIVITY

LEVEL: MEDIUM

Teaching Objective

The objective of this activity is to familiarize students with waste recycling and waste separation.

Exercise

Waste bins can be made out of plastic bottles in 6 steps:

1. Cut a hole at the bottom of 36 bottles of the size of the bottle cap, so that another bottle can snap right in and not fall out. This can be done with a sharp knife or by heating a knife in a candle for a few seconds.
2. Fill another 18 bottles halfway with trash, soil/sand. These bottles will be used for the bottom row of the bin to give the waste bin some weight.
3. Measure 10 cm from the bottom of each bottle and mark it on both sides of the bottle. Use a candle to heat a piece of wire and poke two holes through the markings of each bottle.
4. Make 3 rows of 18 bottles each. The row of bottles with trash or sand/soil is at the bottom. Snap an empty bottle (with a hole at its bottom) onto each bottle top of the row of bottles with trash or sand/soil and then make another row on top of that.
5. Line up all 3 rows. Start inserting a wire through the side holes of the bottom row. Repeat again for the middle row of bottles and then the top row. To make it easier, keep the bottles in a line as you insert the wire.
6. After inserting the wire through the whole row, bring the two ends of wires together and fix them together with wire cutters. Adjust the bottles so that they are standing as straight as possible. Put a big plastic or jute bag inside and make a sign of what type of waste should be thrown into this bin.

Required Materials

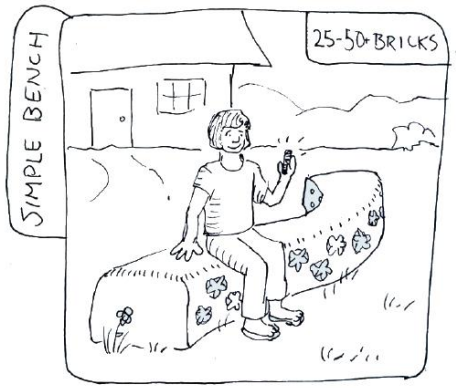
36 clean plastic bottles of same size | knife | candle | trash or sand/soil | wire | big plastic/jute bag | cardboard | pens

Additional Resources (hyperlinks)

Wikihow Guidelines

Image source: Wasteaid

Examples of *Ecobricks* constructions



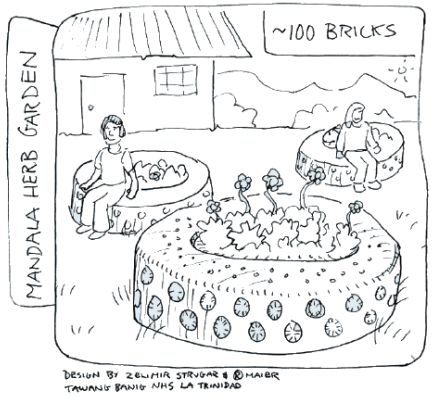


Image source: Ecobricks

Image source: Eawag

3.7_Ecobricks – Building with plastic

OUTDOOR ACTIVITY

LEVEL: ADVANCED

Teaching Objective

The objective of this activity is to demonstrate students how to recycle plastic waste by producing a building material.

Exercise

To create an *Ecobrick*, the following steps need to be undertaken:

1. Clean, dry and collect soft plastic waste
2. Compress the waste into a plastic bottle with a stick
3. Pack tightly many bags into the bottle until the bottle cannot be squeezed by hand at its sides
4. Squeeze with one hand to measure if it is full enough (for reference, a 1.5 litre PET bottle should weight around 400 g). Then close with a bottle top.

Once enough *Ecobricks* are produced, construction can begin. See the additional resources for more information. If you don't have enough *Ecobricks* or space for construction, you can also use them as an efficient way to store plastic waste.

Required Materials

PET bottles| soft plastic | stick

Additional Resources (hyperlinks)

Ecobrick Construction Guide, Wasteaid toolkit

Image source: Parenting Times (CC BY-NC-SA 2.5)

8.8_Recycling your own paper

CREATIVE ACTIVITY

LEVEL: SIMPLE

Teaching Objective

The objective of this activity is to teach students how to make their own recycled paper.

Exercise

To produce recycled paper, the following steps need to be carried out:

1. Tear your used paper into strips and soak it in water for several days
2. Use a fork to crush the soaked paper into tiny pieces
3. Pour the slurry of crushed paper into a fine sieve and drain the excess water from the crushed and soaked paper
4. Use a glass bottle to roll out the crushed paper into a flat sheet
5. Let the sheet dry in the sun and then you can start drawing on it

Required Materials

used paper | bowl | fork | sieve | glass bottle | water

Image source: CCAC Waste Initiative

8.9_Composting – Moisture test

EXPERIMENT
LEVEL: SIMPLE

Teaching Objective
The objective of this activity is to teach students how to check for the right moisture content of a composting heap.

Exercise
To ensure that the moisture content of a composting heap is around 50-60%, which is ideal for the composting process, the following steps can be carried out:

1. Put on a glove and take a handful of material from the centre of the composting heap
2. Squeeze the material in your hand and observe what happens:
   If you can squeeze water out of it: the compost is too wet
   If it does not release water or just a few drops: it is just right
   If it does not release water but crumbles apart when released: it is too dry

Based on your observation, if it is too wet you can either add dry material or turn the heap during a warm and sunny day to allow moisture evaporation. If it is too dry you can sprinkle the heap with some water.

Required Materials
gloves

Additional Resources
CCAC Handbook

List of references and additional resources

A lot of the exercises 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	Links
1.1_Transect Walk	http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Guidelines_for_triggering_CLTS_0.pdf https://www.sswm.info/humanitarian-crises/urban-settings/planning-process-tools/exploring-tools/transect-walk https://siteresources.worldbank.org/EXTTOPPSISOU/Resources/1424002-1185304794278/4026035-1185375653056/4028835-1185375678936/1_Transect_walk.pdf
1.2_Participatory Mapping	https://www.sswm.info/planning-and-programming/decision-making/deciding-community/participatory-mapping-for-decision-making
1.3_Participatory Modeling	http://www.iapad.org/wp-content/uploads/2015/07/JCGaillard.pdf http://www.mspguide.org/sites/default/files/case/pacctechrep10lr.pdf
2.1_What is the Water Cycle?	https://d43fweuh3sg51.cloudfront.net/media/media_files/strand-3-background-article.pdf https://www.sswm.info/concept/water-cycle https://pubs.usgs.gov/gip/146/images/WaterCycle-Kids-USGS.jpg
2.4_ Water Cycle Wheel	https://i.pinimg.com/736x/8d/a8/fd/8da8fd9fe6aed62e807364ef8b6fa3e7--teaching-science-teaching-ideas.jpg
2.9_Cloud In A Jar	http://scienceillustrated.com.au/blog/wp-content/uploads/2010/11/ministorm.jpg https://thewaterproject.org/resources/lesson-plans/condensation-experiment
2.12_Global Warming in a jar	http://peabody.yale.edu/sites/default/files/documents/education/Global%20Warming%20In%20A%20Jar.pdf https://archive.bigelow.org/virtual/ https://thewaterproject.org/resources/download/water-cycle-water-crisis.pdf
2.13_Water & Nutrient Cycle Puzzle	http://www.aguasan.ch/ws2016/SDG-6-Water-&-Nutrient-Cycles.pdf
3.1_What is a Watershed?	https://water.usgs.gov/edu/watershed.html
3.4_Drawing my Watershed	http://www.geo.brown.edu/research/Hydrology/FTP_site_5099-05/maine_appD_watershed-delineate.pdf
4.2_Water Filter in a Bottle	https://www.wikihow.com/Make-a-Water-Filter
4.6_Water quality testing	https://www.sswm.info/content/water-quality-testing http://www.indiawaterportal.org/
4.7_Safe storage and transportation	https://www.sswm.info/taxonomy/term/4026/safe-storage https://www.caritas.ch/fileadmin/user_upload/Caritas_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/kenia/wash/Caritas_CHAST_Manual.pdf https://www.sswm.info/water-nutrient-cycle/water-purification/hardwares/point-use-water-treatment/point-of-use-water-treatment-

List of references and additional resources

4.8_Treating water with Moringa seeds	http://c.ymcdn.com/sites/www.echocommunity.org/resource/collection/12164DCB-6FCC-42E5-899A-DBA41B1A9B19/TN_52_Moringa_Water_Treatment.pdf https://resources.cawst.org/appendix/436ffef5/appendix-b-household-water-treatment-technology-fact-sheets https://www.cawst.org/en/resources/biosand-filter http://www.sodis.ch/index_EN
5.6_Eco Sanitation Puzzle	http://www.ecosanres.org/publications.htm http://www.eawag.ch/en/department/sandec/publications/compendium/
5.7_Pile sorting of good and bad hygiene practices	https://www.caritas.ch/fileadmin/user_upload/Caritas_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/kenia/wash/Caritas_CHAST_Manual.pdf
5.9_Soap making	https://resources.cawst.org/fact-sheet/96362884/soap-making-fact-sheet https://www.wikihow.com/Make-Handmade-Soap
5.10_Glass of water	http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/cltshandbook.pdf
5.14_Demonstration of good hygiene practices	https://www.caritas.ch/fileadmin/user_upload/Caritas_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/kenia/wash/Caritas_CHAST_Manual.pdf
5.15_Construction of tippy tap	http://www.tippytap.org/wp-content/uploads/2011/03/How-to-build-a-tippy-tap-manual.pdf http://www.washplus.org/resources/tools/2014/05/01/how-make-other-types-tippy-taps.html
6.5_Knock Down the Myth	https://www.unicef.org/gender/
6.6_As we grow up	http://wsscc.org/wp-content/uploads/2015/10/As-We-Grow-Up-West-Africa-EN-web.pdf https://www.caritas.ch/fileadmin/user_upload/Caritas_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/kenia/wash/Caritas_CHAST_Manual.pdf
6.7_My Menstrual Cycle	http://wsscc.org/resources-feed/menstrual-wheel/
6.8_Keeping my menstrual calendar	https://www.caritas.ch/fileadmin/user_upload/Caritas_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/kenia/wash/Caritas_CHAST_Manual.pdf
6.9_Reusable Pad Making Workshop	https://www.sswm.info/humanitarian-crises/camps/hygiene-promotion-community-mobilisation/hygiene-promotion-community/menstrual-hygiene-management https://ww.unicef.org/wash/schools/files/Ethiopia_MHM_Conf.pdf https://www.wikihow.com/Make-Your-Own-Reusable-Menstrual-Pads
6.10_Disposal	https://www.menstrupedia.com/

List of references and additional resources

7.7_Terra-Decomposition-Aqua Column	http://www.bottlebiology.org/investigations/terraqua_main.html
7.8.a_Plant Moringa Oleifera	https://pfaf.org/user/Plant.aspx?LatinName=Moringa+oleifera https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4490473/ http://www.fao.org/traditional-crops/moringa/en/ https://resources.cawst.org/fact-sheets/5b700dbf/household-water-treatment-and-safe-storage-fact-sheets-detailed
7.9_COMPOST PIT	http://www.fourthway.co.uk/posters/pages/compost.html https://permaculturenews.org/2008/07/26/18-day-compost-the-appliance-of-science/ https://wasteaid.org.uk/toolkit/how-to-turn-organic-waste-into-compost-using-worms/
7.10_ Keyhole garden	https://www.youtube.com/watch?v=ykCXfjzfaco https://www.youtube.com/watch?v=ktg9Z1tGGcI
8.2_Impacts of unmanaged waste	https://wasteaid.org.uk/toolkit/making-waste-work/
8.5_Waste assessment	http://www.wasteauthority.wa.gov.au/media/files/wws/waste-audit-toolkitv4_web.pdf
8.6_Waste Bins from Plastic Bottles	https://www.wikihow.com/Make-a-Trash-Can-from-Plastic-Bottles
8.7_Ecobricks – Building with plastic	https://www.ecobricks.org/pdfs/EcoBrick%20Construction%20Guide%20-%20v0.7.pdf https://wasteaid.org.uk/toolkit/how-to-turn-mixed-plastic-waste-and-bottles-into-ecobricks/
8.9_Composting – Moisture test	h ttp://www.waste.ccacoalition.org/document/handbook-schools-organic-waste-management

Citation (suggestion)

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