WASH solutions for schools

A handout for the ARC Water schools Programme

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This publication is work in progress. Any comments, additions or suggestions for corrections are more than welcome.

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This handout was created by Dick Bouman of Aqua for All, Henk Holtslag and Frederik Claasen of EMF as a contribution to ARC's Waterschools programme. This programme intends to improve water and sanitation in religious schools. In many countries, these schools receive little funding. As well as facing the same water and sanitation issues as every school, they also possess a deep understanding of the religious/cultural significance of water and cleanliness, which brings an extra dimension to these issues.

In 2005 UNICEF set a target of ensuring that all schools have adequate child-friendly water and sanitation facilities and hygiene education programmes by 2015 as part of its WASH (water, sanitation and hygiene) programme. That target year has to be postponed, but without involving faith-based schools, it will never be attained. This handout consists of a short step-by-step approach, followed by a more elaborate background document.

Sanitation is culturally sensitive and often a taboo area. Terminology is often misleading ('restroom' or 'bath room' – or 'water-closet' or 'WC' even when there is not a drop of water). In this publication we use the word 'latrine' for all types of 'toilet' and the word 'seat' for all kinds of structures used for defecation (whether a raised seat, a French or Turkish toilet, or a drop hole).

A draft reader with cases/fact sheets is provided separately. Most of the pictures are taken from third parties.

A first content screening was made by Mrs Annemarieke Mooijman and Jan Heeger.

Photo cover: Water for Life/Wetterskip Fryslan: Hygiene campaign in South Mozambique

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Preface by ARC

ARC's increasing involvement with the issue of water is a story of both the development of how the environment is understood in relation to development as well as a story of partnership. When ARC (the Alliance of Religions and Conservation) was created in 1995, emerging from the world of WWF, its focus was on the major issues facing the natural environment. These included climate change; protection of eco-systems and habitats; conservation of species and so forth.

Unlike many environmental groups at that time, we always took development seriously but within the context of justice and equality. But we were unusual in this. Many of the major conservation bodies were still trying to work out their relationship with development, which they saw as a basic threat to the natural world.

It was Islam which first alerted us to the importance of religion and water conservation as part of a grander vision of our relationship with all creation. From the 9th century AD, Islam has had strict Shariah laws protecting watersheds and water holes, not just for human use but also for their use by all creatures. In all their plans for faith-based conservation work, these teachings and models were cited as something they wished to reintroduce or reinvigorate.

However, to be honest, we felt that the issue of water was so profoundly complex and riven with competing groups and ideologies, that it was an area best left alone while we concentrated on more manageable topics such as forests or land.

Enter Allerd Stikker and EMF (the Ecological Management Foundation). For Allerd, as he has written, water is the great issue facing humanity and it was his constant insistence that we had to grasp this most complex of issues which led us to start the Water Schools project. It was his vision that we should concentrate on the untapped potential of faith schools, a potential of which we had only just begun to grasp the significance.

We discovered that over 50% of all schools worldwide were either set up, run, or contributed to, by the faiths. This gave us a potential field for significant faith action. It was Allerd and EMF's vision that led us all to see faith-based schools as places not just of learning about water protection, sanitation and health but as places of practice. We began to realise that they could make a truly significant difference and that through them we could tackle the issues of water – environmental and health.

Allerd spent many days discussing with us not just the why but also the how, and through the generosity of EMF ARC was able to start a modest programme exploring the potential. This had its first big launch at the Salisbury Conference in 2007 when faith organisations and major international development agencies began to make tentative steps towards working together.

From this meeting and from the partnership between ARC, EMF and the Rev Al Bailey of the New Psalmist Church in Baltimore, USA, links with UNICEF have begun to develop. This has led to UNICEF beginning to work as a potential partner with faith-based schools. It is in this context that this handbook has to be understood.

Around the world, there are hundreds of thousands of faith-based schools. They are administered through a vast array of local, national, regional and international networks. It might be an Anglican Diocese in sub-Saharan Africa with responsibility for as many as 100 schools; it might be a network of mosques that run hundreds of pasentrans – Islamic boarding schools in rural Indonesia; it might be a Catholic religious order running schools in South America; or the Sikhs in the Punjab and their school network. Each faith has its central body with responsibility for the overall planning and development of the educational work of the faiths.

This handbook is designed to be a crucial tool for those bodies. It offers swift and easily accessible advice, insights and technical help when planning large-scale, water-based development programmes many of which in the past have resulted in failures. Those failures often happened because the models were unsustainable or inappropriate to the specific needs of a community.

We hope that through this handbook some of those mistakes of the past can be avoided but also, more importantly, that new plans can be developed which benefit from decades of experience drawn from the international water sector as well as ARC's own specialty in working with faith communities. Thanks to our partnership with EMF and, through them, with many of the major international water bodies, we are creating truly significant alliances. This handbook is a visible manifestation of this and we are proud to have helped it come into being.

The role of the faiths is the best-kept secret in the world, but the secret is out. It is the emerging partnership between secular bodies and faith groups that gives hope for the future of millions of children around the world.

Religious understanding of water and sanitation

Water is a theological issue. Water is a theological issue in a way that, for example, forests are not, nor even the soil. The creation stories of all the major faiths feature water as both an essential element of the start of life on earth but also as a problematic one.

In the Abrahamic traditions (Judaisim, Christianity and Islam) water is both life giving and life taking. It is an instrument of divine power – Noah's Flood was sent to punish sinful humanity – and it is also a symbol of rebellion. In the Psalms, water is depicted as unruly, a force associated with chaos needing to have its boundaries set. It is further seen as a symbol of God's life-giving gifts; for example, when Moses strikes the rock during the Israelites' flight from slavery in Egypt and water gushes forth to stop them dying of thirst in the desert.

In Chinese mythology the greatest hero of antiquity, Yu the Great, earns his title because for ten years without ceasing he fights the Yellow River, which had broken its banks and was destroying the land and people of China. Yet water is also the element within which the powerful and protector dragon deities live and it is across the seas and oceans that Guan Yin, goddess of compassion and greatest of all Chinese deities floats.

In Hinduism, the world is born from an ocean upon which floats the supreme deity Vishnu and the end of the world will once again bring back this primal ocean, which, in time, will give birth to all life again.

Water also features in many sacred rituals from baptism to offerings to the deities. Water is sacred because the faiths have known for millennia that without water there can be no life.

Even hygiene is sacred. The earliest examples of enforced hygiene are probably the codes written down in the 2nd millennium BC for washing your hands after touching anything that is polluting. These laws, to be found in the Laws of Mani or in the laws of the Old Testament, were designed to enshrine the ritual of hand washing as both a sacred responsibility and a necessary health protection measure. In Islam this is manifest in wudu - the ritual washing before the five daily prayer times – and thus the need to provide running water and proper drainage in the mosques. Similarly, when you enter a Shinto shrine in Japan you must wash your hands and mouth and so running water and proper drainage is a central part of the shrine complex.

It is, therefore, clear that from all faith perspectives, the role and significance of water and education should be strong. If there are some contexts where that importance has been dimmed over the centuries then this is why the faiths can benefit from secular partners such as EMF or UNICEF to remind them of what they always knew but might have forgotten.

It is equally important that the faiths are able to speak openly to the secular world about the sacred dimension of water. A few years ago ARC was asked to help the World Water Forum in understanding this. When we asked the organisers why they wanted faiths to come and celebrate the sacred dimension of water, they said: ”We know everything about water. We can create it, break it down, engineer it, control it and destroy it. But what we have forgotten is how to have an actual relationship with it.”

This handbook brings together two worlds: the world of the experts who can manage water and the world of the faiths who understand water and our relationship with it. They come together through the medium of faith-based schools and the dramatically growing role of these schools in addressing water issues – issues of both environmental and sanitary significance.

In the Daoist religion there is a beautiful description of why a cup works as a holder of water. As the ancient sacred book, the *Dao De Jing,* says, it is the void within the cup, which makes it useful. Faith brings an ability to leave space for understanding water while technology helps to make the cup, which can carry both the void, the space and the water. I think in this ancient Chinese wisdom we can see a model for partnership and I hope this handbook will help provide the material for the faiths to construct the space to hold the significance of water and its protection.

Water playing a significant part in faith is nothing new. What is new is that this wisdom and experience have been reactivated by the major secular organisations working with water. In partnership with the faiths the potential for reaching millions, if not billions, of children through faith-based school networks is now a real possibility. It could change the way ambitious targets such as the millennium development goals or their successors could be achieved.

Martin Palmer
Secretary General of Alliance of Religions and Conservation

Step by Step Approach

Golden rules:

- Involve all stakeholders in preparatory processes and decision making! Be gender sensitive.
- Look wider than the school compound alone.
- Go for the most appropriate solution for the given socio-economic situation.
- Go for solutions that can be maintained (technically and financially).

Preparatory stage

P1. Compose a team of stakeholders and make a plan for the preparation. Involve parents, teachers, pupils, special groups, technicians and create a good balance of representation of men and women.

P2. Determine the present WASH situation at the school and try to aim one or two steps higher

Level	Typical situation
○○○○○	No safe water, no hygienic sanitation and/or no hand washing facilities
●○○○○	Some water and sanitation (such as a protected defecation area) but insufficient and imperfect
●●○○○	Pit latrines/urinals for each 50-75 children and good hand wash facilities with water and soap (or ash); hygiene education at school; but water to be brought by children, which might be treated at school
●●●○○	Pit latrines for each 50-75 children, separated by gender, and good hand wash facilities with water and soap (or ash); hygiene education at school. Water collected from nearby safe source,
●●●●○	Basic sanitation blocks (one seat per 25-50 children, separated by gender); good hand wash facilities with water and soap (or ash); hygiene education at school; safe water in school compound (>3 l/cap for drinking and hand washing); teachers have their own units.
●●●●●	Well designed sanitation blocks (one seat per 25 girls/30 boys; separated by gender; some adapted for disabilities); hand wash facilities at all critical points; school-led total sanitation/PHAST; Safe water point near classes with > 5 l/cap for drinking and hand washing; teachers have their own units (also separated by gender). (an extra plus can be obtained with re-use of water and/or re-use of compost & urine)

P3. What is the demography of the school (nr male/female teachers, nr girls and boys separately in age categories 5-7, 8-11, 12-13, 14-18. How many pupils/teachers with (physical) disabilities (and what type)? What is the growth prognosis for the school in 10 years?

P4. How many classes are there now and what are the 10-year plans? What is the (ground) size of any hard roof structures? Are there gutters available?

P5. What is the present number of water points and sanitation seats and what is their condition?

P6. Make a sketch map of the area, indicating the school compound, the school buildings (dimensions, including future plans), trees at the compound, neighboring buildings, access roads, water sources/facilities/pipes, latrines, defecation and solid waste areas etc.

P7. Make an institutional/context analysis, including the following questions:

- Who is finally responsible for the property (Ministry, local government/municipality, school board, church/mosque/temple)
- Who is to do the regular operation and maintenance and what is the education level?
- Is there a local service provider that can do exceptional repairs and at what level?
- Are there building standards/guidelines and laws to be respected?
- What is the distance to different suppliers?
- Is there a nearby support organization that can work on capacity building?
- Does the school have experience with tender procedures?
- Is there a chance that the school will be used as a refuge in time of emergencies (different standards and demands)?

P8. Make a preliminary funding analysis:

- What funding is available and what are the conditions?
- What is the available annual budget for operation and maintenance?
- Are there possibilities to earn money from the new services?

P9. Redraft the plan (time, people, communication, funding, need for external support)

Water technology selection

The following steps are recommended to select a water facility at a specific school.

W1. Water that is safe to drink and water for hand washing. Determine the ***water quantity*** per pupil per day and per year; Distinguish two options: (A) minimum option for drinking and limited other use like hand washing (2-6 liter/pupil/day) and (B) most desirable option (also water for cleaning, cooking, toilets, school gardens etc.; >10 liter/pupil/day).

W2. Make an inventory of ***all the potential options*** in the vicinity of the school: public water scheme, nearby public improved water point, shallow groundwater, deep groundwater, stream or pond, rain water harvesting. If there is an old supply, include the rehabilitation of the old system as an option.

Determine for each source the possible ***quantity*** (does it match outcome of step 1) and the ***quality*** (is there a need for treatment regarding physical, chemical or biological contamination?).

W3. ***Select*** the preferred alternatives from a water source perspective. Choose a maximum of 3 In case of scarcity of water or limited funds; source separation for drinking and other purposes might be an option.

W4. Determine for each selected alternative the ***full chain from source to mouth*** (water source development, pump/lifting device, transport, storage, treatment, provision, drainage). The position in the chain can be different (treatment before storage or even before transport; pumping after storage etc.). *Table 7 shows a matrix of possible chain elements/needs for each source type. Include also the links to sanitation, hand washing options and other desired uses.*

W5. Determine for each part of the chain the most likely choices.

This might be a complex exercise. It should be limited to technologies that are available or can easily be introduced in the area of the school. *The water portal site at akvopedia (www.akvo.org) provides many technology choices under the headings 'water access', 'pumps and distribution', 'storage and recharge', 'treatment and tests' and 'irrigation and other uses'.*

W6: Determine investment costs and operational costs and express them in cost per liter or m3 and in cost per pupil per year. *Mind that there are several new low cost solutions which can be more effective, easier to maintain and cheaper than the options traditionally applied.* Sometimes, it may be more cost effective to invest in very robust and high quality technology when this reduces the maintenance costs.

W7. Evaluate the best source option, together with teachers, parents and local experts. The best option is a balance between the desire and the financial ability for investment, use, maintenance and replacement. Do look at the entire chain: remember that a solution that serves both a community and a school has many advantages.

W8. Define with the most relevant stakeholders for the selected chain elements the most relevant design parameters that have emerged from your discussions (related to target groups, age level etc.) and hand these specifications/list of preferences to a design engineer.

Sanitation technology selection

In designing the sanitation (including options for hand washing) facilities, the following ***steps*** need to be taken. The steps are mainly derived from a Decision Support Tool, developed by WASTE and AKVO.

S1: decide on the ***design criteria*** and the desired final destination of excreta and urine. Among the design criteria are the maximum number of users, any group divisions and, for each group, any specific aspects around access, safety, hygiene, privacy etc. It is good to start from the experience with a possible existing system or a known system from another school. Do also evaluate whether eco-sanitation or urine/excreta separation is a socially/culturally acceptable option and whether there is a desire to explore other types of re-use.

S2: for ***dimensioning*** determine the likely number of users (gender and age specific) and the volume of excreta and urine produced daily, annually or for each emptying cycle.

S3: Determine possible ***limiting factors*** with regard to soil/rock, risk of inundation and space. Pre-indicate possible ***sites*** for the sanitary units and possible storage and treatment facilities. Remember that sanitation blocks should be at least 20 m from a (groundwater) source and 1.5 m above groundwater table. If there are prevailing winds, one could also look for the most suitable location with respects to odours. The web-based Decision Support Tool of Waste and Akvo (www.akvo.org – sanitation portal) provides a useful short list of relevant factors to be considered.

S4: Define the ***desired situation*** if money was not a problem and define the ***'intermediate' steps***, which might be affordable and acceptable. If money were not an issue a school with only 1 latrine for 50 boys and 50 girls could dream of a concrete sanitary block with 3 flushed toilets for girls, and 1 urinal and 1 flushed toilet for boys. A more realistic intermediate step may be just to build two more pit latrines: one extra for girls and one for boys.

S5: Carry out the ***design evaluation process*** for each part of the chain, namely: the 'toilet'/superstructure, the collector, possible transportation/conveyance, possible treatment and possible re-use. For this purpose the web-based Decision Support Tool of Waste and Akvo (www.akvo.org – sanitation portal) is very useful. Possible options for consideration in the design process can also be found on the Akvo website.

S6: Make a choice from the selected chain options, based on technical, economical and cultural criteria and feasibility criteria (see chapter 1).

S7: With the most relevant stakeholders define the most relevant design parameters for the selected chain elements (related to target groups, age level etc.) that emerged from the discussions. Hand these specifications/list of preferences to the design engineer.

Follow-up:

- Finalise plans for both Construction and for Operation & Maintenance
- Secure funding
- Undertake tendering and contracting
- Arrange supervision
- Carry out monitoring

1. Introduction

This paper summarizes a number of ***technology solutions*** for schools on water, sanitation and hygiene facilities. Technology solutions are, however, only part of the story: hygiene awareness, ownership and maintenance are equally important **and hygiene education/practice and hand washing are 7 times more effective for health than improved water supply alone.**

Regarding water the absolute minimum of ***basic quantities required*** for day schools per child and staff are 1 liter for safe drinking water and 1-4 liter for hand washing.

Regarding sanitation basic requirements are

- maximum 75 children per toilet (temporary maximum; longer term target is 25 girls per toilet, 50 boys per urinal (of 1 m) and 50 boys per toilet (if there is a separate urinal)
- separate toilet blocks for boys, girls and school staff (facilities regarding menstruation)
- for each block there is at least one toilet for disabled users (wider door and room, ramp, support)
- distance between school and toilets maximum 30 meters
- hygienic hand washing facilities with soap.

We prefer solutions that are ***appropriate*** to the local situation. There are many definitions of 'appropriate technologies' but we define them as technologies that are effective (performance), have proper quality, are financially affordable for the users, are available in the area, and are manageable and fit into an enabling environment. They should also be environmental friendly with special attention to be given to designs that can be used by disabled pupils and teachers.

The capacity to cover operational expenses is critical for sustainable usage and these expenses must be part of the school budget. Some solutions may even provide the opportunity to generate income themselves.

School solutions may be different from community solutions or family solutions. Children need specific design (height, size, security, not requiring too much muscle power). Facilities are intensely used at rush hours (breaks). Hygiene measures are required, otherwise the improved source might create more problems than it solves. Adolescent girls need separate attention with provision of good hygiene and privacy. Facilities may be vulnerable to vandalism especially in suburban communities. There can be a rapid rotation of pupils and staff, which makes sustainable maintenance a challenge. And, of course, the costs will have to compete with other priority items in the school budget.

Young children are afraid to use a latrine in the dark and are afraid of all the possible insects, reptiles and small animals around. Many of them are afraid of falling into the hole. About one third are afraid about 'bad powers' in the hole and 14% are afraid to be left alone. They prefer a light and well-ventilated latrine with a decent (small) hole, a grip on the wall and a door that can be locked from inside only. They might have little muscle power to use a hand pump or to open a tap. And they are often too small to reach taps and hand pump handles. An example: The play pump (a merry go round) is an enjoyable invention, but might breach the children's rights if they have to pump for the community, as well.

Before starting a selection process for the best technology solution, one should know whether there is an ***existing system*** and, if it is dysfunctional, what are the reasons for that. And what lessons could be learned. For a non-working system rehabilitation might be a possible option.

The final choice of technology will depend on a wide number of ***factors***, including available financial resources, demand, available water sources, the physical, socio-cultural, economic and institutional environment, the existing infra-structure and other specific design criteria.

Financial Resources

1. Availability of ***investment funds*** (including funds from donors, government, parent contribution local sponsors, companies who might advertise on walls or tanks). For the parent contribution, the income level distribution of the parents is relevant.
2. Available budget/affordability for ***recurrent costs.*** One might explore the possibility to raise 'income' from the sale of water, re-use of urine and excreta, sale of advertisement space or subsidies from health insurance.

Demand

3. Defined (real) ***need*** (including the girls' perspective) and optional additional needs (cooking, cleaning, gardening, surrounding community)

Physical Conditions

4. Type, quantity and quality of available ***water source***(s), including seasonal variations. *For example: is the (new) water source an existing system, a river or ground water? If accessing ground water with a well or borehole is too expensive then rainwater harvesting could be a cost effective option.*
5. ***Physical*** environment (climate, rainfall /year, rain pattern, soils, slopes, vegetation),
6. ***Building*** characteristics of the schools (roof type and height, lay-out, space) and available building materials and construction skills. For example; *Trees above a school building might provide shadow and suppress high temperatures. At the same time they may encourage insects, obstruct effective rain fall for rainwater harvesting and their leaves may contaminate and block the harvesting system.*
7. Availability of a ***reliable energy source;*** manual/muscle power, electricity, other fuel ***or*** possibly a renewable energy source (wind, sun, hydropower)

Socio-cultural environment

8. ***Cultural*** aspects (including gender and religion) with regard to technology choice; ease of operation; user acceptance/preferences. For example; *Hand pumps on wells are not easily accepted in Papua New Guinea, because women are traditionally not allowed to stand above a water source. Some Maasai prefer muddy water above groundwater and believe in the cleaning potential of the mud. The doors of latrine blocks for women should not be in the sight of Maasai men.*

Institutional

9. ***Institutional*** setting (standards, responsibilities, ownership of land, assets and resources, legal aspects)

10. Reparability. There should be the capacity to maintain and repair the systems either by the school staff / teachers themselves or and external ***supporting skills/services*** in the vicinity of the school
11. Access to ***spare parts and replacements*** preferable in the vicinity of the school and locally manufactured

Specific design factors:

12. The technologies used should be '***vandalism and disaster proof***' (robust, absence of loose elements, possibly raised) and respond to the local security situation. For example a *tippy tap may do in a rural setting, but is too vulnerable in a suburb (destruction or theft). In case of frequent inundations, sanitation facilities should be raised to prevent excreta floating out of the pits. Even better are facilities that can remain in use, even when flooded.*
13. The chosen technology should be ***easy to use*** (specifically for children) and ***easy to clean***. Smooth surfaces are important.
14. Facilities should be accessible for ***disabled people***. There are several good hand outs on this (WEDC, Briefing Note 1; Share/Water Aid, UNICEF)
15. The design should be chosen for ***sustainability*** and environmental friendliness (e.g. non- or limited use of fuels and chemicals)

Whatever technology is chosen, the most critical aspect is operation and maintenance. Some 30% of communal water points in Sub-Sahara Africa are not functioning. Essential criteria are: ownership, availability of funds, capacity and will for good operation and maintenance.

You might want to consider starting a more ***centralized 'maintenance' service***, which may also be the owner of the facilities. This is especially feasible in areas with a high population density, as in the example of the service provided to over 400 schools in Eastern Cape Province (RSA) by CSIR/Kevin Wall

Good practice in water and sanitation at school is often considered to have a ***demonstration purpose*** to the surrounding community. Be aware that the chosen technology for schools is often different to what individual families can afford. For example water treatment with small filters might be an option for families, but a rooftop harvesting system with a ferro cement tank is often too expensive at family level

The Water Schools programme (www.Water Schools.org) initiated by ARC is part of UNICEF's WASH in Schools initiative. There are several other programmes and organizations focused on water, sanitation and hygiene in schools and the following links can provide further information about some of them:

- FRESH (UNESCO): www.unesco.org/education/fresh
- WASH in schools (UNICEF and IRC): www.washinschools.info, www.washinschoolsmapping.com
- Plan (development organisation for children): plan-international.org
- Save the Children (development organization for children): www.savethechildren.org

Chapter 2 and 3 explore the steps needed to make a proper choice of water and sanitation facilities and the hand washing device is included in the water chapter

Once the best facility has been identified the follow-up phases will include finalizing the design (and Bill of Quantities), budgeting and fund raising, selection and contracting of the contractor, implementation and supervision and final reporting. In the main, a consultant/construction engineer should guide this process. Tendering is usually the preferred option to get a good price/quality ratio, but ‘price deals’ between bidding contractors may occur so both price and quality need to be evaluated in the tender process. *In the city of Gedaref (Sudan), bidding contractors got a pre-briefing on the design, quality aspects and contract conditions and the winning contractor(s) were trained on quality standards.*

In the meantime an ***operation and maintenance plan*** will need to be drawn up, preferably before the final version of the design report so that it can also serve as a last check on feasibility (financial, technical and organizational). Capacity building and training will be an essential element and any arrangements with external parties will need to be established.

Before reading further the following list of pit-falls and ‘lessons learned’ may be useful. It was drawn up by faith schools participating in an ARC/KOEE workshop on education for sustainable development held in Nairobi, March 2012

Pit-falls	**Lesson**
Going directly to a 5 stars system: • High Operation, Maintenance and Replacement costs • Sensitive for failures • Not replicable in the local households • Fails when one component fails	Start from local context and take one step only (from 1 to 2 stars)
Improving only one component: • For sanitation you need at least water for hand washing • Drinking water alone makes little improvement; better to first improve sanitation and hygiene (and a bit of hand wash water & soap)	Give priority to sanitation & hygiene and bit of hand wash water Drinking water can be brought by pupils as a short term solution
UNICEF Evaluation in schools in Malawi shows that: • Many Ventilated Improved Pit latrines (VIP) do not work (no screen; false winds) • Many Pit latrines fail because of high groundwater tables, poor hygiene or slabs proving difficult to clean • Pits take long to fill; but when full then no option to empty • Ramps for disabled people should not be too steep (5%)	When investing in something you need to be sure that it works. Think, discuss and test with users before implementing
UNICEF Evaluation in schools in Malawi shows: • That schools cannot be left alone after installing an ecosan* facility. Support is required in treatment of manure and safe application of compost and urine in the gardens	Ecosan* is a great idea, but needs long term support. Better no application than a poor application
Community sharing: a blessing or a threat? • For water supply, costs can be reduced if the source (and costs) can be shared with a public system. Many schools aspire to having a separate facility, but this overlooks costs and maintenance. • For rainwater harvesting, sharing with the community can harm the effectiveness of water management of the source during dry spells	Evaluate the pro’s/con’s of sharing with community beforehand

• For sanitation, sharing the facilities with the community is mostly a threat	
Bias to what is known • Most people choose quickly what they know: a shallow well, rain water, pit latrine • There are many other alternatives that might be more appropriate (and/or cheaper)	Seek advice to find the most appropriate solutions
• The facility is part of a chain Most people think only in terms of 'a well' or 'a latrine', but do not realise that it is also part of a chain. • For a well one should prevent the water from being easily contaminated, the water should be pumped, transported and stored. In each step it can become contaminated. • A latrine produces waste that will have a destination. For example transport, treatment, storage/dump and re-use	See a facility as part of a chain and study the entire chain

** Ecosan = toilet design that enables composting of feces and/or diversion of urine with the purpose of re-use the end product*

2. Water

2.1 Quantity

Basic quantities of water required for schools per day, per child and staff, as defined by UNICEF (2009):

- 1 litre of safe drinking water,
- 1-4 litre of clean water for hand washing,
- 1 litre for anal cleansing/washing (if applied),
- 1.5 -3 litre for poor flush toilets and 10-20 liters for conventional flush toilets (this can be re-used grey water)
- For schools that provide a warm meal, extra water per child will need to be added.

The World Food Programme (WFP) recommends a minimum of 5 litres per day for drinking, hygiene and cooking, but puts the standard at 15 – 30 litres (depending on the presence of flush toilets).

For boarding schools the recommended range is 90 – 140 l/day.

Multiple water uses should be considered. If a system is designed for drinking water and domestic use, for instance, you could think about making it a bit bigger to provide water for irrigation of a school garden. This could (partly) cover operational expenses and contribute to food security.

2.2 Quality

Water is considered ***safe*** when it has no harmful micro-organisms like pathogens (e.g. E.Coli bacteria and viruses related to feces) and when any chemical substances are within the limits established by the WHO guidelines (see table). Some of these guidelines, such as the maximum acceptable daily intake of fluoride related to body weight, relate specifically to children. Except for radioactivity, physical contamination (organic material, sand or clay) is not in itself harmful, but may reduce the effectiveness of treatment methods and may influence taste and acceptability.

Among the more common contaminations that cause water borne diseases are bacteria (E-Coli), viruses (like rota virus) and protozoa (like giardia). These organisms are disseminated via latrines near water sources, rivers, dirty hands, unwashed vegetables etc. In general the combination of hand washing, good hygiene and the reduction or elimination of harmful micro organisms will drastically reduce water borne diseases, but the idea that you can avoid them entirely is a false hope, sadly. Selection of preventive measures should therefore look at cost efficiency and include assessing the environmental impact.

Of the micro-organisms, viruses have the smallest size (0.02-0.07 micron), followed by bacteria (0.5-3 micron) and protozoa (8-12 micron). Filters that block bacteria also reduce virus contamination but the more affordable filter models do not guarantee that sufficient viruses are eliminated. In general water filters do not fully eliminate all micro-organisms but will reduce the number. To eliminate viruses, filtering needs to be combined with chlorination or boiling but remember that chlorine will not also eliminate protozoa.

It is the concentration of harmful micro-organisms that leads to infection but a healthy adult body can tolerate much higher concentrations of pathogens than a sick or malnourished child. Drinking contaminated water is much more infectious to an empty stomach than a filled one which has created a very acidic environment so eating is recommended before drinking untreated water.

Of the inorganic chemical compounds, arsenic, fluoride and nitrate/nitrite are most common and therefore warrant the highest priority for attention.

Substance	Limit	unit	degree of harm	Remark	measurement	ease of treatment	Treatment method
E-Coli bacteria	<1	counts/ 100 ml	high	Measuring error could overlook about 10 counts/100 ml. Moreover, 100% sterile water is hard to get. Some tolerance could be expected.	Petri, H2S kits	easy	chemical, physical, biological
Turbidity	5	NTU	low	hampers other treatment	photometric	easy	coagulation/flocc, sedim.
Total Dissolved Solids (TDS)	1000	mg/l	low	depending the substances	EC-meter	difficult	Reversed osmosis, destillation
Electrical Conductivity (EC)	1500	uS/cm	low	depending the substances	EC-meter	difficult	dito
Acidity (pH)	6-8.5	-	low	effect on materials	pH meter/strip	easy	bleach or acid
Hardness (as $CaCO_3$)			low	effect on materials, encrustation, taste; >120 mg/l is hard	strips etc	difficult	
Arsenic (As)	0.01	mg/l	high	provisional guideline, different appearances, can also be in rice and smoke	field kits, colour	medium	Coagulation, Ion exchange, prec., adsorption, membranes, biol
Calcium			low			difficult	
Chlorine (Cl_2)	5	mg/l	high	target residual is 0.5 mg/l (Sphere)	DPD1 tablet/ comparator		
Chloride (Cl)			low			difficult	
Fluoride (Fl)	1.5	mg/l	medium	0.2 mg/l per 10 kg body weight; also other sources (salt, food)	field kits, colour	difficult	adsorption, membranes, coagulation
Iron (Fe)	0.3	mg/l	low	only aesthetic		easy	oxydation, coagulation, membranes, biol
Lead (Pb)	0.01	mg/l	high				
Manganese (Mg)	0.4	mg/l	low			easy	Oxydation, membranes, biol, coag
Mercury (Hg)	0.006	mg/l	high	inorganic Mercury			
Nitrate (as NO_3)	50	mg/l	medium	babies	Strips etc	difficult	Ion exchange, membranes, biol
Nitrite (as NO_2)	3	mg/l	high	0.2 mg/l for long term exposure!		difficult	Oxydation
Silver				no harm determined			
Sodium (Na)							
Sulphate (SO_4)	250	mg/l	low	aestehic			
Uranium	0.015	mg/l				difficult	Ion exchange, adsorption, coag, prec

Table 1: Water Quality standards: WHO Guideline Values (Unicef 2008 and WHO 2011)

Water for drinking and domestic use should come from an ***improved source*** (protected spring, covered well/borehole and (hand) pump, tap from public water scheme) or protected rain water harvesting (in combination with treatment). An 'improved source' is, however, no guarantee for safety. A recent UNICEF study in 6 countries found that 10% of the water from taps and 30-60% of the so-called other improved sources (JMP 2010, RADWQ survey) were unsafe on the day they were examined.

Water that is safe at the source can easily get ***(re-)contaminated*** before it is used. This can be caused by the use of contaminated cups and container, unclean hands, or contamination from the air and insects. Water that is stored for a longer time (in tanks) may lose quality (entrance of animals/insects, algae growth, bacteria; rotting of organic elements). Tanks and vessels need to have a lid / cover and any openings must be protected with mosquito wire.

If no safe water source is available, or where there is a danger of recontamination, water should be ***treated*** at the point of use to reduce bacteria (and viruses). Options are physical treatment (boiling for 1 minute, ceramic filters, sand filters or UV-light), chemical treatment (chlorine or silver) or biological treatment (slow sand/biosand filters). Application of too much chlorine might be harmful. Turbid water needs pre-treatment using coagulation/flocculation, sedimentation or pre-filtration to remove the suspended particles.

Water with too high content of certain minerals needs special treatment. This is especially true for Arsenic, Fluoride, Nitrate and heavy metals but removal of minerals is often too complicated for a school application, except for some minerals like iron and manganese (through oxidation).

Remember that the water children drink at schools is only part of their daily intake.

In general the first action regarding water is making sure that it is safe to drink.

In case of absence of a safe water source near the school, children can bring their water ***from home*** to school, so it can be treated there.

Water testing

Water quality can be tested with different methods but they are often too expensive to be used for educational purpose at an individual level. This has been used in India (http://www.indiawaterportal.org/data/kits/index.html) and through UNICEF in Sri Lanka following the tsunami (http://www.irc.nl/page/38743) using Pathoscreen.

Contamination with ***fecal micro-organisms*** is mostly tested by measuring the presence of E-Coli bacteria, usually counting the number of E-Coli bacteria per 100 ml. Cost of single tests like Hach, Millipore or Petri film vary from 2 to 5 US$. Some of these tests simply indicate the presence of harmful bacteria while others provide a more quantitative measure and tests can take from a few hours to a day to deliver results. Regrettably the tests are too expensive to apply as a regular measurement at single schools.

The total salt content of the water is mostly tested by measuring the conductivity of the water, expressed as EC (Electrical Conductivity) in µS/cm. Instruments can do many tests and can be obtained from US$ 30 and above. Water with an EC of 1.500 µS/cm or more is not recommended for drinking for long periods of time.

Acidity (pH) is not so much a problem for health but does have a corroding effect on concrete and metal, especially when combined with low calcium content or the presence of free CO2. Instruments, which can do many tests, can be obtained from US$ 30 and there are simple test strips or other method, which cost less than US$ 010 each.

Most other minerals will have to be analyzed in a laboratory though field indications of their presence can be obtained by the use of color strips, drip methods, colormetric methods or others. In areas with arsenic problems, field test kits for arsenic are recommended.

2.3 The water delivery chain

Depending on the selected water source, the overall water delivery chain may consist of:

1. water source development and protection,
2. a pumping device,
3. a storage facility,
4. a transport device,
5. a treatment facility (central or decentral)
6. distribution,
7. provision and drainage.

A storage device can be used at different points in the chain and some use storage for pre-treated water or with clean, safe water. Appendix I provides the full water chain in relation to the selected water source. Try to think beyond conventional solutions: there is a lot of *literature* available on different water facilities and www.akvo.org water portal/akvopedia may be a good starting point as it contains references to a lot of literature.

The diagram below (fig1) is a nice example of a complete water chain that also includes facilities for sanitation. It is taken from Godfrey et al (2010) and comes from rural India where water use in a toilet is common despite the semi-arid conditions. While the diagram does not show some details, like pumping and treatment it is interesting to note the use of excess rainwater for groundwater replenishment.

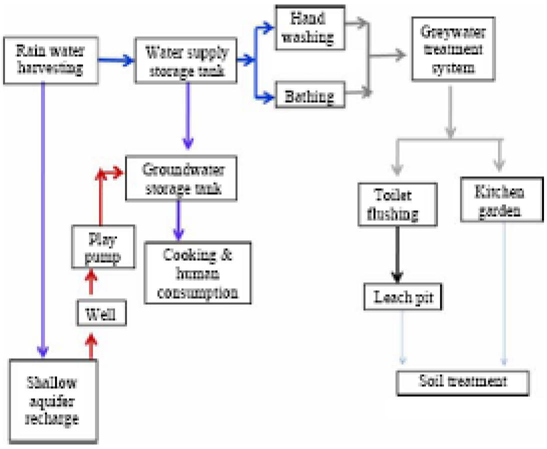


Figure 1: Example of a water supply chain from the Wise Water Management project in rural India (Godfrey et al (2010))

2.4 Water sources

Water can come from a number of sources.

The easiest source is an **existing** piped water scheme or a nearby community water point.

Surface water can be collected directly from streams or from ponds/reservoirs and go to the users through either a pumped or gravity-fed scheme. Water from such sources needs treatment and a screen at the inlet, a sediment trap, a pre-treatment unit and a point of use treatment are all recommended.

Groundwater can come from natural springs, shallow (hand dug) wells and machine or manually drilled boreholes. Wells need a cover and boreholes a cap to avoid contamination from above and both need to have aprons and so called hygienic seals to avoid contamination from the surface or ground. No water may re-enter into the borehole and, in hand dug wells, buckets are disregarded as they might contaminate the source. Manual drilling techniques can be a cheap and accessible alternative to both digging and machine drilling.

Rain water can be harvested from roofs with gutters and also paved surfaces **before being** collected in storage tanks. This option certainly needs a sediment trap and further water treatment can either be done in or near the storage or at the point of use with disinfection and /or water filters.

Rain water or storm water can also be used **to recharge** a groundwater body, from where it is collected by a well. A typical example is a sand dam (which creates a sand body with groundwater), or a sub-surface dam (which block sub-surface flow in a river bed). Other options to increase water filtration in the ground might include vegetation strips along contours (Vetiver), mulching, tree planting or making so called tube recharges (small ponds with a 5 meter deep hole and a filter). This is done to increase water volumes around wells that will dry up in the dry season. More information can be found in the Smart Water Harvesting booklet produced by the Netherlands Water Partnership (NWP).

Below is a series of examples, organized according to water source. If the option is available, the following priority sequence is the most likely, but exceptions are always possible. Except for the second and third solutions (link to existing water points), the solutions are elaborated in separate fact sheets. Lifting devices, tanks and treatment options are dealt with in later sections.

1.**Gravity systems.** Connection to a nearby spring and bring water to the school by gravity with pipes. While investment cost can be high 1.000 - 50.000 US$, depending on soil type, slopes, yield and distance, the operational costs are very low and quality is mostly very reliable. Protection of the spring area (and feeding area) and seasonal variation are points to consider.

2. Connection to an existing **Piped Water scheme** if it is reliable. Cost is mostly at a very acceptable level (0.2-0.8 US$/m3), quality is reasonable and operation and maintenance is shared with others. Additional point of use treatment might be necessary.

3. Use of an existing nearby **Public water point**. If this is far from the school the disadvantage is the walking distance with a heavy container, especially for small children, and security may be an issue for small children and girls. A wheeled cart with containers might make it easier to supply a school.

4. **Shallow well with cover**. Disadvantage is the maintenance of pumps and the risk of contamination. Making a shallow well is difficult or impossible where the soil is too rocky or where water levels are deeper than 15 meters. Depending on the type of hand pump a shallow hand dug well with a hand pump costs € 500 - € 4.000. Maintenance costs are relatively low, but one should allow money for the cost of replacement(s) and any major repairs to both hand pumps and concrete superstructure.

5. **Deep well/borehole**. The disadvantages are the high investment cost, risk of failure to find water at or near the school and the maintenance of pumps. Cost of a borehole with a hand or electric pump depend on depth of the aquifer and geology. Drilling through rocks is expensive - in Africa, cost ranges from € 3.000 and € 12.000 – but new drilling methods and low-cost/locally-produced hand pumps can be an option in some situations. In the South of Tanzania (Njombe) school water points consist of a manually drilled borehole and a rope pump at 40 m deep at a total cost of € 650 – 800. The Rural Water Supply Network (RWSN) has a good website for guidance on boreholes and handpumps (www.rwsn.ch). Maintenance costs for hand pumps are relatively low but one should allow money for replacement(s) and major repairs.

6. **Rain water harvesting**. This is mostly applied where there is no alternative method or to complement other systems. Apart from roof top harvesting you might also consider run off collection, stream water collection, ponds and reservoirs, sand dams and subsurface dams. Plastic (Poly) tanks are widely available and cost about €100 per m3, excluding transport, concrete support and gutters). Prices of storage options are shown in table 2 (section 2.6). Small dams will cost easily €5,000 – €15,000 and require various additional measures.

2.5 Water lifting devices for schools

Pumps are mounted on wells and boreholes and are applied to raise water from low tanks/chambers to raised tanks. In pump selection, it is very important to make a full financial analysis for the full life-time and to look at the servicing capacity and spare part availability in the area.

Pump types can be divided according to energy source (manual, fuel, electric, eco-powered) or to the lifting methodology. These can range from simple foot operated suction pumps, manually operated pumps like rope pumps, manual piston pumps (Nira, Indian Mark 2, Afridev, Volanta, etc) to motorized pumps, with an energy supply from wind, sun, fuel or electricity. The use of a bucket in open wells is not considered as safe, as dirt on the buckets can contaminate the water.

Hand pumps exist in different types and capacities. Suction pumps can pump up water from a maximum depth of 5-7 m, which is a common depth for cisterns. Direct action piston pumps like Nira or Canzee can pump from 10-20 m (but might be heavy for children). Piston hand pumps like Afridev and Indian Mark II and rope pumps can pump from 3 to 50 meters deep, and pumps like Volanta and Blue can pump from boreholes to 60-100 meters deep. The EMAS pump is designed to lift water from a well and to pump it directly to a raised tank. In general maintenance of these pumps has to be done by specialists.

If children are expected to do the pumping, special attention needs to be given to the required power, the height of the device and safety. Some projects promote the so-called 'play pump', which is a merry-go-round in which the children's play is used to pump the water. Main problems are maintenance and the safety and the 'mis-use' of children to pump the water for the community, also during the weekend.

For more information on hand pumps see www.akvo.org and http://www.who.int/water_sanitation_health/hygiene/om/linkingchap4.pdf)

Electric pumps and some types of hand pump can pump water into a ***raised tank*** on the roof level of the school, after which the water can be distributed to taps. For small volumes, a 'hand wing pump' might do.

Springs situated 'above' schools can use the force of ***gravity***. The same might be true for stream water, but in most cases, the water needs to be pumped to a higher storage tank. Pumps and pump houses must be safe from flooding.

A special device is the '***ram pump***', which uses the force of falling water (for instance from a river) to bring a fraction to a higher level (one tenth of the water about 7 meter higher for every meter of fall).

If the height difference between pump and tank is over 50 meters, it might be necessary to have a number of pumps arranged in series. Such systems are mostly too expensive for a single school.

If ***fuel pumps*** are used or diesel generators, care should be taken that the fuel is not contaminating the water source.

Solar driven pumps are an expensive investment but maintenance costs will be low if the battery and panels remain in good order. Care should be taken to prevent theft of panels, battery and converter.

2.6 Storage for schools

Water storage can serve different purposes:

1. to create a buffer between the supply and the peaks in the demand, whether on daily or seasonal basis
2. to create rest periods during the day or night for a pump or the caretaker.
3. to create (constant) pressure in taps if tanks are raised
4. to allow treatment such as the settlement of suspended particles.

There are many different tank types, from the traditional masonry and concrete ones to the cheaper ferro-cement, or wire cement types, which are made with, wire, cement local materials like bamboo, bricks or clay. These options are more economic than the traditional concrete tanks. All need skilled labour. Another option is a plastic tank of 500 to 5,000 litre, but these are (still) rather expensive and need protection against sun light. A recent development is strong plastic bags (foldable tanks; flexible tanks; collapsible tanks) as now used in Uganda. Other 'cheaper' solutions are pre-fabricated tanks of metal sheets, lined with plastic. These tanks can be of a very large volume and can be roofed.

It is recommended that water tanks have a wash out (to ease regular cleaning and to flush the sediments) and a regulated overflow (in case the inflow is too high) thus tanks should be equipped with entrance and outlet valves. A good quality automatic floating valve (which closes when the tank is full) is recommended, but will be costly. Openings (vent pipe, overflow and others) should be protected against insects and animals (with mosquito wire). If tank-stored water is to be used for drinking it is recommended that there should be some treatment at the outlet or a Point of Use treatment option like disinfection or filtering.

A well sealed and durable roof is the most complicated part of the tank. Experience in Kenya of roofing large volume tanks (>50 m^3) has demonstrated the importance of a central column, well designed positioning of any iron bars and the importance of wet curing.

	Unit cost €/m^3	typical size m^3	
Brick plastered	10-20	0.5-1.5	
Wire cement	13-27	0.5-20	
Ferro cement	20-40	1-8	
Plastic PE	70-130	0.5-10	
Concrete	50-120	2-210	Kenya: 100 m3= € 6.100
foldable bags	27	1.5	Enterprise Works, Uganda
prefab sheets with lining	90-150	100-500	ex factory; Bucon; 100 m3 ex factory NL = €12.000

Table 2: Summary of tank types and their unit prices (different sources; Africa; 2005-2012)

2.7 Water conveyance

Water conveyance can be manually or through (closed) pipes. Manual transport requires clean jerry cans or containers that can be closed to avoid contamination and a school might develop or buy a transporter on wheels to carry the water from the source to the school.

Pipes are made of different materials (galvanized steel, pvc, polyethylene), have a range of diameters (inches or mm) and different pressure class ratings (10 meter water pressure = 1 Atmosphere = 1 PN pressure class). Not all plastics are UV-resistant (sunlight). Pipes are preferably buried into the ground to avoid damage and to prevent the risk of viruses like legionella due to water standing at high temperatures for too long. Steel pipes are much more expensive than plastic and mostly used for plumbing and when pipes cannot be buried (rocks, valley crossings).

If water conveyance is over a long distance, it is important to have wash-outs in low points and (automatic) air valves on high points. Remember that taps and most pipes cannot sustain more than 60m of water pressure (6 Atm) and that pipe walls provide resistance to water. The friction loss is to be taken into account when calculating pump dimensions or pipe diameters and such hydraulic calculations need to be done by a specialist.

2.8 Water treatment

Water treatment is required for all surface waters and sometimes for groundwater, spring water or rain water. As mentioned, water may become recontaminated during transport and storage, which is the reason why treatment is needed to avoid regrowth of micro-organisms. One cause of recontamination in pipes can be where the distribution is done by rotation (one may get water during a few hours per day only): when there is no (or low) water pressure contaminated groundwater may enter into the pipes. Usually chlorine is applied (4 mg of free chlorine per litre) to avoid regrowth of algae and bacteria, but a newer and less well-known option is colloidal silver, which is less problematic for health (see below), but more difficult to monitor for as a residue than is chlorine.

Centralized treatment can be done by the water company/ supplier or there are decentralized treatment options through plants like Perfector, Water maker Naiade etc. These systems have capacities of 500 to 50.000 litres per day and need very regular operation and maintenance with more or less skilled technicians.

Turbid water needs to be pre-treated to remove the suspended particles. This can be done with 'filters' or by adding flocculants like Aluminum Sulphate/Alum, Moringa seed powder or other local products. Water that has *no oxygen* needs to be oxidized (mostly by letting it fall through the air). This may also remove excessive iron and manganese.

Disinfection technologies can be divided into:

1. **Ceramic Filters**, Examples are ceramic filter of the Pot, candle or Siphon model. Other options use membrane technology like the Perfector in large systems and Life straw family in small systems at household scale,
2. **Sand filters** combine the physical filtering of sieved sand with the biological treatment of the bio-film at the surface. Biosand filters are applied for small scale and slow sand filters for larger scale. Rapid sand filters are not meant for disinfection.
3. Other physical removal is done by **boiling** or by the application of **UV-light** (lamp or sun rays). Both are very effective in eliminating bacteria and viruses but boiling has disadvantages like cost of fuel, indoor pollution, time required to prepare, carbon emission etc
4. **Chemical Disinfectants**, The most common used disinfectant is chlorine, which is used in piped and centralized treatment systems. At the household level chlorine options come as a liquid (Waterguard, Certeza) or as tablets (Aquatabs). Chlorine can be locally made by the electrolysis of salty water (e.g. by using the WATA). There are several chlorine products, which do not affect the taste and are healthier (NaDCC-tablets/Aquatabs, Twinoxyde). Another disinfectant is silver, which can eliminate all harmful bacteria but is not toxic by comparison to chlorine, does not have a smell or taste and has a long shelf life. Silver may be applied in liquid form like Silverdyne or as a floating ceramic sphere like Plation. The presence of residual silver is more difficult and expensive to measure, compared to chlorine but several companies are further developing this promising option.
5. Products that use **combinations** of the above mentioned technologies such as the Pureit filter.

Information about a wide sample of water treatment products is provided on the next page and their evaluation in appropriateness, performance and price (cost per m3 over the life cycle) is provided in table 3.

Filters like Life straw family and Pureit eliminate turbidity and practically all bacteria and viruses. Other filters like the Berkefeld, Brita, Swach and Tulip eliminate turbidity and up to 99.99% of all harmful bacteria. Ceramic pot filters eliminate turbidity and reduce bacteria by 90 -99% and biosand filters reduce turbidity and bacteria with 50-98%. New generation filters like the Tulip or Life straw family model have high filter speeds of 80 to 150 litres per day and could be used in schools. One filter would be enough for 15 to 30 children. Cost of these high capacity filters range from €9 -€30 with a filter capacity of 5.000 to 15.000 litre. As with other technologies, training in maintenance is essential. When evaluating the different options, one should also evaluate the readiness of people to use the method for a longer period.

Table 3. Example of Product comparison table
BB = Best Buy (very good performance (all >6.5) and within price level of € 2/m^3)
CB = Cheapest Buy (low price level at acceptable appropriateness level (all sub-scores >5.5))

Best/Cheap Buy	**Product process, removal agent**	**Product name, brand**	**Capacity** ltr/day	**Unit price** €/m^3	**Overall AT-score ***	**Sub-score Performance**	**Sub-score Planet/People**
	Limited virus and bacteria reduction						
	Plation floats (ceramic silver balls) **	*AquaEst*	(50)	€ 0,75	6,6	6,1	7,0
	Biosand filter	*CAWST; Hydraid*	100	€ 0,11	6,4	5,7	8,0
	Arsenic reducing biofilter	*Kanchan, ENPHO*	50-75	€ 0,11	6,1	5,3	7,0
	Limited virus reduction						
BB	Ceramic Silver Pot Filter	*Potters for Peace*	15-30	€ 0,57	7,9	7,9	8,0
CB	Ceramic/carbon candle	*Water4Life*	25-50	€ 0,42	6,3	5,7	5,5
CB	Siphon ceramic silver filter	*Tulip, Basic Water Needs*	50-80	€ 0,51	6,1	6,1	5,5
	Plation Rain Purification Centre	*AquaEst RainPC*	275	€ 2,00	5,4	5,7	5,0
	Slow Sand Filter	*e.g. Jal Tara*	(2.750)	€ 0,22	5,2	4,4	7,0
	Good virus reduction, individual-family size						
	Chlorine drops, hypochlorite	*e.g. Safe Water Storage*	NA	€ 0,24	7,0	8,3	4,6
BB	Solar UV - PET bottles	*SODIS*	1-mrt	€ 0,87	7,0	7,0	6,5
	Boiling (electrical; wood)		NA	€ 17,85	6,8	7,9	4,0
	Sodium dichloroisocyanurate tablets **	*NADCC aquatabs*	NA	€ 3,25	6,5	7,9	4,6
	Sachets flocculant/disinfectant	*PUR, Procter&Gamble*	NA	€ 7,14	6,5	7,9	4,6
	Solar UV/IR heat, plastic bag	*Aquapak*	5	€ 3,13	6,4	6,1	6,0
	Iodine & micro-filter in suction 'straw'	*Lifestraw, Vestergaard*	1 (max 10)	€ 4,08	6,4	6,1	6,3
	Iodine & ultrafilter, gravity	*Lifestraw, Vestergaard*	15 (max 150)	€ 0,79	5,3	4,9	5,2
	Carbon, filter, chlorine	*Pureit, Unilever*	20	€ 4,35	5,1	5,3	5,0
	Good virus reduction, group size						
CB	Multi-filter and UV	*Perfector-E, Norit*	32.000	€ 0,69	6,2	6,6	6,0
CB	UV-(solar PV energy), macro filter	*Naiade, Clean Water Now*	2.000	€ 0,59	5,8	5,7	6,5
	Ultra-filter; hypochlorous (electrolyse)	*WaterPurifier*	600	€ 1,21	5,7	6,1	5,0
	Chlorine production (electrolysis)	*WATA (mini)*	(4800)	€ 0,02	4,9	5,3	5,8
	Quality distribution	good/green	green	6	7	7	7
		medium/orange	orange	9	9	9	6
		poor/red	red	6	5	5	8

** The overall AT score is using the weight of the criteria and is not by definition the average of the sub-scores*
*** Post treatment application only*

The selection of treatment technologies for schools is dependant on a number of factors:

- type of water source, its water quality and the variability of turbidity
- the need for pre-treatment to reduce turbidity for more effective treatment
- the need for reduction of specific chemical compounds (e.g. iron, arsenic, fluoride, nitrate)

- the need for reduction of biological contamination (bacteria, viruses, helminthes)
- the choice for a centralised or decentralised treatment
- financial, technical and cultural factors

For financial reasons, it may be necessary to separate ordinary non-potable water from taps and specially treated water for drinking. This requires good education and sufficient warning information at any water points with non-potable water.

Taste can be improved by the use of activated carbon. Filter brands that use this are for instance Korean king, Berkefeld, Stefani, Brita and Tulip.

Some *inorganic chemical elements* can be easily removed, but most of them need sophisticated devices and hence skilled staff. Special care should be taken with Arsenic, Fluoride and Nitrates.

For more information about disinfection see Smart Disinfection Solutions

Remember, much can be done by *prevention*. This can be done by ensuring the full coverage of spring box or well heads and the avoidance of entry of drainage water into the water source. For rainwater a sieve and a first flush device are needed before the water enters the storage tank. Tap water should be collected in safe jars, jerrycans or other containers, which can be closed.

2.9 Water provision

The way the water is given to the children is important and should guarantee that no contamination can take place. Education and monitoring are essential in this respect and these are a few observations/ suggestions:

- One option is to provide drinking water in a canteen or in the classroom and have one vessel/container per class of which it is clear that it contains water for drinking only, and is seen as precious (and may be holy).
- Pupils should be prevented from touching the water with hands or dirty cups. This can be helped by using storage tanks with a lid and a tap or by using bottles or a kettle. Using a ladle or spoon to take water from a container is not recommended as this may easily become contaminated in a school environment.
- Ideally, each pupil has its own cup or plastic bottle, which is regularly cleaned. If there is only one cup, this needs to be cleaned with hot water, soap and a clean brush after each use.
- It is best to keep the drinking function separate from the other functions of water, like toilet units and hand washing, because these other devices get easily contaminated.
- Pupils should be discouraged from drinking straight from a tap, or using their hands as cups.
- Care is to be taken not to waste water - a dripping tap can drain a full tank, even if it looks minimal.

Hand washing facilities are very important for improved health in schools. Hand washing with soap can be more effective in reducing diarrhea than a safe drinking water facility and a sanitary unit. Hand washing with soap needs to be done after a toilet visit, before food preparation, before eating and often after eating. Although hand washing is more related to the subject of hygiene, we include it in the 'water' chapter, as it needs to be integrated with the water supply facility.

A few observations:

- The hand washing location is preferably near the toilet but there should also be a facility near the school building so that hands can be washed before eating.

- From a monitoring perspective, the hand washing device is preferably positioned outside the building structure, but for small children a hand washing device near the classroom is recommended.
- The size and ease of use of the facility should take into account that younger children need to be able to use it. Having an optional step near the device might help this.
- Do not use 'one bowl for all' but ensure instead that clean water is used every time.
- Recontamination of fingers/hand may take place by retouching the tap with the fingers or by using a shared towel so these should be avoided. Teach children to close the tap in a different way (e.g. using the back of the hand or the elbow), or by the use of alternative designs (automatically closing taps, constant flow, taps that can be manipulated by elbow, knee or foot). There are some very simple self-closing devices like Tippy taps which are opened by the feet.
- Drainage is very important. Children will be discouraged from using the tap if they have to step into mud.
- Great care needs to be taken to avoid wasting water. One good idea is to use a tippy tap, which is very economic in water use.

Hygiene and hand washing will often have a religious connotation and function. If the religion describes certain practices, this should be incorporated into the design of the water provision, and such practices can be used and explained in the hygiene education.

2.10 Water technology selection

The following steps are recommended in selecting a water facility for a specific school.

Step 1: Remember to consider both water that is safe to drink and water to be used for hand washing. Determine the ***water quantity*** per pupil per day and per year; Distinguish two options: (A) the minimum option for drinking and limited other use like hand washing (2-6 litre/pupil/day) and (B) the most desirable option which includes water for cleaning, cooking, toilets etc.

The minimum option is essential if one has to rely on rain water or water supplied by tankers.

Step 2: Make an inventory of ***all the potential options*** in the vicinity of the school: this might be a public water scheme, nearby public improved water point, shallow groundwater, deep groundwater, stream or pond, rain water harvesting. If there is an old supply, the rehabilitation of the old system should be included as an option.

Determine for each source the possible ***quantity*** (does it match outcome of step 1?) and the ***quality*** (is there a need for treatment regarding physical, chemical or biological contamination?).

The table below provides a rainwater harvesting calculation of the once in 10 years minimum daily water availability for a school of 200 users, having 1.5 m2 roof per pupil and having different rain characteristics. From this table one can evaluate whether rain water harvesting is feasible. It is quite clear, that for boarding schools, the rainwater option is not very feasible.

rainfall			pupils& teachers	roof area	efficiency**	Availability
mean annual	variability index *	once in 10 years minimum				Once in 10 years minimum
mm/yr	%	mm/yr		m2	%	l/cap/d*
500	40%	300	200	300	65%	1,46
750	35%	488	200	300	70%	2,56
1000	30%	700	200	300	75%	3,94
1250	25%	938	200	300	80%	5,63
* variability increases with aridity						
** efficiency increases with rainfall (in arid situation, a lot is evaporated/lost before reaching the tank						
*** 200 school days in a year						

Table 4: Example of school water need calculation and feasibility of roof top rainwater harvesting

*The required (minimum) storage volume can be calculated from the once in 10 years maximum length of the dry season in days, multiplied by the school day factor (200/365) and further multiplied by the average daily availability times the total number of users. In case of a mean annual rainfall of 750 mm and a once in 10 years dry season of 8 months, the required volume is 8*30*200/365 * 2,56 * 200 = 67,330 litres or 67 m$^{3.}$ Rationalization is required, right from the beginning.*

Depending on the depth of wells or boreholes, hand pumps supply 300 – 2.000 litre/hour (15 – 100 buckets of 20 litres), but one should realize that the power of children is limited and time elapses between the filling of buckets (including rinsing). 300 – 600 litres is more realistic in this sense. The time lag is also valid for taps, which mostly have a rather limited yield.

Step 3: ***Select*** a maximum of three preferred alternatives from a water source perspective. In cases of scarcity of water or limited funds, identifying separate sources for drinking and other purposes might be an option.

Step 4: Determine for each selected alternative the ***full chain from source to mouth*** (water source development, pump/lifting device, transport, storage, treatment, provision, drainage). The position in the chain can be different: for example, water treatment may happen before storage or even before transport; pumping may be after storage etc.).

Table 7 shows a matrix of possible chain elements/needs for each source type. You should also include the links to sanitation, hand washing options and other desired uses.

Step 5: Determine for each part of the chain the most realistic choices.

This might be a complex exercise. It should be limited to technologies that are available in the area of the school as it is unwise to try technologies that are unknown in the area or innovations in isolation unless you are working with a large school programme or project. For instance if a school is situated in an area with ground layers where manual drilling is possible and water layers (aquifers) are expected to be less that 40 meters deep, hand drilled boreholes and simple hand pumps like a rope pump could be an option. However, if there are no local skills to do this then a programme is needed to train local technicians and workshops in these technologies before work can begin. Similarly for water treatment: if chlorination or ceramic filters are an option but there is no supply chain of spares, this chain first has to be developed. For each part of the chain, one should consider the criteria/factors under chapter 1 and the general issues under section 2.2.

In some areas, specific technologies are not allowed by the authorities. In Zimbabwe, groundwater may not be used from wells in urban areas. Also many water treatment options need to be approved (certified) by the local authorities.

The water portal site at akvopedia (www.akvo.org) provides information about many technology choices under the headings 'water access', 'pumps and distribution', 'storage and recharge', 'treatment and tests' and 'irrigation and other uses'. For sanitation, there is a ready-made web based decision support tool at www.akvo.org. Such a supportive tool is not yet developed for the full water chain. Rain Foundation has made a beginning for rain- and storm-water and Aqua for All/Akvo have begun to develop a tool for treatment options.

Step 6: Determine investment costs and operational costs and express them in €/litre or €/m3 and in € per pupil per year.

Mind that there are several new cost-effective solutions, which can be more effective and cheaper than more traditional methods: for instance, instead of hand digging or machine drilling, one might consider manual drilling methods. If expertise is not available programmes are needed to create that expertise. In the past heavy duty hand pumps (like India Mark II/III or Afridev) have been put on wells with shallow groundwater but there are now cheaper alternatives, which are also lighter to operate and more easy to repair. These include suction pumps like Jibon or Treadle pumps for water levels up to 5m deep as well as direct action pumps like Nira, Canzee, Mark 5 for water levels up to 12-20 meters, although at 20 meters they might be heavy to operate. For water levels up to 40 meters deep, locally produced rope pumps can be used, but are not fit for very intensive and uncontrolled use.

Sometimes, it may be more cost-effective to invest in very robust and high quality technology in order to reduce the maintenance costs. This is especially true for hand pumps at deep water levels. *For middle deep boreholes up to 50 meters pumps like Afridev and Indian Mark 2 are advised and for deep boreholes, high quality pumps like Volanta and Blue are advised as they can pump from boreholes down to 100 meters deep. Spare part delivery and qualified technicians are critical factors.*

There are also very low cost technologies available for water storage and water treatment.

*See Smart Series on water harvesting and disinfection**

Cost	Unit	Evaluation	Remark
Lifetime	year	5	
capacity	l/day	50 - 80	
Volume in lifetime	m3	35	5 filters * 7 m³
Investment	€	€ 8,00	€ 7 - 9
Replacement during lifetime	€	€ 10,00	5 * € 2/year
O&M lifetime	€		none
Salary cost Lifetime	€		none
Unit price	€/m^3	€ 0,51	€0,49-0,54

Table 5: Example of a cost calculation for water treatment with a Tulip Siphon Filter for its full life cycle:

Step 7: Together with teachers, parents and local experts evaluate the best water source option. This will be a balance between the ideal solution and the financial ability for investment, use, maintenance and replacement. Be sure that you have looked at the entire chain and remember that a solution for both community and school can have many advantages.

The relative higher investment in the shallow well option in appendix II is easily compensated by the lower unit costs per m^3, due to the higher volume of the water source. Rain water in this example is only attractive if little water is required, or if wells or boreholes have disadvantages, like high cost, risk of lowering water table, water quality/taste, taboos or cost of maintenance.

Roof top harvesting can be considered as a back-up option for the other sources, but is mostly too costly as a sole water source. Harvested rainwater is often used for hygienic purposes only.

	Unit	Evaluation	Remark
Lifetime	year	10	
Capacity	l/day		
Volume in lifetime	m3	400	4 * 10yr * 10 m3
Investment	€	€ 1.000,00	incl gutters
Replacement during lifetime	€		NA
O&M lifetime	€	€ 200,00	cleaning
Salary cost lifetime	€		NA
Unit price	€/m3	€ 3,00	

Table 6: Example of cost calculation of rain water tank with 4 fills per year and no treatment

Step 8: Define with the most relevant stakeholders for the selected chain elements the most relevant design parameters that come up from the discussions (related to target groups, age level etc.) and hand these specifications/list of preferences to a design engineer.

Table 7: Water Source Options and likely chain for school water supply

	Condition	Chain													Remarks
		Source	Collection	Lifting	Transport	Storage	Treatment						Provision	Drainage	alternatives
							Turbidity	oxydation	Organic/disinfection	mineral reduction	Taste	posttreatment			
FACTORS		Quantity, Quality, depth, distance, protection	protection; pre-treatment; efficiency	energy source; maintenance	pipes, manual, tankers (clean)	volume, price (material), land, height			group or individual; filter; UV; chem; heat	pre-test; or local know-how	culture;		water saving; hygiene;		
rain rooftop	hardened roof/surface; >400 mm/yr		gutter, first flush	Rare; only with subsurface tanks	Rare	Tank; above or subsurface	Rare	Rare	Preventive	No	Carbon	yes	tap at tank; or pipe>tap	attention	fog nets; electrical device
rain protected surface	land, rain, protection	protection	sand trap	optional; manual or energy	optional; pipes or manual	subsurface tank	yes	no	yes	No	Carbon?	yes	Mostly lifting; some gravity	prevent return flow in tank	rock catchment
spring	No inflow of surface drainage; pref above school	protection	small chamber	optional; energy driven	pipes or manual	If yield is low: tank for night inflow	Rare	Possible	Rare	Possible	Possible	Rare	taps at source or at school	attention	
public scheme nearby	reliability (daily and quality)	x	connection	x	pipes	if pressure fluctuates	Rare	Rare	Possible	Rare	Rare	possible	taps	yes	
nearby public water point other than tap	improved type; otherwise improve!	improve; rehab (cap; disinfect)		see wells	manual; or pipe to overhead tank	containers (or overhead tank)	Rare	Rare	Possible	Possible	Possible	Rare	manual or tap linked to overhead tank	possible	
shallow groundwater	sanitary seal; clay above sand; protection to overland flow	dug wells or drilled wells; local knowledge	radial tubes?	manual/electr; suction/push;	manual; or pipe to overhead tank	containers (or overhead tank)	Rare	Possible	Possible	Possible	Possible	Rare	manual or tap linked to overhead tank	around well	recharge enhancement
deep groundwater	positive indication from survey	drilled wells	good filters	see above; deep water level	manual; or pipe to overhead tank	containers or overhead tank	Rare	Yes	Rare (after poor transport)	Possible	Possible	Rare	manual or tap linked to overhead tank	around well	
permanent stream/pond	good access; flood protection		protected intake; sediment red; chamber	possible	pipes	Common	Yes	No	Yes	Rare (in case mining or industry)	Possible	Yes	tank and taps	yes	bank filtration
intermittent stream	combine with recharge, retention, wells	sand or subsurface dam; bank filtration	mostly with well; may be drain	see shallow grw	see shallow grw	see shallow grw	Rare	Rare	Common	Rare	Possible	Possible			

Table 8: Example Cost evaluation of selected water supply options

	Condition	Chain													Remarks
		Source	Collection	Lifting	Transport	Storage	Treatment						Provision	Drainage	alternatives
							Turbidity	oxydation	Organic/disinfection	mineral reduction	Taste	posttreatment			
FACTORS		Quantity, Quality, depth, distance, protection	protection; pre-treatment; efficiency	energy source; maintenance	pipes, manual, tankers (clean)	volume, price (material), land, height			group or individual; filter; UV; chem; heat	pre-test; or local know-how	culture;		water saving; hygiene;		
selected option															
roof top with treatment	roof exsisting: 100 m2	roof	gutters	na	12 m pipe& fittings	20 m3; 1 m raised	NA	NA			coal filter	silver balls	tap s	minor	TOTAL
particularities		existing	25 m		PVC-75UV resistent	cleaning & disinfection each year									
Lifetime (year)			7		10	10					5	0,25	20	20	
filling cycles/yr						4						4			
Capacity (l/day)															
Volume lifetime (m3)			560		800	800					400	20	1600	1600	
Investment ($)			50		20	1000					20	0,6	20	25	$ 1.136
Replacements during lifetime ($)			15		15						20		21		
Energy lifetime ($)			0		0	0					0		0		
O&M lifetime ($)						10					0		0	10	
Salary costs liftime ($)						200					50		30	50	
Unit price/m3			$ 0,116		$ 0,044	$ 1,513					$ 0,225	$ 0,030	$ 0,044	$ 0,053	$ 2,02
			6%	0%	2%	75%	0%	0%	0%	0%	11%	1%	2%	3%	
selected option															
shallow well with 5 drinking units and chlorine drops			well 1,5 m diam, 15 m deep	hand pump, IM-IV	NA	Vessel at school; 5 of 20 l	NA	NA	Cl drips	NA	NA	NA	buckets with tap	in well	TOTAL
particularities			soft soil						1 drop per 20 l						
Lifetime (year)			15	7		5							5		
filling cycles/yr						3259							3259		
Capacity (l/day)			2000	2000											
Volume lifetime (m3)			6.518	3.042		326					0	0	326		
Investment ($)			3000	1200		35							40		$ 4.275
Replacements during lifetime ($)			0	60											
Energy lifetime ($)			0	0		0					0		0		
O&M lifetime ($)			0	25		0					0		0		
Salary costs liftime ($)			0	200		0									
Unit price/m3			$ 0,460	$ 0,488		$ 0,107							$ 0,123		$ 1,18
			39%	41%	0%	9%	0%	0%	0%	0%	0%	0%	10%	0%	

3. Sanitation

3.1 Introduction

Sanitation is about more than simply a decent toilet. Effective sanitation means the avoidance of contact between human beings and dangerous micro-organisms (pathogens) to prevent the spread of diseases, like diarrhea.

According to UNICEF the basic sanitation requirements for a school are (UNICEF 2009):

- maximum 75 children for each toilet (target is 25 girls per toilet, 50 boys per urinal (of 1 m), 50 boys per toilet if there is a separate urinal)
- separate toilet blocks for boys, girls and school staff (facilities regarding menstruation)
- for each block there is at least one toilet for disabled (wider door and room, ramp, support)
- distance between school and toilets maximum 30 meters
- hygienic hand washing facilities with soap.

The unit figures may be higher if children can go to the toilet during class hours, when the breaks of class hours are not all at the same time, or when the school period during the day is relatively short.

For schools, special attention needs to be provided to the design for ***small children and disabled people*** (size, ease, security, muscle power, attractiveness) and to adolescent ***girls*** in their period of menstruation (private place for hygiene and washing of clothes or disposal of napkins). Also teachers should preferably have a separate toilet. A good balance needs to be found between having sufficient distance between school building and sanitary unit (30 meters), visibility of the pathway and the need for privacy. One in five poor people are disabled so consideration must be given for adapted designs for ***disabled pupils***, whether visually impaired or physically disabled. Any school having no such students can indicate that the school is not receptive for this group. When it comes to considering sanitation, there are many taboos and the subject is very personal so it is vital to include children, parents and teachers in the design process.

For sanitation, it is important to design for the ***full chain*** from secure access to final destination, whether subsurface storage or ***re-use*** of manure and urine. Waste can be seen as a 'source' for other activities, like the production of biogas, manure and nutrient supply for agriculture, carbon for briquettes and feed for fish ponds. Sanitary systems in a school environment can be of a sufficient scale to exercise such innovations and it is important to have qualified staff to deal with this.

The construction of ***urinals*** needs to be considered and in some countries, even girls' urinals are available. Not only does this support the idea of re-use of urine, but it also reduces the pressure on the more expensive and time consuming common toilet facilities and urinals are easier to maintain and clean. Remember that, for younger children, the height of urinals needs to be appropriate and that it is not the habit among boys to squat when they urinate.

The sanitary provisions in the school environment may challenge the children to change their habits and behavior, which might have a wider impact on their families and society as a whole. The school facilities may thus function as a ***demonstration***, but at a family level such arrangements are often difficult to afford so the teaching of children and parents should also include realistic alternatives for household level.

When selecting their solution, people often aspire to the highest standard, especially if external funding is available. From our perspective, sanitary solutions need to fit with the local environment, and it would not be appropriate to build a 'toilet palace' next to a school with a leaking roof, or worse. It is also very important to consider recurrent costs, as flush toilets require high operational costs. But, on the other hand, a higher quality installation might actually reduce maintenance and repair costs in some circumstances.

The 'sanitation ladder' might provide a guiding tool in choosing sanitary facilities for your school. By defining different levels from a simple pit latrine to a flushed toilet and everything in between it is possible to climb the ladder step by step rather than jumping onto the highest step in one go. (see step 4 under section 3.3).

3.2 The sanitation technology chain

The sanitation chain consists of the following possible elements:

1. Toilet facility (what's above the ground)
2. Collection and storage; in situ treatment
3. Conveyance
4. External treatment
5. Re-use/disposal

The ***toilet facility*** includes the design of the building/structure and the choice of type of toilet.

The different types of conventional toilets are pit latrines (including ventilated improved pit-latrines), pour flush toilets (limited water use, especially where it is common to do anal cleansing with water) or flush toilets. The latter consume a lot of water and need external storage and conveyance. They are discouraged in most developing countries, especially in case of water scarcity.

Ecosan toilets are oriented towards the re-use of the human waste. Most common are composting toilets, but the separation of urine and excreta is becoming more common. For composting, the use of some detergents is not recommended, as the 'good' germs should not be killed. A simple ecotoilet is the arboloo; this is a dry pit latrine with a movable superstructure.

The *form of the toilet unit* should be adapted to the local circumstances, whether just a hole with foot supports (often pre-fab or under the name sanplat; with or without urine diversion), a floor receptacle for poor flush toilets or a raised toilet. The toilet should have a cover/lid. The hole should not be too wide, especially not for small children. Raised seats might have a flexible seat: one with a larger and an inner one with a smaller hole. A grip next to the seat/hole is recommended for small children. Attention is to be given to disabled pupils and special girls' needs.

The use of *urinals* is encouraged, even for (younger) girls. In some cultures, a shared urinating wall is accepted; in others the urinals should be private and individual. Height is very important for minors. They need to be cleaned at least twice a day but frequent flushing with water is not required and non drinkable water may be used for cleaning.

The *superstructure* of the school toilets needs to be robust, roofed and well ventilated and privacy is to be protected. Some specific structural points:

- The accessibility for insects and animals should be prevented as much as possible.
- When doors are applied, special attention is to be given to locking (from inside) and the strength of hinges. They should be wind proof but not too heavy for younger children. *When visiting a project in Kenya, all the doors of the latrines were damaged and on inspection it was found that the carpenter had used nails instead of screws. Moreover, when the doors were blown open by the wind a momentum was created that applied 20 times more force on the nails/hinges, which were then easily wrenched out of the doorframe.*
- Special attention is to be given to the stability of the structure and its foundation, recognizing that the presence of the pit nearby might provide instability.
- The use of wood/bamboo at floor level needs to be avoided and if wooden frames are used, they should be based on raised stone/concrete pillars. Wood should be well protected (by oil or paint).

- Floors need to be designed to be easily cleaned - including the lowest drainage point.
- In choosing a design consider any possibilities for cost saving by the use of alternative materials or design.
- Where there are risks of flood or inundation, the full toilet structure needs to be raised to avoid the entrance of flood water into the building.
- Have separate compartments for boys, girls and teachers. Remember that girls need more space behind the seat/hole than boys.
- Have a 'dust bin' at every toilet unit and next to the hand washing facility
- Include a hand washing facility in the design
- Consider the use of urinals, urine separation devices or Ecosan

What makes latrines accessible for disabled people?

Each latrine block to have one accessible cubicle with:

- additional space (at least an extra $1m^2$)
- wider door (minimum 80 cm wide)
- hand rails for support attached either to the floor or side walls
- raised toilet seat, preferably fixed
- an access ramp ideally with a gradient of 1:20, but if space is limited, maximum gradient 1:12.

WEDC research shows that the additional cost of making a school latrine accessible is less than 3% of the overall costs of the latrine.

(source: WEDC 2011 Briefing Note)

The ***collection and storage unit*** will vary from the simple pit below a pit latrine to a composting compartment and a septic tank or a combined wastewater treatment unit. For urine, a separate collector (jerry can or container) can be used. Urine can be useful for watering the school garden and, as it has 5 times more phosphate than feces, it can sometimes be sold to neighboring farms. The pit/tank may be situated below the superstructure or next to it; in which case, the gradient of the drain should be more than 1:12. For septic tanks, there should be an entry for emptying and that point should have an easy access for a vacuum truck. Pit latrines may have a double vault compartment. When one compartment is full, the other is put into use (by closing the seat or by changing the drain). Double vault systems only work if the non-used compartment can remain out of use during one full year after which time the slurry might be used as manure in orchards.

In case of **ecosan,** most collectors are *above the ground*. If containers are used, they should not become too heavy for handling and be positioned safely so as to avoid human contact. Composting toilets (or dehydrating toilets) have dark painted sun oriented inclined covers. In flood prone areas, a raised latrine with a raised pit is recommended but in this case, rising 'groundwater' levels may lead to the overflow of pits. A raised superstructure may also be needed in case of a rocky sub-soil or where the sands are too loose for pit stability. Ecosan toilets, using both urine and feces, can be considered but in practice this is more complicated and there may be more cultural resistance to their use.

More sophisticated systems such as an anaerobic filter, an anaerobic baffled reactor or an anaerobic biogas reactor combine storage and treatment.

The Wise Water Management project in India developed a model for re-use of grey water for toilet flushing. The grey water comes from the hand washing and bathing in the sanitation facility. It is lead through a pre-filter (sponge) to absorb the soap and hairs, before going on to a baffling tank for sedimentation, and two gravel/sand beds for further treatment, finally followed by some form of aeration. The water in the collection tank is used for gardening and toilet flushing. Each week, the collection tank is disinfected with chlorine.

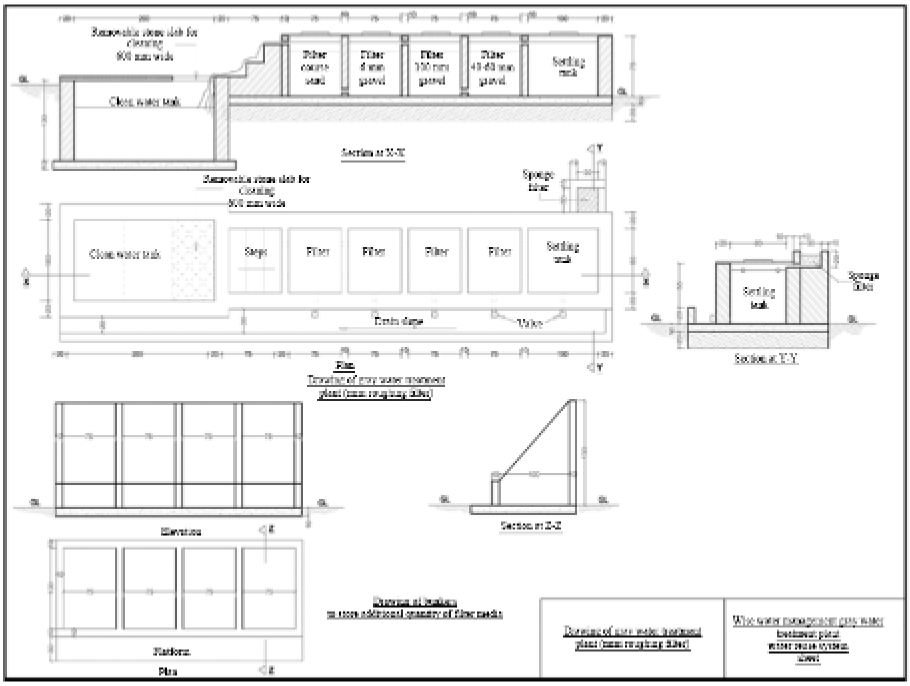


Figure 2: technical drawing of grey-water treatment in the Wise Water Management project in India (Godfrey et al 2010)

The water is filtered at 0,2 m3/m2 h through a gravel bed of 10-20 mm and one of 6-10 mm. The removal efficiency for most of the contamination factors, including turbidity and E.Coli, was around 50%.

The *selection of the volume* of the pit or tank will determine the life cycle or frequency for emptying (see 3.1). An adult living on an almost vegetarian diet produces about 145 litres of excreta per year and 400 litres of urine. For a meat diet, the weight of excreta is much lower and for children in a school situation, these figures will be lower still. Taking into account factors like the 5-day week, holidays, a child's much lower food consumption, avoidance of toilet use during school time and short period of the day we estimate that a school toilet will need to deal with around 15 litres of excreta and 60 litres of urine per schoolchild per year. Any material used for anal cleaning and hygiene pads/napkins for adolescent girls, if dropped into the hole, should be included in the calculations though, ideally, non-degradable materials should be put aside in a separate (covered) collector that is regularly emptied. This separation, combined with access for desludging, will enlarge the life time of a pit and reduce the need for change of location

It is usually recommended that you *seal the walls* and floor of pits to prevent contamination to groundwater but in most cases subsurface drainage water is clear of bacteria within 60 days. As the composting process is more rapid under dryer conditions then it is only where there are water wells nearby or the groundwater table is very shallow, that sealing is recommended.

Septic tanks can also be designed as biogas generators.

Pits (and tanks) may have *vent pipes*, which need to be screened to trap insects flying towards the light and to prevent entrance of animals. Vent pipes in Ventilated Improved Pit latrines need to be at least one metre above the roof, 90-150 mm in diameter, black painted and sun-exposed. Some experts question the effectiveness of VIP-latrines, nowadays.

The ***conveyance of slurry*** (and urine) from pits may be done through sewers, vacuum trucks or by transport using containers, though the compost from composting toilets can be removed safely after one year without further precautions. Human contact with fresh slurry needs to be avoided and protective clothing must be worn when anyone is involved in slurry conveyance. The overflow from septic tanks can be collected using a system of small diameter pipes and for larger schools or boarding schools the pre-treated overflow of the septic tank may pass through a constructed wetland or helophyte plant filter before safely replenishing a fish pond.

Re-use of urine and excreta needs specialist advice and good coaching. Urine in general has no bacteria, is relatively harmless and can be used the same day it is produced. Excreta however is full of harmful bacteria (E Coli), needs to be treated with care and composted for at least 4 months before it can be used. Urine and excreta can also be used to produce biogas, which could be used in the school kitchen or for lighting the building while pathogen-free manure can be re-used in the school garden and pre-treated waste water can be used in fish ponds. There is a lot of literature on this issue, which goes beyond the purpose of this handbook.

Many schools are developing tree nurseries but it should be borne in mind that newly planted trees can grow quickly and their roots can easily destroy buildings and structures, including underground pits.

For ***boarding schools***, the standards need to be higher with regard to sanitation blocks and water availability for hygiene and sanitation. Similarly higher standards apply to washing, laundry and shower facilities and the provisions made available for sick children.

Investment Costs are in the order of € 1.000 per seat and € 20 per child, excluding water supply facilities, hand washing facilities and hygiene education. There is a wide variation and the unit prices are heavily dependent on the number of users. The table below shows a summary of the database of Aqua for All supported school sanitation projects. The difference between minimum and maximum is huge. Some projects have a simple series of pit latrines and others have complicated eco-san with biogas.

	cost per seat			cost per pupil (max 75/seat)			Source A4A
	min	average	max	min	average	max	
Asia	€ 88	€ 894	€ 1.389	€ 4	€ 16	€ 27	1202 seats, 9 countries
Africa	€ 285	€ 1.003	€ 3.036	€ 5	€ 20	€ 40	1491 seats, 11 countries

Table 8: Summary of sanitation infra-structure investments at schools (source: Aqua for All data base; water facilities and hygiene mostly not included in price)

3.3 Sanitation technology selection

In designing the sanitation facilities, the following ***steps*** need to be taken, preferably in a consultative or participatory process with children, parents and teachers. Be sure to include a good gender balance: for some taboo issues, it can be essential to work separately with male and female groups. The steps below are mainly derived from a Decision Support Tool, developed by WASTE and AKVO.

Step 1: decide on the ***design criteria*** including the maximum number of users, the division of groups using the facility and for each group any specific aspects around access, safety, hygiene, privacy etc. as well as the final destination of excreta and urine. It is good to start by considering your experience of any existing system you are using or a known system from another school. In thinking about design criteria you should also evaluate whether eco-sanitation, urine/excreta separation or other types of re-use might be an option.

Step 2: calculate, for ***size estimation*** purposes, the number of users (gender and age specific) and the volume of excreta and urine produced per day/per year or per emptying cycle.

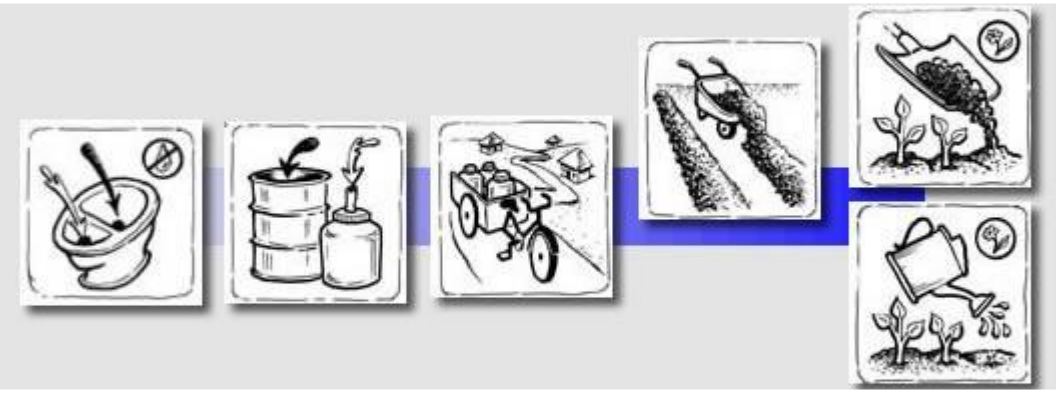
Step 3: Determine possible ***limiting factors*** with regard to soil/rock, risk of inundation and available space and identify possible ***sites*** for the sanitary units and possible storage and treatment installations. Remember that sanitation blocks should be at least 20 m from a (groundwater) source and 1.5 m above the groundwater table. If there are prevailing winds you should consider the most suitable location in terms of any odours. The web-based Decision Support Tool of Waste and Akvo (www.akvo.org – sanitation portal) provides a short list of relevant factors you might need to consider, including availability of water, soil type.

Step 4: Define the ***desired situation*** if money was not a problem and then identify the ***'intermediate' steps***, which might be more affordable and acceptable. A school with only 1 latrine for 50 boys and 50 girls could aspire to a concrete sanitary block with 3 flushed toilets for girls, and 1 urinal and 1 flushed toilet for boys. A positive and realistic intermediate step, however, may be to build two more pit latrines: one extra for girls and one for boys.

Step 5: Enter into the ***design evaluation process*** for each part of the chain, namely: the 'toilet'/superstructure, the collector, possible transportation/conveyance of waste, possible treatment and possible re-use. The web-based Decision Support Tool developed by Waste and Akvo (http://waste-dev.akvo.org/) can help you in this process. Possible further options can also be found on the sanitation portal of the Akvo website.

Step 6: Make a choice from your selected sanitation chain options, based on technical, economic and cultural criteria and using feasibility criteria (see chapter 1).

Step 7: Define with the most relevant stakeholders for the selected chain elements the most relevant design parameters (related to target groups, age level etc.) that have been identified during the design discussions and ensure that these specifications/list of preferences are handed to the design engineer.



Example of a sanitation chain with a diversion toilet, separate storage for excreta and urine, transport of tanks, composting and re-use of manure and urine (source: www.akvo.org).

4. Hygiene

Hygiene is inevitably linked to water and sanitation as a means to break the transmission of dangerous micro-organisms from feces to mouth through dirty fingers, flies, food, floor (soil) and fluids (water). Sanitation reduces the first contact, water treatment reduces the transmission line through water and hygiene reduces transmission through other paths. Hygiene education and effective use of hand washing facilities are 7 times more effective for good health than improvement of water supply (*3IE, 2009*).

Hygiene can also be a link to other aspects affecting physical well being, such as health, nutrition, body hygiene, sexuality, environment and housing/habitat but all these different aspects cannot be considered here. Prevention strategies such as cleanliness, health checks and vaccination is very important, as is health treatment, including very cost-effective deworming campaigns, and improved clothing and foot wear.

Improving hygiene is mainly achieved through education leading to behavioral change, thus most literature on hygiene concentrates on educational methods. Relevant value-based education relating to faith and culture is another major focus of the ARC Water Schools programme.

Positive hygienic behavior will be supported by the improvement of facilities, such as hand washing devices, drainage, solid waste collection and deposition, mosquito nets, ventilation, safe food storage, utensil drying racks and safe cooking places. Others helpful factors are linked to environmental measures against dust and mosquitoes, like elimination of ponds and open water, not planting banana trees in front of windows/doors and the removal of waste such as old tires and other material that may store water.

A hygiene/sanitation/habitat check carried out with children, parents and teachers is recommended as the first step in a participatory design process. The aim of the exercise is to identify situations on the school compound that are good and others that would need improvement from an environmental point of view. Once participants have identified their top 5 issues, the facilitator can invite them to suggest a solution, after which others might give alternative suggestions.

The booklet Smart Hygiene Solutions provides an excellent review on state of the art technologies and methods for hygiene promotion.

References

Websites:

www.akvo.org (akvopedia/water and sanitation portals/studios and decision support tools)

www.irc.nl (specialized library; downloadable for Smart Solutions series) www.washdoc.info/

www.who.org (Guidelines for drinking water. Many publications on water sanitation and health)

www.unesco.org/education/fresh (former UNESCO school community)

www.washinschools.info (IRC school community)

www.washinschoolsmapping.com

http://waste-dev.akvo.org/ (sanitation decision support tool)

www.wsp.org/scalinguphandwashing/enablingtechnologies/index.cfm?Page=Browse (on hand washing devices and tippy taps)

www.who.int/water_sanitation_health/hygiene/envsan/phastep/en/index.html (on PHAST methodology)

Literature:

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