HOUSEHOLD SANITATION AND WASTEWATER REUSE FACILITIES

TECHNICAL GUIDANCE MANUAL

APRIL 2012

unite for children

unicef

Technical guidance manual on household sanitation and wastewater reuse facilities

United Nations Children's Fund
P.O.Box 25141
Shuffat, East Jerusalem

UNICEF occupied Palestinian territory developed this technical guidance manual on household sanitation and waste water reuse facilities. A special thanks to Jan Spit, Sanitation consultant from Delft, The Netherlands, for developing the manual and a special thanks to WASH cluster partners for appropriate facilities in urban and rural communities in occupied Palestine territory and children who cooperated with UNICEF in facilitating this evaluation.

April 2012

Cover photo: UNICEF-oPt/2012/Spit

The purpose of this manual, which is developed by the UNICEF office in the occupied Palestinian territory (oPt) is to recommend improvements in the technical field of wastewater re-use and improved household sanitation design, that is culturally acceptable.

For further information, please contact:
United Nations Children's Fund
P.O.Box 25141
Shuffat, East Jerusalem
Telephone: 972-2-5840400
Fax: 972-2-5830806
E-mail: Jerusalem@unicef.org

TABLE OF CONTENTS

0. List of acronyms

BOD	Biochemical oxygen demand
C	Oxidizing carbon
CO_2	Carbon dioxide
COD	Chemical oxygen demand
C4D	UNICEF communication for development
DALY	Disability-adjusted life year (DALY) is a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death
DO	Dissolved oxygen
EC	Electric conductivity
EPA	Environment Protection Agency
FAO	Food and Agriculture Organization of the United Nations
G	Grams
GRC	Glass concrete cement
H_2O	Water
H_2S	Hydrogen sulphide
HDPE	High Density Polyethylene
ICT	Information and communication technology
JMP	Joint Monitoring Programme
Kg	Kilograms
Lcd	litres per capita per day
MLD	Mega liters per day
N	Nitrogen
NGOs	Non-governmental organizations
NO_3	Nitrate
O_2	Oxygen
ODA	Official Development Assistance
oPt	occupied Palestinian territory
P	Phosphorous
PA	Palestinian Authority
PSI	Palestinian Standard Institute
PO	Phosphate
PWA	Palestinian Water Authority
QMRA	Quantitative microbial risk Assessment
S	Sulphur
SO_4	Sulphate
TDS	Total Dissolved Solids
WASH	Water, sanitation and hygiene
WHO	World Health Organization

1. Introduction

1.1. Background

In January 2009, the Wash Cluster approach for the occupied Palestinian territory (oPt) was activated to coordinate urgent humanitarian response to the populations affected by the Israeli Operation 'Cast Lead' in Gaza. UNICEF (see section 1.2) assumed the responsibility as the WASH Cluster Lead Agency to provide technical support, coordination and capacity building for approximately 59 partners in both Gaza and West Bank. One of the WASH Cluster activities is to discuss and compare sanitation designs due to the difficulties in the terrain and restrictive planning and permitting system. Presently there are no specific guidelines or technical specifications for implementing agencies or contractors to install structurally and environmentally sound household sanitation systems. There are equally no public health guidelines for handling raw sewage when emptying existing systems. Hence, WASH Cluster partner agencies have expressed the need for further improvements in the technical field of wastewater re-use and improved household sanitation design.

In March and April 2010 Jan Spit, Sanitation consultant from Delft, The Netherlands, developed the training and the accompanying manual to answer these need, with UNICEF's technical guidance and supervision. The Terms of Reference for this assignment are presented in Appendix 1-1. The main objectives were to:

- Assess a range of technical excreta disposal options that would ensure environmentally sustainable solutions that encompass the 'do no harm' principle, and which are culturally appropriate and gender sensitive;
- Recommend excreta disposal designs for early recovery humanitarian emergency situations for rapid installation and relocation;
- Consider a range of household and/or small-scale excreta disposal designs for: peri-urban / urban congested areas with no connection to the wastewater network, within terrain that can be liable to flooding, in areas of hard rock or impermeability, and in rural areas hosting nomadic Bedouin communities;
- Facilitate linkages and examples with relevant global and regional standards that identify ways in which household wastewater can be reused or recycled for more efficient livelihoods production utilising excreta disposal and wastewater re-use/recycling at household or community level.

There are two parts to this manual. Part one, which is the basics, a variety of background material is introduced, part two reviews the technical design options.

Chapter one highlights the relationship between sanitation and public health, the current sanitation conditions to several principles to accelerate the implementation of improved sanitation. Chapter two includes the characteristics of domestic wastewater and the essentials of wastewater treatment, and chapter three discusses the guidelines associated with sanitation, public health and waste water re-use. Chapter four provides the basis for the selection of systems fit for oPt conditions. In area 'C' it is impossible to implement durable super structures, hence chapter five discusses some possible remediation/ rehabilitation improvements to the existing super structures. Chapter five proposes some immediate improvements. In part two, the design of sanitation systems is elaborated: from dry (chapter seven), to wet (chapter eight), grey water (chapter nine) and neighbourhood based systems (chapter 10). Finally chapter 11 presents an option to deal with septage.

1.2. UNICEF Core Commitments for Children in humanitarian action[1]

UNICEF has committed itself to effective leadership in WASH cluster organization as part of its Core Commitments. See Table 1-1.

Table 1-1 : UNICEF Core Commitments on WASH

WASH strategies result

Girls, boys and women have protected and reliable access to sufficient, safe water and sanitation and hygiene facilities.

Commitments	Benchmarks
Commitment 1: Effective leadership is established for WASH cluster/inter-agency coordination, with links to other cluster/ sector coordination mechanisms on critical inter-sectoral issues.	**Benchmark 1:** Coordination mechanism provides guidance to all partners on common approaches and standards; ensures that all critical WASH gaps and vulnerabilities are identified; and provides information on who is doing what, where, when and how, to ensure that all gaps are addressed without duplication.
Commitment 2: Children and women access sufficient water of appropriate quality and quantity for drinking, cooking and maintaining personal hygiene.	**Benchmark 2:** Children and women have access to at least 7.5–15 litres each of clean water per day.
Commitment 3: Children and women access toilets and washing facilities that are culturally appropriate, secure, sanitary, user-friendly and gender-appropriate.	**Benchmark 3:** A maximum ratio of 20 people per hygienic toilet or latrine squat hole; users should have a means to wash their hands after defecation with soap or an alternative (such as ash).
Commitment 4: Children and women receive critical WASH-related information to prevent child illness, especially diarrhoea.	**Benchmark 4:** Hygiene education and information pertaining to safe and hygienic child-care and feeding practices are provided to 70% of women and child caregivers.
Commitment 5: Children access safe water, sanitation and hygiene facilities in their learning environment and in child-friendly spaces.	**Benchmark 5:** In learning facilities and child-friendly spaces, 1–2 litres of drinking water per child per day (depending on climate and individual physiology); 50 children per hygienic toilet or latrine squat hole at school; users have a means to wash their hands after defecation with soap or an alternative; appropriate hygiene education and information are provided to children, guardians and teachers.

UNICEF Communication for Development (C4D)[2] is one of the most empowering ways of improving health, nutrition and other key social outcomes for children and their families. C4D is defined as a systematic, planned and evidence-based strategic process to promote positive

[1] Source: UNICEF (2010)
[2] www.unicef.org/cbsc/index.html accessed April 2012

and measurable individual behaviour and social change that is an integral part of development programmes, policy advocacy and humanitarian work. C4D uses dialogue and consultation with, and participation of children, their families and communities. It privileges local contexts and relies on a mix of communication tools, channels and approaches. C4D is not public relations or corporate communications.

1.3. Relationship between sanitation and public health[3]

In the framework of this manual, sanitation is referred to as the hygienic and proper management, collection, disposal or reuse of human excreta (faeces and urine) and domestic wastewater to safeguard the health of individuals and communities[4]. It is concerned with preventing diseases by hindering pathogens, or disease-causing organisms, found in excreta and wastewater from entering the environment and coming into contact with people and communities. This usually involves the construction, operation and maintenance of adequate collection and disposal or reuse facilities and the promotion of proper hygiene behaviour so that facilities are effectively used at all times.

Sanitation (and hygiene promotion) programs have three primary objectives:

- Improving health conditions;
- Promoting dignity of living or enhanced quality of life; and
- Protecting the environment.

The combined positive effects of these conditions lead to wider wellbeing and economic benefits.

Disease-causing organisms in human excreta may find their way into a host and cause diseases. See section 2.2. One of the symptoms of these diseases is diarrhoea. Diarrhoea poses such a significant health impact, especially on children and yet it is easily preventable with proper sanitation and hygiene.

Pathogens are transmitted through a number of routes. These routes can be remembered with the acronym, **WASH**:

- Contamination of **W**ater that we ingest;
- Spread by vectors like **A**rthropods or other insects;
- Contact (with our feet) through the **S**oil or floor; and
- Contact through our **H**ands.

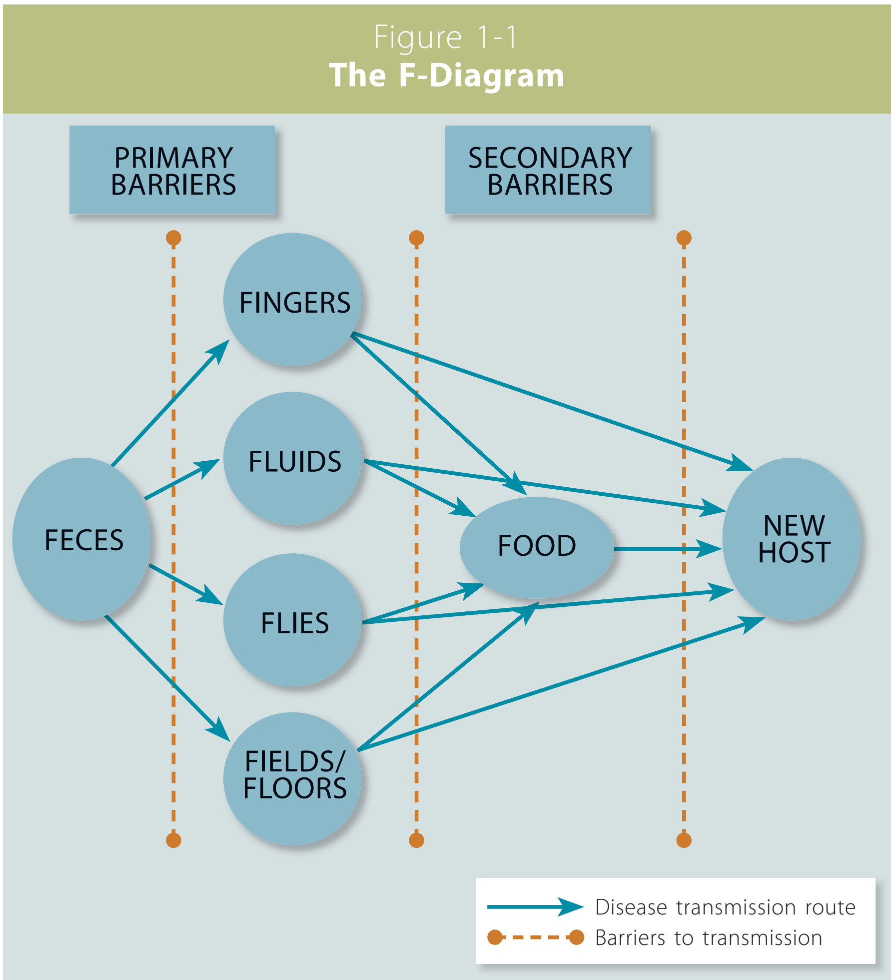
The first three routes are blocked by constructing sanitation facilities that effectively separate excreta from human and animal vectors (including insects) contact and secure against the contamination of drinking water and soils. The last route is barred by proper hygiene practices such as washing hands with soap after defecation or cleaning up children post-defecation.

The 'F-diagram' shown in Figure 1-1 illustrates these contamination routes through fingers, flies, fields/floor and fluids. In oPt, the transfer through fields/floor is often a result of animal faeces rather than indiscriminate or open human defecation[5]. The most effective way of reducing transmission of disease is to erect 'primary barriers' which prevents pathogens from entering the environment through the provision of safe excreta disposal. The 'secondary

[3] Based on WSP (2007)
[4] Often sanitation also includes solid waste management and drainage. In this manual it is restricted to human waste management.
[5] Info UNICEF WASH Cluster manager on 20 April 2012

barriers' are practices that prevent the contact or use of the contaminated 4Fs into the food or new host.

Figure 1-1: The 'F'-diagram (WSP, 2007)



Source: Sanitation and Hygiene Promotion Programming Guidelines (2005), after Wagner and Lanoix

1.4. Definition acceptable sanitation oPt

The term 'basic sanitation[6]' includes the critical components of sanitation services: privacy, dignity, cleanliness, and a healthy environment. From a monitoring viewpoint, such characteristics are difficult to measure. To resolve these issues, the UNICEF-World Health Organization (WHO) Joint Monitoring Programme (JMP) classifies sanitation facilities as either 'improved' or 'unimproved', as shown in Table 1-2. (www.unicef.org).

It is important to bear in mind that the question is not whether the population has access to sanitation, but whether the quality of sanitation provided is appropriate for all household

[6] Based on Tilley/Sandec (2008)

members, affordable and prevents contact to human excreta and wastewater within the home and wider neighbourhood.

Table 1-2: Classification sanitation options (UNICEF JMP)

Improved technologies:

- Connection to a public sewer
- Connection to a septic system
- Pour-flush latrine
- Simple pit latrine

Ventilated improved pit latrine (VIP)

Unimproved technologies:

- Bucket latrines
- Public latrines
- Open latrines

Table 1: Classification of improved and unimproved sanitation options. Access to adequate sanitation facilities is based on the number of inhabitants using „improved sanitation". (JMP, <www>)

In order to be able to judge whether a certain sanitation system is acceptable and appropriate for oPt conditions[7], the WASH cluster partners developed the following definition in April 2012:

"An acceptable and appropriate sanitation facility is a facility that is:

1. ***Environmentally acceptable*** and safe from a Public Health point of view: excreta (faeces and urine) are handled in such a way that it cannot affect human beings. Excreta are not accessible to flies, mosquitoes, rodents etc. The handling of fresh excreta is avoided. In areas where the people depend on ground water as a resource for drinking water, the groundwater should not be polluted;
2. ***Convenient and safe****:* there are limited odours and unsightly conditions. The facility is a short walking distance from the house and can be used safely by women, girls and elder people, also at night. The facility is also safe in the sense that people can walk on the subsurface pit without the fear of falling in;
3. ***Simple to operate***: the daily operation is minimal and only requires simple and safe routines;
4. ***Sustainable*** with minimal maintenance: a long technical lifespan and only occasional maintenance, i.e. every 1 or 2 years*;*
5. ***Upgradable****:* in the future 'step-by-step' (incremental) improvements and extensions are possible;
6. ***Acceptable cost****:* this does not mean necessarily that the system is cheap. The technology selected should be within the economic and financial reach of the household and (local) government budgets".

[7] Based on Simavi Sanitation Hygiene And Water (SHAW) project (2012)

1.5. Current sanitation conditions in the occupied Palestinian territory

In the West Bank, about 86 per cent of the population (1.7 million people in 648 communities) rely on on-site sanitation systems[8]. Predominantly these are cesspits, often erroneously labelled septic tanks. In Gaza city, most of the wastewater treatment plants (WWTPs) are overloaded and are working beyond their designed capacities. This means that about 60 MLD[11] untreated or partially treated sewage is discharged into the sea. Wastewater lagoons in Gaza have seen breaches due to capacity overloads coupled with lack of maintenance, flooding the neighbourhoods with sewage. Subsequently, there are about 40,000 cess-pits being used in Gaza, by the communities that are un-connected to the sewer networks. This has a cumulated impact and potentially grave consequences for public health and the environment both in Gaza (and southern Israel), and could cause further contamination of Gaza's aquifer[9]. Typically a cesspit is a large unlined pit, 2-3 meter wide and 2-3 meter deep in which both grey and black water is discharged. Although the cesspits are usually covered with metal sheets, these are not sealed allowing flies and mosquitoes access to the waste. See Figure 1-3. The contents of the cesspit leak freely into the subsoil and are a threat to drinking water supply. See Figure 1-2.

[8] WASH Cluster assessment (2010) and WASH MP
[9] WASH Cluster NAF, 2011

Figure 1-2: Cesspit (Burnat, 2010)

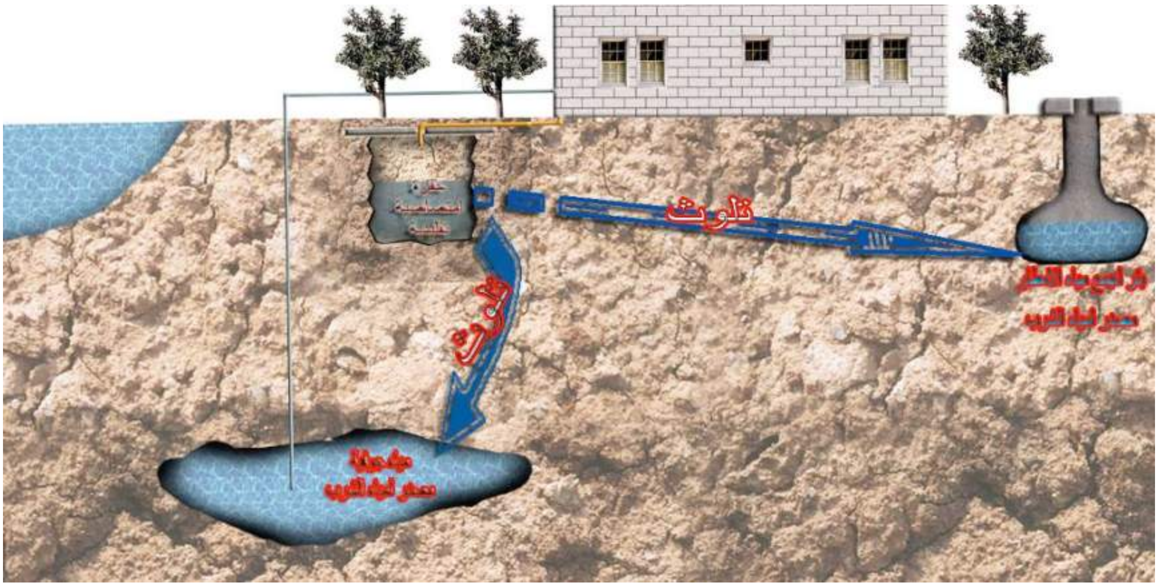


Figure 1-3: Open access to cesspit (UNICEF-oPt/2012/Spit)

When the cesspit is full, the contents, is discharged uncontrolled by 6-7 m^3 vacuum tankers at the nearest open space. See Figure 1-4.

Figure 1-4: Dumping septage in Wadi Gaza (UNICEF/Spit, 2012)

During emergency situations, agencies provide beneficiaries with portable toilets that collect waste in buried metal containers. These containers are usually very small (250 litres) and fill up quickly. See Figure 1-5 and Figure 1-6.

Figure 1-5: Full 250 litre cesspit (UNICEF-oPt/2012/Spit)

The same system is also often provided for static Bedouin communities as the superstructure can be moved to alternative locations while the metal receptacle remains in the ground. This is often to overcome the issue of handling or removing waste, which is seen as either culturally unacceptable or uncommon to communities who previously relied on digging shallow pits for defecation.

Figure 1-6: Metal sheet toilet superstructure with overflowing cesspit (UNICEF-oPt/2012/Spit)

Additional difficulties are encountered in areas of hard bedrock or poor accessibility that prevent access for tankers to dislodge or construct large cesspits. Such designs although successful in their attempt to circumvent the restrictive planning rules and adapt to the hard physical environment are unsustainable in their longevity and offer poor environmental protection measures.

In villages or towns connected to networks (sewerage), intermittent water supply results in irregular wastewater flow, which results in sedimentation of sand and debris in the sewers. To remove this, flushing of the sewers is needed and grit/sand need to be removed from manholes. If desludging is not practiced, due to a lack of regular maintenance for instance due to budget constraints, pipes can get blocked whilst the sedimentation basins of sewage treatment plants can fill up with sand and sludge and become inactive. If the sedimentation basin is full of sand and sludge, the hydraulic retention time becomes too short for proper wastewater treatment. Hence, wastewater leaves the treatment facility untreated. Even when the collection system works properly, only 1/6 of the collected water is being treated in wastewater treatment plants[10].

See Figure 1-7.

Figure 1-7: Village communal septic tank full of sand and sludge (UNICEF-oPt/2012/Spit)

Hence in sewered areas the situation is rarely better than in the areas relying on on-site systems.

[10] See Zimmo (2005): "*35% of the population is served with sewerage networks, but less than 6% of the total population is served with treatment plants (Mahmoud, personal communication)*" (page 33)

Estimation pollution load West Bank. Assuming a per capita biochemical oxygen demand (BOD) generation of 60 gBOD/day (see section 2.3) and a treatment efficiency of 10 per cent for the cesspits and 20 per cent efficiency for the off-site systems, the West Bank discharges daily almost 90 per cent or 90 ton BOD of its daily 100 ton BOD generation: {86% * (100%-10%) + 14% * (100%-20%)} * 1.7 mln capita * 60 g BOD/cap/day.

In Gaza, 0.5 mln people use (often unlined) cesspits. When full, the contents are dumped in the neared watercourse. 70 per cent of the population is connected to sewerage networks but in the treatment works, only 50 per cent of the BOD is removed.

Estimation pollution load Gaza. Assuming a per capita BOD generation of 60 gBOD/day and a treatment efficiency of 10 per cent for the cesspits and 50 per cent efficiency for the off-site systems, Gaza discharges daily around 60 per cent or 54 ton BOD of its daily 90 ton BOD generation: {30% * (100%-10%) + 70% * (100%-50%)} * 1.5 mln capita * 60 g BOD/cap/day.

Limited range of technological sanitation options. Due to a combination of factors such a climate, terrain, cultural sensitivity, restricted planning systems in 'Area C' and the effects of the blockade, these result in a limited choice of technological options which are currently reduced to either a cesspit or connection to the sewer network. At present, there is no separation of grey and black water, therefore the relatively 'clean' grey water mixes with the 'dirty' black water which aggravates the polluting effect of the cesspits.

Estimation future pollution load oPt. If and when the improvements proposed in this manual would be implemented and if and when off-site systems would be improved at the same time, a treatment efficiency of 80 per cent for the future on- and off-site systems could be possible, thus reducing the BOD load on the West Bank to 20% or 20 ton BOD of its daily 100 ton BOD generation: 20% * 1.7 mln capita * 60 g BOD/cap/day and the pollution load in Gaza to 18 ton BOD/day: 20% * 1.5 mln capita * 60 g BOD/cap/day.

1.6. How to accelerate the implementation of improved sanitation

In this section we introduce a series of principles that are being introduced elsewhere to accelerate the implementation of improved sanitation and which could be adopted in oPt as well.

1.6.1. Bellagio principles

During a meeting in Bellagio, Italy, 1−4 February 2000, an expert group brought together by the Environmental Sanitation Working Group of the Water Supply and Sanitation Collaborative Council agreed that current waste management policies and practices are place a negative impact to human wellbeing, are economically unaffordable and environmentally unsustainable. They, therefore, called for a radical overhaul of conventional policies and practices worldwide, and of the assumptions on which they are based in order to accelerate progress towards the objective of universal access to safe environmental sanitation, within a framework of water and environmental security and respect for the economic value of waste[11].

The principles governing the new approach are the following[12]:

[11] After Tilley/ Sandec (2008)
[12] Annex 1 Household centred sanitation, EAWAG (2005)

1. Human dignity, quality of life and environmental security at household level should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local and national setting:
    a. Solutions should be tailored to the full spectrum of social, economic, health and environmental concerns;
    b. The household and community environment should be protected;
    c. The economic opportunities of waste recovery and use should be harnessed;
2. In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services:
    a. Decision-making at all levels should be based on informed choices;
    b. Incentives for provision and consumption of services and facilities should be consistent with the overall goal and objective;
    c. Rights of consumers and providers should be balanced by responsibilities to the wider human com- munity and environment;
3. Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flows and waste management processes:
    a. Inputs should be reduced so as to promote efficiency and water and environmental security;
    b. Exports of waste should be minimized to promote efficiency and reduce the spread of pollution;
    c. Wastewater should be recycled and added to the water budget;
4. The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, community, town, district, catchment, and city) and wastes diluted as little as possible:
    a. Waste should be managed as close as possible to its source;
    b. Water should be minimally used to transport waste;
    c. Additional technologies for waste sanitization and reuse should be developed.

1.6.2. Sustainability FIETS[13]

WASH projects and programs will have a sustainable character if the following is taken into account:

- **Financial sustainability**: Does the WASH program/project provide financial concepts, which diminish dependency on external subsidies and make optimal use of business approaches and private sector involvement, therewith, strengthening the oPt structural finance?;
- **Institutional sustainability**: Does the program/project integrate WASH in national policies with non-governmental organizations (NGOs) in close collaboration with local stakeholders working as capacity builders, facilitators and watchdogs representing the voice of ordinary people and complementing governmental efforts, working from a rights based approach?;
- **Environmental sustainability**: Does the WASH program/project adopt and mainstream Integrated Water Resource Management and ecosystem approach principles and does it build climate resilient solutions?;
- **Technological sustainability**: Does the WASH program/project seek and apply locally appropriate technologies and innovative information and communication technology solutions (ICT) solutions, which are context-specific, affordable and demand-driven?;

[13] Inspired by the Dutch WASH Alliance (2010)

- **Social sustainability**: Are WASH interventions demand-driven and needs-based, being sensitive to local and cultural incentives and focuses the PPP specifically on women as change agents?

1.6.3. Business approach[14]

A business approach to WASH seeks to address the challenge of financial sustainability, while empowering a local community and individuals to make their own decisions about obtaining WASH services and facilities, and strengthening the role of the local private sector. The thrust of this approach is to make on-going WASH services the goal, rather than the facility itself. On-going refers to a long-term relationship between local businesses and customers. WASH is then seen as a vehicle for businesses to provide services and gain revenues that can be reinvested to keep expanding coverage of WASH facilities and to develop economical activity while improving peoples' living conditions. This requires a market analysis and means a shift from the traditional input based official development assistance (ODA) approach to an output based balanced business approach. The business approach is illustrated in the Cambodia 'easy latrine case'. See text box.

The prospective entrepreneurs are encouraged to join the programme from the slogan, "invest $3090 to earn $4200 in just 4 months". The initial investment needed includes a $2000 vehicle for making deliveries, $440 worth of concrete moulds, and $650 worth of raw materials for making the latrines (power tools & ash/cement/sand for concrete). The projected $4200 is generated from the sale of 25 of the $35 latrines per week for the first two months, then 50 per week for the following two months (with a second investment of $440 in an additional set of moulds). The remarkably low-cost nature of the latrine design therefore allows profit to be made quite quickly, which serves as a powerful incentive for potential business partners.

Source: Cambodia case studies, Appendix 1-2.

1.6.4. Waste = resource, and averting the Phosphorous crisis[15]

In addition to the view expressed in the Bellagio principles that waste is to be regarded a resource, there is the fact that global fossil phosphorus reserves are finite, while demand for this nutrient is increasing. Phosphate is a key component of fertilizers for which there are no alternatives. The implications of these predictions are potentially very serious for particularly global food production. According to experts, these reserves will have been used within the foreseeable future; 75 to 175 years is the general estimate[16]. Furthermore, the bulk of fossil phosphorus is found in only five countries: Morocco/Western Sahara, China, the USA, South Africa and Jordan. Phosphorus depletion will thus become a global problem, which eventually affects us all. Finding effective solutions for preventing losses and recycling is therefore vital.

[14] After The Dutch WASH Alliance (2011)
[15] After: Strategic Plan Nutrient Platform, the Netherlands (2010)
[16] For more info see: Cordell, D., J.-O. Drangert & S. White (2009). *The story of phosphorus: Global food security and food for thought*.

Human waste contains considerable amounts of phosphorous, see section 2.2, and recycling contributes to preventing a phosphorous crisis.

1.6.5. Behaviour change

A research study (Corotech Project[17]) aimed at examining on-site sanitation systems from the perspective of the community with special emphasis on social and economic aspects. This study was conducted in 2002 in the three Palestinian rural areas located in the Ramallah / Al-Bireh district. These areas were Birzeit, Jifna, Ein Sinya, and Jalazoun camp. Besides the latter, the two other towns had cesspits and no sewerage system. In this study, a questionnaire was provided to the local population to evaluate their existing sanitation systems, the introduction of low cost alternatives, the option of decentralized treatment technology, and their willingness to participate, pay and utilize the treated effluent in agriculture.

The findings and results derived from the questionnaire revealed that people didn't accept paying for on-site sanitation or handling their own wastewater. They also rejected the idea of reusing wastewater even in agriculture.

The basic information obtained from the questionnaire is presented in the following text box.

Results questionnaire Corotech project

- *People don't have money for construction equipment and those who do are not ready to pay;*
- *Customs and tradition interfere with the treatment and usage of sewage especially in handling sewage and sludge. Social and cultural traditions don't allow or accept persons who work on monitoring reactors to enter their homes;*
- *85 per cent of the respondents accepted the idea of having a decentralized sanitation system but they wanted technical and financial support from the local community;*
- *People who have special cesspits think that they don't need to participate in new on-site sanitation facilities;*
- *The majority of people (90 per cent) using the treated wastewater to irrigate indoor plants and some people also refuse to buy any vegetable or fruits that were irrigated with treated wastewater;*
- *A few people (20 per cent) want to pay only for the construction part but refused to pay for the on-going monitoring and maintenance costs;*
- *The on-site area is an unpleasant view for people. In addition, houses are not designed to consider on-site sanitation systems; especially source separation of wastewater;*
- *During the survey it was observed that the majority of people (8 per cent) prefer to construct central sewerage networks and construct an off-site treatment facility rather than on-site sanitation systems;*
- *Many people believe in a safe wastewater disposal with less pollutant to valleys instead of discharging sewage without treatment;*
- *Nobody fancies the separation of black and grey wastewater;*
- *Some people (40 per cent) accepted the on-site sanitation system with reservation; unless they are sure it will not cause waterborne diseases or harbour/transmit harmful insects.*

[17] Cited by Zimmo (2005)

Triad model for behaviour change. From the above-cited questionnaire it is clear that, when implementing the improvements proposed in this manual, substantial efforts are required to change the behaviour of the population. In addition to effective communication, see section 1.2, a change of behaviour is required. Professor Theo Poiesz developed the Triad model. The model 'forecasts' the behaviour of people using three factors: Motivation, Capacity and Context.

Behaviour 'T' score = Motivation * Capacity * Context

The model is explained using an example. Mr X currently has no household sanitation facilities. If he wants to construct a household toilet depends on his **motivation**. He can be motivated because he would like a clean toilet in his house for his family, especially so the female members of his household do not have to walk outside in the dark. However, even if he is motivated but does not have the funds to purchase a new toilet and/or if he does not know how to construct one (**no capacity**), the facility will not be constructed. But, if he is motivated and has the capacity, but other factors prevent him from doing so (i.e.if he has no room at the premises and/or if the groundwater table is high and/or the soil is impermeable and/or if his house is far from the city sewerage), he will still not be able to construct his toilet. It is therefore important to know how to assess each situation in order to invest most effectively in achieving the goal.

Unlike most behaviour models, the Triad model uses a **multiplication** to assess the 'T' (behaviour) score.

If during an assessment it is found that the motivation is 50 per cent, the capacity is 10 per cent and the context is 100 per cent, the T-score = 0.5 * 0.1 * 1 = 0.05 (5 per cent). If the energy is put in raising the 'Motivation' with 10 per cent (as is the case with most sanitation programmes) the T-score becomes: (0.5+0.1) * 0.1 * 1 = 0.06 (6 per cent), an increase of only 20 per cent. However, if the energy is put in raising the 'Capacity' with 10 per cent, the T-score becomes: 0.5 * (0.1+0.1) * 1 = 0.1 (10 per cent), an increase of 100 per cent!

Motivation *deals with the* ***willingness*** *of a household to implement and use sanitation. On the one hand motivation can be intrinsic, and specific to the individual:*

- ***Interests,*** *for example: "Mr X is interested in new technologies, so he wants to have a modern wastewater treatment technology";*
- ***Desires,*** *for example: "Mr X likes to have guests and wants them to have clean facilities to use at his house";*
- ***Purposes and aims,*** *for example: "Mr X knows that a good sanitation facility does not pollute the groundwater which his family uses as drinking water source";*

On the other hand, motivation can be extrinsic, steered by:

- ***Social validation****, for example: "Mr X wants to have a toilet because everybody else has one and he does not want to be left out";*
- ***The fear from penalties****, for example: "Mr X has a toilet because that is demanded by the building code of his town. If he does not have one, he will get a penalty or: If he has one he pays a lower property tax".*

Cialdini, see below, has described six methods to increase motivation.

Capacity deals with the **ability** of a household to implement and use sanitation. Intrinsic capacity has three aspects:

- **Financia**l aspects (ability to pay). For example: *"Mr X is farmer and has the capacity to pay for improved sanitation but only immediately after the harvest"*;
- P**hysical** aspects (ability to construct, operate and maintain). For example: *"Mr X is old and does not have a son to dig a pit for the improved sanitation facility"*;
- **Knowledge** aspects (ability to understand how a sanitation system is working). For example: if Mr X does not understand that bacteria and viruses can pollute his drinking water, he will not understand the importance of constructing a leaching pit above the groundwater level.

Context deals with the aspects that stimulate or impede sanitation:

- Intrinsic aspects that people can influence such as 'time available'. For example: How much time does Mr X have available to work on the implementation of his sanitation facility?;
- Extrinsic aspects that individual households cannot influence. For example: planning and permitting system, high groundwater table, impermeable soils and high population densities that impede on-site sanitation systems.

Cialdini[18]defines six 'weapons of influence':

- **Reciprocation**. People tend to return a favour. Thus, the pervasiveness of free samples in marketing;
- **Commitment and Consistency**. If Mr X commits, orally or in writing, to an idea or goal, he is more likely to honour that commitment. Even if the original incentive or motivation is removed after he has already agreed, he will continue to honour the agreement.
- **Social Proof**. People will do things they see other people doing. Hence, if Mr X sees people in the community purchase a toilet, he will follow;
- **Authority**. Mr X will tend to obey authoritative or influential figures;
- **Liking**. Persuasiveness. People were more likely to buy if they liked the person selling it to them;
- **Scarcity**. Perceived scarcity will generate demand. For example, offers that are available for a 'limited time only' encourage sales.

[18] **Dr Robert Cialdini** is best known for his popular book on persuasion and marketing, Influence: The Psychology of Persuasion (ISBN 0-688-12816-5). His book has also been published as a textbook under the title Influence: Science and Practice (ISBN 0-321-01147-3). In writing the book, he spent three years going "undercover" applying for jobs and training at used car dealerships, fund-raising organizations, telemarketing firms and the like, observing real-life situations of persuasion. The book also reviews many of the most important theories and experiments in social psychology. Harvard Business Review lists Dr. Cialdini's research in "Breakthrough Ideas for Today's Business Agenda".

2. Wastewater and wastewater treatment

2.1. Domestic wastewater

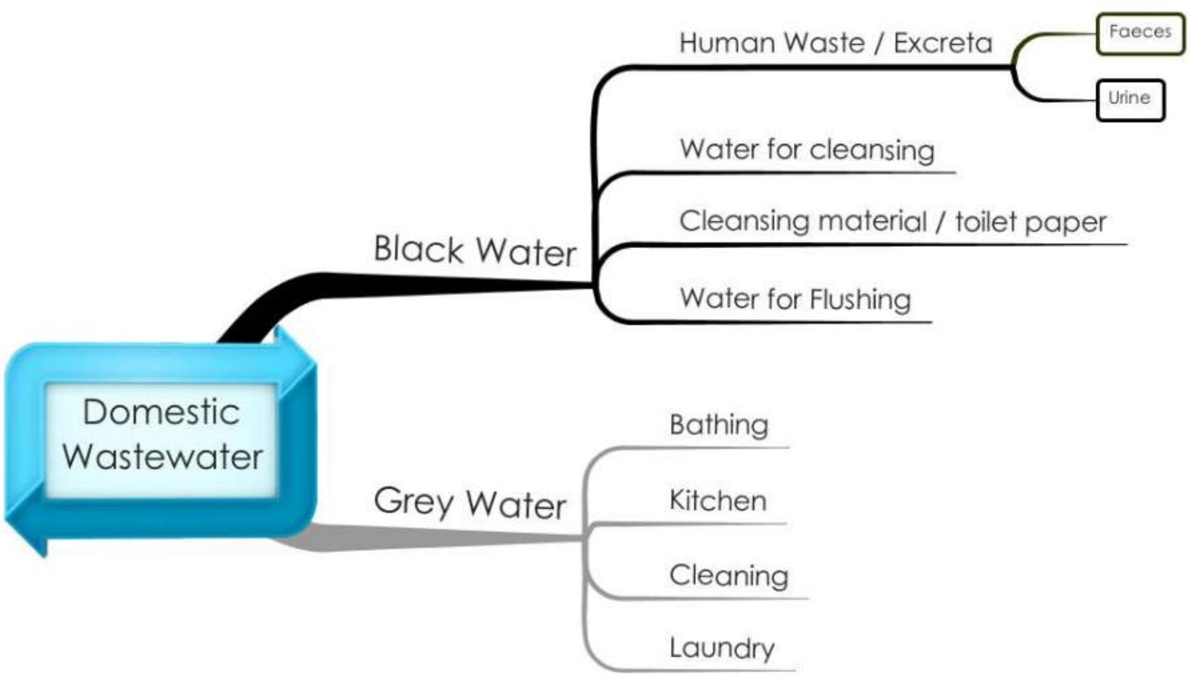
This manual only deals with domestic wastewater, although the same principles can be applied to schools and other institutions. However, if applying these techniques for other institutions other than households, specific guidance from the Ministry of Education and Higher Education, or the relevant authoritative body would have to be sought.

When describing wastewater, the following terms are used:

- **Black water** which is the mixture of urine, faeces and flushing water along with anal cleansing water (if anal cleansing is practised) or dry cleansing material (e.g. toilet paper) if this not kept separately;
- **Grey** water is used water generated through bathing, hand washing, cooking or laundry. It is sometimes mixed or treated along with black water;
- **Urine** is the liquid not mixed with any faeces or water;
- **Faeces** refer to (semi-) solid excrement without any urine or water;
- **Excreta** is the mixture of urine and faeces not mixed with any flushing water (although small amounts of anal cleansing water may be included);
- **Septage or Faecal sludge** is the general term for the undigested or partially digested slurry or solids resulting from the storage or treatment of black water or excreta.

See Figure 2-1.

Figure 2-1: Elements domestic wastewater (UNICEF/Spit, 2012)



Domestic wastewater comprises all sources of liquid household waste: black water and grey water; see Figure 2-1 and Figure 2-2. However, it generally does not include storm water. **Storm water** in a community settlement is runoff from house roofs, paved areas and roads during rainfall events. It also includes water from the catchment of a stream or river upstream of a community settlement.

Figure 2-2: Black and grey water (Burnat, 2010)

2.2. Parameters to describe wastewater[19]

Wastewater is characterized in terms of its physical, chemical and biological composition. Several relevant parameters, which are used to describe the specific wastewater characteristics, are briefly presented here. These parameters are useful when designing wastewater treatment facilities, monitoring performance and determining compliance with wastewater discharge standards. It should be noted that many of the physical properties and chemical or biological characteristics listed hereafter are interrelated. (Metcalf and Eddy 2003, pp. 30−81)

Suspended Solids are those solids that do not pass through a 0.2-um filter. About 70 per cent of those solids are organic and 30 per cent are inorganic. The inorganic fraction is mostly sand and grit that settles to form an inorganic sludge layer. Total suspended solids comprise both settleable solids and colloidal[20] solids. Settleable solids will settle in an Imhoff cone within one hour, while colloidal solids (which are not dissolved) will not settle in this period. Suspended solids are easily removed through settling and/or filtration. However, if untreated waste- water with a high suspended solids content is discharged into the environment, turbidity and the organic content of the solids can deplete oxygen from the receiving water body and prevent light from penetrating. In the West Bank*, "quarrying, stone crushing, and stone processing generate the largest amount of liquid and solid waste along with air-born pollutants. Most are located in residential and agricultural areas"* (Zimmo, 2005).

[19] After Tilley/Sandec (2008)
[20] A colloid is a substance microscopically dispersed evenly throughout another substance. (Wikipedia, access 26 April 2012). Colloidal suspension is the state in which the particles of a substance are mixed with a fluid but are un-dissolved (dictionary.com, April 2012)

Organic constituents. Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Biodegradable organics are composed mainly of proteins, carbohydrates and fats. If discharged untreated into the water environment, their biological stabilization can lead to the depletion of natural oxygen and development of septic conditions. BOD test results can be used to assess the approximate quantity of oxygen required for biological stabilization of the organic matter present, which in turn, can be used to determine the size of wastewater treatment facilities, to measure the efficiency of some treatment processes and to evaluate compliance with wastewater discharge permits. See section 3.3.

Nutrients. Nitrogen and phosphorus, also known as nutrients or bio stimulants, are essential for the growth of microorganisms, plants and animals. When discharged into the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life, which deplete the water of dissolved oxygen. When discharged in excessive amounts on land, they can also lead to groundwater pollution.

Heavy metals. Heavy metals are usually added to wastewater by commercial and industrial activities and may have to be removed if the wastewater is to be reused. Cadmium, chromates, lead, and mercury are, for ex- ample, present in industrial waste. In the West Bank, metal processing is a major health hazard: "*the most hazardous wastes are the ones from the electroplating, metal finishing, and casting industries. Some units use rubber tires and vehicle oil as furnace fuel. The particulate solid and toxic compounds emitted may contribute to serious health problems*" (Zimmo, 2005).

Acidity/basicity. The concentration range suitable for the existence of most biological life is quite narrow (typically pH 6 to 9). Wastewater with an extreme concentration of hydrogen ions is difficult to treat biologically. If the concentration is not altered prior to discharge, the wastewater effluent may alter the concentration in natural waters, which could have negative effects on the ecosystem. In the West Bank, the effluent of textile dyeing is a problem: "*The effluent contains high concentrations of ionic substances, organic colour and reactive dyes. High temperature and high pH values characterize the effluents from such industries. Chock loading of such waste to Ramallah wastewater treatment plant is commonly practiced*" (Zimmo, 2005).

Alkalinity. Alkalinity in wastewater results from the presence of calcium, magnesium, sodium, potassium, carbonates and bicarbonates, and ammonia hydroxides. Alkalinity in wastewater buffers (controls) changes in pH caused by the addition of acids. Wastewater in the West Bank is normally alkaline due to the presence of groundwater (which has high concentrations of naturally occurring minerals) and domestic chemicals. The alkalinity of wastewater is important where chemical and biological treatment is practiced.

Conductivity. The measured electric conductivity (EC) value is used as a surrogate measure of total dissolved solids (TDS) concentration. The salinity (i.e. 'saltiness') of treated wastewater used for irrigation is also determined by measuring its electric conductivity. The wastewater in Gaza has a high conductivity due to the salinity of the drinking water.

Temperature. The wastewater temperature is commonly higher than that of local water supplies. Temperature has an effect on chemical reactions, reaction rates, aquatic life, and the suitability for beneficial uses. Furthermore, oxygen is less soluble in warm than in cold water.

Coliforms. Pathogenic organisms present in wastewater can transmit communicable diseases, see Table 2-1. The World Health Organisation[21] (WHO) distinguishes between high-risk transmission of intestinal parasites (Helminths eggs), and the relatively lower risk transmission of diseases caused by pathogenic bacteria. The number of Helminths eggs and the number of faecal coliforms are indicative of these risks. Regardless of the number of ova, bacteria or viruses, wastewater is unsafe to man. See section 3.3 for standards. E-coli bacteria are not pathogenic but used as an indicator of faecal bacteria.

EPA Explanation of Faecal Bacteria[22]. Coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. In addition to the possible health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand (see BOD).

Total coliforms are a group of bacteria that are widespread in nature. All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, and submerged wood and in other places outside the human body. For recreational waters, total coliforms are no longer recommended as an indicator. For drinking water, total coliforms are still the standard test because their presence indicates contamination of a water supply by an outside source.

Fecal coliforms, a subset of total coliform bacteria, are more fecal-specific in origin. However, even this group contains a genus, *Klebsiella*, with species that are not necessarily fecal in origin. *Klebsiella* are commonly associated with textile and pulp and paper mill wastes. *E. coli* and enterococci as better indicators of health risk from water contact. Fecal coliforms are still being used in many states as the indicator bacteria.

E. coli is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. EPA recommends E. coli as the best indicator of health risk from water contact in recreational waters.

Enterococci are a subgroup within the fecal streptococcus group. Enterococci are distinguished by their ability to survive in salt water, and in this respect they more closely mimic many pathogens than do the other indicators. Enterococci are typically more human-specific than the larger fecal streptococcus group. EPA recommends enterococci as the best indicator of health risk in salt water used for recreation and as a useful indicator in fresh water as well

[21] After Sasse (1998)
[22] US EPA site http://water.epa.gov/type/rsl/monitoring/vms511.cfm

Table 2-1: Viral, Bacterial and Protozoa in faeces (Kalbermatten, 1982)

Diseases and symptoms caused by pathogens in wastewater

Organism	Disease / Symptoms
	Virus (lowest frequency of infection)
polio virus	poliomyelitis
coxsackie virus	mengitis, pneumonia, hepatitis, fever, common colds, etc.
echo virus	mengitis, paralysis, encephalitis, fever, common colds, diarrhea, etc.
hepatitis A virus	invectious hepatitis
rota virus	acute gastroenteritis with severe diarrhea
norwalk agents	epidemic gastroenteritis with severe diarrhea
reo virus	respiratory infections, gastroenteritis
	Bacteria (lower frequency of infection)
salmonella spp.	salmonellosis (food poisening), typhoid fever
shigella spp.	bacillary dysentry
yersinia spp	acute gastroenteritis, diarrhea, abdominal pain
vibro cholerae	cholera
campylobacter jejuni	gastroenteritis
escherichia coli	gastroenteritis
	Helminth Worms (high frequency of infection)
ascari lumbrocoides	digestive disturbance, abdominal pain, vomiting, restlessness
ascaris suum	coughing, chest pain, fever
trichuris trichiura	abdominal pain, diarrhea, anemia, eight loss
toxocara canis	fever, abdominal discomfort, muscle aches, neurological symptoms
taenia saginata	nervousness, insomnia, anorexia, abdominal pain, digestive distrubance
taenia solium	nervousness, insomnia, anorexia, abdominal pain, digestive distrubance
necator americanus	hookworm disease
hymenolepsis nana	taeniasis
	Protozoa (mixed frequency of infection)
cryptosporidium	gastroenteritis
entmoeba histolytica	acute enteritis
giardia lamblia	giardiasis, diarrhea, abdominal cramps, weight loss
balantidium coli	diarrhea, dysentery
toxoplasma gondii	toxoplasmosis

various sources, after EPA, Winblad

Table 2-2: Wastewater transmitted diseases and their symptoms (Sasse, 1998)

Table 2-1. *Viral, Bacterial, and Protozoan Pathogens Found in Excreta*

Biological group and organism	*Disease*[a]	*Reservoir*
Viruses		
Coxsackievirus	Various	Man
Echovirus	Various	Man
Hepatitis A virus	Infectious hepatitis	Man
Poliovirus	Poliomyelitis	Man
Rotavirus	Gastroenteritis in children	?
Bacteria		
Campylobacter species	Diarrhea in children	Animals and man
Pathogenic *Escherichia coli*	Gastroenteritis	Man
Salmonella typhi	Typhoid fever	Man
S. paratyphi	Paratyphoid fever	Man
Other salmonellae	Food poisoning	Man and animals
Shigella species	Bacillary dysentery	Man
Vibrio cholerae	Cholera	Man
Other vibrios	Diarrhea	Man
Yersinia species	Yersiniosis	Animals and man
Protozoa		
Balantidium coli	Mild diarrhea	Man and animals
Entamoeba histolytica	Amebic dysentery and liver abscess	Man
Giardia lamblia	Diarrhea and malabsorption	Man

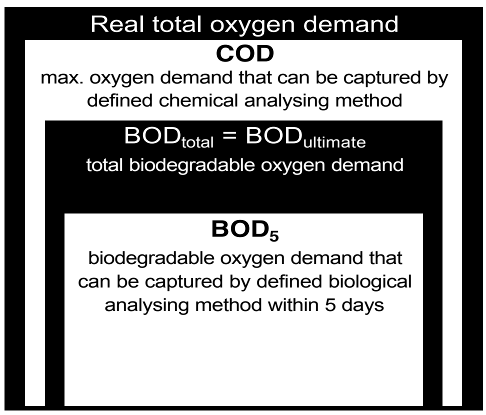
Source: Feachem and others (forthcoming).

a. In all diseases listed, a symptomless carrier state exists.

2.3. Biochemical oxygen demand (BOD)[23]

Of all parameters, the chemical oxygen demand (COD) is the most general parameter to measure organic pollution. It describes how much oxygen is required to oxidise all organic and inorganic matter found in water. The biochemical oxygen demand (BOD) is always a fraction of the COD. See Figure 2-3. It describes what can be oxidised biologically; this is with the help of bacteria. It is equal to the organic fraction of the COD. Under standardised laboratory conditions at 20°C it takes about 20 days to activate the total carbonaceous BOD (=BOD ultimate, BOD total). In order to save time, the BOD analysis stops after 5 days. The result is named BOD_5, which is simply called the BOD, in practice. The BOD_5 is a certain fraction (approximately 50 to 70%) of the absolute BOD. This fraction is different for each wastewater

COD and BOD are the results of standardised methods used in laboratory analysis. They do not fully reflect the bio-chemical truth, but are reliable indicators for practical use. Biological oxygen demand is a practical description of that portion which can be digested easily, e.g. anaerobically. The COD/BOD total vaguely indicates the relation of total oxidisable matter to organic matter, which is first degraded by the most common bacteria. For example, if a substrate is toxic to bacteria, the BOD is zero; the COD nonetheless may be high as it would be the case with chlorinated water. In general, if the COD is much higher than the BOD (>3 times) one should check the wastewater for toxic or non-biodegradable substances. In practice, the quickest way to determine toxic substances is to have a look into the shopping list of the institution, which produces the wastewater. What kind of detergent is bought by a hospital may be more revealing than a wastewater sample taken at random



COD and BOD_5 are not in any case comparable to each other.

Fig. 14.
Definition of oxygen demand. The BOD_5 is a part of the total BOD, the total BOD may be understood as part of the COD and the COD is part of the absolute real oxygen demand. The total BOD may be equal to the COD; the COD may be equal to the real oxygen demand.

[23] Sasse (1998)

Figure 2-3: Definition BOD (Sasse, 1998)

COD in a laboratory test shows the oxygen donated by the test-substance, which is normally potassium dichromate. The tested substrate is heated to mobilise the chemical reaction (combustion). Easily degradable wastewater has a COD/ BOD5 relation of about 2. The COD/BOD ratio widens after biological, especially anaerobic treatment, because BOD is biologically degradable. COD and BOD concentrations are measured in mg/l or in g/m^3. Absolute values are measured in grams (g) or kilograms (kg); the higher the concentration of BOD, the 'stronger' the wastewater. See Table 2-3.

Table 2-3: Sewage strength in terms of BOD and COD (Mara, 1976)

Strength	BOD (mg/l)	COD (mg/l)
Weak	< 200	< 400
Medium	350	700
Strong	500	1000
Very strong	> 750	> 1500

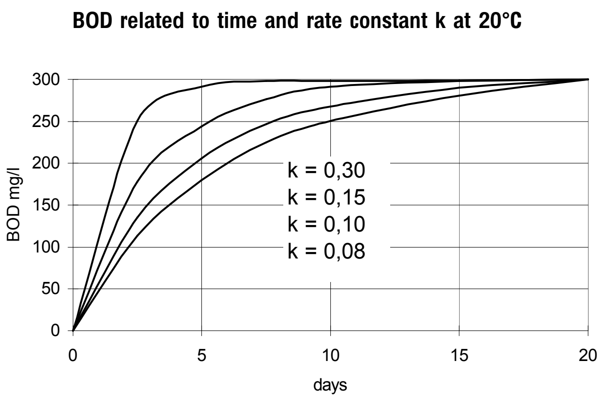


Fig. 15.
BOD removal rates are expressed by rate constants (k) which depend on wastewater properties, temperature and treatment plant characteristics. The curve shows the BOD removal rates at 20°C. The value after 5 days is known as BOD_5.

Figure 2-4: BOD related to time and rate constant (Sasse, 1998)

Too much BOD or COD discharged into surface water could mean that the oxygen present in that water that is normally required to sustain aquatic life will now be used for decomposition of pollutants. Effluent standards for discharge into receiving waters may tolerate 30 to 70 mg/l BOD and 100 to 200 mg/l COD. See section 3.3.

The strength of wastewater is governed to a very large degree by the individuals or community's general water consumption. The other factor determining the strength is the BOD produced per person per day. This varies from country to country and the differences are largely due to differences in quantity and quality of grey water and variations in diet. Examples worldwide are:

- South-East Asia: 30-45 g/cap;
- Africa: 25-36 g/cap;
- United Kingdom (UK) and the Netherlands (NL): 50-59 g/cap;
- United States of America (USA): 45-78 g/cap.

Table 2-4 provides some wastewater characteristics worldwide.

Table 2-4: Some wastewater characteristics worldwide (Sasse, 1998)

Some selected domestic wastewater data

examples	COD g/cap.*d	BOD_5 g/cap.*d	COD / BOD_5	SS g/cap*d	Flow l/cap*d
India urban	76	40	1,90	230	180
USA urban	180	80	2,25	90	265
China pub.toilet	760	330	2,30	60	230
Germany urban	100	60	1,67	75	200
France rural	78	33	2,36	28	150
France urban	90	55	1,64	60	250

BORDA

The values for oPt, based on wastewater treatment reports are presented in Table 2-5 and Table 2-6.

Table 2-5: BOD wastewater oPt[24]

		Hajja 2012	Hajja 2031	Jericho JICA	Khan Younis
BOD Black water	mg BOD/l	1 050	1 050	1 050	972
BOD Grey water	mg BOD/l	350	170	350	170
Water consumption	lcd	70	120	166	100
Return ratio	%	90%	90%	90%	90%
Wastewater production	lcd	63	108	149	90
Black water production	lcd	32	30	32	30
Grey water production	lcd	32	78	117	60
BOD contribution Black water	gBOD/cap	33.1	31.8	33.5	29.5
BOD contribution Grey water	gBOD/cap	11.0	13.2	41.0	10.1
BOD contribution	gBOD/cap	44.1	45.0	74.5	39.6
BOD wastewater	mgBOD/l	700	417	500	440

Table 2-6: Characteristics West Bank Wastewater (Zimmo, 2005)

Table 5.5: Characteristics of raw municipal and rural domestic wastewater in the West Bank

	Municipal Urban Wastewater				Rural Domestic Wastewater	
Parameter	Ramallah	Nablus	Hebron	Al-Bireh	Gray	Black
BOD_5	525	11850	1008	522	286	282
COD	1390	2115	2886	1044	630	560
Kj-N	79	120	278	73	17	360
NH_4-N	51	104	113	27	10	370
NO_3-N	0.6	1.7	0.3	-	1	-
SO_4	132	137	267	-	53	36
PO_4	13.1	7.5	20	44	16	34
Cl-	350	-	1155	1099	200	-
TSS	1290	-	1188	554	-	-

* All data in mg/L; - = No data were given

From these figures it becomes clear that the BOD of oPt wastewater is relatively ‘strong’. ARIJ uses a figure of 60 gBOD/cap to calculate the wastewater strength[25]. Factors that could attribute to this strength could be:

[24] CW Wastewater Treatment Plant for Hajja Village, IRIDRA (2011); Upgrading Works for Khan Younis Wastewater Treatment Plant submitted to CMWU, Dr. Fahid Rabah (2011) and Feasibility Study Jericho, Andréa Lambert (2011)

[25] Verbal communication Mr. Elias Abu Mohour, ARIJ, March 2012

- High consumption of soap, especially in Gaza due to the fact the water is saline;
- The diet: people eat relatively a lot of meat;
- Discharge of oil and grease into the wastewater.

A good way to 'predict' the wastewater strength that reflects the cultural and geographical differences is to use the formula:

BOD oPt = 30 gBOD + 280 mg BOD/l * q

Where q = per capita grey water discharge:
Hence,

- For q = 60 lcd, the BOD = 30 + 280 * 60 / 1000 = 30 + 16.8 = 46.8 gBOD/cap and BOD combined wastewater: 46.8 g BOD / 90 lcd / 1000 = 520 mg/l when black water generation is 30 lcd;
- For areas with abundant piped water supply: q = 110 lcd, the BOD = 30 + 280 * 110 / 1000 = 30 + 30.8 = 60.8 gBOD/cap and BOD combined wastewater: 60.8 g BOD / 140 lcd / 1000 = 434 mg/l when black water generation is 30 lcd;
- For areas with tanker water supply: q = 30 lcd, the BOD = 30 + 280 * 30 / 1000 = 30 + 8.4 = 38.4 gBOD/cap and BOD combined wastewater: 38.4 g BOD / (30+10) lcd / 1000 = 960 mg/l when black water generation is 10 lcd.

2.4. Principles of wastewater treatment

The term ‘treatment’ means separation of solids and stabilisation of pollutants. In turn, stabilisation means the degradation of organic matter until the point at which chemical or biological reactions stop. Treatment can also mean the removal of toxic or otherwise dangerous substances (for example heavy metals or phosphorus), which are likely to distort sustainable biological cycles, even after stabilisation of the organic matter. Polishing is the last step of treatment. It is the removal of stabilised or otherwise inactive suspended substances in order to clarify the water physically (for example reducing turbidity). Treatment systems are more stable if each treatment step removes only the ‘easy part’ of the pollution load, but send the leftovers to the next step.

Basics of Biological Treatment. The stabilising part of treatment happens through degradation of organic substances via chemical processes, which are biologically steered (bio-chemical processes). This process is the result of the bacterial metabolism in which complex and high- energy molecules are transformed into simpler, low-energy molecules. Metabolism is the transformation from feed to faeces in order to gain energy for life, in this case for the life of bacteria. Wastewater treatment is a matter of degradation of organic compounds, and finally a matter of oxidising carbon (C) to carbon dioxide (CO_2), nitrogen (N) to nitrate (NO_3), phosphorus (P) to phosphate (PO_4) and sulphur (S) to sulphate (SO_4). Hydrogen (H) is also oxidised to water (H_2O).

In anaerobic processes some of the sulphur is formed into hydrogen sulphide (H_2S), which is recognisable, by its typical ‘rotten eggs’ smell. The largest amount of oxygen (O_2) is required for burning carbon (‘wet combustion’).

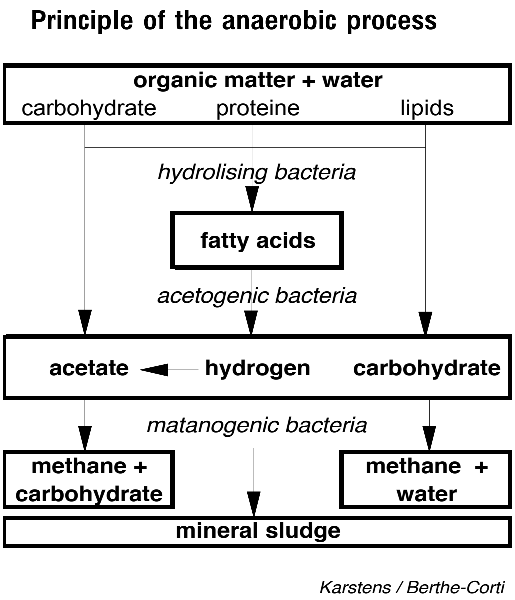
The process of oxidation happens aerobically, with free dissolved oxygen (DO) present in water, or anaerobically without oxygen from outside the degrading molecules. Anoxic oxidation takes place when oxygen is taken from other organic substances. Facultative processes include aerobic, anoxic and anaerobic conditions, which prevail at the same time at various parts of the same vessel or at the same place after each other. In anoxic respiration and anaerobic fermentation as there is no oxygen available; all oxygen must come from substances within the substrate. Anaerobic treatment is never as complete as aerobic treatment, because there is not enough oxygen available within the substrate itself. The principles of anaerobic treatment are presented in Figure 2-5, those aerobic processes in Figure 2-6.

Anaerobic versus aerobic. Aerobic decomposition takes place when dissolved oxygen is present in water. Composting is also an aerobic process. Anaerobic digestion happens when dissolved oxygen is not available. Bacteria however, get oxygen for ‘combustion’ of energy by breaking it away from other, mostly organic substances present in wastewater, predominantly from nitric oxides.

Anaerobic digestion happens by breaking up molecules, which are composed of oxygen and carbon to ferment to carbohydrate. The aerobic process happens much **faster** than anaerobic digestion and for that reason dominates always when free oxygen is available. The high speed at which decomposition takes place is caused by the shorter reproduction cycles of aerobic bacteria as compared to anaerobic bacteria.

Anaerobic bacteria leave some of the energy unused. It is this unused energy, which is released in form of **biogas**. Aerobic bacteria use a larger portion of the pollution load for production of their own bacterial mass compared to anaerobic bacteria, which is why aerobic processes produce **twice as much sludge** as compared to the anaerobic process. For the same reason, anaerobic sludge is less slimy than aerobic sludge and is therefore easier to drain and to dry.

Figure 2-5: Principles anaerobic processes (Sasse, 1998)



Aerobic treatment is highly efficient when there is enough oxygen available. Compact aerobic treatment tanks need external oxygen, which must artificially be supplied by blowing or via surface agitation. Such technical input consumes technical energy. The anaerobic treatment process is **slower**. It demands a higher digestion temperature quasi to make good for the unused nutrient energy. The anaerobic treatment process is supported by higher ambient temperature. Therefore, it plays an important role in this manual for oPt. Ambient temperature between 15° and 40°C is sufficient. Anaerobic digestion (fermentation) releases biogas (CH_4 + CO_2), which is usable as a fuel.

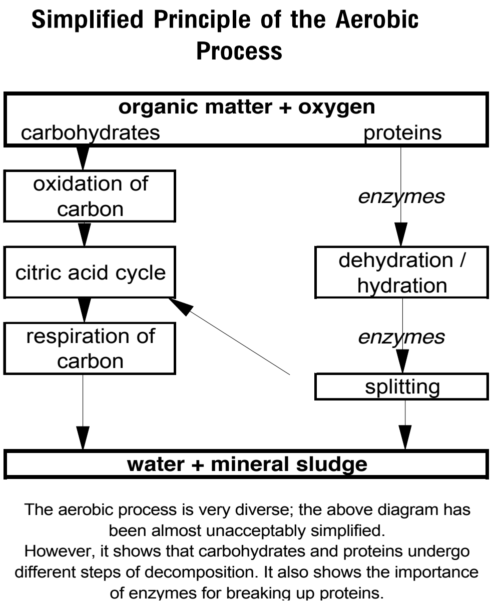


Figure 2-6: Principle aerobic processes (Sasse, 1998)

3. Guidelines

In this chapter we present a series of standards and guidelines that influence the number and quality of facilities (section 3.1 on Sphere) and possibilities to reuse treated wastewater (section 3.3).

3.1. Sphere guidelines[26]

The Sphere Project was initiated in 1997 by a group of NGOs and the Red Cross and Red Crescent Movement to develop a set of universal minimum standards in core areas of humanitarian response: the Sphere Handbook. The aim of the handbook is to improve the quality of humanitarian response in situations of disaster and conflict, and to enhance the accountability of the humanitarian system to disaster-affected people. The Humanitarian Charter and Minimum Standards in Humanitarian Response are the product of the collective experience of many people and agencies.

With regards to excreta disposal, SPHERE has the following guidelines:

- Minimum Standards:
  - Excreta disposal standard two appropriate and adequate toilet facilities;
  - Adequate, appropriate and acceptable toilet facilities;
  - Sufficiently close to their dwellings;
  - Rapid, safe and secure access at all times, day and night;
- Key indicators (for use predominantly in first phase emergencies):
  - Toilets are appropriately designed, built and located to meet the requirements on the next sheet;
  - Maximum of 20 people use each toilet;
  - Separate, internally lockable toilets for women and men are available in public places, such as markets, distribution centres, health centre, schools, etc.;

[26] Sphere project 2011, from www.sphereproject.org accessed April 2012

- No more than 50 m’ from dwellings;
- Use of toilets is arranged by household(s) and/or segregated by sex;
- All the affected population is satisfied with the process of consultation and with the toilet facilities provided and uses them appropriately;
- People wash their hands after using toilets and before eating and food preparation;

- Requirements:
  - Can be used safely by all sections of the population, including children, older people, pregnant women and persons with disabilities;
  - Sited in such a way as to minimize security threats to users, especially women and girls, throughout the day and the night;
  - Provide a degree of privacy;
  - Sufficiently easy to use and keep clean and do not present a health hazard to the environment;
  - Appropriately provided with water for hand washing and/or for flushing;
  - Allow for the disposal of women’s menstrual hygiene materials;
  - Provide women with the necessary privacy for washing and drying menstrual hygiene materials;
  - Minimize fly and mosquito breeding;
  - Provided with mechanisms for disludging, transport and appropriate disposal in the event that the toilets are sealed or are for long-term use and there is a need to empty them;
  - High water table or flood situations, the pits or containers for excreta are made watertight in order to minimize contamination of groundwater and the environment.

Table 3-1: Possible options for sanitation (Sphere handbook, 2012)

	Safe excreta disposal type	Application remarks
1	Demarcated defecation area (e.g. with sheeted-off segments)	First phase: the first two to three days when a huge number of people need immediate facilities
2	Trench latrines	First phase: up to two months
3	Simple pit latrines	Plan from the start through to long-term use
4	Ventilated improved pit (VIP) latrines	Context-based for middle- to long-term response
5	Ecological sanitation (Ecosan) with urine diversion	Context-based: in response to high water table and flood situations, right from the start or middle to long term
6	Septic tanks	Middle- to long-term phase

3.2. The Palestinian Standard institute (PSI) implementation guidelines

The information on PSI implementation guidelines is provided separately.

3.3. The Palestinian Standard Institute (PSI) guidelines water quality and wastewater reuse[27]

For a long time, the occupied Palestinian territory did not have any specific wastewater regulation; references were usually made to the WHO recommendations or to the neighboured countries standard (Egypt, Jordan). Recently, the Environment Quality Authority with coordination of Palestinian ministries and universities has established specific wastewater reuse regulations. The draft of Palestinian legislation for reuse of treated wastewater is still under study in the Palestinian Standards Institute.

The draft Palestinian standard principles mainly envisage; a) Sanitary, b) Environmental and c) Agro technical quality requirements.

a) Sanitary requirements centred upon the pathogens potentially present in wastewater, namely bacteria and intestinal nematodes (Ascaris and Trichuris species and hookworms). Where its recommended less than 1 intestinal nematode per litre and 200 to 1000 faecal coliforms per 100 ml of wastewater depending on the reuse conditions.

b) From the environmental viewpoint concentration of various heavy metals (particularly cadmium, copper, zinc), salt, nutrients (N and P) and malodours have taken into consideration.

c) Agro-technical requirements firstly include total salt and several anion (Cl, SO_4, HCO_3), cation (Ca, Mg, Na) and boron concentrations which determine traditional irrigation water quality standards depending on the plant species, soil physical and chemical properties, climate and irrigation methods.

Most of the reuse projects in Gaza Strip and West Bank are using treated wastewater for irrigation according to WHO and Food and Agriculture Organization of the United Nations (FAO) guidelines. The WHO guidelines are strict in respect of the requirements to keep the number of eggs (Ascaris and hookworms) in effluent below one egg per litre whether the effluent is used for restricted or unrestricted irrigation using surface and sprinkler irrigation. This is not applicable in case of restricted irrigation where exposure of workers and public does not occur.

On the other hand these guidelines are less onerous for faecal coliforms, as no standard is recommend for these pathogens in the case of restricted irrigation and 1000 or less per 100 ml in the case of unrestricted irrigation. This is based on the assumption that the treatment that results in effluent of having less than one egg per litre of intestinal will be practically safe in case of virus and bacteria.

In addition to the microbiological quality requirement of effluent used for irrigation attention also is given to water quality parameters with respect to ground water contamination, soil

[27] Mogheir (2004), Treated Wastewater Reuse in Palestine

structure and crop productivity. These include the nutrients content of the effluent (mainly nitrate), total dissolved solids, and sodium adsorption ratio and toxic elements (boron and heavy metals), which are available as part of FAO guidelines.

The draft guidelines are presented in Table 3-2.

Table 3-2: Draft Guidelines Ministry of Agriculture (Zimmo, 2005)

A1: Recommended Guidelines by the Palestinian Standards Institute for Treated Wastewater Characteristics according to different applications

Quality Parameter (mg/l except otherwise indicated)	Fodder Irrigation		Gardens, Playgrounds, Recreational	Industrial Crops	Groundwater Recharge	Seawater Outfall	Land-scapes	Trees	
	Dry	Wet						Citrus	Olive
BOD_5	60	45	40	60	40	60	60	45	45
COD	200	150	150	200	150	200	200	150	150
DO	> 0.5	> 0.5	> 0.5	> 0.5	> 1.0	> 1.0	> 0.5	> 0.5	> 0.5
TDS	1500	1500	1200	1500	1500	-	1500	1500	500
TSS	50	40	30	50	50	60	50	40	40
pH	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9	6 – 9
Color (PCU)	Free	Free	Free	Free	Free of colored matter	Free of colored matter	Free	Free	Free
FOG	5	5	5	5	0	10	5	5	5
Phenol	0.002	0.002	0.002	0.002	0.002	1	0.002	0.002	0.002
MBAS	15	15	15	15	5	25	15	15	15
NO_3-N	50	50	50	50	15	25	50	50	50
NH_4-N	-	-	50	-	10	5	-	-	-
O.Kj-N	50	50	50	50	10	10	50	50	50
PO_4-P	30	30	30	30	15	5	30	30	30
Cl	500	500	350	500	600	-	500	400	400
SO_4	500	500	500	500	1000	1000	500	500	500
Na	200	200	200	200	230	-	200	200	200
Mg	60	60	60	60	150	-	60	60	60
Ca	400	400	400	400	400	-	400	400	400
SAR	9	9	10	9	9	-	9	9	9
Residual Cl_2	-	-	-	-	-	-	-	-	-

A1: Recommended Guidelines by the Palestinian Standards Institute for Treated Wastewater Characteristics according to different applications "continue"

Quality Parameter (mg/l except otherwise indicated)	Fodder Irrigation		Gardens, Playgrounds, Recreational	Industrial Crops	Groundwater Recharge	Seawater Outfall	Landscapes	Trees	
	Dry	Wet						Citrus	Olive
Al	5	5	5	5	1	5	5	5	5
Ar	0.1	0.1	0.1	0.1	0.05	0.05	0.01	0.01	0.01
Cu	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
F	1	1	1	1	1.5	-	1	1	1
Fe	5	5	5	5	2	2	5	5	5
Mn	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Ni	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Pb	1	1	0.1	1	0.1	0.1	1	1	1
Se	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Cd	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zn	2.0	2.0	2.0	2.0	5.0	5.0	2.0	2.0	2.0
CN	0.05	0.05	0.05	0.05	0.1	0.1	0.05	0.05	0.05
Cr	0.1	0.1	0.1	0.1	0.05	0.5	0.1	0.1	0.1
Hg	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Co	0.05	0.05	0.05	0.05	0.05	1.0	0.05	0.05	0.05
B	0.7	0.7	0.7	0.7	1.0	2.0	0.7	0.7	0.7
FC (CFU/100 ml)	1000	1000	200	1000	1000	50000	1000	1000	1000
Pathogens	Free	Free	Free	Free	Free	Free	Free	Free	Free
Amoeba & Gardia (Cyst/L)	-	-	Free	-	Free	Free	-	-	-
Nematodes (Eggs/L)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1

(-) Undefined

Table 3-3 presents the Palestinian Water Authority (PWA) classification on water quality, A = very clean, D = ‘dirty’.

The classification on effluent is as follows:

1. Effluents of very high quality, suitable for unrestricted irrigation—no barriers required
2. Effluents of high quality—2 barriers required for irrigation
3. Oxidation pond effluents—2 to 3 barriers required for irrigation
4. Effluents of medium quality—3 barriers required for irrigation
5. Effluents of low quality—only specific “no-barrier” crops are allowed to be irrigated

Table 3-3: Palestinian Water Authority (PWA) classification water (PSI, 2012)

(D)	(C)	(B)	(A)	(/)
60	40	20	20	BOD_5
90	50	30	30	TSS
1000	1000	1000	200	(100/) FC
150	100	50	50	COD
1<	1<	1<	1<	DO
1500	1500	1500	1200	TDS
9-6	9-6	9-6	9-6	pH
5	5	5	5	Fat, Oil & Grease
0.002	0.002	0.002	0.002	Phenol
25	15	15	15	MBAS
40	30	20	20	NO_3-N -
15	10	5	5	NH_4-N -
60	45	30	30	Total-N
1000	1000	1000	100	(100/) *E. coli*
1≥	1≥	1≥	1≥	Nematodes (Eggs/L)

3.4. WHO guidelines wastewater reuse[28]

Table 3-4 lists reuse options for different waste products and recommends guidelines for their safe reuse according to WHO. The numerical quality values can be used to define process specifications.

Regulations and guidelines are increasingly based on the risk concept. By applying quantitative microbial risk assessments (QMRAs), based partly on predictions and assumptions, sanitation systems can be evaluated and compared with established limits for

[28] After Tilley/Sandec (2008)

acceptable risks. QMRAs are used to determine the degree of pathogen reduction required to obtain the admissible additional disease burden of less than 10−6 DALY per person per year. Thus, the parameters in the new WHO guidelines are given in ‘log10 pathogen reduction needed’. For further information, consult the WHO guidelines for the safe reuse of wastewater, excreta and grey water. (WHO 2006, Vol. 4 pp. 59).

Table 3-4: WHO guidelines (Tilley/Sandec, 2008)

Waste product	Reuse Application	Guidelines		
Urine[1.)]	Irrigation of food and fodder crops to be processed	≥1 month storage (4° C)		
	Irrigation of food and fodder crops to be processed, fodder crops unprocessed	≥6 month storage (4° C)	or	≥1 month storage (20° C)
	Irrigation of all crops	≥6 month storage (20° C)		
Treated wastewater[2.)]	Unrestricted irrigation	$\leq 10-10^{0}$ EC/100 ml	<1 helminth eggs/l	
	Restricted irrigation	$\leq 10^{5}-10^{3}$ EC/100 ml	<1 helminth eggs/l	
	Localised irrigation	$\leq 10^{6}-10^{5}$ EC/100 ml	<1 helminth eggs/l	
Greywater[3.)]	Unrestricted irrigation	$<10^{5}-10^{6}$ EC/100 ml	<1 helminth eggs/l	
	Restricted irrigation	$<10^{4}-10^{3}$ EC/100 ml	<1 helminth eggs/l	
Excreta (untreated FS)	Agriculture (soil conditioner) [3.)]	$<10^{3}$ EC/g total solids	helminth eggs/ g total solids	
	Aquaculture[4.)]	$\leq 10^{-6}$ EC/100 ml	≤1 helminth eggs/l	No detectable trematode eggs

Table 7: Numerical guidelines for agricultural or aquacultural waste reuse. (WHO 2006, 1.) Vol. 4, pp. 70; 2.) Vol. 2, pp. 60, 70; 3.) Vol. 4, pp. 63; 4.) Vol. 3, p. 41)

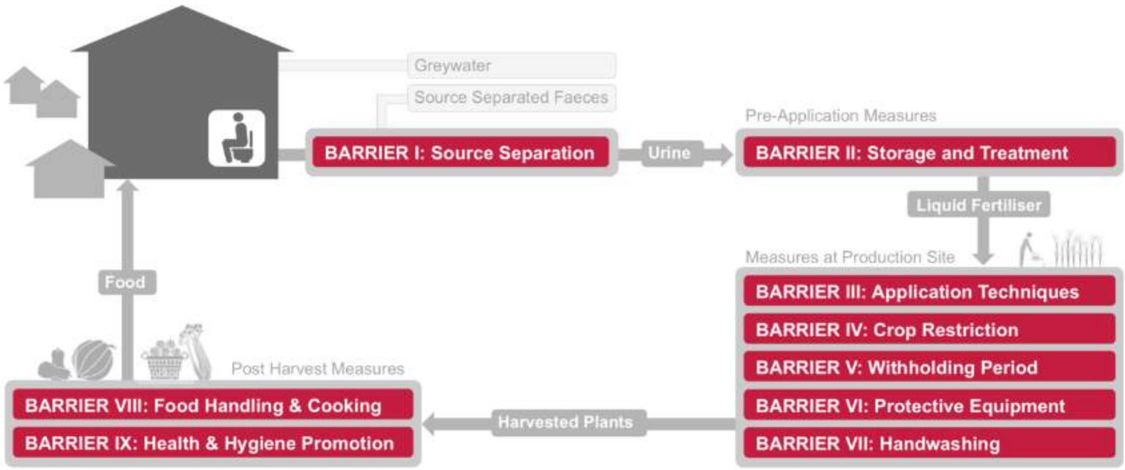
In 2006, WHO has issued the multi-barrier approach[29]:

- WHO recognizes the potential of using excreta in agriculture;
- Promotes a flexible multi-barrier approach for managing the health risks;
- Series of measures/barriers along the entire sanitation system from ‘toilet to table’;
- Each of the barriers has a certain potential to reduce health risks associated with the excreta use;
- Recommended to put in place several of these barriers (if needed) in order to reduce the health risk to an acceptable minimum.

Figure 3-1 illustrates some barriers.

[29] WHO Guidelines for the safe use of wastewater, excreta and grey water (2006)

Figure 3-1: WHO barriers (CAPS, 2012)



The barriers for wastewater reuse in agriculture are:

- Use of drip irrigation can significantly reduce contamination of root crops and leafy vegetables growing just above ground, especially crops not in contact with the soil (e. g. tomatoes). The system should be clearly marked, see Figure 3-2;
- Use of spray irrigation systems can also reduce crop contamination. However, a buffer zone of 50−100 m’ to residents should be maintained;
- An increase in the period between irrigation and consumption will reduce crop contamination (0.5−2 log units / day);
- Washing, disinfecting, peeling, and cooking of fruit, crops or vegetables effectively reduce the health risk to consumers (WHO 2006, Vol. 2, pp. 64).

Regarding grey water reuse:

- Direct reuse of untreated grey water in irrigation is not recommended. Irrigated grey water should undergo at least primary treatment;
- Irrigated soil can act as a natural secondary treatment step.

Figure 3-2: Coloured drip irrigation pipes to indicate the application of treated effluent (UNICEF/Spit, 2012)

3.5. EPA guidelines wastewater reuse

Table 3-5 lists the EPA guidelines.

Table 3-5: EPA guidelines[30]

Table 8-3. Summary of Water Quality Parameters of Concern for Water Reuse

Parameter	Significance for Water Reuse	Range in Secondary Effluents	Treatment Goal in Reclaimed Water
Suspended solids	Measures of particles. Can be related to microbial contamination. Can interfere with disinfection. Clogging of irrigation systems. Deposition.	5 mg/L - 50 mg/L	<5 mg SS/L - 30 mg SS/L
Turbidity		1 NTU - 30 NTU	<0.1 NTU - 30 NTU
BOD_5	Organic substrate for microbial growth. Can favor bacterial regrowth in distribution systems and microbial fouling.	10 mg/L - 30 mg/L	<10 mg BOD/L - 45 mg BOD/L
COD		50 mg/L -150 mg/L	<20 mg COD/L - 90 mg COD/L
TOC		5 mg/L - 20 mg/L	<1 mg C/L - 10 mg C/L
Total coliforms	Measure of risk of infection due to potential presence of pathogens. Can favor biofouling in cooling systems.	<10 cfu/100mL -10^7 cfu/100mL	<1 cfu/100mL - 200 cfu/100mL
Fecal coliforms		<1-10^6 cfu/100mL	<1 cfu/100mL - 10^3 cfu/100mL
Helminth eggs		<1/L - 10/L	<0.1/L - 5/L
Viruses		<1/L - 100/L	<1/50L
Heavy metals	Specific elements (Cd, Ni, Hg, Zn, etc) are toxic to plants and maximum concentration limits exist for irrigation	---	<0.001 mg Hg/L <0.01 mg Cd/L <0.1 mg Ni/L - 0.02 mg Ni/L
Inorganics	High salinity and boron (>1mg/L) are harmful for irrigation	---	>450 mg TDS/L
Chlorine residual	To prevent bacterial regrowth. Excessive amount of free chlorine (>0.05) can damage some sensitive crops	---	0.5 mg Cl/L - >1 mg Cl/L
Nitrogen	Fertilizer for irrigation. Can contribute to algal growth, corrosion (N-NH4) and scale formation (P).	10 mg N/L - 30 mg N/L	<1 mg N - 30mgN/L
Phosphorus		0.1 mg P/L - 30 mg P/L	<1 mg P/L - 20 mg P/L

Source: Adapted from Lazarova, 2001; Metcalf and Eddy, 1991; Pettygrove and Asano, 1985

3.6. Regional guidelines: Jordan[31]

In June of 1998, the Ministry of Water and Irrigation and the Prime Minister of Jordan issued a set of strategies and policies on water and wastewater*.* The Wastewater Management Policy of 1998 was among the official government policies that were issued. The official policy demands that treated effluent be considered as a **water resource** and not separated in policy or thought from other water resources. It stresses the improvement of the quality of treated effluent by blending with higher quality water. The policy suggests that crop selection should be made to suit the irrigation water, soil type, soil physical and chemical properties, and the economics of reuse operation.

[30] EPA/625/R-04/108 September 2004
[31] After Nazzal (2010)

The Wastewater Management Policy of 1998 institutionalizes 62 points regarding the future use and management of wastewater. The following important assertions were made a part of the national wastewater strategy by the policy:

- Wastewater shall not be disposed of, instead, it shall be a part of the water budget;
- There shall be basin-wide planning for wastewater reuse;
- Use of recycled and reclaimed water for industrial use shall be promoted;
- Fees for wastewater treatment may be collected from those who use the water;
- Any crops irrigated with wastewater or blended waters shall be monitored;
- Ultimately, the role of the government shall be regulatory and supervisory and private operation and maintenance of utilities shall be encouraged.

Although much progress has been made in Jordan on laws and standards for wastewater reuse, the critical water situation suggests the need for further evolution of wastewater reuse standards and related law. Due to the expected rapid growth of treated wastewater supplies, it will be necessary for Jordan to expand the agricultural reuse of wastewater and to enhance industrial recycling of water in the future. Most wastewater treatment plants in Jordan are designed to meet Jordanian Standard 893 with 'Discharge to Wadis' being the primary standard. This standard requires BOD reduction to 50 mg/l, presumably for the protection of aquatic environments. In practice, however, discharges typically occur to dry wadis that experience only occasional runoff. BODs as high as 150 mg/l or more are acceptable to most farmers and, in some cases; the costs of treatment could be substantially reduced by the reuse of higher BOD treated wastewater. Similarly, the standard for total suspended solids in the wadi discharge standard, 50 mg/l may be too rigorous a standard when there is no real threat to aquatic environments. The achievement of 15 mg/l ammonia concentration as nitrogen that is a part of the 'Discharge to Wadis' standard is difficult and expensive to achieve. Higher concentrations would have little effect on health or the environment in most circumstances in Jordan where surface water is scarce.

Currently, Jordanian Standards forbid the use of reclaimed water for irrigation of vegetable crops that may be eaten raw like lettuce, tomatoes and onions. In the future, wastewater treatment processes and treated wastewater quality will improve in Jordan and quantities of reclaimed wastewater are likely to grow substantially. Jordan is also making progress in on-farm management of irrigation. Thus, it may be beneficial for Jordan to expand the use of high-quality reclaimed water standard on high-value crops where a good standard of public health can be assured. The standards for the use and processing of sludge severely limit what can be done with sludge and septage. There appears to be an opportunity for a new standard on sludge use and the conversion of sludge to soil conditioners. Improved standards coupled with careful oversight of commercial companies could lead to a significant industry in the production of safe soil conditioners made from sludge.

In the longer term, Jordan's standards for wastewater treatment may be amended to achieve even greater flexibility to meet specific conditions of effluent reuse and to control the cost of treatment. Such amendments may include suggested ranges of constituent concentrations in standards rather than single maximums. Collaborative processes for the prudent decision-making on what standard to apply to specific cases could be specified in an advanced set of standards and decision-process for wastewater reuse. The increasing value of reclaimed wastewater and the obligation for improved use of this resource is underlined in Jordan's

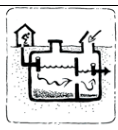
Wastewater Management Policy of 1998. In the future, it will be increasingly necessary for wastewater plant designers and planners to carefully consider wastewater reuse as an important part of the planning for wastewater treatment. Thus, concepts for wastewater treatment may be increasingly driven by the need for optimal wastewater reuse. Wastewater treatment plant location, the priority of treatment plant construction, the type of treatment, downstream conveyance and the treatment standard may all be linked to the planned reuse of the water produced. It seems likely, therefore, that the next step will be improved standards and flexible decision-making processes that allow designers to shape the entire wastewater collection, conveyance and treatment design around the anticipated reuse of wastewater.

4. Systems and technologies fit for oPt conditions

4.1. Functional groups[32]

A sanitation system should consider all the stages along with all direct and by-products generated prior to disposal. Domestic products mainly run through five different Functional Groups, which form together a system. Depending on the system, not every Functional Group is required. See Table 4-1.

Table 4-1: Functional groups (WASTE, SSWM)

User interface	Collection and Storage / On-site treatment	Transport / conveyance	Semi-centralized Treatment	Reuse and Disposal
				

User interface describes the type of toilet; pedestal, pan or urinal the user comes in contact with. User interface also determines the final composition of the product, as it is the place where water is introduced in the system. Thus, the choice of user interface is often dependent on the availability of water.

Collection and storage/treatment describes the ways of collecting and storing products generated at the user interface; storage often also performs some level of treatment.

Transport/ Conveyance describes the way in which products are moved from one process to another. Although products may need to be moved in various ways to reach the required process, the longest and most important gap lies between on-site storage and (semi-) centralized treatment.

[32] After Tilley/Sandec (2008)

(Semi-) centralized treatment refers to the treatment systems which, unlike those used on-site, are larger, require a greater inflow (that can usually not be met by just one family) and often more skilled operation.

Use and/or disposal refer to the ways in which products are ultimately returned to the soil, either as harmless substances or useful resources. Further- more, products can also be re-introduced into the system as new products. A typical example is the use of partially treated grey water used for toilet flushing.

4.2. oPt sanitation technology menu

There are many sanitation options and the reader is invited to study all of them, especially those described on www.sswm.info, www.akvo.org and www.waste.nl. For the sake of this manual we have made a pre-selection of 3 'dry' on-site systems, 3 'wet' on-site systems and 2 'neighbourhood' systems. The selection of the most appropriate system for different oPt conditions is presented in the flow chart in Figure 4-1.

The selection process is as follows:

1. If and when use can be made of a municipal conventional sewerage system without pumping, this option is chosen;

2. If there is no sewerage available, and/or limited water supply for flushing it is investigated whether urine can be diverted from the faeces and that reuse of dried faeces can successfully be promoted as a resource. This is dependent on the acceptability of the households concerned and how much time can be dedicated to introducing and sustaining behaviour change. If this is possible, Ecological Sanitation systems can be introduced;

3. If intentional reuse is not likely, the density is to be considered as a criterion. If the density is low, say less than 250 person/ha, on-site systems are almost always possible. If the density is more, neighbourhood sewerage is an option, see step 7;

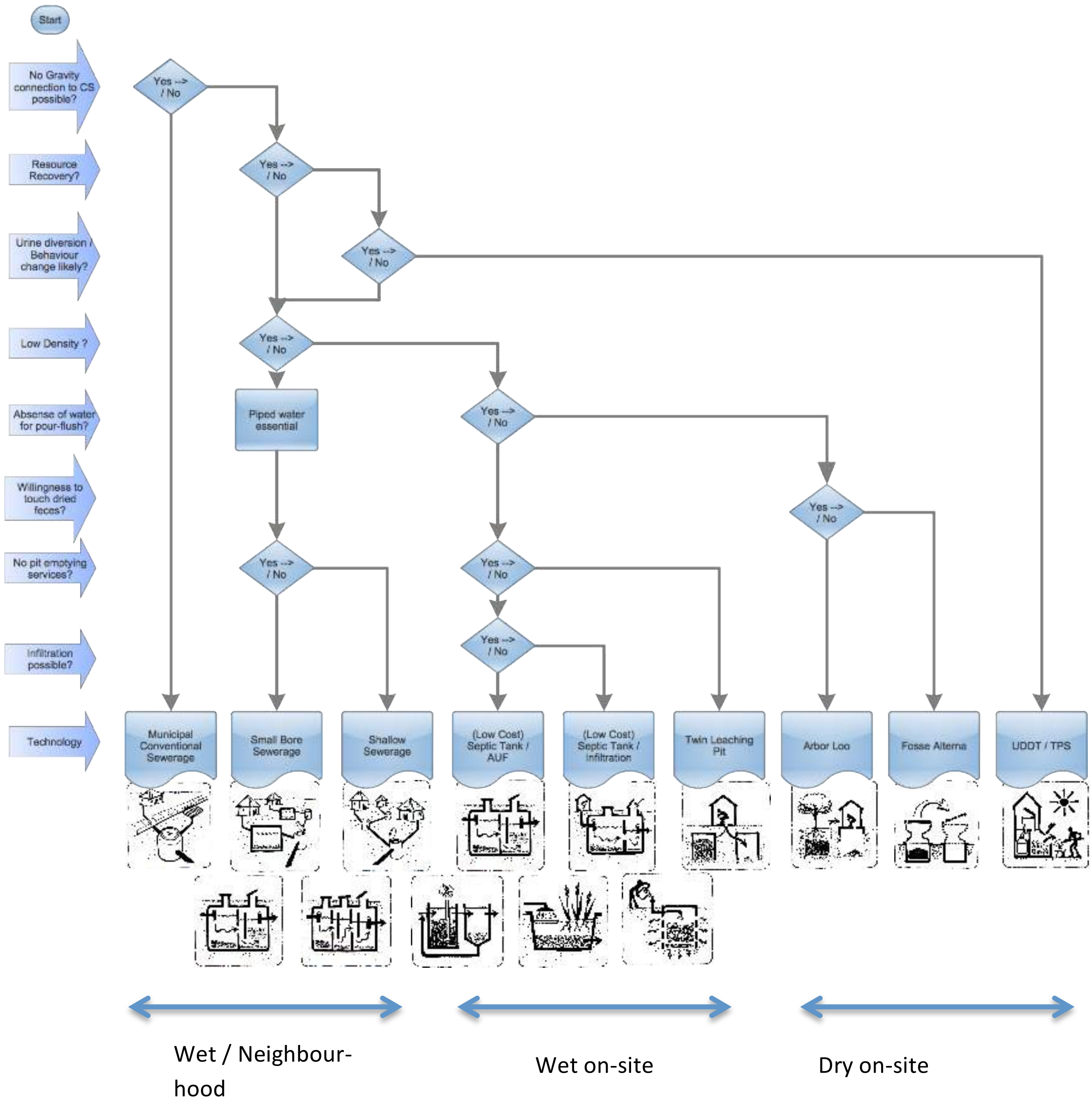
4. For on-site systems it is important to judge whether there is enough water available to pour-flush the excreta through a syphon into the on-site treatment unit. A minimum of 3 litres per person per day (lcd = litres per capita per day) is needed for flushing, which can be a problem in dry areas in summer. If this is not the case, we rely on **dry systems.** If it is likely that people can be persuaded to empty a non-smelling dry pit with 'humanure', a Fossa Alterna or PEVIP, Permanent Emptyable, Ventilated Improved Pit latrine can be considered. If not an Arbor Loo;

5. If there is sufficient water we can use **wet systems**, the most important question is whether there are reliable, environmentally sound mechanical pit emptying services such as vacuum trucks and a septage treatment facility available. If this is not the case, Twin Leaching Pits are favoured;

6. If we can use wet systems and there are pit emptying services available, (low cost) septic tanks can be applied: if infiltration is possible with an Infiltration system; if infiltration is not possible with an Anaerobic Upflow Filter;

7. In high-density areas, piped water supply is required to assure that enough water is available for flushing the sewer lines. In areas where on-site systems are available, they can be used as sedimentation tanks for a Shallow Sewer System. In areas without on-site systems, Shallow Sewerage can be applied. These neighbourhood systems can also convey grey water. For all other systems, separate grey water management is recommended to keep the hydraulic load and consequently the dimensions and costs of the treatment systems small/low.

Figure 4-1: Flow chart selection oPt sanitation technology (UNICEF/Spit, 2012)



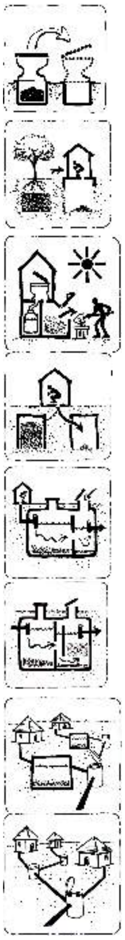
The results of the selection process is presented in the oPt sanitation technology menu in Figure 4-2.

Figure 4-2: oPt sanitation technology menu (UNICEF/Spit, 2012)

	User interface	Emptying conditions	Soil conditions	Collection Storage / Local Treatment	Transport/ Conveyance	Treatment	Reuse/ Disposal
Black water	Dry	No willingness to empty		Arbor Loo			
		Willingness to empty	Digging possible	Fossa Alterna			
			Hard rock	UDDT/		EcoSan	
	Wet	No desludging services	Ground water table > 3 m' deep	Twin Leaching Pit			
		Desludging services	Infiltration possible	Septic Tank & Soakaway			
			No infiltration Possible	Septic Tank & AUF			
Grey Water			Permeable soil	Soakaway			
			Low permeability	Leach field			
			Any soil	Constructed Wetland			Irrigation
				Anaerobic Upflow Filter (AUF)			Disposal
				Evapotranspiration field			
Combined water	Wet	No desludging services	Piped Water supply	None	Shallow Sewers	AUF ABR-UASB-AS / CW	Disposal
		Desludging services	Piped water supply	Septic Tank	Small Bores Sewers / SBS		Irrigation

Opinion applicability. We have investigated the opinion on the applicability of these options in oPt amongst the WASH partners. The results are presented in Figure 4-3. The colour coding indicates the opinion: green (++) means very applicable, and red (--) not applicable at all.

Figure 4-3: Preference training participant (UNICEF/Spit, 2012)



System	West Bank	Gaza
Fossa Alterna	2.07	2.77
Arbor Loo	2.21	2.02
UDDT	2.43	1.91
TLP	3.00	2.94
ST	2.79	3.25
ST/AUF	2.64	3.38
SBS	2.62	2.99
SS	2.64	3.37

This ranking illustrates that the participants are the opinion that the implementation of ‘dry systems’ will be very challenging, except for the Fossa Alterna in Gaza. It also illustrates that in the relatively well sewered Gaza, sewered systems rank higher than wet on-site systems. In the West Bank, the Twin Leaching Pit, is thought to be the best applicable system: it uses the pour-flush system and does not need mechanical desludging. Although, from the selection methodology in Figure 4-1 is became clear that there is logically a ‘market’ for dry systems given the challenging conditions, it illustrates that a lot of ‘behaviour change’ will be needed to convince the population that these are most appropriate in the particular condition.

4.3. Design parameters

Besides the composition and strength of the wastewater (see section 2.0) and the required effluent quality (see section 3.3.), the following design parameters are important:

a. Number of users, N, (in capita = cap);
b. Daily flow of wastewater entering the system;
c. Sludge production – accumulation rate;
d. Infiltration capacity of the soil;
e. Survival rate coliforms;
f. Groundwater depth.

Ad a. Number of users, N, (capita = cap)
The number of users is the future number of persons who use the facility under consideration. In this manual we will use 'N' to indicate the number of users. The unit used is 'capita'. For villages and towns, N represents the population.

Population[33]. Population figures for the village/town as a whole should be available from published census records. Published census reports are another useful source of information on the population and number of households. It may be possible to go back to census records to obtain information relating to individual enumeration districts but this will normally take time and effort and will not normally be justified at the planning stage. Some care is needed in interpreting census figures since they may apply to an area that extends beyond the limits of the town itself. A small town may cover only part of a larger ward while a larger town may consist of more than one ward, some of which also include surrounding rural areas.

Plans deal with the future and so require estimates of future population. For towns and cities as a whole, the simplest way to estimate future population figures is to extrapolate on the basis of recent population growth rates. Once the population growth rate is known, the future population can be calculated using the formula:

$$P^n \quad = \quad P^o\,(1+r)^n$$

Where P^n is the estimated population in 'n' years time, P^o is the current population and 'r' is the population growth rate.

The normal procedure is to take the population at the last two censuses and invert the equation to give the expression:

$$r = (P^n/P^o)1/n - 1$$

Where P^o is the population at the first census, P^n is the population at the second census and 'n' is the number of years between them.

This calculation can be carried out on a spread sheet, as shown in the example below.

[33] WASTE (2007): Tool for strategic sanitation planning by Kevin Tayler

Pn	Po	n	Log (Pn/Po	log (r-1)	r-1	r
27886	22103	10	0.2324	0.0232	1.0235	0.0235

Enter the term =ln (A2/B2) to calculate the value in the fourth column, then divide this figure by n (10) to obtain the figure in the fifth column. Finally, use the term exp (E2) to obtain the value of r-1 in the sixth column. (The cell locations (A2, B2 E2 will depend on where the calculation is located on the spread sheet).

Note that 'r' is an absolute rather than percentage figure and that 0.0235 can be presented as 2.35 per cent.
Different techniques will normally be required to calculate population growth rates of smaller areas. The text box below sets out a step-by-step description of a possible process.

Procedure for estimating present and future populations at the local level

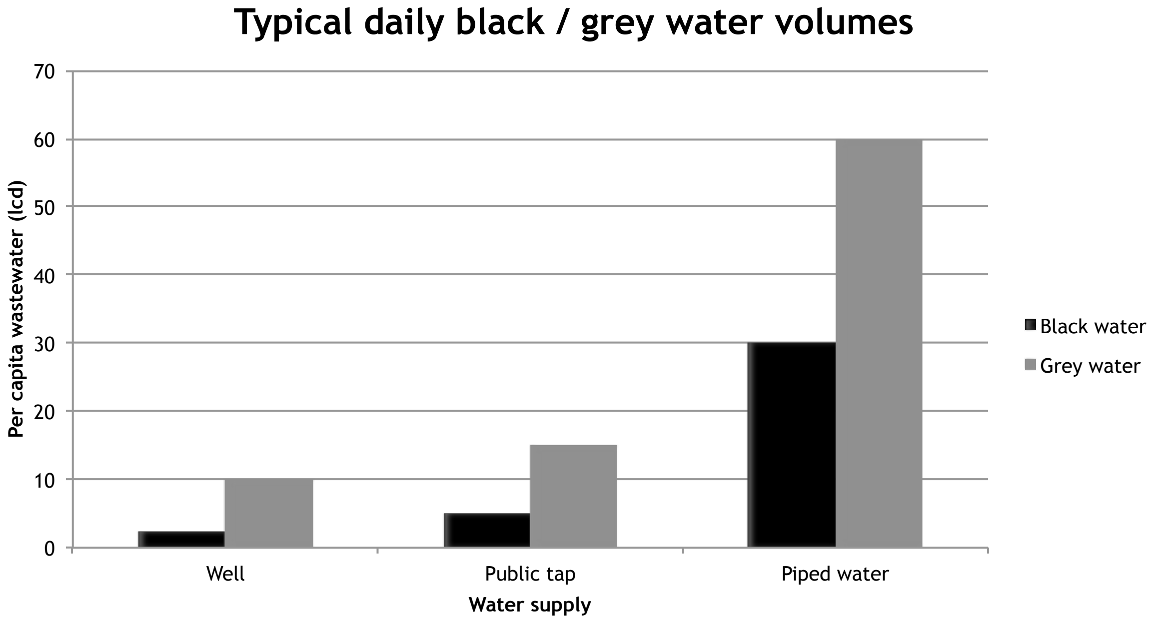
1. Identify the boundaries of the area for which a population estimate is required and calculate the size of the area within these boundaries[34]. The area should be reasonably homogeneous, with the mix of plot sizes and street widths roughly the same throughout. Large open areas should not be included at this stage;
2. Count the existing number of houses within the boundaries, using available satellite imagery and/or maps;
3. Calculate the current average housing density by dividing the number of houses by the calculated area. (The housing density should be expressed as the number of houses per hectare);
4. Calculate the average population density by multiplying the average housing density by the average household size, obtained either from census data or from a social survey in the study area;
5. Estimate the potential future number of houses in the area, allowing for infill of internal open areas and empty plots and, where appropriate, replacement of single housing units with multiple units on the same plot. (This can happen when a house is subdivided, extended upwards or replaced by walk-up apartments);
6. Calculate the potential future population of the area based on the potential number of houses and the average household size;
7. Carry out this exercise for a number of typical areas and use the results to calculate potential population densities for similar areas.

Ad b. Wastewater entering the system or 'wastewater generation rate', q

The wastewater entering the wastewater ('return ratio') is usually 80%-90% of the drinking water supplied. We will use 'q' to indicate it. It is usually measured in litres/cap/day or m^3/day. It depends very much on the way the drinking water is organized and whether black and grey water is separated. In this manual we use 30 lcd for black water and 60 lcd for grey water.

[34] This can be done automatically when a GIS program is being used. A manual method is to divide the area into squares with a standard size, counting the number of squares and multiplying the number of squares by the area of a standard square.

Table 4-2: Typical daily wastewater generation rates



Ad c. Sludge production – accumulation rate, 'S', litres/capita/year (lcy)

The sludge production or sludge accumulation rate is the volume of sludge that remains after anaerobic or aerobic decomposition. It depends on the type of decomposition and the type of material used for anal cleansing. Based on experiences in Indonesia (Spit, 2011) and Kalbermatten (1982) the following values can be used as a 'rule of the thumb:

- In a wet environment (anaerobic conditions):
  - Water for cleansing: 25 lcy;
  - Degradable cleansing material: 40 lcy;
  - Non-degradable cleansing material: 60 lcy;
- In a dry environment (aerobic conditions):
  - Water for cleansing: 40 lcy;
  - Degradable cleansing material: 60 lcy;
  - Non-degradable cleansing material: 90 lcy.

Ad d. Infiltration capacity of the soil

All wastewater must be absorbed by the soil. The leaching capacity is best determined by a leaching test. See Appendix 4-1. If it is not possible to perform a leaching test, the following 'rules of thumb' can be applied in litres/m^2/day [35]:

- Clay soils: 15 litres/m^2/day;
- Loam soils: 20 litres/m^2/day;
- Sand soils: 25 litres/m^2/day.

[35] Heynes (1985)

Ad e. Survival rate coliforms

The period sludge needs to be left alone before it can be handled without any harm depends on various factors. One factor is time, the survival rate of coliforms. In soil, the survival rate is (Kalbermatten, 1982):

- Viruses up to 6 months, generally < 3 months;
- Bacteria up to 3 years, generally < 2 months;
- Protozoa up to 10 days, generally < 2 days;
- Helminths up to 10 years, usually < 1-2 years.

Other factors are temperature and moisture content, see Table 4-3. Figure 4-4 shows the relation between time and temperature (Kalbermatten, 1982).

Table 4-3: Factors that influence die-off of pathogens (WASTE, 2006)

Pathogens die off after excretion, as environmental conditions outside the human host are generally not favourable to their survival. Environmental factors that contribute to the die-off of pathogens are listed in the table below.'

Factor	Description
Nutrients	Pathogens living in the gut are not always capable of competing with other organisms outside the body for scarce nutrients.
Temperature	Most microorganisms survive at low temperatures (<5 °C) and rapidly die off at high temperatures (>40-50 °C) during composting and/or dehydration.
pH	Many microorganisms are adapted to a neutral pH (7). Increasing acidic or alkaline conditions through adding ash or lime will have an inactivating effect.
Dryness	Moist conditions favour the survival of micro-organism. Dry conditions decrease the number of pathogens.
Solar radiation / UV light	The survival time of pathogens will be shorter when they are exposed to sunlight (when excreta are applied to the soil).
Presence of other organisms	Organisms may affect each other by predation, release of substances or competition as happens when waste water is treated in soil filters or excreta is applied in agriculture.
Oxygen	Microbiological activity is dependent on oxygen. Most pathogens are anaerobic and are likely to be out-competed by other organisms in an aerobic environment. For this reason, application of excreta to soil and exposure to ventilation contributes to die-off.
Time	All the above conditions only become relevant in relation to time. In other words, the more time pathogens are exposed to these conditions, the less chance they have of surviving.

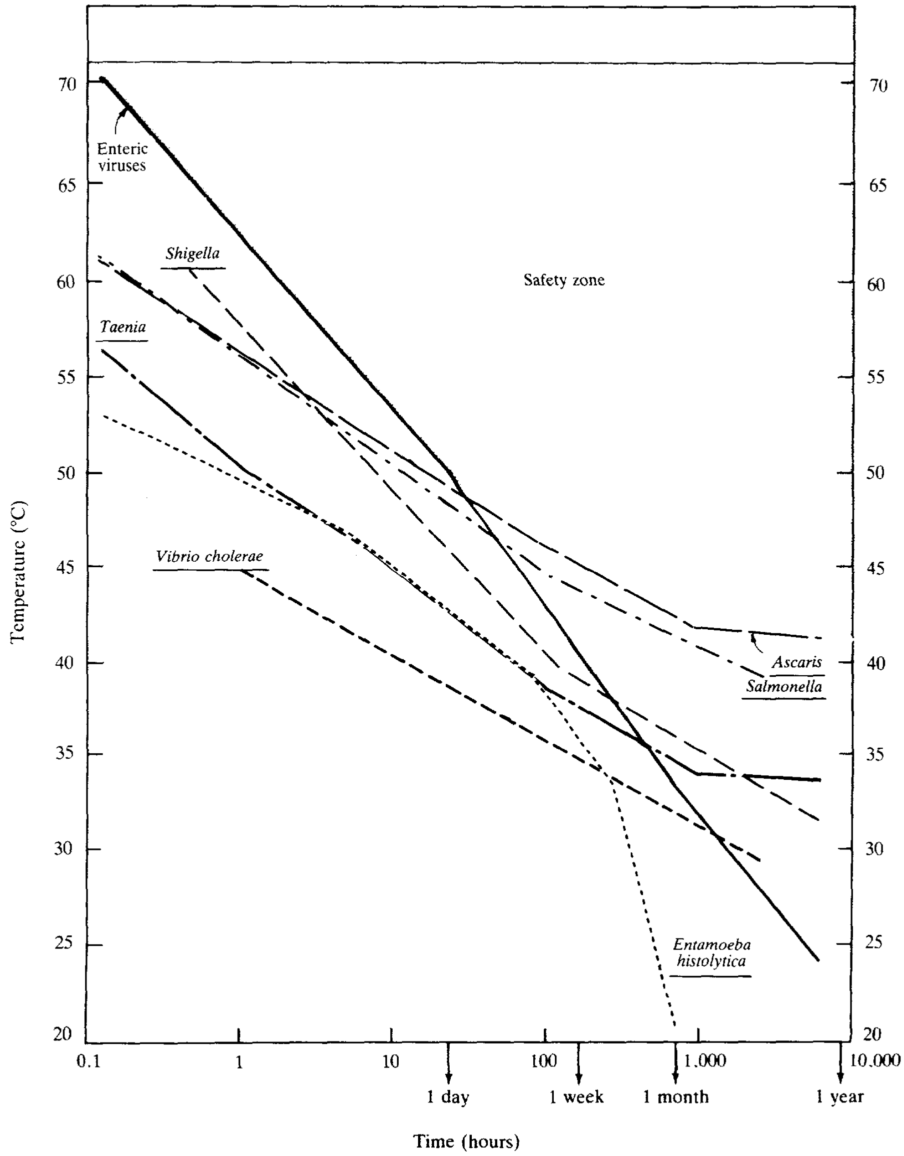
Ad f. Groundwater pollution (Kalbermatten, 1982)

On-site disposal of human waste presents a potential hazard of groundwater contamination and, thus disease transmission from the disposal site through groundwater to users of well water. Contaminants are pathogens (bacteria, viruses, protozoa, Helminths) and inorganics (principally chlorides and, in areas where baby formulas replace breastfeeding, nitrates). The severity of contamination and the distance pollutants travel depend on factors such as soil type and porosity, distance to and type of underlying rock, groundwater level and hydraulics, composition of waste (presence and characteristics of contaminants), natural contaminant removal processes (filtration, dispersion, sorption), distance to surface water, and the like. The effects on people depend on the type of water service (individual shallow or deep wells, piped systems and their water sources), climate, and so forth.

Clearly, the most serious problem exists where a pit penetrates the groundwater that provides drinking water through shallow wells located nearby. In such a situation, septic tanks should be used or the water piped to standpipes from a protected well. The most favourable situation exists where the water supply is already a piped system, pits do not reach groundwater and soil porosity is low. It is not possible to establish detailed, universally valid guidelines for horizontal and vertical separation of latrines, drain fields, and wells. Much further work is required to determine the travel distance and survival of pathogens entering the soil through latrines. It is clear, however, that the greater the groundwater abstraction, the more porous or fissured the soil, the greater the distance should be between a latrine and a well. It is generally accepted practice to keep a minimum distance of 10 meters between latrine and well in loam or sandy silt soils. Where wells are equipped with mechanical pumps and supply a large number of people, a groundwater study should investigate and subsequently monitor both water quantity and quality. The inorganic pollutant of concern is nitrate, which occurs in groundwater as a result of natural and man-made pollution. Nitrates do not appear to affect adults even at levels far higher than those specified by WHO drinking water standards, but bottle-fed infants contract methemoglobinemia ('blue babies syndrome') at nitrate levels considerably below the WHO standard. As a consequence, it is suggested that where groundwater contains more than 10 milligrams per litre of nitrate nitrogen and where the local water supply is used in preparing infant formulas, the local health officer be consulted to determine the possible effect on infants.

Figure 4-4: Influence of Time and Temperature on pathogens (Kalbermatten, 1982)

Figure 15-1. *Influence of Time and Temperature on Selected Pathogens in Night Soil and Sludge*



Note: The lines represent conservative upper boundaries for pathogen death—that is, estimates of the time-temperature combinations required for pathogen inactivation. A treatment process with time-temperature effects falling within the "safety zone" should be lethal to all excreted pathogens (with the possible exception of hepatitis A virus—not included in the enteric viruses in the figure—at short retention times). Indicated time-temperature requirements are at least: 1 hour at ≥62°C, 1 day at ≥50°C, and 1 week at ≥46°C.

Source: Richard G. Feachem and others, *Sanitation and Disease: Health Aspects of Excreta and Wastewater Management*, World Bank Studies in Water Supply and Sanitation, no. 3 (Baltimore: Johns Hopkins University Press, forthcoming).

5. Toilet superstructure

In this manual we pay special attention to the superstructure because in Area 'C', it is difficult to obtain permits to construct durable, permanent, stone/concrete based, superstructures. The function of the toilet superstructure[36] is to provide privacy and to protect the user and the toilet from the weather. Superstructure design requires assessment of whether separate facilities are required for men and women in the same household. Local customs and preferences often influence superstructure location, orientation, shape, construction material, design (for example, roof, window details), and size. Colour may strongly influence a householder's use and maintenance of the facility. These details should be designed in consultation with the user. The technical design requirements of the superstructure are relatively straightforward and may be stated as follows:

- **Size:** The plan area should be at least 0.8 m^3 to provide sufficient space and generally not more than 1.5 m^3. The roof height should be a minimum of 1.8 m';
- **Ventilation:** There should be several openings at the top of the walls to dissipate odours and, in the case of Fossa Alterna and Arbor/Sabar Loo, to provide the through draft required for functioning of the vent pipe (see section 7.4). These openings should be about 75 to 100 mm by 150 to 200 mm in size; often it is convenient to leave an open space between the top of the door and the roof which can be meshed to prevent entry of vectors;
- **The door**: This should open outwards to minimize the internal floor area. In some societies, however, an outward opening door may be culturally unacceptable. In either case it must be possible to fasten the door from the inside, and it may also be necessary to provide an external lock to prevent use by unauthorized persons or battering of the winds. At its base the door should be just clear of the floor to provide complete privacy and to prevent rot of the bottom of the door planks;
- **Lighting**: Natural light should be available and sufficient. The toilet should be sufficiently shaded, however, to discourage flies; this is particularly important in the case of Fossa Alterna and Arbor Loo. Artificial lighting should be considered for night-use and safety both en route to and within the toilet itself.
- **Walls and roof**: These must be weather proof, provide adequate privacy, exclude vermin, and be architecturally compatible in external appearance with the main house.

Although the toilet superstructure should match the features of the house, because of the building restrictions in area 'C', metal superstructures are implemented. See Figure 5-1 and Figure 5-2.

[36] After Kalbermatten (1982)

Figure 5-1: Metal sheet superstructure with weak floor (UNICEF-oPt/2012/Spit)

Figure 5-2: Rusting metal sheet superstructure (UNICEF-oPt/2012/Spit)

While these superstructures respond to the need to show clearly that is a 'temporary' structure, they have several drawbacks:

- The metal sheet is feeble and rusts easily away, especially the floor;
- It is very hot in summertime.

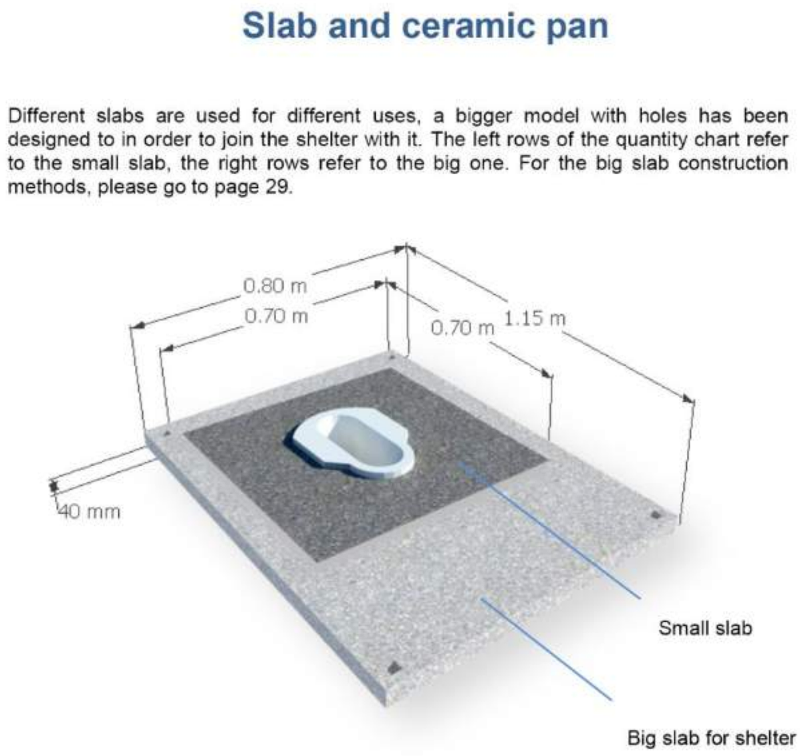
Two ways are suggested to overcome this problem:

a. Introducing pre-fab concrete tiled floors;
b. Introduce plastic sidewalls or Glass Reinforce Concrete panels.

Ad a. Introducing pre-fab concrete tiled floors

By introducing a pre-fab concrete tiled floor such as applied in the 'Easy Latrine'[37], corrosion is avoided and a high level of user comfort is introduced. See Figure 5-3 and Figure 5-4.

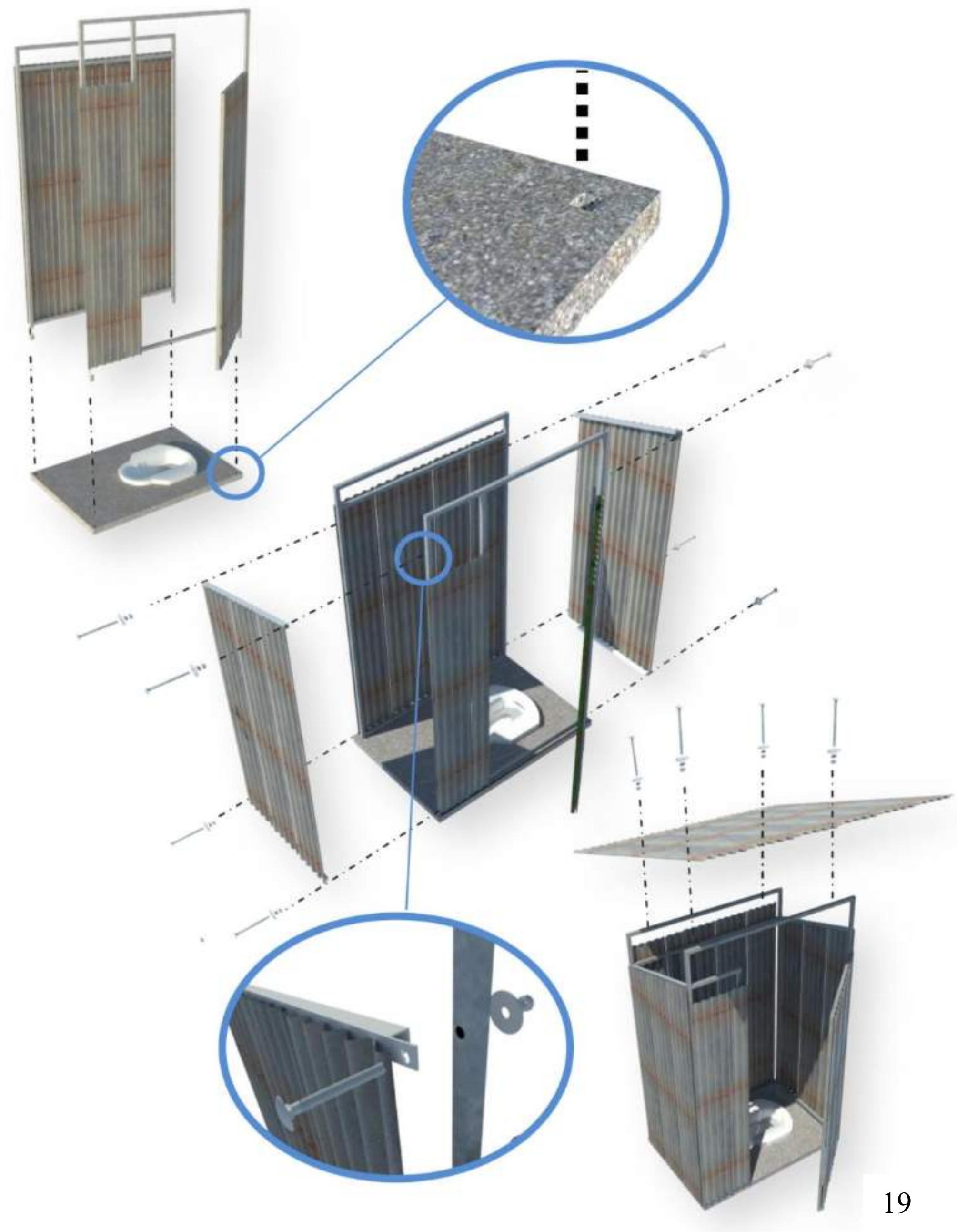
Figure 5-3: Prefab slab 'Easy Latrine'



[37] See GET and IDE (2010): Easy Latrine Shelter Handbook

Figure 5-4: Shelter 'Easy Latrine'

The shelter is made out of 5 flat elements that are manufactured separately then joined on the top of the slab. Making it easy and quick to manufacture, to store, transport, and easy for a villager to install themselves.



Ad b. Introduce plastic or Glass reinforced cement (GRC) sidewalls

At present there are many easy to clean non-corrosive materials available for the shelter. Figure 5-5 illustrates the materials used in the SHAW project by Yayasan Dian Desa.

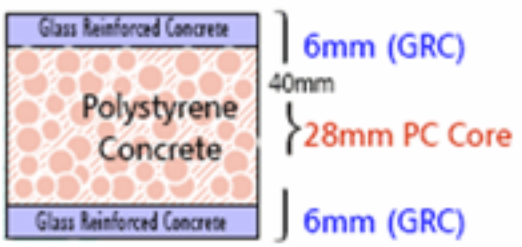
Figure 5-5: Superstructure latrine, Yayasan Dian Desa (SHAW/Spit, 2011)

Figure 5-6: Superstructure SHAW latrine (SHAW/Spit, 2012)

Figure 5-7: Artist impression SHAW toilet (Yayasan Dian Desa, 2011)

Recently the Water Research Committee in South Africa published a research on movable superstructure. Figure 5-8 shows a panel construction, which resembles a sandwich of two 6 mm glass reinforced cement (GRC) skins and a 28 mm polystyrene and cement core.[38] See Figure 5-9.

Figure 5-8: Glass reinforced concrete with Polystyrene concrete core (Kearsley, 2011)



Hand-washing. In water scarce locations in Area 'C' alternative hand-washing facilities could considered for temporary or mobile latrines:

- Tippy Tap;
- Handy Andy;
- Cap tap.

See Figure 5-11.

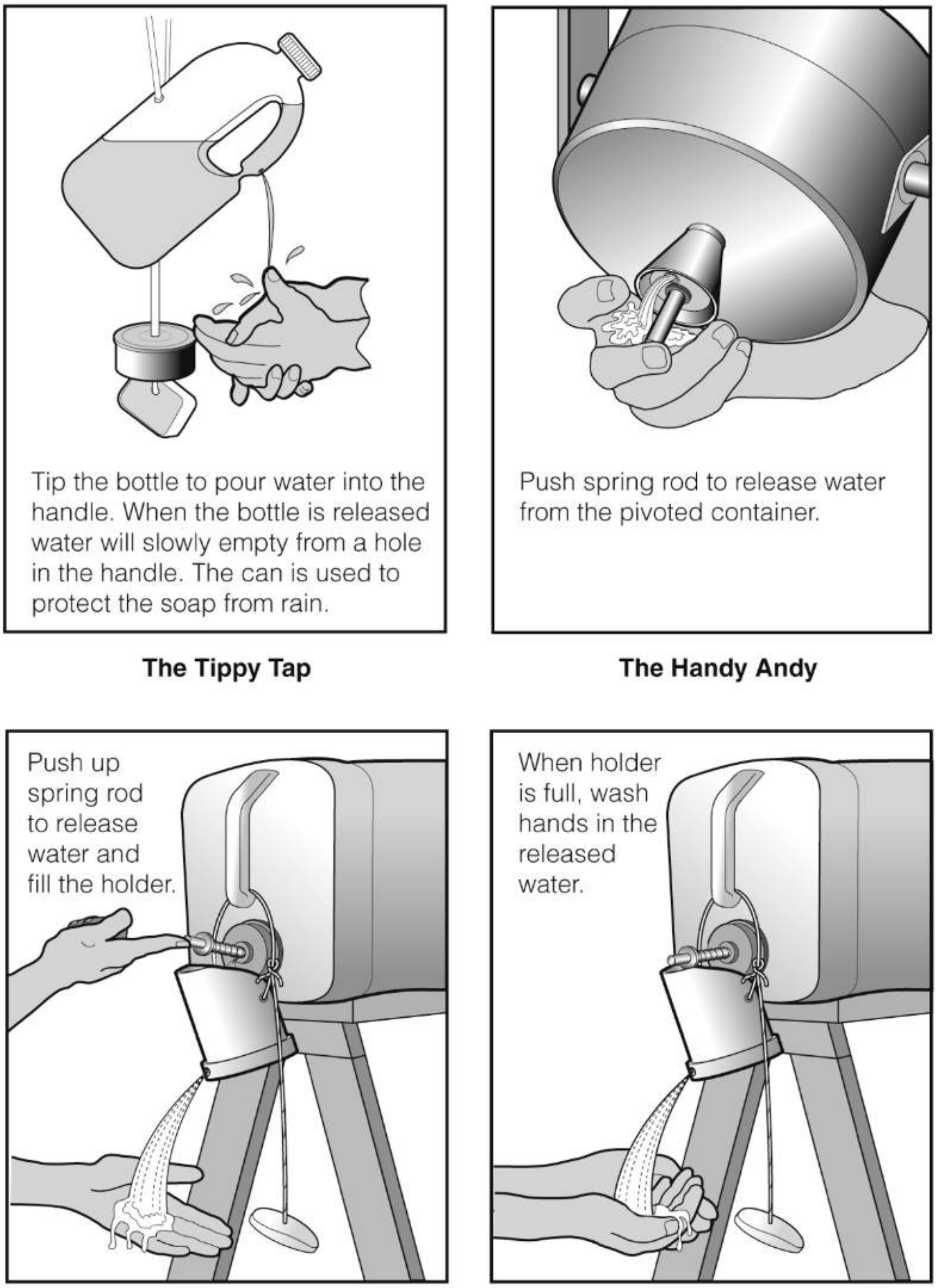
[38] Kearsley, Ep (2011): Lightweight moveable superstructures for VIP toilets, Water Research Commission, South Africa.

Figure 5-9: Illustration study on movable superstructures in South Africa (Kearsley, 2011)

The Polystyrene concrete can also be made in situ. See Figure 5-10.

Figure 5-10: Polystyrene cement made in situ (Spit, 2009)

Figure 5-11: Improved hand-washing devices (WEDC, accessed March 2012)



The Captap - Stage 1

The Captap - Stage 2

6. Immediate improvements

6.1. Shortcomings

Immediate improvements are focussed on answering the shortcomings of existing systems. The main shortcomings and the answers are:

a. Cesspits of emergency toilets fill up quickly. The automatic answer by the community is to construct a large cesspit. A more appropriate and environmentally sound answer is to provide a control box / Y-junction (see Figure 8-7) and introduce a second leaching pit parallel to the first one. In this way a Twin Leaching Pit is born. See section 8.2;
b. Pollution groundwater due to high hydraulic load. This also results in the need for frequent desludging. The answer is to decrease the hydraulic load by separating grey water from black water. See section 6.2;
c. Pollution groundwater due to leakage of the cesspit. The answer is sealing the cesspit and introducing a soak away and use of the treatment capacity of the subsoil. See section 6.3;
d. Indiscriminate dumping of collected septage. The answer is introduction of decentralized septage drying and management installations. See section 11.

6.2. Separation grey water from black water

As seen in section 2.3, grey water is relatively clean compared to black water. Separation will reduce the problem of groundwater pollution by 2/3: the ‘problem’ has been reduced from 90 lcd to 30 lcd. An additional advantage is that the cesspit desludging period can be reduced from once every two months to once every 10 -20 years. Of course, separation in existing constructions is not an easy task. See Figure 6-1.

Interviews revealed that it may cost NIS 700 to change the existing piping. In addition a grey water management system has to be constructed. See section nine on the technological options. Ideally this is a grey water reuse systems so that the drinking water usage can be reduced, money is saved and the local groundwater is recharged. Our field visits and the questionnaire discussed in 1.6.5, revealed that the separation will be a challenge to implement on a large scale. Both motivational and capacitating actions are needed to change the behaviour. Table 6-1 presents some first ideas on this, which need to be elaborated in a pilot project.

Table 6-1: Behaviour change interventions for black and grey water separation

Present condition / opinion on separation	Present status	Suggested focus	Suggested Intervention
Intrinsic Motivation	• Short horizons; • Insecurity; • Environment is low on the agenda; • Financial difficult times; • People like agriculture	• Focus on financial gains; • Focus on agriculture	• Stress the 'profit' that can be made by separation: less frequent desludging / lower water bill; • Stress the higher yield • in the garden
Extrinsic Motivation	Limited measures to protect the environment	Incentives and rewards, improved understanding and guidance	Good examples at schools, government buildings etc.;
Physical Capacity	Support from extended families, Each person repairs his house	Holistic programming with joint WASH and agriculture projects	Community incentives once all the system is completed to encourage joint cooperation from all the community
Knowledge capacity	Lack of experience and knowledge and first hand use of an infiltration system	Dissemination of technical possibilities	Display and build examples of grey water systems; Brochures; TV and radio dissemination.
Financial capacity	Relatively cheap	None	Cash for work joint schemes

Figure 6-1: Separating grey from black in existing houses (UNICEF-oPt/2012/Spit)

The picture shows the difficulty in retrofitting grey water separation systems after a house and plumbing system have been installed. However, this is possible and can be installed to suit the location and type of sanitation system as selected from figure 4-1 and 4-2.

6.3. Sealing of cesspits

A simple and effective solution to seal a cesspit is to place an HDPE septic tank in the ground after removal of septage. See section 8.3 on the details of a septic tank. See Figure 6-2 for an example of a HDPE septic tank. HDPE rather than concrete/masonry tanks are suggested as they guarantee a water-tight seal. If cement built tanks are selected contractors must be aware not to use hollow cement blocks. All tanks should be tested for leakages by filling the tank, marking the water level and measuring the level after 24 hours to gauge the water retention capability.

Figure 6-2: HDPE Septic Tank (UNICEF-oPt/2012/Spit)

A cheaper possibility might be to line the cesspit with plastic foil. See Figure 6-3.

Figure 6-3: Plastic foil septic tank (AAWS, 2012)

Another low cost solution is to infiltrate in a gravel collar around the tank, see Figure 6-4. Alternatively, the application of corrugated iron sheets with plastic protection (Figure 6-5) or stone masonry with HDPE foil (Figure 6-6) can be considered.

Figure 6-4: Septic tank with infiltration around it (SHAW/Yayasan Dian Desa, 2011)

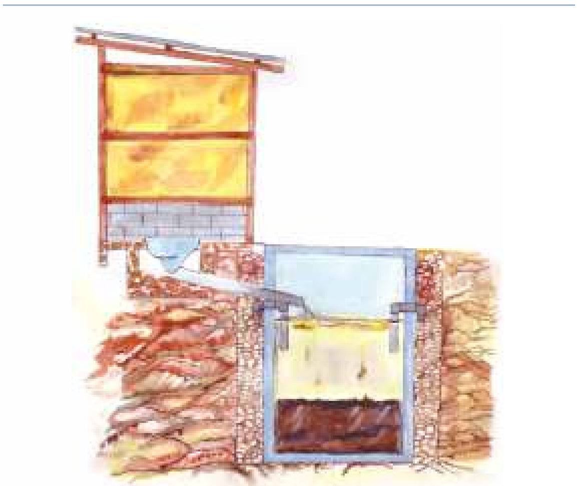


Figure 6-5: Corrugated iron sheet tank (www.waterforaridland.org)

This can be used as a water tank or in loose soil areas as supporting walls for a septic tank to replace concrete walls. A plastic liner can be placed inside to prevent corrosion as shown in figure 6-6.

Figure 6-6: HDPE lining (Spit, 2009)

Our field visits, the questionnaire discussed in section 1.6.5. and the present government focus on piped systems, indicates that the replacement of the cesspit with a septic tank will be a challenge. Both motivational and capacitating actions are needed to change the behaviour. Table 6-2 presents some first ideas on this, which need to be elaborated in a pilot project.

Table 6-2: Behaviour change interventions for replacing cesspits with septic tanks

Present condition / opinion on separation	Present status	Suggested focus	Suggested Intervention
Intrinsic Motivation	• Short term solutions; • Insecurity; • Environment is low on the agenda; • Financially difficult times; • Agriculture is seen as important.	• People want to be ‘modern’; • People prefer to be self-reliant.	• Stress the fact that this is a ‘modern’ solution; • Stress the fact that ‘self-help’ is possible.
Extrinsic Motivation	Limited measures to protect the environment	• Incentives and rewards, improved understanding and guidance	• Good examples at schools, government buildings etc.; • Good new business for contractors; • Legislation that in all new houses septic

Present condition / opinion on separation	**Present status**	**Suggested focus**	**Suggested Intervention**
			tanks are installed
Physical Capacity	• Heavy tools required • Not many available in oPt.	Through contractors	• Stimulate contractors to enter this market • Initiate community cooperatives/ schemes • Provide loans to contractors and businessmen that enter the market.
Knowledge capacity	People do not know how a septic tank looks like	Dissemination of technical possibilities	• Examples of septic tanks; • Brochures; • TV and radio dissemination.
Financial capacity	• Relatively expensive; • Lack of successful cooperative credit schemes; • Total cost of initiatives provided by external organisations which hampers sustainability and ownership	Promote ownership Promote re-use and waste as resource and for financial gains Highlight financial savings through reduced frequency of emptying with grey and black diversion systems Promote public health aspects of eliminating overflowing pits, vector reduction, improved health benefits and less doctors bills	Intensive awareness, Documented good practice and case studies from households and communities who have witnessed the benefits. Focus on household improvements to promote ownership rather than community schemes

References

BAKALIA, ALEXANDER (1994), Albert Wright, Richard Otis and Jose de Azevedo Netto, Simplified Sewerage, Design Guidelines, UNDP/World Bank

BURNAT, JAMAL (2010): The Practical Manual For Installation of the Household Grey Wastewater Treatment System, FAO – Project No:- OSRO/GAZ/909/SPA

EAWAG (2005): Household-Centred Environmental Sanitation, Implementing the Bellagio Principles in Urban Environmental Sanitation, Provisional Guideline for Decision-Makers, Eawag: Swiss Federal Institute of Aquatic Science and Technology.

HEYNES, FRANS (1985): Twin Leaching Pits Toilets, Design and Construction Manual, Puslitbang Pemukiman, UNDP Low Cost Sanitation Investment Project INS/81/002, Bandung, Indonesia.

GET and IDE (2010): Easy Latrine Shelter Handbook, Cambodia.

KALBERMATTEN JOHN M, DEANNE S. JULIUS, CHARLES G. GUNNERSON (1982): Appropriate Sanitation Alternatives, A Technical and Economic Appraisal, World Bank.

KALBERMATTEN, JOHN M., DEANNE S. JULIUS, CHARLES G. GUNNERSON, AND D. DUNCAN MARA (1982): Appropriate Sanitation Alternatives, A Planning and Design Manual, World Bank.

KEARSLEY, EP (2011): Lightweight moveable superstructures for VIP toilets, Water Research Commission, South Africa.

MARA, DUNCAN (1976): Sewage treatment in hot climates, John Wiley & Sons, Chichester.

MARA, DUNCAN (2001), Andrew Sleigh and Kevin Tayler: PC--based Simplified Sewer Design
School of Civil Engineering University of Leeds and *GHK Research & Training*, London

MCLLWAINE STEPHEN (2010) AND MARK REDWOOD, Grey water Use in the Middle East Technical, Social, Economic and Policy Issues

MOGHEIR (2004), Treated Wastewater Reuse in Palestine

NAZZAL, YASSER, MOHAMMED MANSOUR, MOHAMMAD AL NAJJAR AND PETER MCCORNICK (2010):
Wastewater Reuse Law And Standards In The Kingdom Of Jordan, The Ministry of water and irrigation Amman, Jordan

SASSE, LUDWIG (1998): DEWATS Decentralized Wastewater Treatment in Developing Countries, Borda.

TILLEY, E.; LUETHY, C.; MOREL, A.; ZURBRUEGG, C.; SCHERTENLEIB, R. (2008): Compendium of Sanitation Systems and Technologies. Duebendorf and Geneva: Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

TILLEY, ELIZABETH AND SYLVIE PETERS (2008): Sandec Training Tool: Module 4 Sandec: Department of Water and Sanitation in Developing Countries, Sanitation Systems & Technologies EAWAG.

UDERT, KAI AND TILLEY, ELIZABETH (2008), Sanitation systems and technologies for developing countries, EAWAG, 2010

UNICEF (2010): Core Commitments for Children in Humanitarian Action, www.unicef.org, accessed April 2012

WASTE (2006): Smart Sanitation Solutions, NWP, The Hague, The Netherlands

WHO (2006): Guidelines for the safe use of wastewater, excreta and grey water

WSP (2007): Philippines Sanitation Sourcebook and Decision Aid

ZIMMO, OMAR (2005), Prospects of Efficient Wastewater Management and Water Reuse in Palestine, EM Water Project

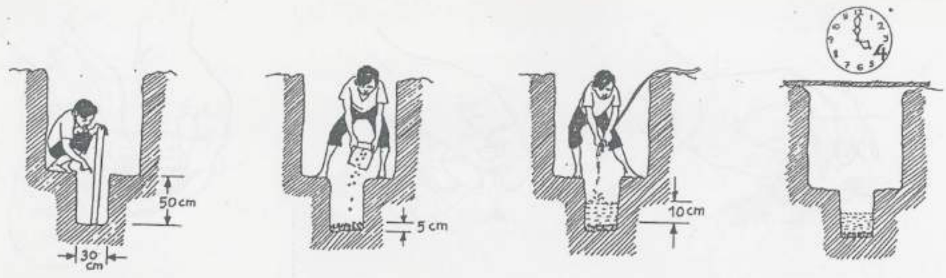
Appendices (separate documents)

Appendix 1-1: Terms of Reference

Appendix 1-2: Cambodia case studies (CAPS)

Appendix 4-1: Soil test: Leaching capacity of the soil (Heynes, 1985)

LEACHING PITS — 54 — DESIGN



SOIL TEST 3: leaching capacity of the soil

A percolation test is the most commonly used indicator to measure the ability of soils to absorb water. A simple percolation test to perform in the field is the falling head test. The procedures are as follows:

1. Dig or bore at one meter deep a test hole 50 cm deep and with a diameter of 30 cm. If you expect different conditions in the two pits dig test holes at both locations.

2. Scratch the sides and the bottom of the hole with a sharp stick to get a natural soil surface and remove any loose material.

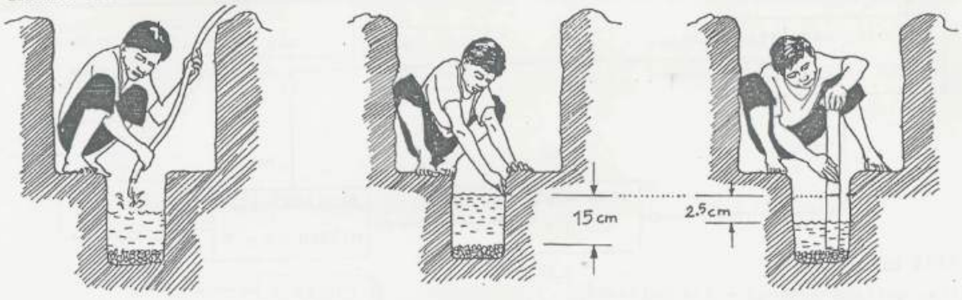
3. Place crushed gravel (Ø 10-20 mm) to a depth of about 5 cm in the hole to protect the bottom from scouring when the water is added.

4. Fill the holes slowly with at least 15 cm of clean water. Do this slowly to prevent the water washing away the sides of the hole. You may use a funnel with a hose attached.

5. Cover the hole and leave it for 4 hours so the soil becomes saturated. This is very important. Immediately after the 4 hours soakage period begin measuring the percolation.

If the water seeps away completely in less than ten minutes after filling the hole twice, you may begin the measurement immediately.

Twin Leaching Pit Toilets - Design & Construction Manual



Measuring the percolation rate

1. Fill the hole with water to a depth of 15 cm above the gravel.

2. Record the period of time it takes for the water level to drop 2.5 cm, beginning immediately after the hole has been filled.

3. As soon as the level has dropped 2.5 cm, repeat (1) and (2) until two successive measurements differ by less than 2 minutes. You must repeat the test at least 3 times even if the first two measurements differ by less than 2 minutes.

4. Take the last time period recorded and mark the leaching capacity of the soil on the table opposite.

time period minutes	leaching capacity per day
1	35 liters/m2
2	28 liters/m2
3	25 liters/m2
4	23 liters/m2
5	22 liters/m2
10	19 liters/m2
20	17 liters/m2
30	16 liters/m2
60	14 liters/m2
90	13 liters/m2