GREEN HOSPITALS

CONCEPT MANUAL FOR IMPROVING INFRASTRUCTURE

SECTION 3

Best Practice:

Water Supply and Wastewater for Health Facilities

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EPOS Health Management

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Developed as part of the 'Greening Hospitals Integrated Infrastructure Competence Project' in Tajikistan, co-funded by EPOS, ETLog and GIZ • December 2013 - October 2015

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This Concept Manual has been prepared in five section within the framework of the 'Greening Hospitals — Integrated Infrastructure Competence Project' in Tajikistan, by the development partnership of EPOS Health Management and ETLog Health GmbH, as part of the part of the develoPPP.de programme that Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is implementing on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

The five sections are as follows:

- SECTION 1 — Best Practice: Basic Planning Principles
- SECTION 2 — Best Practice: Building & Building Services Maintenance
- SECTION 3 — Best Practice: Water Supply and Wastewater in Health Facilities
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Introduction—Importance of Water Supply and Wastewater at Healthcare Facilities

The supply of safe and sufficient amounts of water is important in the healthcare sector, as water is not only needed for consumption and cleaning, but also for different medical and non-medical procedures and processes, such as hydrotherapy, cooling water and haemodialysis. The vulnerability of renal dialysis patients was demonstrated in 1996 in Caruaru, Brazil by the death of 52 such patients after exposure to water contaminated by high levels of microcystin (Jochimsen et al., 1998; Pouria et al., 1998). Dialysis patients are also sensitive to chloramines and this needs to be considered when chlorination is used to disinfect water supplies.

Microbiologically contaminated drinking water is a cause of community-acquired infection and guidelines for prevention of such infections have been established. Microbes in healthcare facility water are even more critical as they might come into contact with patients who already have a weakened immune system. Likewise this may result in out-breaks of Healthcare Associated Infections (HCAI), also known as nosocomial infections. Incidents such as outbreaks of legionnaires' disease among patients in hospitals from unsafe water contaminated with Legionella pneumophila are well documented and water-borne nosocomial infections caused by Pseudomonas aeruginosa have been reported dozens of times. Microorganisms in water also have the potential to cause infections if water is used to wash burns or to wash medical devices such as endoscopes and catheters.

Water safety in a healthcare facility must be assured by operating protocols, regular cleaning and maintenance. A healthcare facility must be responsible for developing and implementing a healthcare facility water safety plan (WSP) as part of their infection control program. The WSP shall not only address normal water systems, but also other technical water systems, such as boiler water, cooling water, water for steam production, etc.

During usage in a healthcare facility, water becomes polluted and might get contaminated with toxic chemical or pathogens. Improper management, collection, treatment and disposal of hospital wastewater and sludge might result in the pollution of local water sources with pathogens and can produce risks for patients, staff and the public. Numerous water-borne and vector borne diseases can result from inefficient waste water treatment and it might favour the spreading of para-sites (e.g. roundworms or Ascaris lumbricoides). Eutrophication of watercourse might be the result of disposing untreated or inefficiently treated wastewater in the environment.

Sanitation systems worldwide can be classified into two major categories, namely: offsite and on-site sanitation systems. The conventional sewerage system with proper treatment and disposal, and small-bore sewers are classified as off-site sanitation systems whilst, others such as dry pit latrines, ventilated improved pit latrines, pour-flush latrines (with single or twin pits), aqua privies, and septic tanks fall under on-site sanitation systems.

Organization & Management of Services

Roles & Responsibilities

Without safe and continuous water supply a healthcare facility cannot be operated. Water is essential and required for different purposes. The Board of Directors or management team of a healthcare facility has the overall responsibility to ensure that all departments are supplied with safe water in the right quality and quantity and at the correct pressure and that the water is regularly monitored and tested.

In addition, the waste water and sewage system must be kept in proper working order to avoid damage to infrastructure, blockages that may pose environmental or public health risks.

The Director

The Director of the healthcare facility will be responsible to ensure a continuous supply of water from internal and external sources. To safeguard the necessary water quality, the Director must establish a Water Safety Plan and should appoint persons for the regular testing of the water. A maintenance plan must also be set up and monitored to keep the water supply systems operational. Additionally, the Director must ensure regular and appropriate maintenance is carried out to keep the waste water and sewage systems operational.

Further he/she should ensure sufficient financial resources to allow sustainable operation and maintenance of the water supply system including all treatment and distribution facilities, as well as the upkeep of the sewage and wastewater system.

Facility Manager

The Facility Manager will be responsible to oversee the daily operation of the water supply system. He/she will be responsible to communicate with external water providers, will organize the regular testing of the water by independent organizations and will report directly to the director on all water issues. His/her responsibility includes the planning and coordination of preventive and corrective maintenance issues and will require cooperation with the maintenance department to achieve this. The facility manager should raise awareness on water safety and water saving measures among the healthcare facility staff.

The Facility Manager must also ensure that waste water and sewage system is kept in good working order. Arranging appropriate and regular—planned, preventative and corrective. This may require instructing in-house technicians or sub– contracted service providers.

Healthcare Facility Engineer/ Technician

The Healthcare Facility Engineer will be responsible for operating the water treatment facilities and the water distribution network, as well as monitoring the waste water and sewage system. In cooperation with the Facility Manager he/she will be responsible to plan and execute the maintenance system for the water supply, waste water and sewage systems.

Other Healthcare Workers/ Operational Staff

The tasks of other staff in the healthcare facility will include reporting of water shortages and quality problems. They also will have to report leakages and shall be included in any water saving strategies.

The staff should also report blockages, damage or malfunction of the sewage and wastewater system and ensuring the proper use of WC, shower, wash hand basin and sink facilities by staff and patients.

Human Resource Management

The management of the healthcare facility is responsible to ensure that the following job positions are introduced and that appropriate job descriptions are provided to the responsible staff:

Foreman: The Foreman of the water supply system (Facility Manager) will be the person responsible for the entire water system, including own and external supply, water meters, treatment systems, storage tanks, pumping stations and the piping system. Likewise the role of Foreman must monitor the condition of the waste water and sewage system.

Water Supply Operator: The Water Supply Operator is responsible for operate the water treatment systems (e.g. water softener, chlorination), to regularly clean and disinfect the water storage tanks and to regularly check the piping network and tapping points on leakages. His/her task includes carrying out minor repairs and minor preventive maintenance actions.

Infection Control Person: The Infection Control Person provides independent auditing and advice on water supply issues together with reviews and witness/validation of processes. He/she shall be also designated to carry out regular inspections of the water treatment plant and storage system, shall develop and keep the water safety plan updated and carry out regular internal testing of the water supply. In case of outbreaks of water borne nosocomial infections, he/she shall assist in the investigations and shall recommend counter measures. The Infection Control Person should advise and monitor the waste water and sewage system may lead to any adverse effects on environmental or public health.

Maintenance Person: The Maintenance Person is designated to carry out the major corrective and preventive maintenance activities.

Quality Controller: The Quality Controller is defined as a person designated by the management to be responsible for quality control of the healthcare facility water supply system with the authority to establish, verify and implement all quality control and quality assurance procedures.

Infection Control Committee: the Infection Control Committee is responsible for monitoring the safe water supply of the hospital, to review the water safety plan, to review monitoring and testing results and to report to the director all issues related to water safety.

Budgeting

To ensure a safe and continuous supply of water with the right pressure and adequate physical infrastructure, a separate budget line will be needed. The budget line should be included in the general budget of the healthcare facility. The facility manager will be responsible to estimate the needed annual budget.

Water Supply

For capital costs, the following items must be considered:

- Water treatment equipment: water softening, chlorination, specialized water treatment system for selected department (e.g. laboratory, haemodialysis, etc.).
- Water supply and distribution equipment: Central and decentral storage tanks, pumping stations and booster pumps, water piping network.
- Quality control: Water testing equipment.

For recurrent costs, the following items must be considered:

- Consumables for water treatment and testing: salt for water softener, chlorine, test-kits, etc.
- Minor equipment: fittings and valves for minor repairs, other spare parts, cleaning equipment, filters, membranes, etc.
- Services: Water supply fee, external maintenance services, water testing fee, etc.

Waste Water and Sewage System

For capital costs, the following items must be considered:

* Waste water and sewage infrastructure: internal infrastructure connecting all outlets of the system to the municipal network or localized septic tank, as appropriate.

For recurrent costs, the following items must be considered:

* Consumables and equipment for minor repair and management of blockages, leaks or damaged components.

Setting Up & Managing Water Supply Systems for Healthcare Facilities

Supply Strategies and Required Quantities

Water is a substance with the chemical formula H_2O: one molecule of water has two hydrogen atoms covalently bonded to a single oxygen atom. At standard temperature (20°C) and pressure (1 bar) water is a liquid. It is tasteless and odourless. The intrinsic colour of water and ice is a very slight blue hue, although both appear colourless in small quantities. Water vapour is essentially invisible as a gas.

For the operation of a hospital, water is an essential resource and is used for different purposes. This includes the preparation of food, patient and wound washing, cooling liquid for medical apparatuses, environmental cleaning, laundry services, toilet flushing, preparation of medicine, hand washing, medical procedures and processes and much more. The daily water requirements of a healthcare facility depends on many factors including the offered services, the number of inpatients and outpatients, the number of staff and others. If no information on required quantities is available, the number of beds can be used as factor for the need estimations. The daily needs will be:

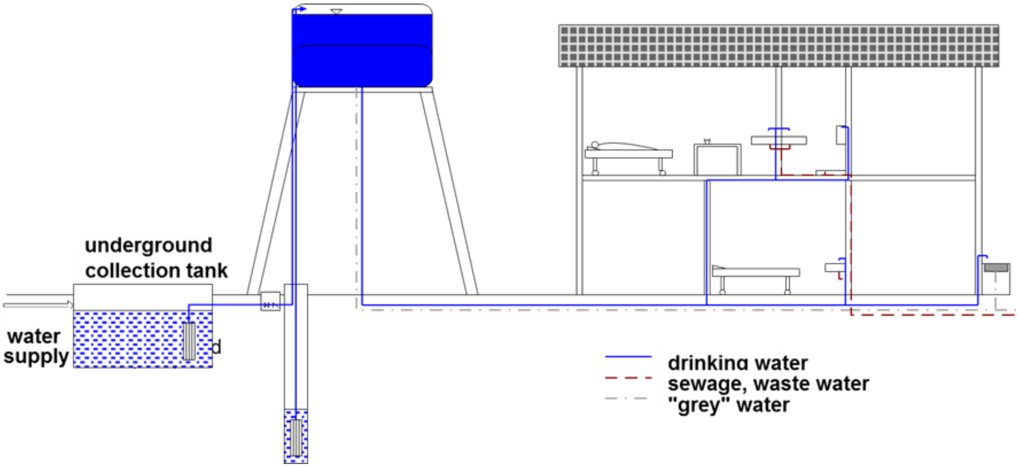
- About 300 l per day and bed for a Rayon healthcare facility
- About 500 l per day and bed for an Oblast hospital
- About 500 – 1000 l per day and bed for a National hospital

For example it can be expected that a 450 bed Oblast hospital will consume about 225 m³ water per day. For concrete planning it is strongly recommended to use water meters to measure the water consumption. All water provided, regardless of the source, including own wells should be metered. To be able to better monitor the consumption and to detect leakages, it is recommended to have meters for each department.

The supply of a healthcare facility may be from a municipal supply, private water supplier or from its own source (well or water catchment). If the supply is the facilities own, a hand dug well wells is not recommended as this will only exploit shallow aquifers and might be susceptible to yield fluctuations and possible contamination from surface water, including sewage. Drilled wells can get water from a much deeper level - often up to several hundred metres. Drilled wells are usually cased with a pipe, typically steel or plastic/PVC. At the bottom of the well, dependent on formation, a screening device, filter pack, slotted casing or open borehole is left to allow the flow of water into the well. If the health facility is using its own water source it must be tested at least once a year for coliform bacteria, nitrates, and other contaminants.

To guarantee a consistent water supply and to ensure the supply even during emergency situations, water storage tanks are needed. These can be underground, surface mounted or elevated water tanks. The water tank should have a sufficient capacity to ensure a 48 hour supply of the healthcare facility during interrupted water supply. In the case of underground storage tanks to ensure easy cleaning and disinfection, they should be separated in two sections. The storage tanks might be also used as water reservoir for firefighting. Additionally, above ground water towers might be set up to ensure the supply of the healthcare facility and, if used, booster pumps with a minimum pressure.

Fig. 1—Diagram of Water Supply System



Water pressure is an important issue for health facilities with sophisticated medical equipment, since this often needs a minimum pressure of >3 bar for operation. If the water pressure is not high enough, internal safety valves will not allow the operation of the equipment. The water pressure from elevated water tanks is often not sufficient and booster pumps are needed to increase the pressure. For the operation of a water supply system in a hospital a general pressure of 3-5 bar is recommended. To ensure this, a pressure boosting system is needed which should consist out of 3 to 6 parallel-switched, stainless steel high-pressure multistage centrifugal pumps.

Supply of Safe & High Quality Water

Water used in healthcare facilities should be:

- colourless, sparkling clear, free from solids in suspension and must not deposit sediment on standing;
- free from odour and taste good;
- reasonably soft;
- free from disease producing bacteria or organisms;
- free from objectionable dissolved gases, such as sulphuretted hydrogen and must contain sufficient quantity of dissolved oxygen;
- free from harmful salts;
- free from objectionable minerals, such as iron, manganese, lead, arsenic and other poisonous metals;
- free from radio-active substances such as radium, strontium etc.;
- free from phenolic compounds, chlorides, fluoride and iodine;
- non-corrosive and not lead to scale formation.

It is important to understand that water in healthcare facilities is used for different purposes and that for different purposes different qualities of water may be needed. Special technical requirements on water quality exist for laboratories, central sterile supply departments, departments using endoscopy, haemodialysis, laundry department and for chiller and boiler systems. Water might be also a source for nosocomial infections.

Modes of transmission for waterborne infections include :

- direct contact (e.g. via wound washing);
- ingestion of water (e.g. via food preparation, drinking water);
- indirect-contact transmission (e.g. via hand washing, from endoscopes, or other medical devices);
- inhalation of aerosols dispersed from water sources (e.g. showering);
- aspiration of contaminated water.

Often the water provided from the town/municipal supply or health facility's own source does not fulfil the appropriate requirements and needs treatment. Under normal circumstances treatment is carried out to improve the physical and the bacteriological characteristics of drinking water. If problems with chemicals exist, the improvement of chemical quality (softening to reduce hardness, reduction of Fluor contents, etc.) must also be considered. The most serious threats to the safety of a water supply is faecal and raw sewage contamination.

If contamination with faecal bacteria occurrs, the water needs to be disinfected. Disinfection serves to destroy pathogenic organisms which may cause various types of water-borne disease.

Disinfection can be accomplished by:

- Addition of certain chemicals (chlorination)
- Ozone
- Radiation (ultraviolet light)
- Thermal treatment (boiling)

The chlorination of water is still the most recommended method, especially for healthcare facilities with existing and older piping network. Chlorine may be applied to water as hypochlorite (mainly Calcium hypochlorite Ca(OCl)2), chloramines, chlorine gas or as chlorine dioxide. When added to water, chlorine reacts to form hypochlorous acid and hypochlorite to "free available chlorine". This is a powerful bactericide, because chlorine destroys the microorganisms membrane and kills them. Chlorine is cheap, reliable and easy to handle as well as it being easy to test the chlorine concentration. When chlorine is added to water, it will attack organic matter and attempt to destroy it. If enough chlorine is added, some will remain in the water after all possible organisms have been destroyed. What is left is called free chlorine. This free chlorine will ensure the safety of water even if the water is re-contaminated during distribution.

The dosing of chlorine to the water should be done in three steps: Solution preparation, flow control, and application. The dose of the chlorine should be adjusted so that the residual chlorine (free available chlorine) is about 0.1 to 0.2 mg/l before distribution. During dosing, full turbulence when mixing and a sufficient contact time (e.g 30 minutes) have to be guaranteed. The chlorine is applied to the water before it enters the distribution system.

Water Used for Technical Purposes

Municipal water supplies and water from deep wells often have a high rate of hardness. Hardness is defined as the content in water of calcium ions (Ca^{2+}) and magnesium ions (Mg^{2+}) in mmol/l. The main problems caused by hard water are:

* It causes formations of scales on the boilers and other hot water heating system;
* It causes serious difficulties in process which require water with low mineral content such as rinsing water in the CSSD, etc.;
* It causes more consumption of soap, making laundry processes uneconomical;
* It leads to the modification of some colours, and thus affects the working of any dyeing system;
* It causes choking and clogging of plumbing due to precipitation of salts causing hardness.

To reduce and avoid these problems centralized or decentralized water softening methods are applied. These methods mainly rely on ion-exchange by the removal of Ca^{2+} and Mg^{2+} from water. The ion-exchange materials contain sodium ions (Na^{+}) that are electrostatically bound and that readily are replaced by hardness ions such as Ca^{2+} and Mg^{2+}. The water to be treated passes through a bed of the resin where the hardness is removed. After the resin's capacity is exhausted the resin must be regenerated, typically done by sodium chloride.

Operation & Maintenance

Operation refers to the everyday running and handling of a water supply which involves several activities:

- Major operations are required to treat and convey safe drinking water to the users.
- The correct handling of facilities by users to ensure long component life.
- The proper operation of a supply results in its optimum use and contributes to a reduction in breakdowns and maintenance needs.

Maintenance refers to the activities required to sustain the water treatment and supply system in a proper working condition. Maintenance can be divided into:

- Preventive maintenance – regular inspection and servicing to preserve assets and minimize breakdowns.
- Corrective maintenance – minor repair and replacement of broken and worn out parts to sustain reliable facilities.
- Crisis maintenance – unplanned responses to emergency breakdowns and user complaints to restore a failed supply.

Underground water storages and elevated storage tanks (water towers) might be contaminated and need regular maintenance to prevent contamination of the stored water. Typical steps for maintenance are:

- Assess the storage tanks
  - Identify needs for repair (covers, insect nets, etc.) and for removal of sludge and other sediments.
  - Ensure that water supply is possible during maintenance services.
- Cleaning the tanks
  - Remove all the water. Use a mixture of detergent and hot water to scrub and clean all internal surfaces of the tank (stiff brush or a high pressure jet). Take special care to clean corners and joints.

* Wash and flush the tank until there are no longer traces of detergent in the water.
* Repair the water storage if needed
* The hoses, pumps and pipes used for filling and emptying the tank must also be cleaned.

- Disinfection of storage tanks & pipes
    * Calculate the volume of the tank, gill the tank a quarter full with clean water, add disinfectant, fill the tank completely and leave to stand for 24 hours.
    * With the tank full of water and disinfectant, start the pump so that the mixture passes through the hoses and pump. Run the pump for about an hour. Repeat this procedure with the tank full of clean water.

- Prepare for use
    * Completely empty the tank and carefully dispose of the disinfecting water as it will contain a high concentration of chlorine.
    * Fill the tank with drinking-water, allow to stand for 30 minutes then empty the tank again. Fill again and check the chlorine concentration.

Within healthcare facility internal water distribution system, water may become contaminated or lost during supply from the water source/treatment plant to the departments via breakages or leaks. The first priority is to repair the system. Once the supply is in place, work should begin to clean and disinfect the distribution network.

Recommended steps for the repair and re-disinfection of distribution pipes are:

- Assess the distribution network
  - * Obtain any available drawings of the distribution network layout of the hospital, including information about the size of pipes and positions of fittings such as valves and washouts.
  - * Obtain a plan of the healthcare facility showing main roads, main consumers and other important healthcare facility buildings (e.g. dialysis, operating theatre, laundry, etc.)
  - * Inspect the whole of the piped network and mark on the plans the positions of all major damage, its nature as well as the type.

- Preparing the maintenance
  - * Inform the consumer / users of the water about planned maintenance.
  - * Try to provide alternative supply in case of longer time of repairs.
  - * Isolate damaged sections from the rest of the distribution network.

- Repairing breakages, leakages
  - * Start at, or near, the source of supply and work outwards into the distribution system. Repair the pipeline in a stepped manner.
  - * Excavate and expose the broken sections of the pipelines. Repair the breaks, leakages.

- Test, clean and disinfect the maintained sections
  - * Test the section by partly open the upstream isolation valve and the downstream washout to fill the repaired pipeline section with water.
  - * Once full, increase the pressure in the pipe by at least 50% and maintain the high pressure for at least 4 hours. Check for leakages.
  - * Calculate the water volume in the pipe. Pump chlorinated water in the pipe until chlorine can be smelled in the washout. Leave the pipe for 24 hours. Afterwards wash it until no chlorine is smelled.

Quality Management of Water Supply Services

Testing & Monitoring

New water supplies should be tested before use and existing ones checked periodically. The most important parameters that should be known for the complete assessment of water quality include:

- Physical Characteristics

Colour; Odour; Taste; Turbidity; Temperature; pH; Conductivity; Suspended and Settleable Solids (surface waters, especially from rivers or creeks).

- Chemical Characteristics

Alkalinity; Acidity; Hardness; Nitrite and Nitrate Nitrogen; Total Dissolved Solids (TDS); and the ionic contents of Calcium, Magnesium, Sodium, Potassium, Manganese, Iron, Chlorides, Sulphates, Carbonates, Bicarbonates, Fluorides.

- Bacteriological Characteristics

Bacteriological counts of Total and Faecal Coliforms.

Faecal Coliforms
Faecal coliforms are used as bacterial indicators of faecal pollution. The presence of faecal coliforms is used to indicate the presence of pathogens that can be transmitted via the faecal-oral route such as bacterial, viruses, protozoa and other parasites. Faecal coliforms are expressed as the number of colonies per 100 ml water.

Health Effects:	Diarrhoeal waterborne diseases such as cholera, dysentery, typhoid fever, gastroenteritis and shigellosis are common with the consumption of water contaminated with faecal coliforms.
WHO guideline:	E. coli or thermotolerant coliform bacteria must not be detectable in any 100 ml sample

Nitrite (N) / Nitrate (NO_3)

Nitrates and nitrites occur together in the environment and can be converted from one to the other. A significant source of nitrates in natural waters is from plant and animal debris, sewage and agricultural runoff. Nitrate in drinking water is a primary health concern as it can easily be converted to nitrite in the digestive tract. Nitrite can interfere with the functioning of red blood cells.

Health Effects:	Nitrate can cause tiredness; and may react with proteins from food to form complex compounds that have the potential to cause cancer. Nitrites upon absorption, combines with the oxygen-carrying red blood pigment, haemoglobin, to form methaemoglobin, which is incapable of carrying oxygen.
WHO guideline:	Nitrate (NO_3) 50 mg/l; Nitrite (NO_2) 3 mg/l

Total Hardness (as $CaCo_3$)

This is the sum of the calcium and magnesium concentrations expressed as mg/l of calcium carbonate. The total hardness value indicates whether the water is soft or hard and relates to the ease or difficulty of lathering of soap. Temporary hardness can be reduced by boiling whereby permanent hardness cannot. Total hardness is calculated from the calcium and magnesium concentrations as: Total hardness (mg CaCO /R) = 2.497 x [mg Ca/R] + 4.118 x [mg Mg/R]

Health Effects:	Some total hardness is beneficial as it contributes to the essential elements of calcium and magnesium. Individuals with a history of kidney stones and infants under one year of age should avoid waters with elevated total hardness.
WHO guideline:	Not applicable

PH

The degree to which an aqueous solution is acidic or alkaline depends on the respective concentration of the hydrogen ions (H+) and hydroxide ions (OH–) resulting from the dissociation of water. This is termed by the pH value, or simply the pH. Depending on the respective pH, solutions are referred to as being acidic, neutral, or alkaline (basic):

Turbidity

Turbidity in water is caused by suspended particles or colloidal matter that obstructs light transmission through the water. It may be caused by inorganic or organic matter or a combination of the two. It can seriously interfere with the efficiency of disinfection by providing protection for organisms, and

Solution	pH
Acidic	< 7 (strongly acidic pH 0–3, weakly acidic pH 3–7)
Neutral	7
Alkaline	> 7 (weakly alkaline pH 7–11, strongly alkaline pH 11–14)

much of water treatment is directed at removal of particulate matter before disinfection.

Turbidity is measured by nephelometric turbidity units (NTU) and can be initially noticed by the naked eye above approximately 4.0 NTU. However, to ensure effectiveness of disinfection, turbidity should be no more than 1 NTU and preferably much lower.

Total Dissolved Solids

Palatability of water with a total dissolved solids (TDS) level of less than about 600 mg/l is generally considered to be good; drinking water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/l. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances. Electrical conductivity (EC) is an indicator of total dissolved solids

"… All health-care facilities should have specific WSPs as part of their infection control programme. These plans should address issues such as water quality and treatment requirements, cleaning of specialized equipment and control of microbial growth in water systems and ancillary equipment."

WHO Guidelines for Drinking-water Quality – 4th ed., 2011, p. 107

Healthcare Facility Water Safety Plan (WSP)

The WHO Guidelines for Drinking-water Quality recommend Water Safety Plans as the most effective means of consistently ensuring the safety of a drinking-water supply. WSPs require a risk assessment encompassing all steps in water supply from catchment to consumer, followed by implementation and monitoring of risk management control measures. WSPs should be implemented within a public health context, responding to clear health-based targets and quality-checked through independent surveillance.

For the setting up and operation of a WSP, the following steps and actions are recommended:

* Assemble the WSP team;
* Describe the water supply system of the healthcare facility;
* Identify hazards and hazardous events and assess the risks;
* Determine and validate control measures, reassess and prioritize the risks;
* Develop, implement and maintain an improvement / upgrade plan;
* Define monitoring of the control measures;
* Verify the effectiveness of the WSP;
* Prepare management procedures;
* Develop supporting programmes;
* Plan and carry out periodic review of the WSP;
* Revise the WSP following an incident.

Setting Up &
Managing Waste Water & Sewage Systems for
Healthcare Facilities

Setting Up and Managing Waste Water and Sewage Systems

Healthcare wastewater is any water that has been adversely affected in quality by anthropogenic influence during providing healthcare services. It is mainly liquid waste, containing some solids produced by humans (staff and patients) or during healthcare related processes including cooking, cleaning or laundry.

Healthcare wastewater can be divided into:

- Black waters (sewage) is heavily polluted wastewater that contains faecal matter, urine, significant food residues or toxic chemicals.
- Grey waters (sullage) are the low polluted residues of from washing, bathing laboratory processes, laundry, or technical processes such as cooling water or the rinsing of X-ray films.
- Stormwater is technically not a wastewater itself, but rainfall collected on hospital roofs, yards, hard-standings, surface run, etc. This may be used for groundwater recharge, irrigation of hospital grounds, toilet flushing, washing of yards etc,

Quantity & Quality of Wastewater

Quantity of wastewater

The quantity of wastewater produced in a healthcare facility depends on the amount of water used and is best measured by water consumption. The water consumption depends heavily on factors such as the kind of services provided, number of beds, accessibility to water, climate situation, level of care and local water-use practices.

Quality of wastewater

Wastewater from healthcare facilities contains organic particles (faeces, hairs, food, vomit, paper fibres, etc.), soluble organic material (urea, proteins, pharmaceuticals, etc.), inorganic particles (sand, grit, metal particles), soluble inorganic material (ammonia, cyanide, hydrogen sulphide, thiosulphates) and other substances. The composition depends of the source of origin.

Administration and wards generate waste water, comparable to domestic wastewater. The urine of patients from some wards (surgery wards, oncology, infectious disease ward, etc.) might contain higher amounts of antibiotics, cytotoxic and X-ray contrast media. Additionally higher amount of disinfectants can occur.

Kitchen of hospitals often generate the most polluted wastewater stream as it contains leftovers, waste from food processing and high rates of disinfectants and detergents. Starch, grease, oil and the high organic content might create problems during the waste water management.

The Laundry is the place with the highest quantity of produced grey waster. The waste water often is hot, has a high pH (alkaline) and might content high rate of phosphate and AOI if chlorine based disinfectants are used.

Operating theatre and ICU generate a wastewater with higher contents of disinfectants (glutaraldehyde), detergents and pharmaceuticals. Additionally the organic content can be high due to the disposal of body fluids and rinsing liquids (suction containers).

Laboratories are a possible source for chemicals in the wastewater stream. Of special relevance are halogenated and organic solvents, colorants from the histology and hematology (gram staining), cyanides (hematology) and formaldehyde and xylem (pathology).

The Radiology department is the main generator of photochemical (developing and fixing solutions) containing waste water and potentially contaminated rinsing water.

Haemodialysis requires the disinfection of the dialysers and sometimes the used filters. Accordingly the disinfectant content in the waste water can be high.

Dental departments might contaminate the wastewater with mercury (Amalgam) if no amalgam separators are installed.

The CSSD (Central Sterile Supply Department) is one of the main consumer of disinfection solution, including aldehyde based disinfectants. Hot water from the sterilizers and detergents from the CD-Machine (Cleaning & Disinfectant) might also form a problem in the wastewater.

Collection and Treatment of Healthcare Wastewater

A system of sewer pipes (sewerage) shall collect sewage in a healthcare establishment and takes it for treatment or disposal (central system). The de-central collection and treatment is not recommended. Only where a main sewerage system has not been provided, sewage may be collected from the wards by pipes into septic tanks or cesspits, where it may be treated or collected in vehicles and taken for treatment or disposal (de-central system).

Sewer Systems for Healthcare Facilities

For the collection of the generated waste water, separate sewer systems for waste water and stormwater (referred to as sanitary sewers and storm sewers) should be set up. Combined sewer systems (transport of liquid waste discharges and stormwater together to a common treatment facility) are not recommended anymore. The separate collection of grey- and blackwater is normally not recommended, as this might result in hydraulically problems (blockages) during the collection of the blackwater. The separating of brown water (faeces water) and yellow water (urine and water) might make sense if a new sewage system is planned and the sewerage system will be dimensioned on the water quantity.

A sufficient amount of manholes shall be installed to allow maintenance, the distance between manholes inside the healthcare compound should be <50 meter. All sewage pipes and manholes must be watertight.

Pre-Treatment of Wastewater

The basic principle underlying effective wastewater management is a strict limit on the discharge of hazardous liquids to sewers. Chemical

waste, especially photochemicals, aldehydes (formaldehyde and glutaraldehyde), colorants and pharmaceuticals should not be discharged in the wastewater but separately collected and treated.
To remove grease, oil and other floating materials from the kitchen wastewater, a grease trap shall be installed. Collected grease must be removed every 2-4 weeks.
Collected body fluids, small quantities of blood and rinsing liquids from the OT and the ICU can be discharged in the sewer system without pre-treatment if the patient is not suffering on an infectious disease, otherwise it shall be first disinfected, preferably with a thermal method. Larger amount of blood should not be emptied in the sewer as it will result in blockages and shall be disposed of as pathological waste. However, blood can be disposed of directly to a septic tank system if safety measures are followed.
Waste water from the dental department should be pre-treated by installing amalgam separator at the patient treatment chairs.

Discharge in municipal sewage systems

The discharge of generated wastewater from healthcare establishment in the municipal sewage system after adequate pre-treatment is a preferred method if it is ensured that the municipal sewage treatment plant fulfils the local requirements.

On-site wastewater treatment

Hospitals, in particular those that are not connected to any municipal treatment plant, should operate their own wastewater treatment plants. Wastewater treatment is the process of removing contaminants from wastewater. It includes physical, chemical and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce a treated effluent which is suitable for reuse or discharge back into the environment.
Typically, wastewater treatment involves three stages. The first stage is the removal off solids which are separated by sedimentation (primary treatment). Then dissolved biological matter is progressively

converted into a solid mass by using indigenous, water-borne bacteria. Some ingredients will be eliminate by adsorption at the sludge, which will separated by sedimentation afterwards (secondary treatment). At the end, solid and liquid materials are separated and the treated water may be further treated to remove suspended solids, phosphates or other chemical contaminants; or it may be disinfected (tertiary treatment).

Disposal of Sludge

On-site treatment of hospital sewage will produce a sludge that contains high concentrations of helminths and other pathogens and therefore must be treated prior disposal. The most common treatment options include anaerobic digestion, aerobic digestion, and composting. Alternatively, it may be dried in natural drying beds and then incinerated in modern incinerators together with solid infectious health-care waste.

Operation and Monitoring of Sewage Systems

Problems in the management of wastewater in healthcare facilities mainly exist due to insufficient operation and maintenance system. In most hospitals the disposal of liquid hazardous waste via the sink is still daily practice. The sewer systems lack maintenance and heavy losses during collection can be noticed. Treatment plants are often not in operation due to missing budgets for operation costs or are to sophisticate for the often untrained operators.

Operation and maintenance of wastewater systems

Typical occurring problems in the operation of wastewater systems include:

- Missing awareness among the management and senior staff on wastewater problems;
- Insufficient working hazardous waste management system
- Not existing physical asset management (PAM) and preventive maintenance program
- Not available basic tools to carry out maintenance
  Missing pre-treatment and primary treatment systems
- To sophisticated systems are creating to high operation costs and are to complex to be operated by the often unskilled workers
- Missing budgets for operation costs and regular maintenance like emptying of grease traps and septic tanks.

Like for the water management system, also for wastewater management responsibilities must be cleared and a trained, responsible wastewater officer should be available. Starting point for a successful system is a to be carried out wastewater audit to identify to be expected wastewater streams from different generators. Based on the audit, needed pre-treatment solutions and solutions for the collection of liquid hazardous waste should be developed. A maintenance plan which includes corrective as well preventive maintenance should be set up for the pre-treatment and sewer system and implemented. Cost for sanitation should not be included in the overhead cost of the healthcare facility, but a separate budget line is recommended. If an on-site treatment plant exists, this must be included in the maintenance plane and the budget planning.

Quality Management of Waste Water Services

Quality Management of Waste Water Services

The monitoring of the wastewater system includes especially two aspects:

1. Monitoring of the sewer system
2. Monitoring of the effluent quality

An often underestimated aspect in wastewater management is the loss of wastewater during the collection and transport. Losses of 10-30 % of the wastewater due to broken sewer pipes, not watertight manholes, leakages at the connection point of pipes are not uncommon. For monitoring, the installation of flow meter at the discharge point of the healthcare facility is recommended. By regular (daily or at least weekly) comparison of water consumption and discharged water maintenance problems can be identified in an early stage.

For the monitoring of the effluent quality, the most common parameters are:

- Temperature
- pH
- BOD5 (amount of oxygen consumed by biochemical oxidation of waste contaminants in a 5-day period)
- COD (Chemical Oxygen Demand)
- Nitrate
- Total Phosphorous
- TSS (Total Suspended Solids)
- Amount of E.coli

If an on-site treatment plant is operated, regular testing of the influx as well as the output is recommended to monitor the efficiency of the treatment plant.

Maintenance of Infrastructure for Water Supply, Wastewater, Drainage and Sewage Systems

Maintenance of Exterior Drainage for Storm Water

DAILY: Check **open drain channel**. Ensure that open drainages are clean, free from leaves, rubbish and other unwanted items. Wash drain if necessary.

WEEKLY: Check **cross-over drains (1.5m wide)**. Ensure that they are cleaned regularly and are free from trapped rubbish.

WEEKLY: Check **closed drain channels**. Ensure that they are flushed regularly and are free from water and trapped pools.

BI-ANNUALLY: Check for **mosquito and flies breeding**. Ensure that drains are slopped and do not contain breeding environment for mosquitos and flies. If cannot be avoided, carry out pest treatment. Ensure that any pest treatment are bio-degradable and do not contaminate the environment or water system.

QUARTERLY: Check S**torm Water Manholes**. Ensure that regular checks are carried out to clean all irregular contents and the system has only water. Check and verify if water is moving into the central waste water disposal canals. Use pieces of Styrofoam bubbles, no greater than a handful, this will be an indicator which will show the flow. Ensure that water is constantly running during rainy and thawing months. During dry season, optimum conditions would be dry. Rectify if there is any jams.

ANNUALLY: Check **Cast Iron (CI) Covers**. Ensure cast iron covers are installed properly and do not pose a fall hazard to people. Cast iron covers should seal at the lid securely and no smell should exist. Replace covers if broken. All manhole covers should be clearly stencilled in white letters, indicating, "STORM WATER" on the CI cover.

ANNUALLY: Check **manhole maintenance steps**. Ensure that all steps are secured and safe, prior to entry. Ensure that all steps are coated with bitumen paint for corrosion resistance.

Manhole Entry Regulations

CAUTION

DANGEROUS SPIDERS, SCORPIONS, SNAKES, RATS OR OTHER ANIMALS MAY EXIST INSIDE THIS MANHOLE

NO SMOKING INSIDE OR AROUND THE AREA WITHIN 4.5 METRES DURING MAINTENANCE OPERATION

At no time should any personnel enter this area when water is higher than 1.2 meter without approval from hospital director.

3 Man team required for this job at any time, with **1-man inside**, **1-man affixed to waist restraints** and rope affixed to man inside, **1-man on emergency** or duty runner.

PPE is strictly required for entry into this area. PPE will include the following

I. Non slip waterproof boots
II. Sealed Rubber gloves
III. Reflexive vests
IV. Hard Hat with chin strap
V. Sealed Safety goggles with head strap
VI. Full rubber waterproof long pants with boot seals
VII. Safety body harness with lockable latches and Safety ropes (up to 200kg) attached to one man on the top.
VIII. Waterproof rubber Long sleeve shirt.
IX. Waterproof torchlight
X. Face mask
XI. Tool bag with ropes to the top. NEVER throw tools as a form of handing tools to person inside the manhole.

XII. First Aid Kit, trained personnel for first-aid on standby.

XIII.Manual Pulley elevator for lowering tools or retracting person in distress. Required If manhole is deeper than 2 meters)

XIV.Exhaust and supply fan if manhole is deeper than 1.8 meters. Required to supply personnel with fresh air and exhaust of carbon dioxide.

Maintenance of Septic Tanks

MONTHLY: Check **septic tanks**. Ensure that regular checks are carried out to clean all irregular contents and the system has only sewer and water. Check and verify if sewer and water is moving into the central sewer lines. Use pieces of Styrofoam bubbles, no greater than a handful, this will be an indicator which will show the flow and suction. Rectify if there is any jams.

ANNUALLY: Check **cast iron (CI) covers**. Ensure cast iron covers are installed properly and do not pose a fall hazard to people. Cast iron covers should seal at the lid securely and no smell should exist. Replace covers if broken. All manhole covers should be clearly stencilled in white letters, indicating, “SEWER” on the CI cover.

QUARTERLY: Check **vent pipes**. Ensure that all vent pipes are secured against the wall or any retaining posts. Test for water leaks at the bottom base root, seal if necessary. All vent pipes opening are to have a top crown cap and wire mesh wrapped around the opening to ensure that debris, insects or birds do not enter the pipe. Crown should be GI material and properly secured against the pipe (This will ensure that snow does not fill the pipe and jam the vent pipes). All pipe exposed to the environment should be of GI material. If pipes cannot be installed in a secured manner, then the pipe should be supported by steel strip, holding the pipe in 3 equidistance proportion and fastened to the GI roof sheet at 60 degrees inclined angle. Seal all fasteners with sun resistant silicone.

QUARTERLY: Check for **soil settlement** around septic tank. Ensure that soil is filled to the top of the septic tank top slab. If soil has settled, then add agricultural soil and compact to 60% only. Induce grass growth around these areas. Monitor monthly for further settlement.

QUARTERLY: Check **primary cleanout**. Ensure that primary clean out has its cap installed, blocked off with a proper cover and secured from traffic.

DAILY: Check for **traffic flow**. Ensure that no vehicles are allowed within 2m from the septic tank's perimeter. If necessary place bollards around with chains to prevent vehicles from parking over or near the slab. Bollards are to be painted with red and white stripes, affixed with chain guards around, height should be no lower than 90cm from ground to crown. Signs should be installed, hanging from the mid-point of chain guards and read, "No Entry".

ANNUALLY: Check **manhole maintenance steps**. Ensure that all steps are secured and safe, prior to entry. Ensure that all steps are coated with bitumen paint for corrosion resistance.

Manhole Entry Regulations

CAUTION

DANGEROUS SPIDERS, SCORPIONS, SNAKES, RATS OR OTHER ANIMALS MAY EXIST INSIDE THIS MANHOLE
NO SMOKING INSIDE OR AROUND THE AREA WITHIN 4.5 METRES DURING MAINTENANCE OPERATION

At no time should any personnel enter this area when sewer is higher than 1.2 meter without approval from hospital director.

3 Man team required for this job at any time, with **1-man inside**, **1-man affixed to waist restraints** and rope affixed to man inside, **1-man on emergency** or duty runner.

PPE is strictly required for entry into this area. PPE will include the following

I. Non slip waterproof boots
II. Sealed Rubber gloves
III. Reflexive vests

IV. Hard Hat with chin strap

V. Sealed Safety goggles with head strap

VI. Full rubber waterproof long pants with boot seals

VII. Safety body harness with lockable latches and Safety ropes (up to 200kg) attached to one man on the top.

VIII. Waterproof rubber Long sleeve shirt.

I. Waterproof torchlight

II. Face mask

III. Tool bag with ropes to the top. NEVER throw tools as a form of handing tools to person inside the manhole.

IV. First Aid Kit, trained personnel for first-aid on standby.

V. Manual Pulley elevator for lowering tools or retracting person in distress required

VI. Exhaust and supply fan if manhole is deeper than 1.6 meters. Required to supply personnel with fresh air and exhaust of carbon dioxide.

Maintenance of Sewer Main Network System

WEEKLY: Check **Sewer Pipes Cleanouts**. Ensure that all sewer cleanouts in exterior and interior building are fitted with sealed top caps, check if caps are opening properly. If necessary, apply petroleum jelly lubricant on threads or anti-size compound. Cleanouts have different functions, these functions are as follows:

a. **COTF – Clean-Out-To-Floor** – Fittings are flushed mounted on floor, usually inside a building and within a grated trap. This serves a purpose of removing water from washing or wet floor, sometimes this is also called Clean out floor drains. Check for debris collected inside grate, clean and keep dry.

b. **COTL – Clean-Out-To-Line** – Fitting is integrated with sealed trap, acting as line clean out. This serves a purpose of cleaning sewer lines that run within the building. Ensure that trap has its mesh installed (prevention of insects, rats, snakes from entering into building) along with grate. Clean debris and keep dry at all times. Rod clearing to be carried out every month or when required.

c. **COTG – Clean-out-To-Ground** – Fitting are flush mounted to concrete block riser, usually installed outside the build area. Mounted on a 75 - 150mm high concrete block with its fittings integrated with the concrete block and installed with a metal closed cover, in some cases bolted to the sides to prevent removal or dismount during foot traffic. This serves purpose of cleaning sewer lines on main piping system outside the building. Rod clearing to be carried out every month or when required.

COTR – Clean-Out-Traffic-Rated – Fittings are flush mounted to roads, parking area, arteries, where general vehicle traffic pass thru, although in most cases this is avoided, however in some design cases where it cannot be eliminated, such clean-outs will exist. This serves a purpose of cleaning sewer lines on main piping systems outside the building on a road or at the side. These are usually fitted with metal covers and body and integrated with the road. The covers are usually screw in type and fitted with flush mounted special bolts. These require limited cleaning, as they are only used for emergency reverse pumping out or flushing in water to push a choked sewer line. Check and ensure that the brass cover is present and not gone missing.

WEEKLY: Check **emergency sewer pump**. Ensure that at all times, sewer pumps are available and serviceable. These may be required for emergency sewer lifting in case the septic tank is full and choked at the exterior piping network or the central main sewer lines are jammed and causing a back-draft into the septic tank. This is usually a petrol-powered pump. During servicing, engine oil, air filter, line suction filter & pipes, crank starter, spark plugs should be checked and if required, parts to be serviced or changed. Fuel tank should be full and spare tanks should be made available to sustain operation of 24 hours, therefore maintaining 2-3 pumps should be sufficient for back up or relay operations.

Soakage Pits: If used in facility, carry out similar maintenance and inspection checks as Sewer and Septic tank descriptions, as where applicable.

Safety Note: Operator should wear PPE to prevent chemical and biological contamination when handling such servicing or cleaning. General PPE includes:

Safety Eye goggles
Rubber gloves
Rubber boots
Face mask

Maintenance of Water Tank Tower

MONTHLY: Ensure that all structural components are sound. Inspect for visible cracks and other structural defaults. Report immediately.

MONTHLY: Check and ensure that grounding is installed and properly tied in.

BI-ANNUALLY: Clean inner water tank with approved substance, i.e. biodegradable soap solution. To do this, empty the water tank by means of consumption flow, then enter the tank and carry out cleaning. Full PPE is needed for this task, refer to maintenance manning as per Septic tank conditions. After cleaning, drain the tank with fresh water and bleed the tank to an external water truck. REFILL the tank with fresh water and add mild chlorine solution and leave tank for 24 hrs, ensure that covers are open for ventilation of chlorine gas that might build up inside the tank, by covering the opening with wire mesh to prevent birds/insect from entering. No man to be allowed inside the tank beyond this point. Chlorine composition to be calculated by water purification expert so that any residue remains are not reactive to consumers/end-users.

BI-ANNUALLY: Check tank for cracks. If cracks appear, drain tank and carry out gas welding method only.. DO NOT USE Arc welding due to electrocution.

QUARTERLY OR AFTER EARTHQUAKE: Inspect all retaining bolts, stands and tank structures for damages. Replace immediately required parts. Wait 48 hours after earthquake before repair as there might be secondary amplitude tremors. Check Geo-websites for earthquake activities on a daily basis to anticipate primary or secondary warning for earthquakes.

Further Reading

Options for further reading are indicated below:

- Guidelines for drinking-water quality (Fourth Edition), World Health Organization (2011):
http://whqlibdoc.who.int/publications/2011/9789241548151_eng.pdf

- Water Safety in Distribution Systems, World Health Organization (2014):
http://www.who.int/water_sanitation_health/publications/Water_Safety_in_Distribution_System/en/

- Water safety plans: Managing drinking-water quality from catchment to consumer, World Health Organization (2005):
http://www.who.int/water_sanitation_health/dwq/wsp170805.pdf?ua=1

- How to develop and implement a Water Safety Plan, World Health Organization (2009) :
http://www.who.int/water_sanitation_health/publication_9789241562638/en/

- Water safety planning for small community water supplies , World Health Organization (2012):
http://www.who.int/water_sanitation_health/publications/2012/water_supplies/en/