

## Template iWSSP Step 3 – List of hazardous events

---

In the hazard analysis step, it is essential to assess each microbial, chemical, physical and radiological hazard, quantity, reliability and consumer acceptance, and any effects on the health of workers as well as each event through which this could be introduced to the water supply- and sanitation system should be assessed. This is an important basis for assessing the resulting risk for each of these combinations of hazards and hazardous events in the subsequent risk assessment.

For identifying hazardous events, you may use existing lists of hazardous events or documents describing hazardous events, such as this template or the following additional information sources:

- Sanitary and sanitation inspections is on-site inspection to determine actual and potential contamination sources that can pose a threat to the workers and consumers' wellbeing and health. The sanitary and sanitation inspection forms can identify possible hazardous events
  - Sanitary inspection forms ([Water Sanitation and Health \(who.int\)](#))
  - Sanitation inspection forms (<https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/sanitation-safety/sanitation-inspection-packages>)
- Compilation of potential hazardous events and their causes ([Compilation of potential hazardous events and their causes | RIVM](#))
- project on ensuring safely managed on-site sanitation systems (<https://washdata.org/report/jmp-2021-smoss-synthesis-report>)

This template provides a list of hazardous events related to the drinking-water supply and sanitation system. This is not intended to be an exhaustive list, and may need to be adapted for application in the local context, e.g. selection of relevant topics depending on the drinking-water supply and sanitation services.

### 1. How to use this guidance

The structure of this template follows the sanitation elements from capture to end-use/disposal, and the water supply steps from catchment / source via treatment, distribution to the consumers' premises.

The following list gives examples of possible hazardous events and threats that may need to be rephrased and further details or hazardous events added to specify the resulting hazardous events in your local context.

Please go through the list and document which of the hazardous events may potentially occur in your system, or have occurred already.

### 2. Definitions

A **hazard** is a microbial (e.g. pathogens), chemical (e.g. arsenic), physical (e.g. turbidity) or radiological agent in, or condition of water and wastewater, with the potential to cause harm to public health.

A **hazardous event** is an event that introduces hazards to, or fails to remove them from, the drinking water supply or sanitation system. The hazardous event can occur from source (catchment) to consumer (household) or from capture to end-use/disposal, for respectively water supply and sanitation system.

**X-Y formula.** Hazardous events should clearly describe the impact and the cause, i.e. "X happens (to the water supply or sanitation system) because of Y".

Example: Source water is contaminated by agricultural fertilizers (X) due to poor application practices in the immediate vicinity of the extraction point (Y).

### 3. Sanitation safety planning

Sanitation and health are interlinked through multiple possible hazardous events that can occur along the sanitation service chain.

#### Open defecation / in absence of containment

Open defecation can lead to pathogens discharged

- onto fields, infecting new hosts through feet or crops (e.g. soil-transmitted helminths);
- into water bodies, infecting new hosts through water contact (e.g. schistosomiasis from urination/ defecation in surface water) or consumption; and
- overall spread within the environment by insects or animals acting as mechanical vectors.

Hazardous event related to open defecation	Could happen in our system	
	yes	no
Waste (liquid, solid, urine and faeces) including pathogens reaching surface water body/groundwater after rain events along with contaminants on the surface		
Open urination by people in surface water bodies promoting vector breeding which may lead to vector borne diseases		
Direct contact with human faeces leading to sickness / infection		
Solid human waste is dumped in the open without any treatment leading to contamination of the environment		
Solid human waste is dumped in the open by the households leading to contamination of the environment		

#### Toilet

The user interface must guarantee that human excreta is hygienically separated from human contact to prevent exposure to faecal contamination. Toilets are the user interface for urination and defecation.

**Unsafe or not used toilets** can lead to pathogens discharged

- infecting new hosts through feet (e.g. soil-transmitted helminths);
- into water bodies, infecting new hosts through water contact or consumption; and
- overall spread within the household environment by insects or animals acting as mechanical vectors.

Hazardous event related to toilet	Could happen in our system	
	yes	no
Poorly-constructed user interfaces (toilets) and containment (pit latrines), can lead to flies and other insects breeding in excreta or spreading faecal pathogens to food, fingers and surfaces.		
If the slab or toilet floor is not stable or well built (containment), it may collapse or crack, exposing the user to hazards or leading to injury		
Areas inside the toilet or outside the toilet contaminated with faeces may transmit hookworm or pathogens to subsequent individuals if they use the facility bare footed		
Wrong design and/or construction of the toilets (e.g. lack of water seal or lid) leading to vector-borne transmission of pathogens to users		
Sickness / infection of users due to contact with unclean toilets that are not well constructed		
Decreasing water supply impeding function of water-reliant sanitation systems (e.g. flush toilets, sewerage, treatment) leading to no water seal, insect vectors having contact with the faeces and people reverting to open defecation		
Flooding of containment, such as septic systems, due to increasing groundwater levels leading to contamination of the environment		
The water seal may not function leading to contamination of the environment and enabling direct contact with contaminated waste		
Breakage in the exposed pipe between the toilet and containment leading to contamination of the environment and enabling direct contact with waste		
The containment (toilet superstructure) absent or damaged, allowing rainwater to cause the pit to fill up and overflow		
Toilet superstructure the containment absent or damaged, allowing for animals, rodents or insects to enter the containment (e.g. toilet and pit), damage the facility and carry excreta to the community		
Sickness / infection of users due to contact with unclean toilets that are made of a non-durable material that prevents cleaning of the slab (or pedestal).		
Sickness / infection of users due to contact with toilets that are not kept clean and where excreta remain on user interface (toilet) and superstructure surfaces of the room housing the toilet		
Sickness / infection after contact with faecal materials at user interface (e.g. toilets) due to the lack of handwashing facilities		
Practice of improper handling of child faeces or nappies leading to sickness / infection		
Accidental contact with faecal matter after defecation / no handwash leading to sickness / infection		
Access route to the toilet is blocked or not manageable for some intended users leading to open defecation		
Exposure to (microbial) hazards through ingestion or inhalation during flush through aerosols formed (e.g. no lid in place or not closed)		

## Storage/containment

**Unsafe containment (storage):** poor containment such as poorly-constructed latrine pits or septic tanks can cause leakage into groundwater and thereby into water consumed; and lead to overflow into the household environment.

Hazardous event related to storage / containment	Could happen in our system	
	yes	no
Leachate from cracked / damaged containment leads to contamination of groundwater		
Pit or tank overflows lead to contamination of local area and enabling direct contact with contaminated waste		
Poorly-constructed containment systems can lead to flies and other insects breeding in excreta or spreading faecal pathogens to food, fingers and surfaces		
Poorly-constructed containment systems can leak into the soil and contaminate soil and groundwater		
Contamination of watercourses / land due to blockage or overflowing of containment systems, such as septic tanks, reaching the water bodies via the surface		
Effluent outlet leads to contamination of the environment (open drain or water body)		
Containment systems, such as septic tank inadequately sized for the load received leading to contamination of receiving environment due to blockage or overflowing		
Containment systems, such as septic tank inadequately sized for the load received leading to exposure to septic tank contents may lead to sickness/infection		
Containment systems not accessible for emptying leading to overflow to contaminate the soil and groundwater		
High water table slowing down leaching causing water coming out of pan/ failure of water seal		
Blackwater flows out of the containment, such as septic tanks, to the open ground causing contamination of soil and water		
Flooding of on-site systems causing spillage and contamination and enabling direct contact with faecal sludge and/or excreta		
Flooding and collapse of containment systems leading to contamination of the environment and enabling direct contact with faeces		
Overflow and/or obstruction of sewerage and septic systems leading to contamination of the environment and enabling direct contact with faeces		
Unsafe emptying of containment system leading to sickness / infection		
Users damaging containment, such as pit latrine or septic tanks, in order to avoid costs for emptying cause contamination of the groundwater		
Users damaging containment, such as pit latrine or septic tanks, in order to avoid costs for emptying cause direct exposure		
Groundwater contaminated via leachate percolating from containment, such as pits, septic tanks or infiltration wells		
Ingestion of groundwater contaminated via leakage from cracked/damaged septic tanks		

Hazardous event related to storage / containment	Could happen in our system	
	yes	no
Dermal contact with pathogens due to effluent discharging into open drains or water bodies		
Trauma or asphyxiation caused by falling into collapsed pits as a result of reduced soil stability or structural failure of containment structure		

### Emptying / conveyance / transport

**Unsafe conveyance/transportation:** poor emptying practices can lead to

- direct exposure of sanitation workers or others involved in emptying activities to pathogens; as well as
- untreated excreta discharged into water bodies, drains fields and other surfaces can potentially lead to transmission; and
- unsafe sewers can cause exposure through leakage, overflow and unsafe discharge into drains, water bodies, groundwater and open surfaces.

Hazardous event related to emptying / conveyance / transport	Could happen in our system	
	yes	no
Discharge without treatment leading to contamination of the environment (open drains, water bodies or open ground)		
Overflow of sewers due to blockage leading to contamination of the environment		
Overflow of sewers due to failure (e.g. pipe breaks) leading to contamination of the environment		
Overflow of sewers during high flows leading to contamination of the environment		
Leakage from cracked/damaged sewer pipes or joints leading to contamination of the groundwater		
Damage to other infrastructure/systems on which sanitation systems rely (e.g. electricity networks for pumping; road networks used by sludge vehicles) due to heavy rainfall / flooding leading to disruption of the transport and conveyance		
Damage to other infrastructure/systems on which sanitation systems rely (e.g. electricity networks for pumping; road networks used by sludge vehicles) due to earthquakes leading to disruption of the transport and conveyance		
Increased corrosion of piped sewers leads to contamination of the groundwater or drinking-water in underlying pipes		
Damage to underground infrastructure from e.g. rising groundwater levels, earthquakes or poor construction, leading to broken pipes and joints resulting in contamination of the groundwater or drinking-water in underlying pipes		
Spillage during emptying or transport from equipment malfunction leading to contamination of the environment		
Spillage during emptying or transport from unsafe handling leading to contamination of the environment		
Worker contact during sewer cleaning and other maintenance leading to injury / sickness / infection		

Hazardous event related to emptying / conveyance / transport	Could happen in our system	
	yes	no
Worker exposed to hazards (airborne particles) when emptying dried faeces from double vault latrines		
Blockage due to sand and/or oils and fats and/or other improper materials discarded to sewer leading to contamination of the environment		
Higher pollution concentration in wastewater and reduced capacity of receiving water bodies to dilute wastewater in case of drought / decreased rainfall		
Ground movement in soils with high clay content leading to broken pipes and joints resulting in contamination of the environment and eventually groundwater		
Decreases water supply due to droughts impeding function of water-reliant sanitation systems		
Truck operators may be sprayed with sludge, leading to sickness, and the surrounding may accidentally be contaminated due to unsafe handling / operation		
Direct contact to sewage during emptying by opening and closing the collection chambers, connecting hoses and/or pumps		
Contamination of watercourses / land due to spillage of sludge		
Contamination of receiving environment due to flooding or heavy rain from stormwater systems contaminated with sewage or from combined sewers		
Uncontrolled and unknown discharges (e.g. from animal farms, industrial, septic tanks or pollutants resulting road traffic accidents) to stormwater system and water bodies contaminating the environment		
Exposure to untreated sludge from containment due to unsafe removal leading to sickness / infection		
Ingestion of pathogens after contact with excreta during manual emptying of pits using buckets		
Ingestion of pathogens after contact with contaminated soil, caused by discharge of faecal sludge without treatment to open grounds		
Dermal contact with pathogens in open channels and surface waters caused by discharge of untreated faecal sludge		
Ingestion of pathogens after contact with wastewater during sewer cleaning and maintenance		
Ingestion of pathogens after contact with faecal sludge during cleaning sludge beds		

## Wastewater and faecal sludge treatment

**Unsafe off-site treatment:** inadequate treatment can lead to insufficient pathogen removal from faecal sludge, and into water bodies through runoff or by purposeful discharge, contaminating water for human consumption. Poorly-managed treatment processes can also allow animal contact with untreated excreta, contributing to further exposure.

Hazardous event related to treatment	Could happen in our system	
	yes	no
Treatment technology (the whole treatment plant or part of the treatment plant) is dysfunctional leading to contamination of the environment		
Design deficiencies or inadequate construction specifications leading to discharge of untreated wastewater		
Destruction and damage to sanitation infrastructure due to heavy rainfall / flooding leading to contamination of the environment.		
Damage to other infrastructure/systems on which sanitation systems rely (e.g. electricity networks for pumping; road networks used by FSM vehicles) due to heavy rainfall / flooding		
Damage to wastewater treatment works (which are often low lying/coastal) from exposure to saltwater leading to contamination of the environment		
Discharge of untreated wastewater due to operator's failure resulting in environmental pollution		
Discharge of untreated wastewater due to overflow of combined sewers resulting in environmental pollution		
Discharge of wastewater that does not meet quality standards resulting in environmental pollution		
Reduced efficiency of biological wastewater treatment (if temperature exceeds or falls below operational limits) leading to contamination of the environment		
Reduced effectiveness of biological treatment processes due to saltwater exposure from saline intrusion into wastewater influent leading to contamination of the environment		
Obstruction creating reduced capacity in rivers or ponds that receive wastewater		
Reduced capacity of receiving water bodies to dilute wastewater leading to contamination of the environment		
Acts of vandalism or sabotage due to poor infrastructure security leading to discharge of untreated wastewater		
Inadequate treatment due to operators lack of proper technical knowledge		
Inadequate treatment due to non-availability or low quality and irregular supply of chemicals		
Ingestion of surface water contaminated with effluents from treatment plants that have not been designed based on pathogen removal, reduction or inactivation		
Inhalation of aerosols while manual handling of the dried faecal sludge		
Ingestion of pathogens in incompletely treated effluent, resulting from discharge of fresh faecal sludge in wastewater treatment ponds, causing overload and failure		

Hazardous event related to treatment	Could happen in our system	
	yes	no
Inadequate treatment due to general lack of electricity supply for treatment processes		

### Sanitation workers

**Unsafe working environment:** inadequate protection of sanitation workers can lead to exposure to untreated excreta and related hazards.

Hazardous event related to sanitation workers	Could happen in our system	
	yes	no
Direct contact with faecal sludge or raw sewage due to personal protective equipment failure - breakage or mis-use/non-compliance leading to sickness / infection		
Direct contact with faecal sludge or raw sewage due to lack of personal protective equipment leading to sickness / infection		
Contact with sharps by entering or emptying containment systems, e.g. septic tanks or pit latrines leading to injury / sickness / infection		
Contact with sharps from preliminary treatment e.g. screening leading to injury / sickness / infection		
Contact with faecal sludge or raw sewage via contaminated tools and equipment leading to sickness / infection		
Lack of proper hand hygiene after contact with faecal sludge or raw sewage leading to sickness / infection		
Lack of proper handwashing practice with soap and water after contact with human faeces or raw sewage in all critical occasions leading to sickness / infection		

### Disposal

**Unsafe disposal:** discharge of untreated faecal sludge into the environment can lead to hazardous events through multiple pathways.

Hazardous event related to disposal	Could happen in our system	
	yes	no
Direct contact with faecal sludge or raw sewage due to lack personal protective equipment, particularly where disposing of wastewater and, faecal sludge		
Direct contact with faecal sludge or raw sewage due to lack of training on the risks of handling effluents or faecal sludges and on standard operating procedures		
Hazardous event related to disposal	Could happen in our system	
	yes	no
Discharge of effluent from onsite systems into the soil may lead to contamination of groundwater		

iWSSP Step 3 List of hazardous events (February 2024), from: "Tools for the implementation of integrated Water and Sanitation Safety Planning in small systems" - <https://doi.org/10.21945/RIVM-2024-0022>



Discharge of untreated wastewater resulting in environmental pollution		
Discharge of wastewater that does not meet quality standards resulting in environmental pollution		
Dumping used waste, such as napkins, sanitary towels or toilet paper, into the water bodies/other places causing water/environmental pollution		
Unsafe or illegal offsite disposal of sludge may lead to contamination of watercourses / land		
Dumping faecal sludge or septage from the septic tank in an unsafe manner leading to contamination of the environment		
Contact with sharps at dumpsite or landfills place leading to injury / sickness / infection		
Ingestion of pathogens in surface waters due to discharge of partially treated or untreated wastewater		

## Hygiene

**Unsafe hygiene:** can lead to hazardous events through multiple pathways.

Hazardous event related to hygiene	Could happen in our system	
	yes	no
Lack of proper hand hygiene leading to sickness / infection		
Lack of proper handwashing practice with soap and water leading to sickness / infection		
Lack of proper hygiene while cooking/ serving food at home leading to sickness / infection (community)		
Lack of proper hygiene while cooking & serving food in commercial establishments leading to sickness / infection (community)		

## 4. Water Safety Planning

### Catchment

The catchment is the first step of the water supply in which hazards can reach the abstraction point due to direct introduction of hazards into the groundwater body, direct introduction of hazards into surface water body, or via surface runoff and / or groundwater feeding the surface water body. This is also the step where unsafe sanitation may have the largest impact on drinking-water safety.

Hazardous event related to catchment	Could happen in our system	
	yes	no
Discharges from untreated or poorly treated domestic wastewater / faecal matter from on-site systems or open defecation reach source water (directly or indirectly via overland flow), e.g. caused by not removing retained solids on time, causing overflowing of effluents, or poor maintenance of the systems		
Discharges from untreated or poorly treated domestic wastewater / faecal matter from centralized wastewater collection reach source water (directly or indirectly via overland flow)		
Domestic solid wastes or solid waste site leachate reaches surface water body via groundwater feeding the surface water body		
Inadequate re-use of human or animal faeces / wastewater leads to introduction of pathogens and nutrients into catchment and subsequently surface water		
Discharges from untreated or poorly treated industrial discharges and wastewater reach source water (directly or indirectly via overland flow)		
Agricultural chemicals (e.g. fertilizers and agricultural pesticides/ algacides), manure or faecal material from application or storage reach surface water through overland flow and / or via groundwater		
Agricultural activities near the dam (flowers production) cause deforestation and may introduce agrochemicals via surface water runoff or via groundwater contamination		
Nutrients (e.g. from agricultural activities) reach surface water directly or through overland flow, leading to algal blooms		
Lack of Best Management Practices (BMP) for pesticide control, irrigation / drainage / match irrigation to crop needs, nutrient management, design and operation of industrial activities etc. leads to increased contamination		
Aquacultural activities lead to direct discharge of human pathogens from systems using wastewater and from fish excreta, flow of fishpond water into the surface waterbody, particularly during flooding		
Spills or leakages from major spills or continuous small spills, both accidental and deliberate, reach source water (directly or indirectly via overland flow)		
Salinization of river water as a consequence of mining activities, especially of salt mining		
Mining causing acidic water with low pH, reaching the surface water via groundwater flow		
Mining, energy generation or other empoundments causing changes in the hydraulic regime, potentially leading to reduced water quantity		
Hazardous event related to catchment	Could happen in our system	

	yes	no
Faecal matter from intensive animal practices, manure application, livestock and other animals contaminates source water		
Discharges / leachate from e.g. extractive mining, waste disposal or other current or former hazardous waste sites reach source water via groundwater		
Traffic, including waterway transportation and vehicle maintenance activities, contaminates waterbody directly or via overland flow		
Human pathogens reach surface water body through human activities (e.g. swimming, washing of clothes)		
Increased concentration of pollutants when conditions become drier and there is less recharge, particularly in groundwater sources that are already of low quality		
Increased concentration of pollutants in case of increased abstraction / overabstraction with less inflow, particularly in groundwater sources that are already of low quality		
Reduced quantity available if increased winter precipitation is compensated with higher evaporation due to higher summer temperatures		
Higher levels of hazards as long-term rainfall increases, causing rising groundwater levels which decrease the efficiency of natural purification processes		
Transport of contaminants is increased , particularly in shallow aquifers, with increased lateral flow in soils after large rainfall events		
Contamination sources are mobilised or lower quality water intrudes due to increased pumping in times of drought		
Hazards are introduced from surrounding soil to groundwater (e.g. humic material, arsenic, fluoride, manganese, iron, sulphate, radiological agents)		
Nonavailability or shortage of water due to incorrect placement of intake point		
Improper choice of water source because of lack of detailed assessment or reliable survey data		

### Abstraction from groundwater

Hazardous event related to abstraction from groundwater	Could happen in our system	
	yes	no
Reduced quantity due to drying up of wells caused by to reduced groundwater tables		
Reduced quantity due to failure (e.g. due to flood, slips or earthquake-related damage) causing infrastructure to become dysfunctional		
Hazards reach the source water with contaminated water from the surface entering well heads after intense runoff / flooding events		
Contamination enters dug well, borehole or spring source during construction due to contaminated equipment		
Contamination enters borehole during construction due to residual substances used in drilling		
Hazardous event related to abstraction from groundwater	Could happen in our system	
	yes	no

Contamination of the borehole due to poor quality of the bore casing (joints, cracks or corrosion) in the bore casing		
Contamination enters borehole through well head or casing which is damaged due to inappropriate wellhead design or construction		
Contamination of the groundwater due to cracked lining representing a pathway for introducing hazards		
Contamination of the groundwater due to lack of seal on rising main representing a pathway for introducing hazards		
Contamination of the groundwater due to lack of or damaged cover on well representing a pathway for introducing hazards		
Contamination of the groundwater due to cracked or damaged apron or pump-house floor representing a pathway for introducing hazards		
Contamination of the groundwater due to faulty masonry on spring protection representing a pathway for introducing hazards		
Quantity is reduced by break down of pumps (defect, power failure, lack of standby pumps, spare parts, back-up generator)		
Contamination of the groundwater due to eroded backfill on spring source representing a pathway for introducing hazards		
Contamination of the groundwater due to ropes and buckets used to withdraw water from dug well or spring source representing a pathway for introducing hazards		
Hazards are introduced due to vandalism as access to unfenced dug well, borehole or spring source makes it a target		
Contamination is introduced through stagnant water uphill or in the direct vicinity of the dug well, borehole or spring source and absence of drainage channel / diversion ditch		
Available quantity is reduced when sediments, iron or manganese cause the well to clog		
Hazards are introduced during repair and maintenance by untrained staff, e.g. with contaminated tools		
Available quantity is reduced by too high velocity due to poor design causing premature breakages of channels or pipes of the borehole		
Available quantity is reduced in case of breakdown of well pump (defect, power failure)		
Contamination may be introduced through lack or damage to cover of wells in the vicinity of the abstraction point		

## Drinking-water treatment

Inadequate treatment can lead to insufficient removal of hazards, leading to unsafe drinking water for human consumption. Poorly-managed treatment processes can also lead to ingress of hazards.

Hazardous event related to drinking-water treatment	Could happen in our system	
	yes	no
Inadequate back-up (infrastructure, human resources) leads to poor performance of the whole process in case of failure of the initial resources		
Interruption to the treatment process or poor water quality due to damage to treatment infrastructure in case of e.g. flooding, fire or other severe weather events		
Interruption to the treatment process or poor water quality due to failure of alarms and monitoring equipment which hinder quick response in case of treatment failure		
Interruption to the treatment process or poor water quality during accidents and recurring disasters, due to a lack of preparedness		
Introduction of hazards to incoming or treated water through cross-connection to contaminated water/wastewater, internal short circuiting		
Increased turbidity and affected treatment process caused by dust accumulation around the treatment area		
Hazards are insufficiently removed / reduced if the treatment is not well adapted to prevailing raw water quality and flow variations		
Hazards are insufficiently removed / reduced due to poor dose control, leading to poor functioning of treatment step		
Hazards are insufficiently removed / reduced due inadequate treatment as reliable water quality data is missing		
Introduction of hazards to incoming or treated water / hazards are insufficiently removed through operators' lack of proper technical knowledge and hygienic practices		

*Sand filtration*

Hazardous event related to sand filtration as treatment	Could happen in our system	
	yes	no
Compromised hazard removal due to poor source water quality or water of variable quality which compromises filter operation		
Compromised hazard removal if treatment steps (e.g. clarifiers) before the sand filter are not working well, and less particles can be removed before the filter		
Compromised hazard removal and water quality if design of the filter and the operational requirements of the treatment plant do not match the raw water quality, leading to insufficient water treatment		
Compromised hazard removal due to sudden increases in the rate in which water passes through the filter which will shake loose particles that have already been trapped in the sand, causing "spikes" in the turbidity		
Reduced quantity in case of algal blooms with algae blocking the filters		
Insufficient hazard removal if filter design does not match operation flow rates		
Compromised removal of hazards if depth of the filter is insufficient		
Compromised functioning of treatment step due to inappropriate operation of the filter (i.e. how and how often the filter is backwashed, if the backwash water is returned to the head of the plant, how the filter is restarted, the management of the filter ripening and the procedures used in cleaning the filter sand, lack of proper valve lubrication and maintenance, media not inspected and/or cleaned, poor operator training and support)		
Compromised removal of hazards due to frequent filter backwashing which mixes filter layers, and affects particle size of filter particles, leading to reduced filtration capacity		
Compromised removal of particles if the filter bed is not completely fluidized during filter backwashing		
Insufficient backwashing water available to maintain removal of hazards in case of increased temperature, and higher frequency / flow rates may be needed to reach necessary flushing velocity		
Insufficient backwashing water available to maintain removal of hazards in times of higher turbidity, and higher frequency / flow rates may be needed to maintain removal of hazards		

## Chlorination

Hazardous event related to chlorination as treatment	Could happen in our system	
	yes	no
Chlorine dose is too low to leave enough free available chlorine to disinfect the water effectively		
Free available chlorine is in contact with the water for an insufficient time (typical recommendation: 30 minutes) to efficiently reduce microbial contamination		
pH of the water is outside effective range (typically this means that pH is rather too high, resulting in a lower percentage of the free available chlorine existing in its more powerful disinfecting form), compromising disinfection (not enough chlorine is in a form which is good to kill pathogens) which may fail to remove / reduce microbial hazards		
Turbidity of the water is too high when the chlorine is added to it; which can hinder the access of chlorine to target pathogens		
Water temperature is too low to allow for efficient chlorination so that pathogens are insufficiently removed		
Chlorination is not adapted to fluctuations in raw water quality and flow variations, leading to insufficient reduction of pathogens		
Insufficient availability of chlorine or reagent of poor quality / old solution / solution which has been exposed to the sunlight, unapproved or contaminated chemicals and materials may compromise treatment		
Poor dose control / dosing equipment (including calibration of dose controller's sensor, dose calculation) / insufficient chlorine reaching dosing point may lead to poor functioning of chlorination		
Wrong monitoring (e.g. incorrect sampling, incorrect recording of readings, incorrect method for measurement, incorrect calibration) of free available chlorine lead to insufficient dosing		
Power cuts may lead to failure of dosage pumps and / or mixing facilities		
Inadequate back-up (infrastructure, human resources) leads to poor performance of chlorination process		
Process control failure and malfunction and/or poor reliability of equipment compromises treatment		
Failure of alarms and monitoring equipment hinder quick response in case of chlorination failure		
Lack of preparedness for potential accidents and recurring disasters causes interruption to the process or poor water quality		
Cross-connection to contaminated water/waste water, internal short circuiting contaminates the incoming or treated water		

## Drinking-water distribution

Inadequate treatment in the distribution can lead to insufficient removal of hazards, leading to unsafe drinking water for human consumption. Poorly-managed operations and maintenance of the distribution network can also lead to ingress of hazards.

### *Distribution system*

Hazardous event related to distribution system	Could happen in our system	
	yes	no
Negative, or fluctuating, pressure conditions (e.g. intermittent operation or the effect of a pressure wave within the system) allow for ingress of contamination from surrounding soil / surfaces / animal faeces / leaky sewer mains / drains / garbage / pit latrines / valve boxes / canals, especially in the first flush after water pressure is returned, and may carry deposited silt and / or rust with it in first flush		
Loose joints, pin-holes, loose connection, cracks, holes in the pipeline coupled with low internal pressures allow for ingress of contamination		
Lack of prevention device or failure of device leading to potentially contaminated backflow from residential / industrial / commercial customers due to (likelihood increased during low-pressure events)		
Accidental cross-connection (or illegal / unauthorized connections) between drinking-water and non-drinking-water assets or wastewater during construction or maintenance (e.g. opening of usually shut valves) allowing for contamination to enter		
Pipes located above ground are prone to damages, allowing for ingress of contamination from surrounding soil / surfaces		
Insufficient performance of valves may lead to compromised isolation, flushing and/or disinfection of potentially contaminated area		
Unhygienic construction, repair and maintenance methods may introduce contamination (e.g. debris, vermin, soil, groundwater or rainwater entering)		
Unsuitable construction materials may introduce hazards (e.g. impurities such as copper, iron, lead, plasticizers, bituminous lining)		
Inappropriate materials, such as metallic products, which are incompatible with the water quality and / or other materials in the system may cause corrosion and resulting loss of structural integrity, water colour and water quality issues		
Pipe slimes, sediment and deposited minerals such as silicates or oxidised manganese may be re-suspended in the distribution system during high-flow events or flow reversals		
Particles (e.g. floc after the treatment plant, sediments, manganese deposits) may accumulate, particularly at dead ends, due to long stagnation		
Biofilms in piped networks may lead to pathogen survival and growth of pathogens		



### Post treatment storage

Hazardous event related to post treatment storage	Could happen in our system	
	yes	no
Damaged or lacking vent screens allow ingress of animals / vermin /faeces which may introduce contamination (particularly for consumers' premises storages)		
Damaged or lacking tank covers allow ingress of animals / vermin /faeces / roof drainage which may introduce contamination		
Insufficient cleaning of reservoirs may lead to build up of sediment or living organisms (including algal / biofilm growth)		
Lack of surface sealing which slopes away from storage may lead to contaminated water (including potentially animal faeces if access is not restricted) running towards storage and entering it through damages		
Roots of plants / trees in vicinity may damage reservoir and allow for ingress of contamination		
Dissolving or corroding tank materials may introduce hazards		
Unhygienic sampling procedures may introduce contamination		
Unauthorised access by humans may lead to vandalism and sabotage		
If water is disinfected at storage: Insufficient residence time of water does not allow for sufficient contact time to reduce pathogens (event related to post chlorination after treatment, but not in reservoir)		
For underground storage reservoirs: ingress of groundwater from unsealed joints and cracks leads to ingress of contamination		
Inadequate capacity of storage leads to insufficient quantity which is supplied to consumers' demand		
Power cuts leading to failure of booster stations and hence reduced quantity		

### Drinking-water consumers' premises / household

Unsafe hygienic practices can lead to hazardous events through multiple pathways.

### Public fountains

Hazardous event related to public fountains	Could happen in our system	
	yes	no
Leaking public fountains may through unsealed surfaces and / or cracks lead to ingress of contamination into pipes, especially if distribution system is operating intermittently		
Leaking public fountains may reduce quantity of available drinking-water		
Insanitary taps or attachments (e.g. hoses) may introduce contamination to the water collected as well as to the distribution system		
Hazardous event related to public fountains (continued)	Could happen in our system	
	yes	no

iWSSP Step 3 List of hazardous events (February 2024), from: "Tools for the implementation of integrated Water and Sanitation Safety Planning in small systems" - <https://doi.org/10.21945/RIVM-2024-0022>

Spilt water may be contaminated by runoff, especially if animals have access to the collection area, and collection containers may thus be contaminated when placed on the ground to collect water		
Animal faeces, garbage etc. may contaminate the collection area, and collection containers may thus be contaminated when placed on the ground to collect water		
If the collection area is not fenced, animals (including those used for collecting the water) can access the fountain area, damage the taps and pollute the area and / or collection containers		
Hose connection to tap may allow for potentially contaminated water backflow into the distribution system		

*Household level*

Hazardous event related to household level	Could happen in our system	
	yes	no
If water from different sources and with different qualities is used in the same household and collected and stored in the same containers, drinking-water may get contaminated		
If collection- and storage containers are used for storing different liquids or materials, drinking-water may get contaminated		
Cracked, leaking or insanitary collection- and storage containers may introduce contamination and reduce quantity		
If lid of collection- and storage containers is absent, damaged or not in place, contamination may enter and animals/insects may get into container		
Storage containers / jars kept at ground level allows for contamination to enter through e.g. animals or poor sanitation practices		
Faeces, garbage and other wastes in an insanitary area around the storage container / jar may introduce contamination		
Pump from ground level tank to roof tank draws may groundwater because storage is leaky and thus enter contamination		
Insufficient cleaning of storage tank may allow for contamination / sedimentation to accumulate		
Use of an inappropriate or insanitary tap or utensil to draw water from the storage, as well as poor hygiene practices (e.g. dirty hands) may introduce contamination		