Water

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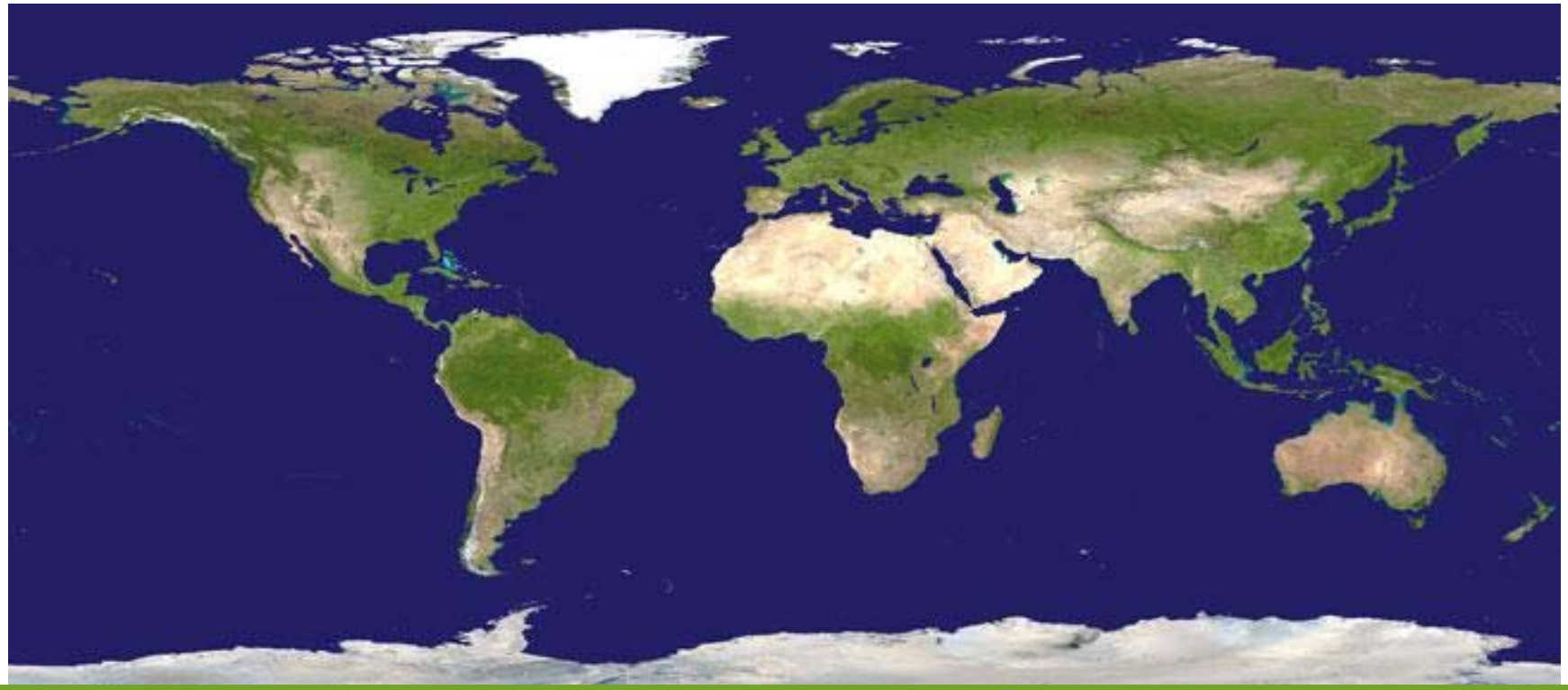
Structure of the lecture

- **Water**
  - Situation
  - Water cycles and human impact
  - Means and ways for a sustainable association with water
  - Reducing driking water
  - Wastewater management
  - Rainwater management
  - Examples

Water - Situation

Water - Situation

About 70 % of the worlds surface is covered by water, while only 3% of water on the earth is fresh water. Most of this fresh water is frozen in glaciers and polar ice caps, which means that just 0.3% of this is actually available to us.



Quelle: http://ecologic-architecture.org/main/

Water - Situation

The development of industry and agriculture, together with an increasing standard of living, has led to an escalating demand for water and has resulted in pollution of the water resources. But there is a water deficiency in poor countries.

Quelle: http://ecologic-architecture.org/main/

Water - Situation

The actual handling with water and wastewater results in high water consumption, considerable quantities of waster water and the overuse of natural water resources. Pure drinking water is used for flushing away sanitary sewage. Large amounts of substances are needlessly water-diluted and are pipelined to central sewage treatment plants. By cost-intensive treatment, this wastewater will be purified and conveyed into waters.

The pollution of water resources, the destruction of natural water reservoirs and the excessive water consumption with its quantities of waste water will sharpen the situation. The techniques have to be changed, the development of new sustainable concepts is important.

Quelle: http://ecologic-architecture.org/main/

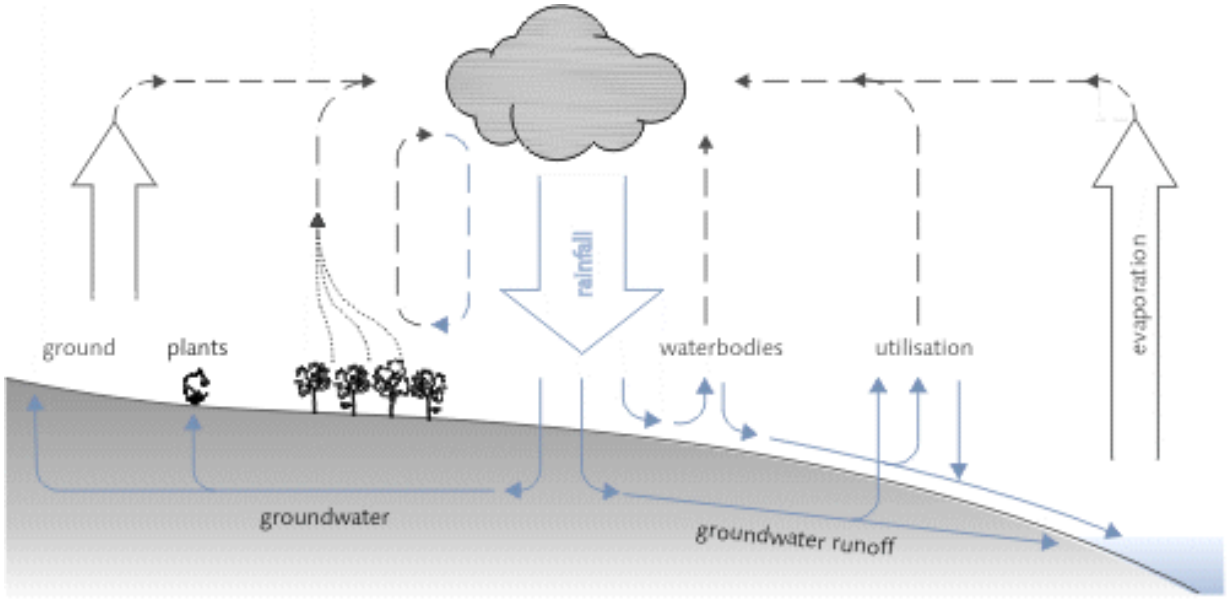
Water - Water cycles and human impact

Water - Water cycles and human impact
The natural water cycle

There are three kinds of water: solid (ice), fluid (water) and gaseous (steam).

The natural water cycle is realised through the uninterrupted sequence of **evaporation, condensation, precipitation** (rain, hail, snow) and **drainage**.

Only ca.1/3000 (ca.1.4 billion km³) of the water amount takes part in the cycle.

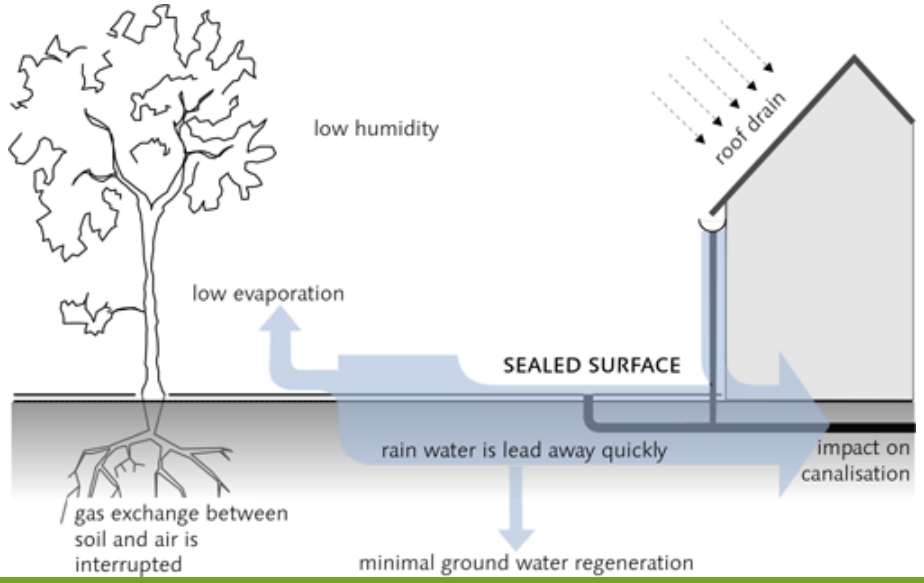


Quelle: http://ecologic-architecture.org/main/

Water - Water cycles and human impact
Human impact on the natural water cycle

Man interferes with the natural water cycle by:

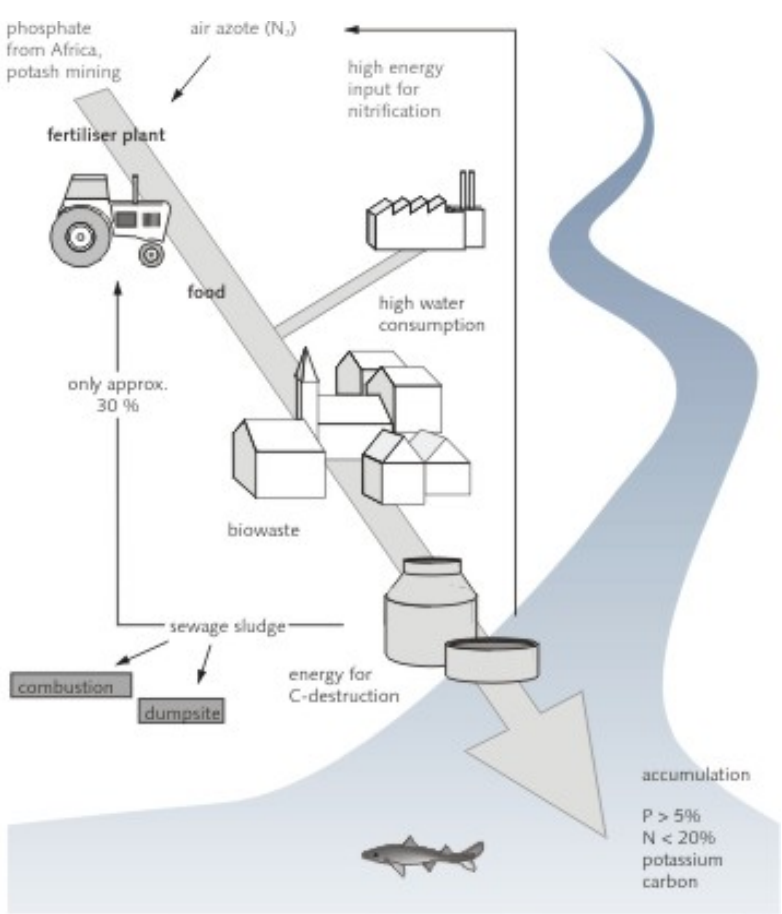
sealing and agricultural use of land
collection of precipitated water and quick drainage into canalisation or ditches
partially use of surface water for the supply of settlements
re-feeding of contaminated water into the cycle

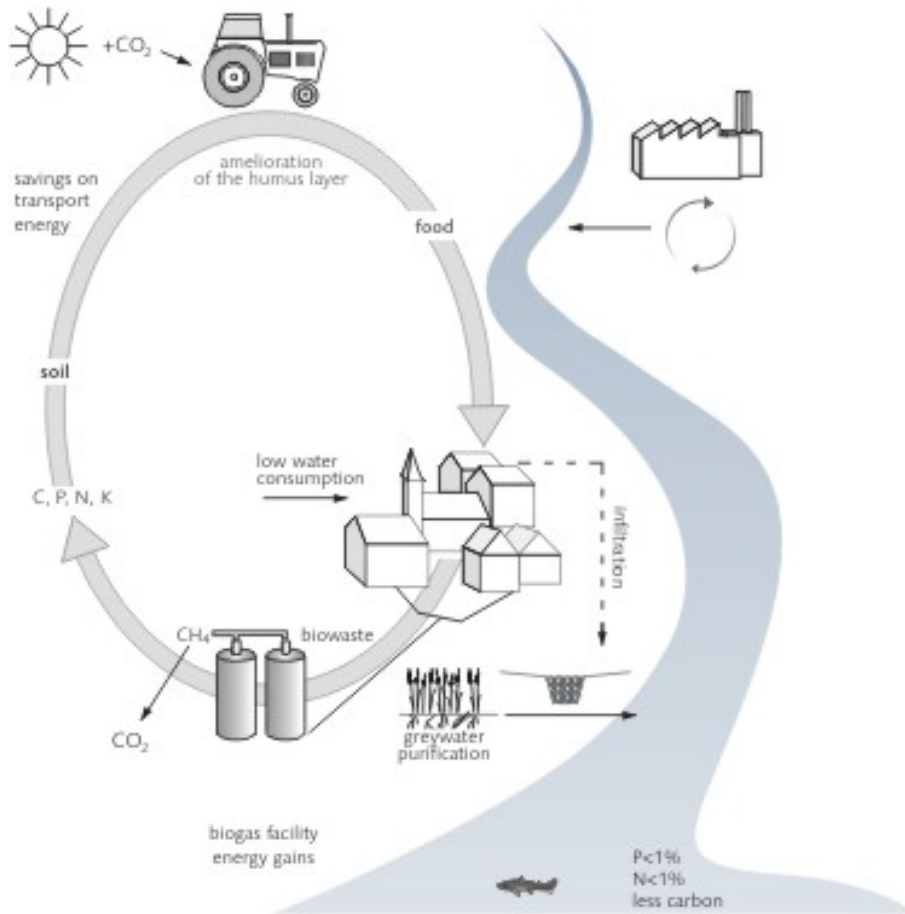


Conventional settlement water balance

Quelle: http://ecologic-architecture.org/main/

Water - Water cycles and human impact
Linear and sustainable substance flow





Green Building

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Water - Means and ways for a sustainable association with water

Water - Means and ways for a sustainable association with water

The development of sensible concepts for a sustainable water management should be **part of the initial phase of urban, regional and project supervision planning** (zoning plan, development plan), in order to provide all necessary prerequisites for the actual building planning and use.

The architect, in conjunction with various specialists, plays an important role in the decision-making process for a general concept on dealing with water, already during the planning of a building or an urban structure.

Quelle: http://ecologic-architecture.org/main/

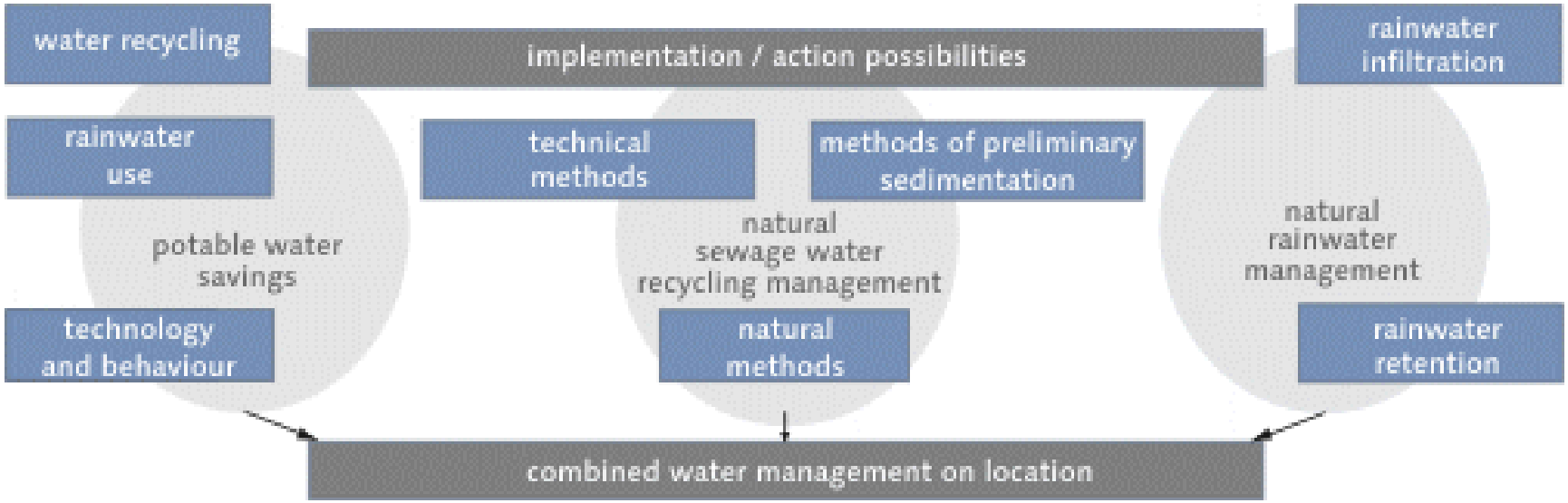
Water - Means and ways for a sustainable association with water

On different levels during the planning process, the aspects to be considered:

- surface and volume demand of the necessary facility
  (swales, ponds, compost toilettes, septic tanks, ground filters, cisterns, tanks,...)
  - within the public space (structure of buildings, density of buildings)
  - on public green and free spaces
  - on private property, free and garden areas
  - within the building
- static aspects (cisterns, compost toilettes, turf roofs, retention roofs,…)
- building installations (double pipe systems, fittings)
- integration within the urban and landscape design
  (biotope network, multiple uses for leisure and design purposes)
- the micro climate of a city
  (percolation and retention of rainwater, turf and retention roofs),
- selection of building materials (avoiding copper and lead pipes, alternative use of polyethylene pipes for potable water or wood pipes for eaves gutters)

Quelle: http://ecologic-architecture.org/main/

Water - Means and ways for a sustainable association with water



Quelle: http://ecologic-architecture.org/main/

Water - Reducing drinking water

Water - Reducing drinking water
Drinking water

Drinking Water – the most important type of food that cannot be replaced – is determined by the regulations of the Lebensmittelgesetz (law concerning food), the Trinkwasserverordnung (Drinking Water Regulation) and the Bundesseuchengetz (BuSeuchG). Water used to prepare and clean food and that is used for personal hygiene must meet the same requirements.

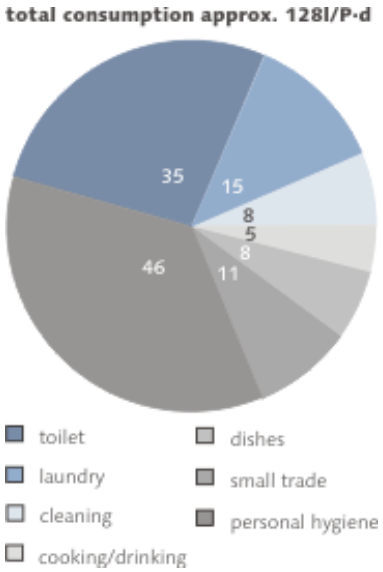
Service water is water, which is used for industry, production, agriculture or something similar (e.g. the watering of gardens, toilet flushing, cleaning and washing) without requiring drinking water quality. Service water needs to obtain certain properties depending on the type of use.

The **centralised water supply** has one system for drinking, process and fire fighting water. Therefore all water has to be of drinking water quality.

Quelle: http://ecologic-architecture.org/main/

Water - Reducing drinking water
Water consumption

- population and small trade
  (the daily water consumption per person in Germany adds up to ca. 130 litres, which can easily be reduced to a level of 80 l/d/p)
- general public demand
- agriculture and industry



Water use of households

Agriculture (irrigation) accounts for 70% of the earths water demands, while industry consumes 20%, and household purposes make up 15% of its use.

Quelle: http://ecologic-architecture.org/main/

Water - Reducing drinking water

The most important means of reducing water consumption are as follows:

- using water-saving technical appliances
  water saving fittings, water saving washing machines and dishwashers
  flushing control devices and water saving WCs
  water saving or even water less urinals and separation toilettes
  (urine separation toilettes, vacuum toilets)
  compost toilettes - dry toilettes
- responsible water saving behaviour by the consumer
- substitution of drinking water with domestic waste water for certain uses
  (water recycling)

Quelle: http://ecologic-architecture.org/main/

Water - Reducing drinking water
Water recycling

For certain purposes drinking water **can be substituted** by lower-quality water:

- Rainwater recycling
- Grey water recycling
- Black water recycling

Greywater is wastewater generated from domestic activities such as laundry, dishwashing, and bathing. It contains no faeces and only limited amounts of pathogenic bacteria and nutrients. It is therefore easier to purify than black water. After the treatment, purified grey water can be seeped away, discharged in receiving waterways or it can be used as service water. This water could be used where no drinking water quality is required.

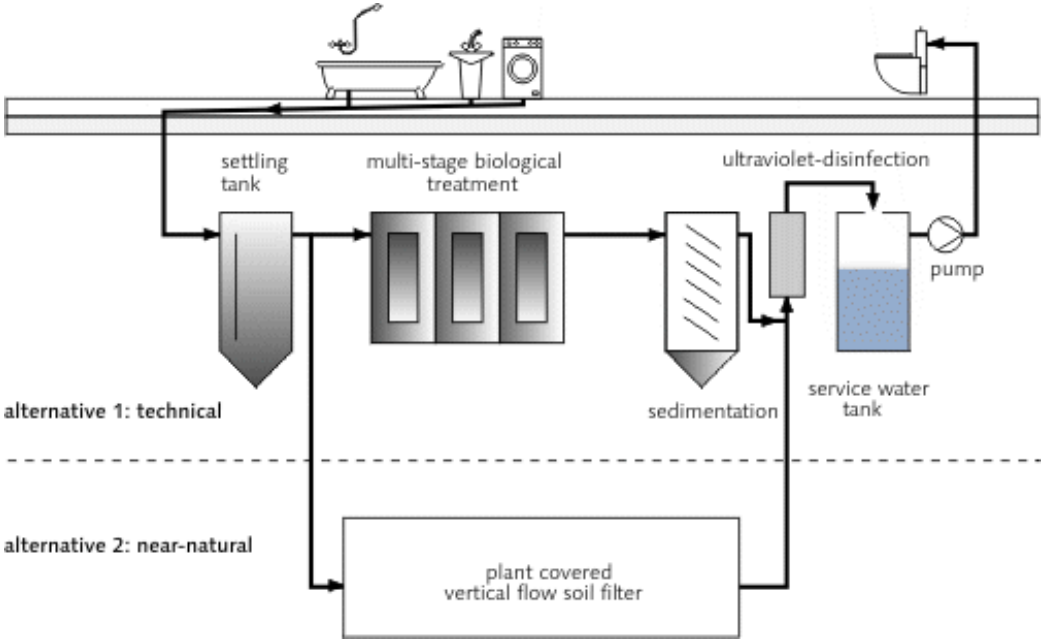
Blackwater is wastewater from water from the toilets, which includes faeces.

Yellowwater is wastewater from the toilets, which contains urine.

Quelle: http://ecologic-architecture.org/main/

Water - Reducing drinking water
Grey water recycling

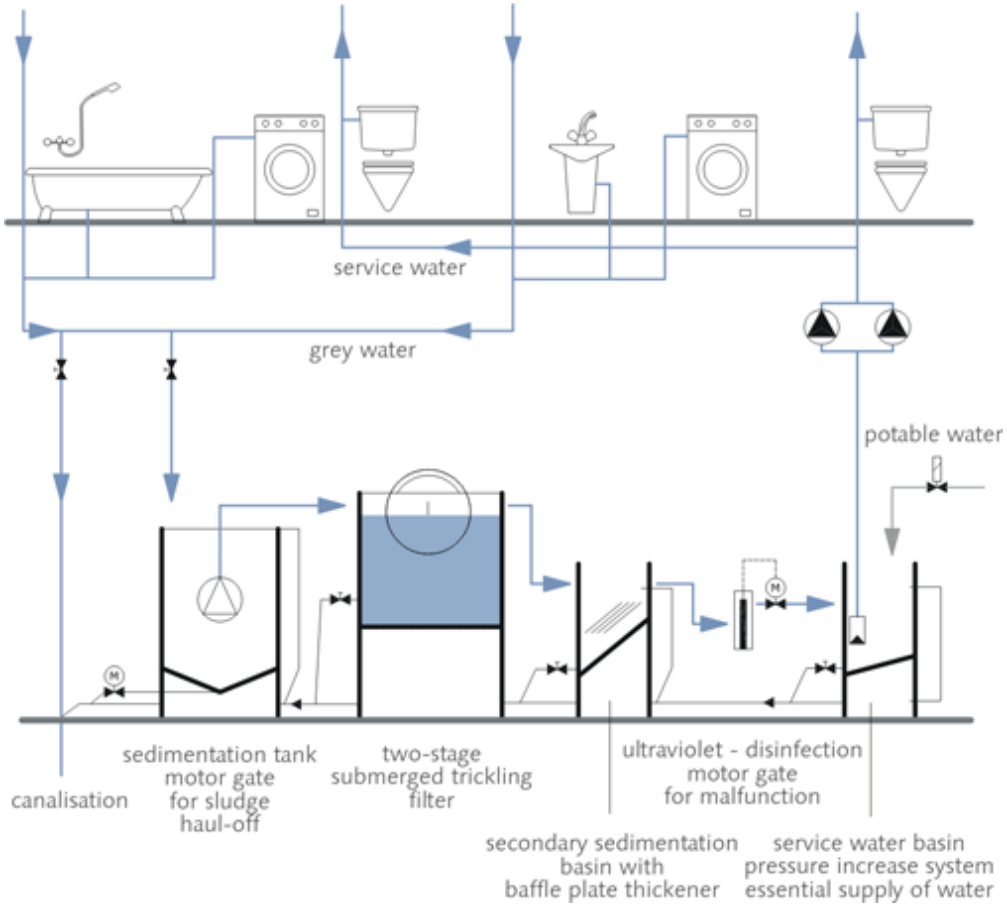
There are **technical and nature-oriented techniques** of gray water recycling. Naturally oriented techniques feature low costs and simple installation while still requiring much space outside the building. Technical systems on the other hand are expensive and require regular inspections, yet they do not need much space.



Grey water recycling

Quelle: http://ecologic-architecture.org/main/

Water - Reducing drinking water
Grey water recycling



Construction of the grey water installation in Hanover-Hängewiesen (acc. to Jochen Ziesel)

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management

Water - Wastewater management
Wastewater

Wastewater is water which has been altered through its utilisation and which runs off, including all water running in the canalisation (DIN 4045)

dirty water	precipitation	extraneous water	mixed water	cooling water
households	rainwater	spring water	dirty water	cooling water
industry	fog	from drainage	extraneous water	
business	dew	from undeveloped areas	precipitation	

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Ingredients of waste water

Easily degradable organic compounds	Persistant organic compounds	Non-degradable substances
urea	polycyclic aromatic hydrocarbons	
carbohydrates, fats, oils, proteins in faeces, remnants of food or waste water from industry	halogenated hydrocarbons in biocides and cleaning agents	highly chlorinated organic compounds in waste water from industry and trade
nitrogen and phosphate compounds in faeces and urine	phosphonates in washing agents	salts such as chlorides, nitrates, sulphates and phosphates in salty waste water caused by potash mines, soda industry, mining etc.
anionic soaps and tensides, made of natural resources washing powder, in detergent substances, shampoo, dishwashing liquids etc.	non-ionic and cationic tensides in detergent substances	heavy metal compounds such as cadmium, mercury, lead, zinc and copper in waste water from industry and trade, sanitary installations

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Convential wastewater treatment

Domestic waste water contains **a high quantity of nutrients** such as Nitrogen, Phosphor, Carbons and Potassium. The largest part of the nutrients are carried in the black water, which can be divided from the grey water.

Nutrients and pollutants arrive at waters and finally to the ocean. This results In **eutrophication** occurring and the **pollution** of ground and surface water.

On other hand, **the fertilisers are missing in agriculture** and the production of them requires energy, rare resources such as phosphor and money.

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Alternative wastewater treatment

Waste water need not be dealt with as refuse but as a valuable resource.

An ecological waste water concept should consider:
Closed nutrient- and water-cycles are basis for sustainable water management.

- avoidance of hazardous substances
- minimising (drinking) water consumption
- water recycling

If reasonable:

- decentralised ‘natural’ waste water treatment where appropriate
- the separate treatment of waste water with different levels of contamination (the separation of domestic and industrial/commercial waste water and the differentiated treatment of black and grey water)
- the recovery of valuable nutrients like nitrogen, phosphorus and potassium (used as fertiliser in agriculture)

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Alternative wastewater treatment

Sludge free of heavy pollutants by house sewage contains nutrients and humus:

- after a hygiene process tales place, the sludge can be used as fertiliser
- fermentation of sewage sludge and the use of resultant Biogas

The objective of an ecological waste water concept :

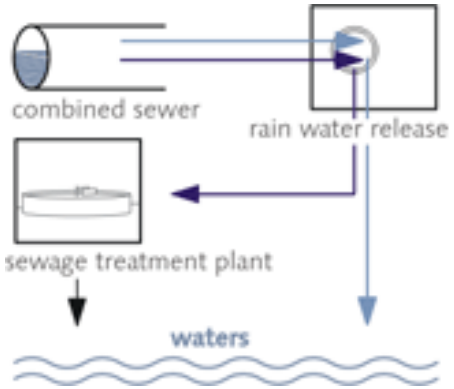
- refeeding of purified waste water into the biological cycle
- percolation of clarified waste water into the soil to enrich groundwater reserves
- close nutrient cycles

Quelle: http://ecologic-architecture.org/main/

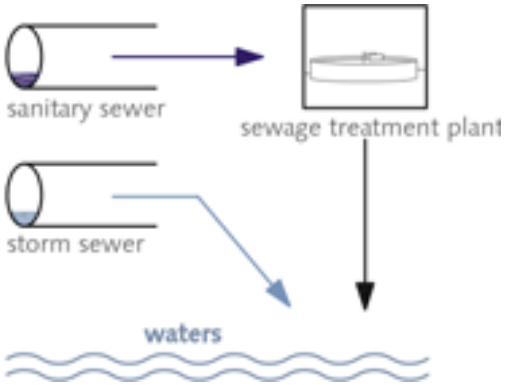
Water - Wastewater management
Sewer Systems

There are 2 different sewer systems depending on the kind of waste water:

Combined Sewer System - system that transport rainwater and dirt water in one pipe. It cannot cope with water quantities of heavy downpours.



Two-pipe System - rainwater and wastewater is collected and conveyed in separate sewer systems (storm sewer and sanitary sewer). Non-polluted rainwater is conveyed to discharge systems like rivers and ditches.



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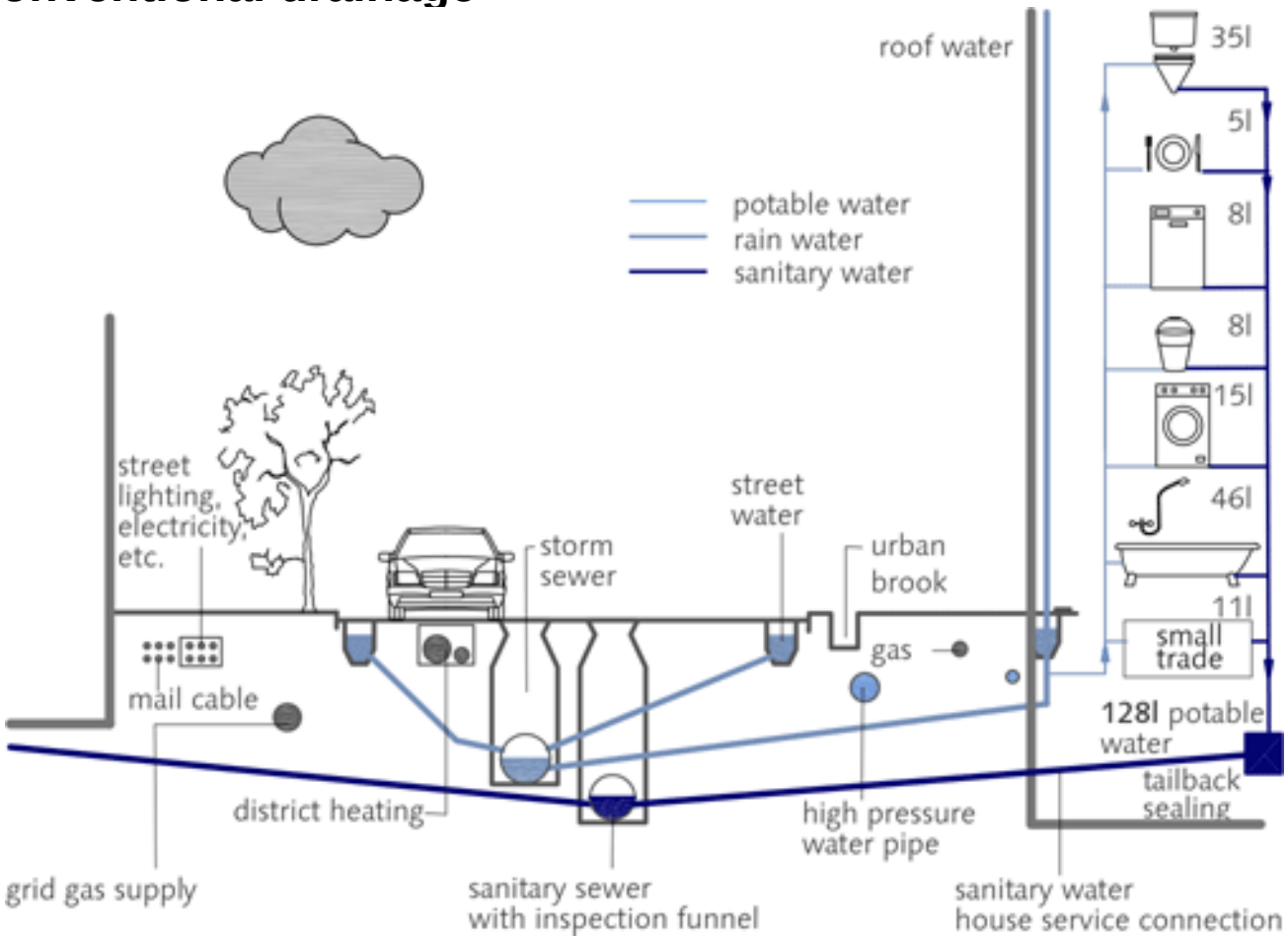
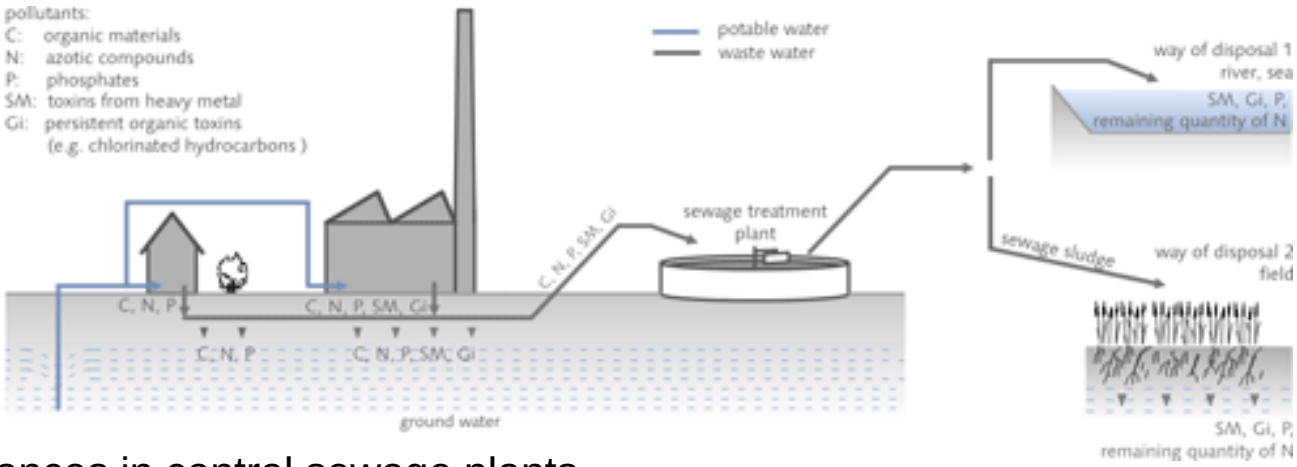
Water - Wastewater management
Cross-section of conventional drainage



Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Centralised waste water treatment plant

In Germany, domestic sewage is a mixture of commercial, industrial, domestic, agricultural and precipitation water. Together they are collected in the municipal canalisation and treated in a centralised sewage plant. This results in a mixture of all ingredients of the different waste waters. Because the separate treatment of waste water fractions is impossible, a complex process of cleaning the entire volume of (polluted) waste water is necessary.



Cycle of harmful substances in central sewage plants

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Decentralised waste water treatment plant

Decentralised or semi centralised structure can serve an individual building or small group of buildings. Decentralised systems clarify the waste water by slow natural processes in the soil and refeed the purified water into the local water cycle. There will be no long transport routes if there are adequate areas for local waste water treatment. Pollutants in the waste water can be avoided or separated a lot easier. But there are only some decentralised waste water treatment plants. Out of densely populated areas, decentralised systems might be better than centralised treatment plants both in terms of ecology and economy. By a useful mixture of centralised and decentralised systems, underused options could be included to obtain a sustainable waste water treamtent.

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Mechanical pre-treatment purification processes

Waste water treatment is a process with several stages. This includes mechanical sedimentation, biological treatment and post-purification and UV-treatment.

The first stage is the **mechanical pre-treatment** in a septic tank. In the mechanical treatment, solids are removed from the influent waste water by rake, sand trap and sedimentation basin. The collection of the resulting sludge is combined with an aerobic or anaerobic pre-treatment.

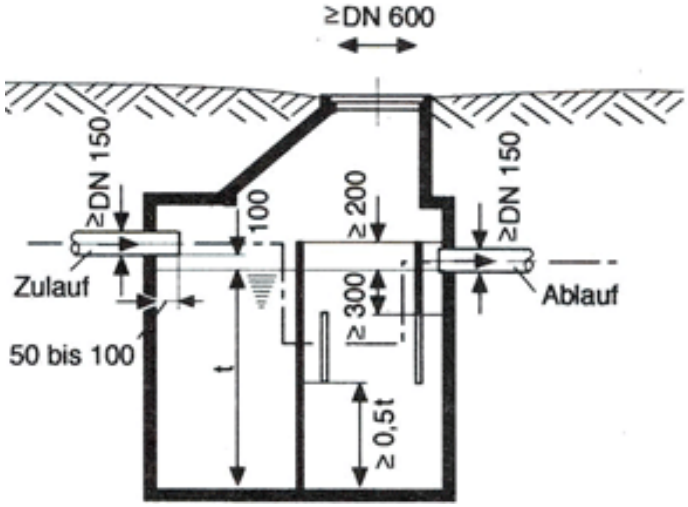
sedimentation chamber
settlement tank
Imhoff tank
aerated and sealed oxidation ponds
decomposition chamber
two-chamber septic tank
three chamber septic tank

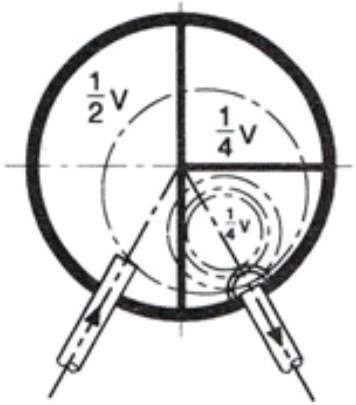
Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Mechanical pre-treatment purification processes

Multi-chamber septic tanks - pre-clarification of domestic black water

Septic tanks are used to separate solid and floating surface material, from the waste water. Due to a large capacity (1500 l per person), waste water takes around 10 days to pass through the tank. This allows micro-organisms within the sewage sludge to begin to break down organic waste material, in addition to the mechanical clarification through sedimentation occurring.



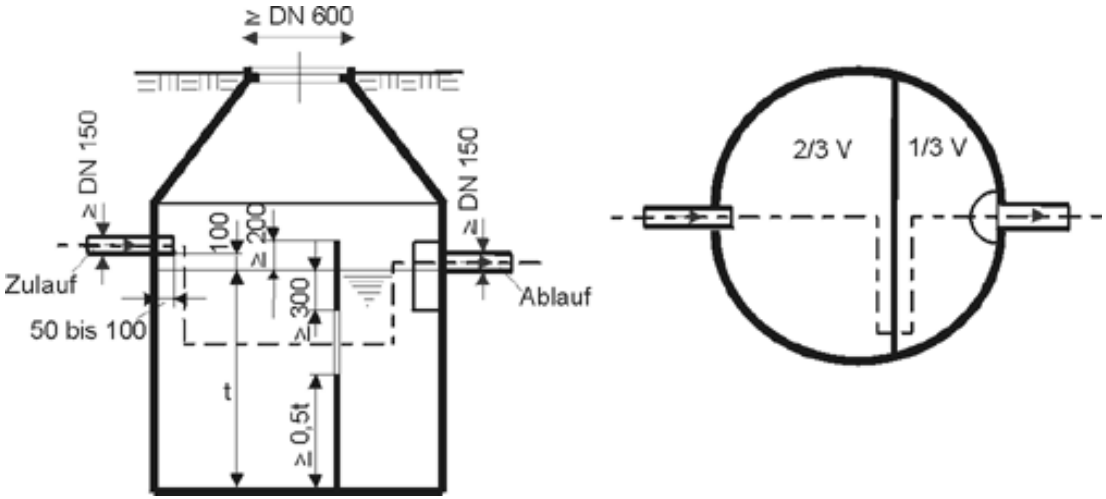


Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Mechanical pre-treatment purification processes

Two chamber sedimentation tanks - pre-clarification of dom. black water

The retention time of the waste water in sedimentation tanks is not as long as it is in multi-chamber septic tanks. Hence the ingredients of the waste water only decompose to a minor degree. Erratic waste water contaminations and waste water quantities can only be buffered to a certain extent. There is no biological clarification and reduction of sludge in two chamber sedimentation tanks.



Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological purification processes

The second stage is the **biological treatment** of the waste water, usually in normal air conditions. Biological treatment degrades biological substances and floating particles. Aerobic microorganisms degrade the organic fractions of the waste water like faeces, food and other easily degradable substances and bind the less soluble fractions into the sludge.

There are two main biological purification processes:

- **natural processes**
- **technical processes**

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological purification processes – natural processes

Natural treatment methods require minimal technology and employ natural processes. There are pond-based and land-based methods.

Pond-based methods include:

enclosed oxidation ponds

marsh reed beds

Land-based methods include

reed-bed treatment systems

reed filters and soil filters

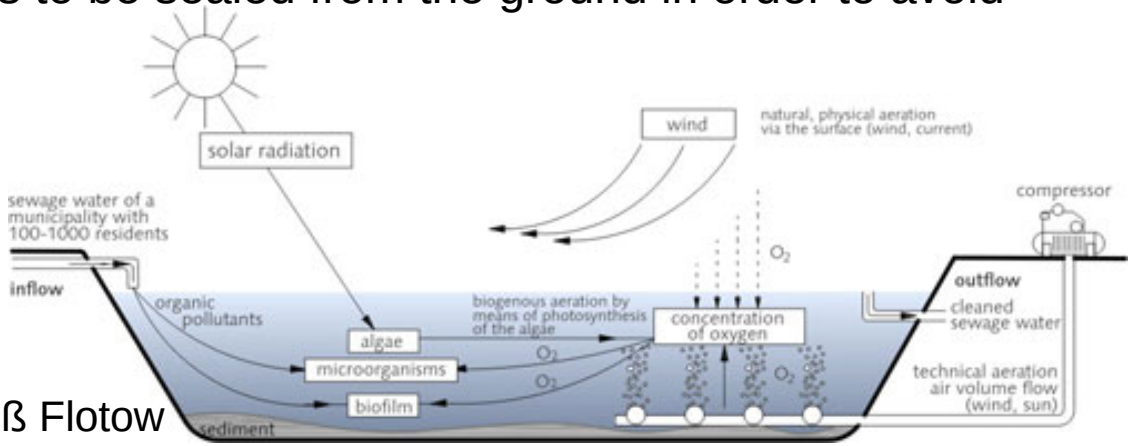
underground irrigation

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological natural processes - Aerated and non-aerated waste water ponds

Waste water ponds are artificial bodies of standing waters. Bacteria, algae, plant life and animal organisms help clean the water. Micro-organisms in aerobic and anaerobic conditions are responsible for the biological degradation of organic compounds such as carbon compounds and nitrogen. The cleansing duration is up to three months. The area required is from 10-20 m³ per person, the entire water area should not be lower than 100 m². A form of pre-treatment with is also necessary and the pond has to be sealed from the ground in order to avoid polluting the groundwater.

Aerated waste water pond Groß Flotow

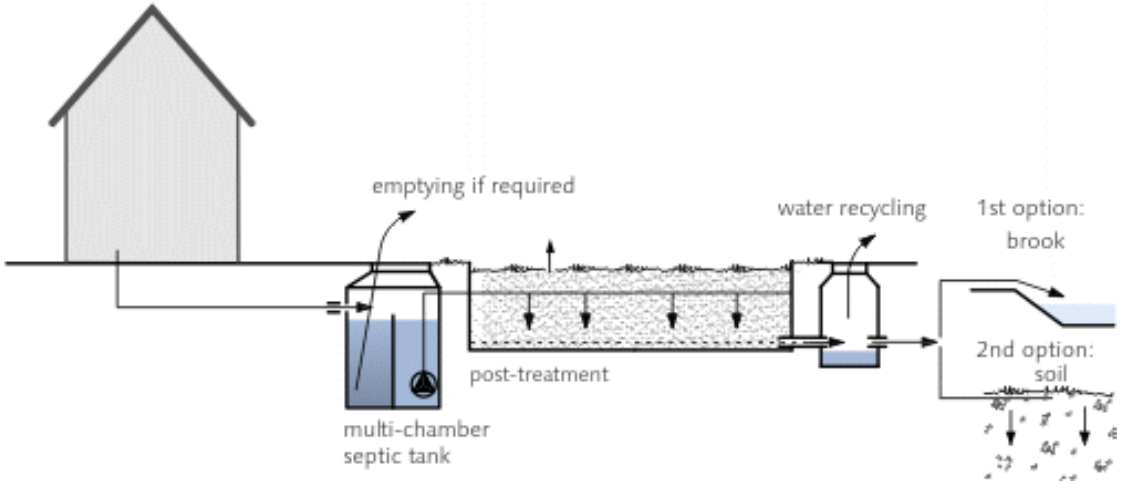


Oxygen balance of an non-aerated waste water pond

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological natural processes - Reed-bed treatment systems / soil filters

Domestic waste water and industrial waste water, also the water flowing off exterior surfaces (motorway run-offs,...) is suitable for treatment with plant based systems. Reed bed or soil filters are particularly apt for rural situations, where there are often no drainage systems. Such filters represent a cheap and ecological alternative. A reed bed treatment system is essentially a sand filter planted with wetland vegetation. Waste water for RBTS-systems require pre-treatment.

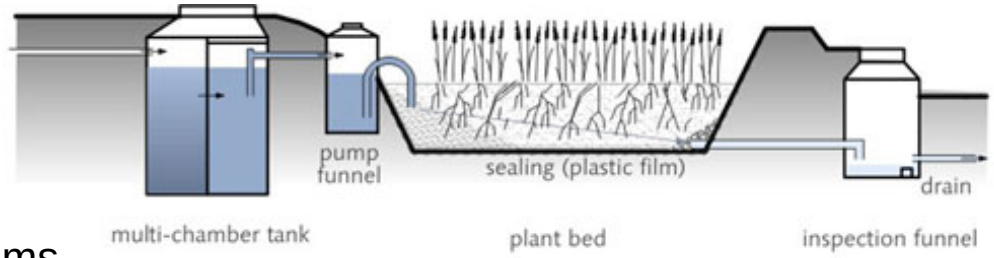


Decentral. sewage systems consisting of multiple-chamber anaerobic digestion and soil filter

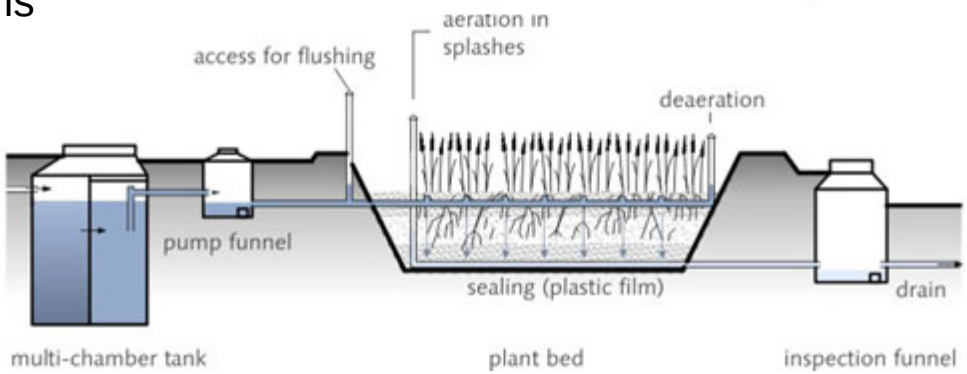
Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological natural processes - Reed-bed treatment systems / soil filters

Horizontal flow systems require 5 m²/person with a depth of 80 cm. Horizontal systems are less prone to odour as they are fed beneath the surface. Vertical flow systems for black water treatment require 3 m²/p with a depth of 100 cm, and only 2 m²/p for grey water. Vertical filter systems are fed from above.



Horizontal flow reed-bed treatment systems



Vertical flow reed-bed treatment systems

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological natural processes - Root system treatment

The root system treatment is a special kind of reed-bed system in which water is fed horizontally through the root system of reed plants and a relatively cohesive soil is used. Micro-organisms living in the root system of plants break down organic substances as well as nitrogen and phosphor compounds.

Legal regulations the European community has approved decentralised water treatment systems, including RBTS systems, as a viable means of long-term waste water treatment. For sewage treatment serving up to 1000 dwellings requirements are set according to a staggered system for removing oxygen degrading contamination given as values for the chemical oxygen demand (CSB) and biological oxygen demand (BSB).

There are no minimum requirements for small-scale treatment plants serving up to 50 dwellings. They are usually certified as fulfilling DIN 4261.

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological purification processes – technical processes

Technical treatment methods are typically employed in urban situations, as their volume and area requirements are lower. The disadvantage here is that they require more energy input for operation and are therefore costlier as natural methods. Such means include:

trickling filter plants
(submerged) rotary biological contactors
activated-sludge plants and more complex multi-stage methods such as sequence-batch-reactors
membrane filter techniques

Plant in Aalen with aeration and after clarification basin

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological purification processes – technical processes

Technical purification processes can be:

- **aerobic treatment methods:** - activated-sludge plants
  - trickling filter methods
- **anaerobic treatment methods**

Aerobic techniques require the addition of oxygen. The oxygenation helps micro-organisms to break down soluble material in the waste water.

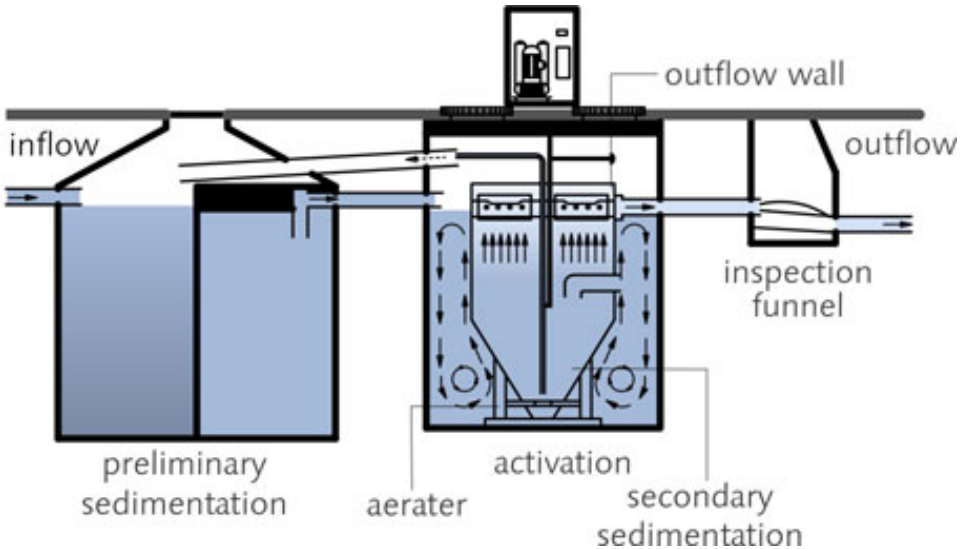
Anaerobic treatment methods aim to reduce the organic contamination of sewage, to reduce its volume and improve dehydration. They are particularly suited to processing heavily contaminated wastewater, mainly from foodstuffs, animal food and paper industries. They can be used to acquire methane gas. Biogas can be used to power a combined heat and power plant.

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological technical aerobic processes - Activated-sludge process

Sewage is fed into open containers and oxygenated. The bacteria convert the biologically degradable material into hydrocarbons, water and organic matter. Sequential systems that dam up the waste water prior to treatment (SBR, BIOCOS – Biological combined system) have become most widespread. These do not require further subsequent clarification.

aerated fixed-basin reactors
Sequence-Batch-Reactor (SBR)

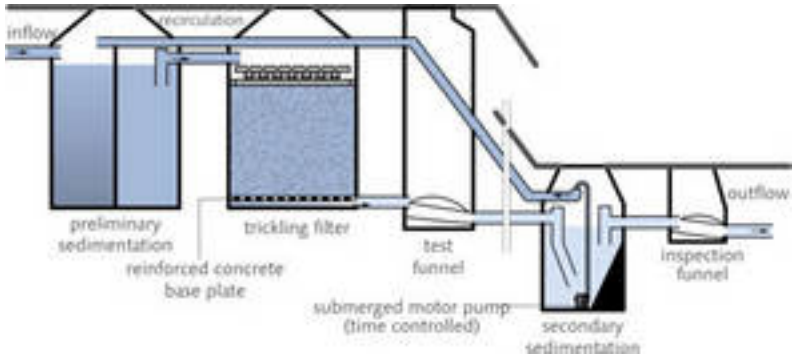


Small activated sludge plant

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological technical aerobic processes - Trickling filter clarification

Trickling filter clarification methods feed pre-cleaned waste water over mechanical aerator-filters in the form of permeable tanks, drums or discs often made of plastic. The waste water trickles over and through the fill material of the filter to the base of the drum and is biologically cleansed by micro-organisms within the filter. The water is collected at the base of the plant and fed into a post-purification plant. Trickling filter installations are less susceptible to breakdowns than activated sludge methods.

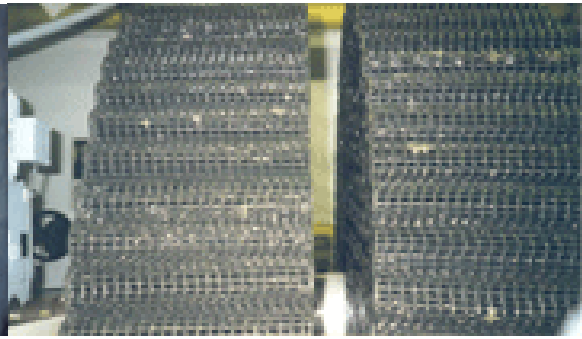


Trickling filter clarification plant

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological technical aerobic processes - Biological contactor process

Biological contactor plants, also known as rotating biological contactor (RBC), consist of discs with a diameter of 2 to 3.5 m mounted on a horizontal shaft. The lower parts of the rotating discs are immersed with the waste water; the upper parts are exposed to the air. The discs are made of plastics. During operation, biological growth of 1.5 to 4 mm becomes attached to the discs. Because of the rotating action, the discs are alternately exposed to waste water and air, which provides aeration and oxygen for the micro-organisms. These micro-organisms digest the organic compounds of the waste water.

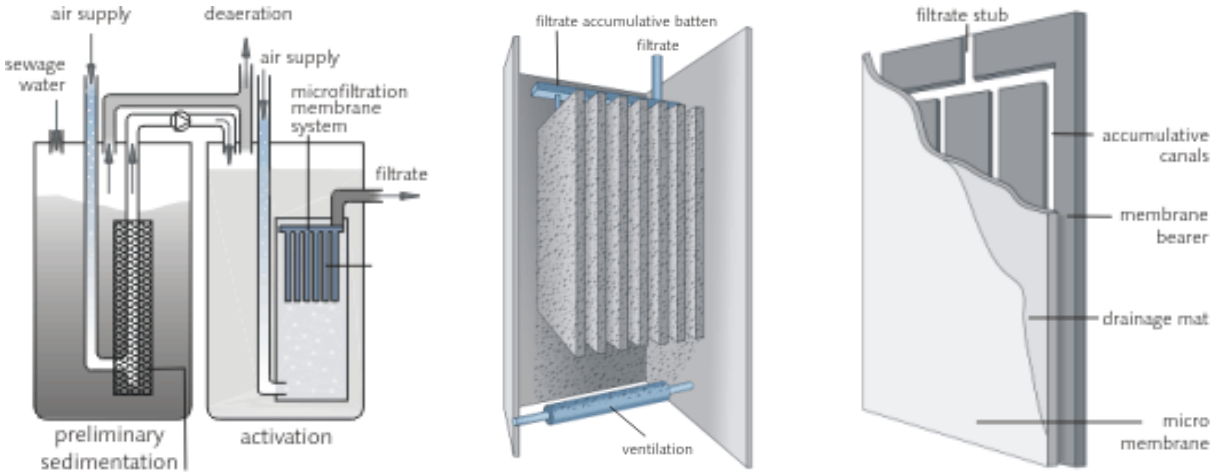


Plunging trickling filter plant, Submerge disc clarification plant

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Biological technical aerobic processes - Membrane filter processes

It is a new process of waste water treatment. Besides the common carbon and nutrient elimination, it even removes bacteria and fungi, while only some viruses are taken out from the waste water. After the mechanical pre-treatment, the water is pumped to the aeration section. At this stage the organic compounds are biologically degraded by aerobic micro-organisms. Subsequently, membrane filters with 0.1–0.4 µm pore size actually purify the waste water. To guarantee smooth operation, the membranes require periodic maintenance.



Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Mechanical-biological treatment, chamical purification processes

The common mechanical-biological treatment degrades about 90 % of the biological degradable ingredients. These ingredients are mainly carbon compounds, which can be easily degraded by aerobic processes in a short space of time. Often waste water contains problematic substances which can not be removed neither in the mechanical process nor in the biological treatment. These substances, e.g. phosphor compounds can only be removed by chemical and/or additional biological purification (tertiary treatment).

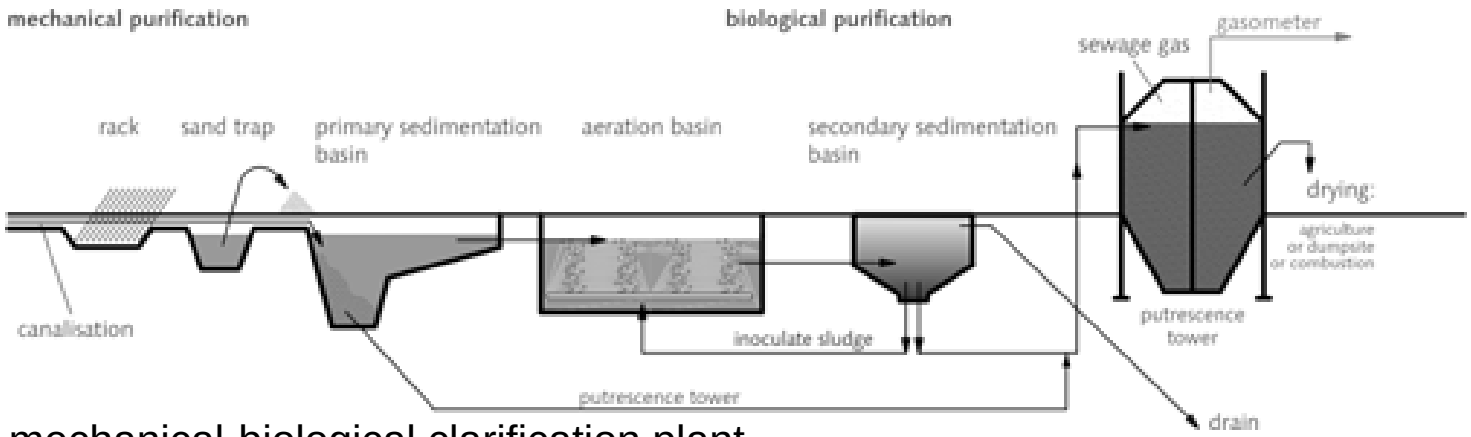
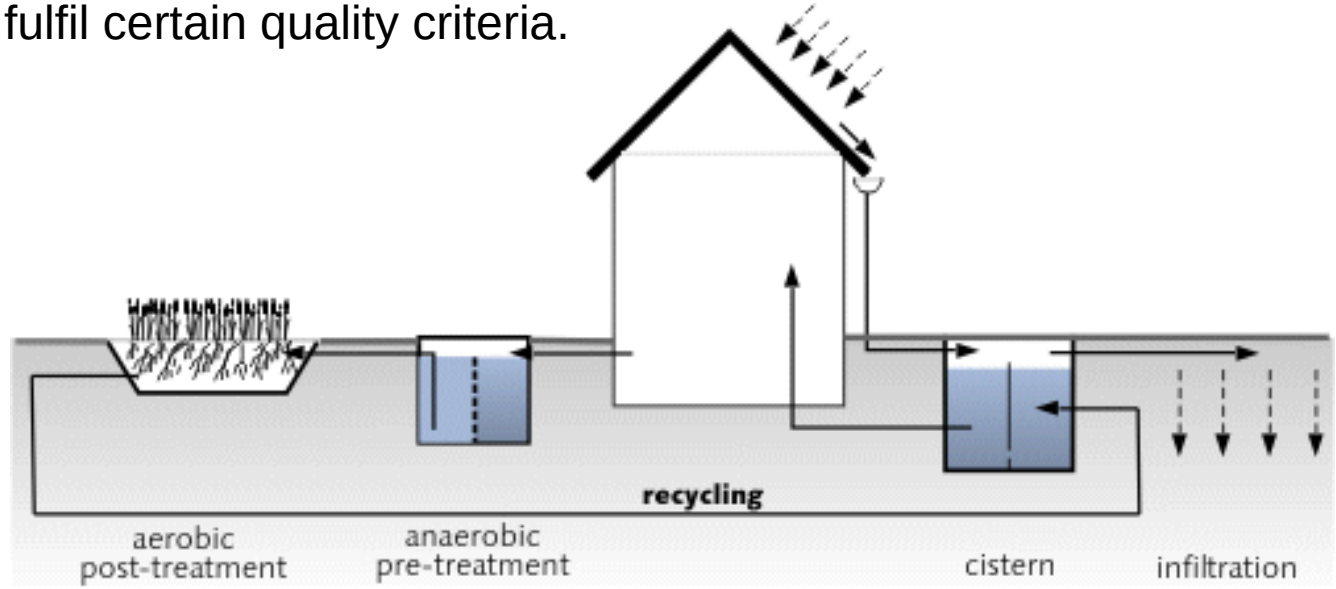


Diagram of a mechanical-biological clarification plant

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Recycling of wastewater or dispersal with a discharger

Treated wastewater can be re-utilised for all processes not requiring drinking water e.g. to irrigate the garden, flush the toilet and possibly for use in the washing machine. This reduces not only the drinking water demand but also the amount of waste water for the drains. Depending upon its use, recycled waste water must fulfil certain quality criteria.



Decentralised waste water treatment and recycling

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Composition of waste water streams

	domestic waste water	grey water	urine	faeces	lavatory flush
quantity	l/(Exa)	50000	500	50	10000
Nitrogen	4 –5 kg/(Exa)	3,00%	87,00%	10,00%	0,00%
Phosporus	0,75 kg/(Exa)	10,00%	50,00%	40,00%	0,00%
Potassium	1,8 kg/(Exa)	34,00%	54,00%	12,00%	0,00%
Carbon	30 kg/(Exa)	41,00%	12,00%	47,00%	0,00%
pathogens	-	existent	barely existent	highly existent	barely existent
		treatment	treatment	fermentation,compost	treatment
		water cycle	food cycle		water cycle

Quelle: http://ecologic-architecture.org/main/

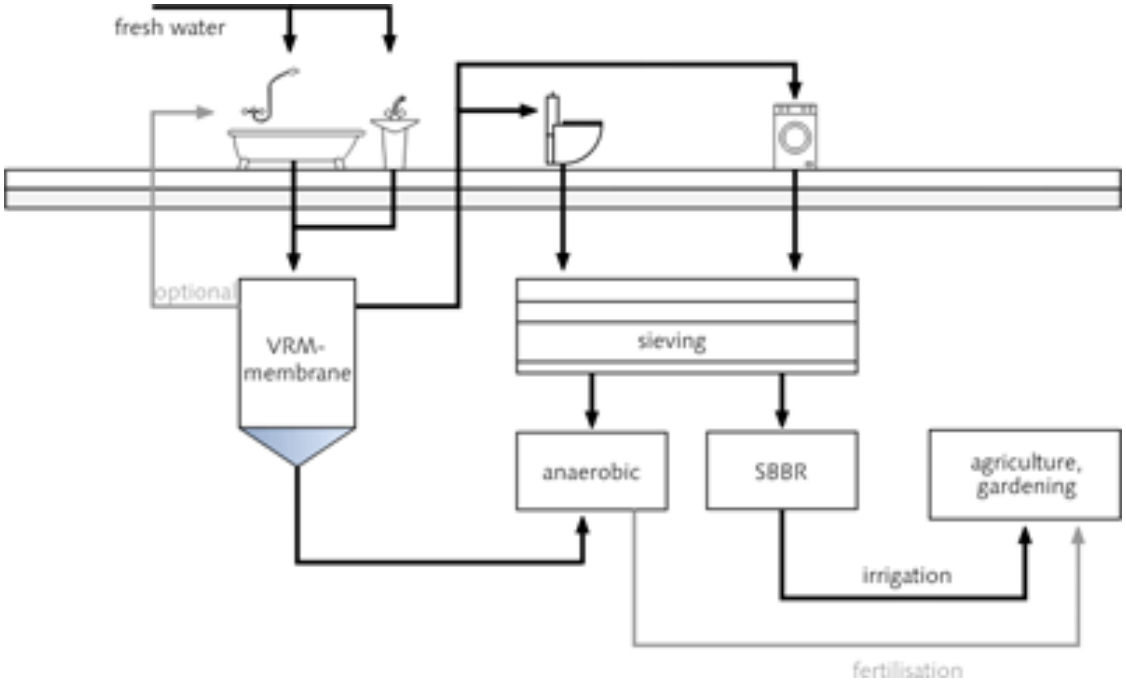
Water - Wastewater management
Treatment and utilisation of waste water streams

waste water streams	treatment	utilisation
rainwater	filtration, biological treatment	water supply, groundwater recharge
grey water (shower, bathroom, washing machine)	biol. sewage treatment, waste water ponds microfiltration	direct use, irrigation or groundwater recharge
yellow water	sterilisation by storage and desiccation	liqid or dry fertiliser
black water (faeces)	anaerobic fermentation desiccation composting	biogas, soil improvement nutrient recharge
kitchen, bio-waste	aerobic fermentation decomposition container	fertiliser for agriculture

Quelle: http://ecologic-architecture.org/main/

Water - Wastewater management
Scheme of an integrated sanitary concept

Special sanitary installations separate waste water from the toilet and that from the kitchen and bathroom and separate faeces and urine so that nutrients from urine such as nitrogen and phosphor can be used more easily.



Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management

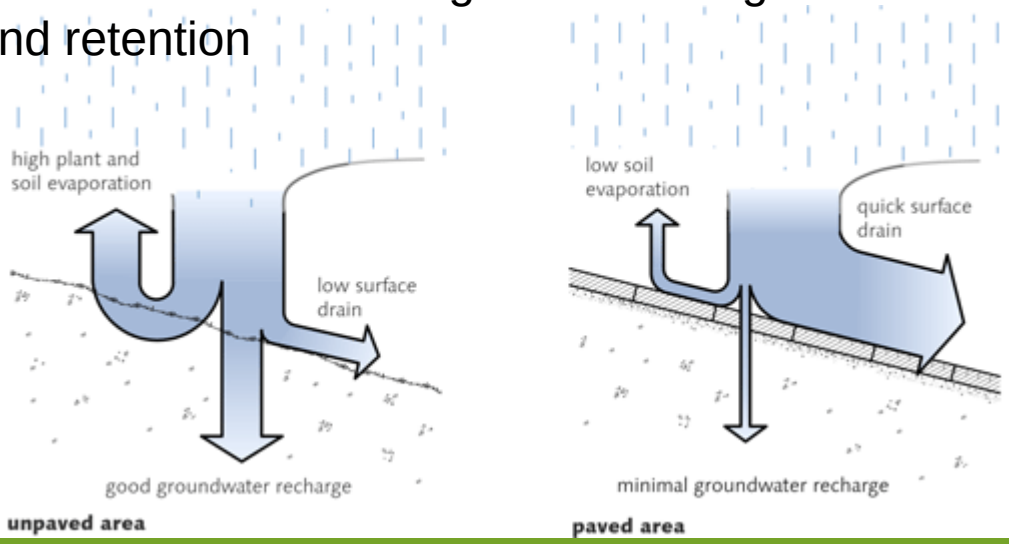
Water - Rainwater management
Rainwater

- because rainwater in built-up areas is classified waste water, it has to be drained and treated in municipal waste water treatment plants
- the rainwater drainage has far-reaching negative impacts on water balance, waters, micro-climate and flora and fauna of cities
- ecological effects of rainwater drainage and the soil sealing are reduced groundwater recharge, increased flood risk, increased pollution by emergency outlets of overloadedsewage treatment plants into streams and a reduction of temperature and humidity equalisation
- there are enormous costs for sewer pipes and retention basins

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater

- natural rainwater management methods positively influence the local water cycle and are based upon the fact that rainwater normally drains into the ground and replenishes the groundwater directly as well as flowing via normal channels into surface water rivers and lakes
- under high rainfall conditions rainwater infiltration is insufficient to deal with large amounts of water and so further rainwater management strategies are required such as its harvesting and retention



Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Possibilities for an environmentally rain water management

The use of rainwater
Rainwater percolation
- surface percolation
- swale and trench percolation
- soak-away pits
- pipe percolation
- infiltration ditch percolation (blind or french drain)
- resp. a combination of different devices)

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater management concept

The following aspects are central to the development of a rainwater management concept:

- precipitation levels
- topography / lowest geographical point
- structure and density of the built environment
- vegetation
- land-use patterns (built area, sealed surfaces)
- contamination sources and levels
- soil conditions and permeability
- groundwater situation
- existence or availability of run-off and infiltration areas
- financial situation / funding programmes

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Sustainable rainwater management - Rainwater retention

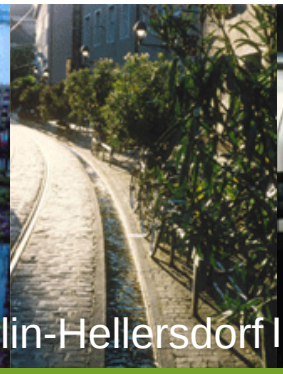
Rainwater is collected in a local storage basin from which it can percolate at a controlled rate as well as evaporate into the atmosphere. Special retention measures are required in densely built areas or where large quantities of rainwater run-off can occur at short notice. Rainwater retention systems are also used to pre-clean more contaminated run-off water.

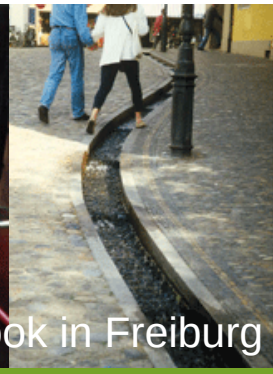
They can also be used in combination:

green roof or collection roof, filter trench, retention pond, ditch or hollow, retention filter basin, retention basin

Rain water retention in Berlin,

Heinrich-Böll-Quarter and Berlin-Hellersdorf

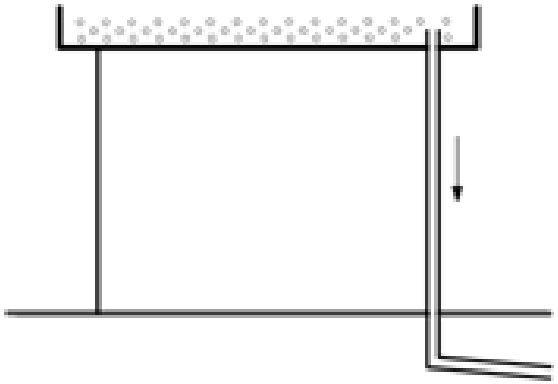



Inner city brook in Freiburg

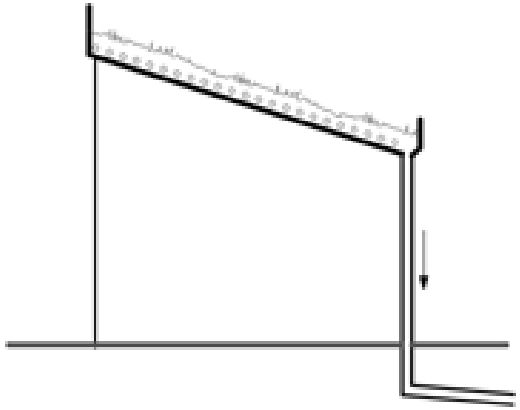
Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater retention - Green roofs

The principle of **green roof**s and **collection roof**s is the retention of rainwater by the planting or construction of retention basins on the roof. Both constructions act as water reservoir and contribute to the natural water cycle. The implementation of green and collection roofs is favourable in densely built-up areas. green roofs act as filter substrate, which purifies the water biologically and mechanically. Potential pollutants might be filtrated by the plants and the growing medium.



Principle of collection roof

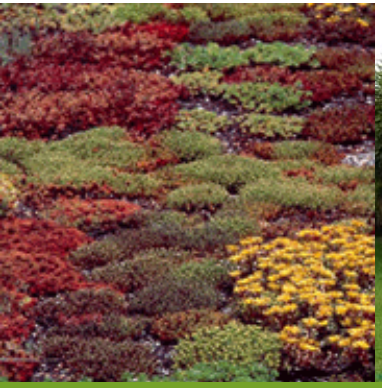


Principle of green roof

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater retention - Green roofs

The two different forms of green roofs are **intensive and extensive** green roofs. The evaporation capacity depends on temperature and saturation level of the air and on vegetation. Basically, the evaporation capacity of intensive green roofs is higher than the evaporation capacity of extensive green roofs. Rainwater collection may not be practical, depending on the amount of additional drinking water provided. Substances that influence water quality can be washed out of the growing substrate. Microbiological processes and fertilisation may cause adverse effects like odour, turbidity or colouring.

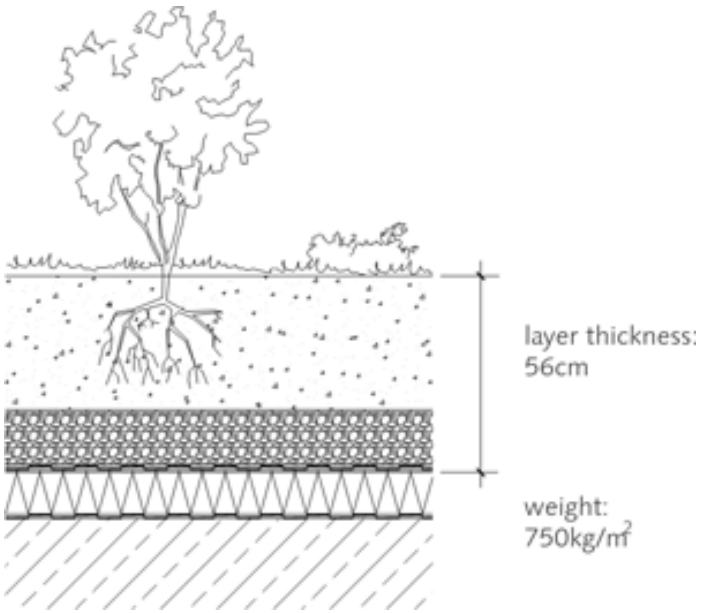


Quelle: http://ecologic-architecture.org/main/

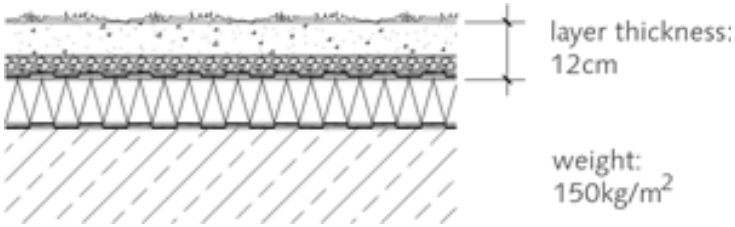
Water - Rainwater management
Rainwater retention - Green roofs

Construction of Green Roofs

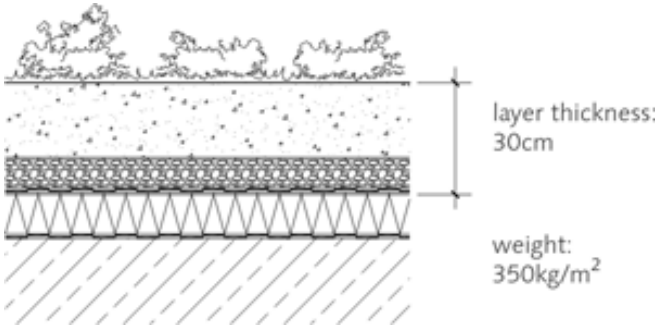
vegetation layer
growing medium
filter layer
drainage layer
protection and water-holding layer
root barrier



Construction of an intensive grass roof



Construction of an extensive grass roof

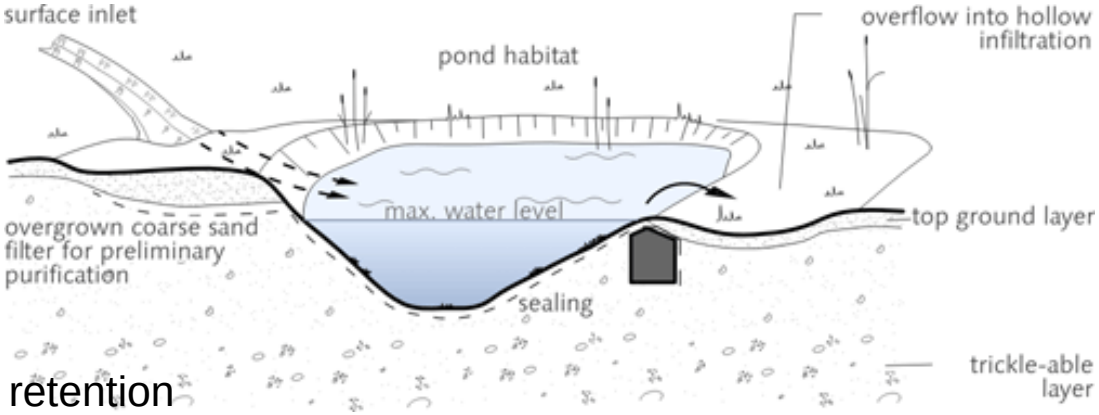


Construction of an intensive grass roof (simple)

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater retention - Retention pond

Ponds for rainwater retention serve to support the temporary storage of on site rainfall-water. A retention pond consists of a pond or ditch sealed against subsoil penetration together with an attached infiltration strip. The infiltration pond is only sealed deep below. After heavy rain, the pond dams the water to its maximum volume. At the same time, the infiltration on the pond edge begins. The degree of evaporation is very high. Retention ponds achieve a high degree of clarification of the water. This kind of retention is inexpensive, it supports biotopes and it is an element of open space design.

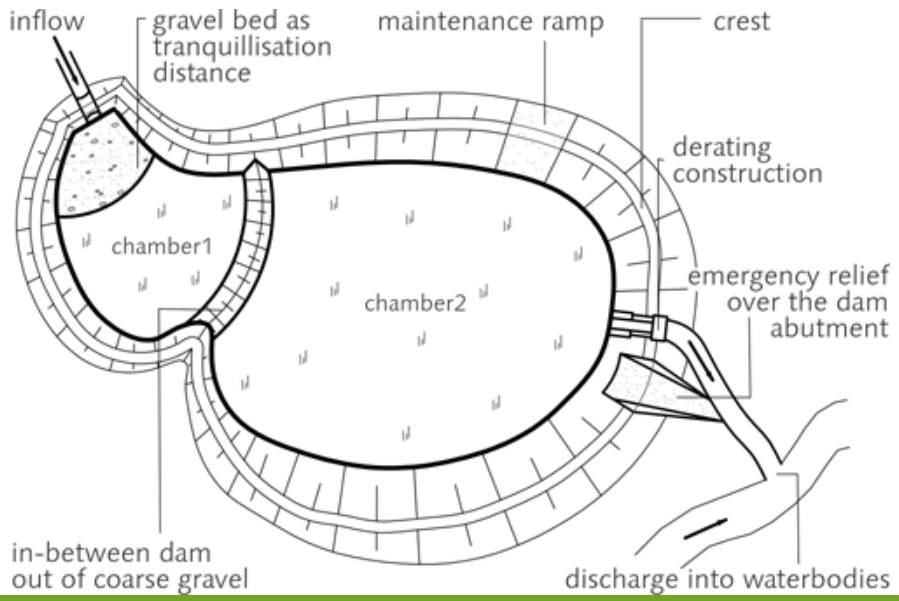


Structure of a pond for rain water retention

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater retention - Retention basin

Retention basins have a considerable storage capacity and a throttled outflow. The process provides a reduction of the peak outflow and it regulates the discharge into further retention and clarification systems.It has low clarification capacity, the floor space required is high. Remnants of sedimentation have to be periodically removed. Maintenance includes technical equipment.

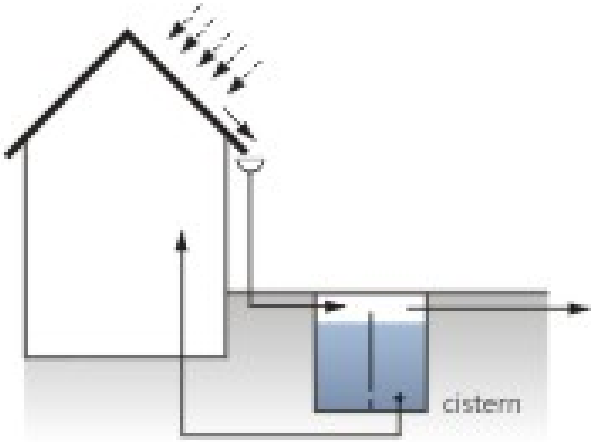


Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Sustainable rainwater management - Rainwater utilisation

Rainwater can be used for a variety of purposes where strictly speaking pure drinking quality is not required. This includes water for

watering the garden
water for cleaning
for flushing the toilet
using in the washing machine
a range of industrial, agricultural
and commercial tasks



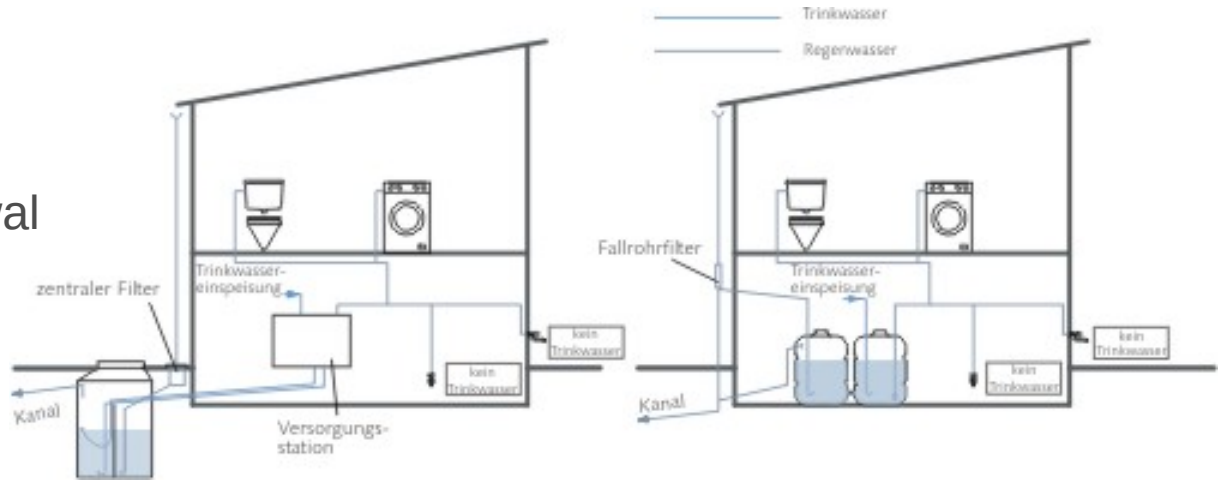
Rainwater utilisation systems are technically relatively simple systems, and are economical and problem-free in use. Rainwater run-off from the roof is collected in a tank or cistern and stored until it is required. The system can be topped up with drinking water in dry periods.The roofing material influences the quality and quantity of the collected rainwater.

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater utilisation - components

A rainwater utilisation system consists of the following components:

collection area
filter system
storage tank
emergency overflow
drinking water top-up
pump
distribution piping and
point for water withdrawal



Rainwater utilisation system with outdoor cistern respectively indoor tank

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater utilisation - calculation

Calculation to determine storage tank size – demand size approach

A very simple method is to calculate the largest storage requirement based on the consumption rates and occupancy of the building.

Storage requirement = Daily consumption x Longest average dry period
Daily consumption = Consumption per capita per day x Number of people

This simple method assumes sufficient rainfall and catchment area, and is applicable in areas where this is the situation. It is a method for acquiring rough estimates of tank size.

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater utilisation - calculation

Calculation to determine storage tank size – supply size approach

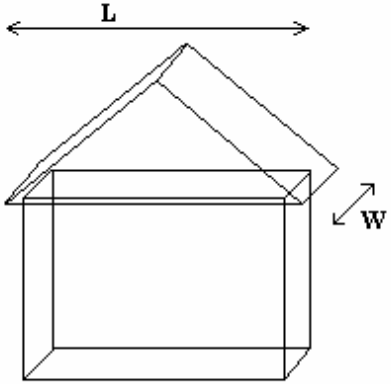
AR(mm) x ECA(m2) x RC(%) x FE(%) x 0,05

AR - the annual rainfall, the annual rainfall of Germany is 760 mm/a

ECA - the effective collection area is equal to the area of roof or hard surface that can be reasonably used to collect rainfall

RC - the runoff coefficient is an incisive factor for the evaluation of material surface in connection with water retention and correlates with percolation behaviour of collecting areas, areas with a low runoff coefficient absorb a lot of water and only a small amount of water runs off

FE - filter coefficient, manufacturers usually advise that 90% of the water flowing into the filter is retained so a filter coefficient of 0.9 can be used in the calculation



Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater utilisation - the runoff coefficient

type of area	material, surface	Ca (ψm)
pitched roof	metal, glass, slate, fibrated concrete roofing tiles, roofing paper	0.9–1.0 0.8–1.0
flat roof (roof pitch up to 3° or approx. 5%)	metal, glass, fibrated concrete, roofing paper, gravel	0.9–1.0 0.9 0.7
green roof (roof pitch up to. 15° or approx. 25%)	humous < 10cm construction humous > 10cm construction	0.5 0. 3
streets, pathes and squares (flat)	asphalt, jointless concrete paving with dense joints layer of gravel paving with open joints loose layers of gravel, gravel lawn interlocking pavers with open joints turf pavers	0.9 0.75 0.6 0.5 0.3 0.25 0.15
slopes and ditches with rainwater drainage into drainage systems	clayey soil loamy soil gravel and sand soils	0.5 0.4 0.3
gardens, grassland and cultivated land with possibility of rainwater drainage into drainage systems	flat terrain steep terrain	0.0–0.1 0.1–0.3

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater utilisation - coefficient 0.05

After knowing how much water we can collect, the next step is to estimate what size tank can be required in practice. The general rule is that the tank size should be around 5% of the annual rainwater supply, or of the annual demand. Therefore a coefficient of 0.05 is applied to calculate 5% of the annual rainwater supply. This final step in the equation gives the estimate of the tank size required. The tank capacity is scaled to cover the demand for one, three or six months.

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Sustainable rainwater management - Rainwater percolation

Rainwater is filtered naturally by the soil. It can therefore safely be allowed to percolate into the groundwater as long as it passes through at least 1m of unsaturated soil before it reaches the ground water level.
In order to maintain the local water cycle, a decentralised rainwater infiltration or percolation is necessary, i.e. at or near to where the rain falls.

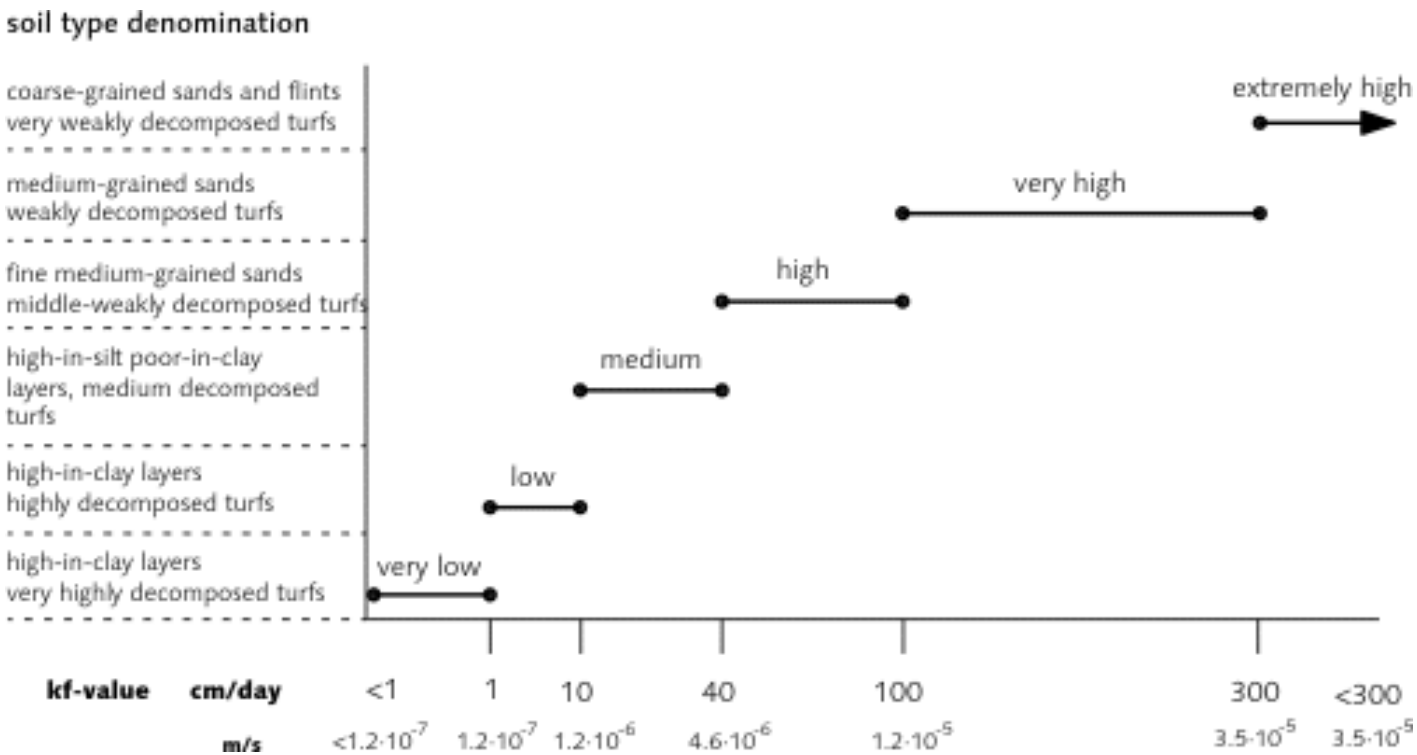
Prerequisites for rainwater infiltration systems are as follows:

hydraulic permeability of the soil (between kf = 5·10-3 to 5·10-6 m/s)
sufficient cleansing ability of upper soil levels
sufficient depth of the natural groundwater level (min. 1 metre)
groundwater conveyors of sufficient capacity
lower-lying buildings are not endangered
conservation of water and soil quality

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation

Classification of water permeability according to type of soil



Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation

There are two principal methods of rainwater infiltration and these are **surface percolation** and **underground infiltration**.

When planning urban environments, above ground methods are typically simple and economical to achieve in conjunction with a general de-sealing of surfaces. Specific measure include the following:

permeable surface percolation
trough percolation
basin percolation

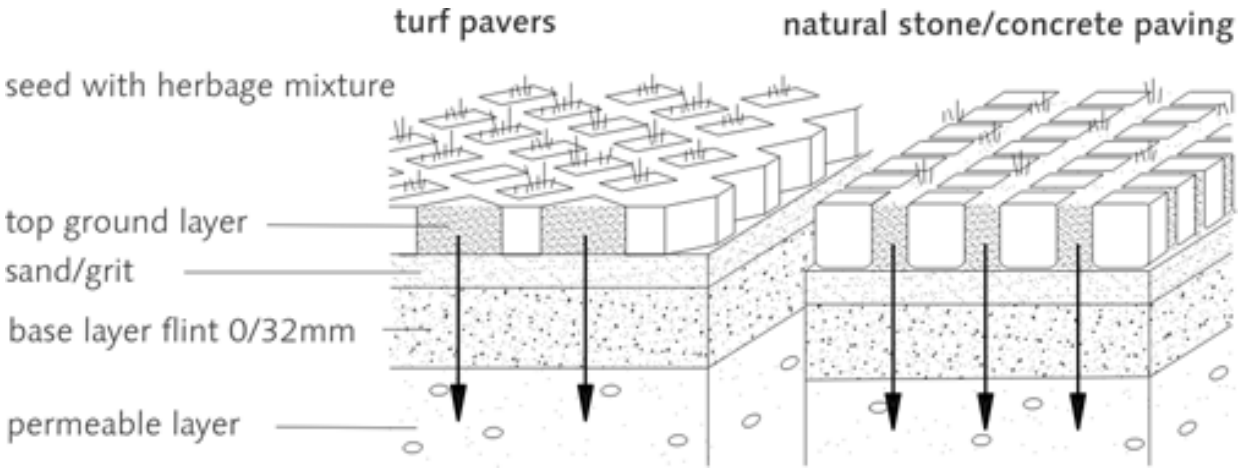
If there is not sufficient surface area available for the retention and infiltration of rainwater, underground methods can be employed. These are the following:

soakaway-pits
drain pipes
blind drains or gravel-filled infiltration ditches

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – Permeable surface (overground) percolation

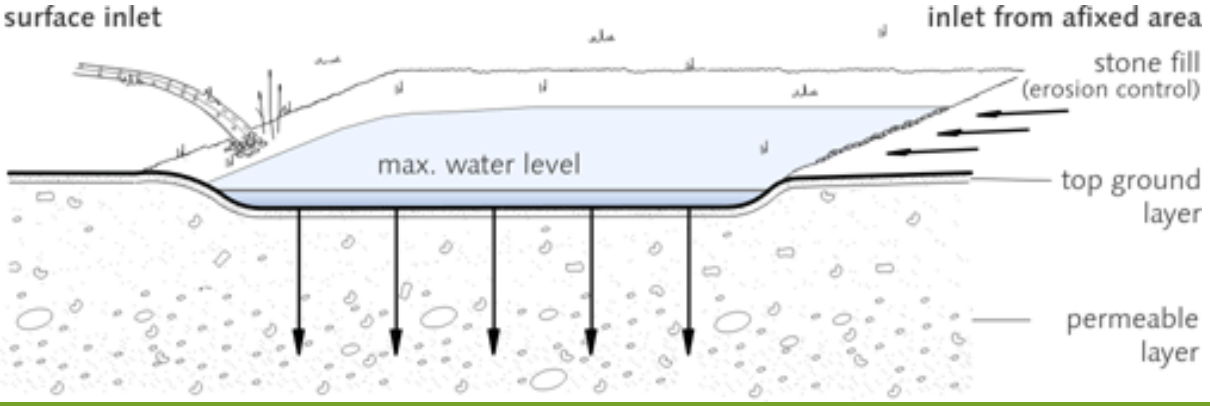
Surface percolation is suitable for parking spaces, courtyards, squares, paths and access ways. The surface can be made green (grass or lawn paving blocks) or gravelled or paved with porous slabs or cobbles. The surface should be permeable enough to cater for the amount of rainfall expected. Key parameters in determining the degree of permeability are the available surface area, possible neighbouring feeding areas (sealed) [m²], the amount of precipitation expected [l/s*ha] and the soil permeability kf [m/s].



Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – Trough (overground) percolation

The trough percolation involves the short-term retention of surface water, i.e. the rainfall is led into a trough or hollow sometimes known as a swale and then seeps gradually into the ground. The water retention period should not exceed one to two days. A greened trough should be no deeper than 30 cm so as not to present a danger to children, and the slope should be around 1:2. Troughs or hollows are inexpensive to build and maintain, have a lasting effect and can easily be integrated into the landscaping. As a rule of thumb, 10-20% of the area to be served is required for the trough or ditch.



Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – Basin (overground) percolation

The principle of basin percolation is very similar to that of trough percolation except that they are deeper and the retention duration can be longer. To avoid accidents such basins should be fenced off. The slope should not exceed 1:1½.

As with both the previous systems the soil serves to clean the water before it reaches the groundwater. The basin is able to retain more water and the clean-sing of the water can be improved by integrating a series of settlement zones.

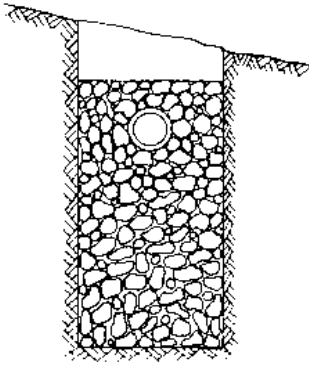
Basins are easily incorporated into landscaping and additionally provide a habitat for plants and animals. Due to their size and capacity they are only suited to larger urban areas of sealed surfaces with enough open space to accommodate them. Maintenance involves regular checking and cleaning of the basin: removal of collected sludge and hardened earth deposits and vegetation control.

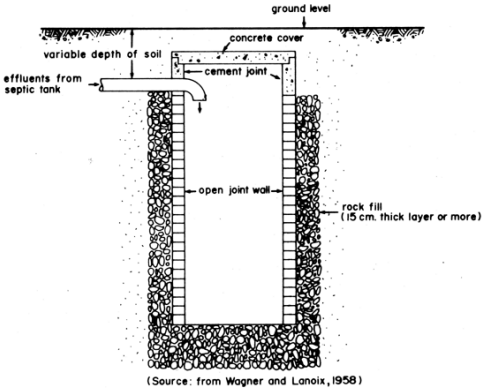
The necessary volume of a basin is dependent upon local parameters such as soil permeability, precipitation levels, available area and run-off surface etc.

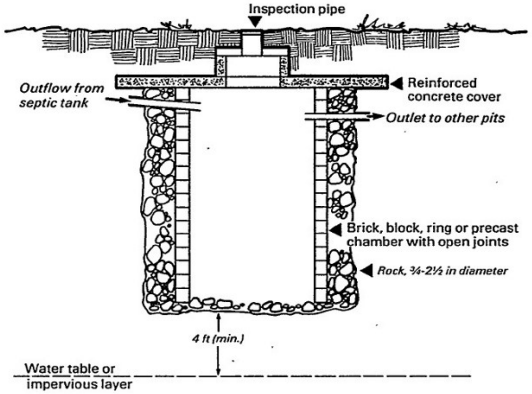
Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – Soak-Away Pit (underground percolation)

Soak-away pits involve the concentration of run-off water in a shaft leading into the ground. Rainwater can be collected from sealed surfaces, retained and allowed to dissipate gradually according to the permeability of the soil. The soak-away pit is embedded in a gravel filtrate that helps pass the water into the permeable soil around it. As the soak-away pit has no cleansing effect of its own, it is advisable to first sift surface water through a settlement chamber or light material separator.







Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – Soak-Away Pit (underground percolation)

The inflow of the water can be arranged above or below the ground. The sludge that settles at the bottom of the soak-away pit should also be removed from time to time. A combination of several soak away pits connected in series, improves the percolation ability of the water.

This system is best suited for individual buildings. Not much space is required and the plot can be used to its maximum potential. The disadvantage of such systems though is that it needs regular maintenance and that there is the possibility that it can gradually clog up, which is costly to remedy.

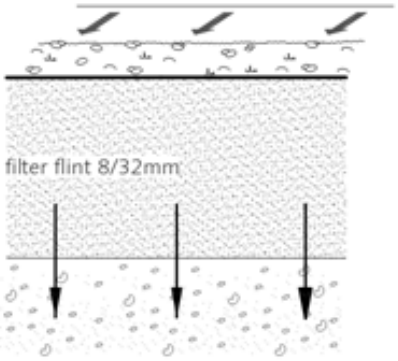
According to DIN 4261 part 1 small domestic treatment work; treatment works without aeration: the required percolation area depends on the permeability of the soil and the water level in the shaft; depending on soil type, the area required is 1-2.5 m^2 per inhabitant

shaft diameter > 1m; minimum distance to groundwater 1m

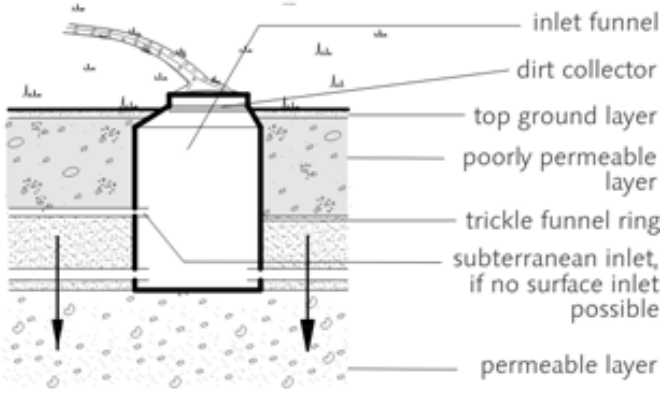
Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – French (blind) drain (underground percolation)

A French drain collects run-off water and feeds it into a drainage trench filled with gravel. The trench can collect water as it is or be fed by a pipe. Such a pipe system requires a distribution pipe within the gravel bed, distributing the water horizontally. French drains do not provide much in the way of water cleansing unless the water passes through a soil layer.
The size of a French drain is dependent upon the area of run-off surface it caters for, the permeability of the surrounding soil and local precipitation levels.



inlet by means of open plane trench

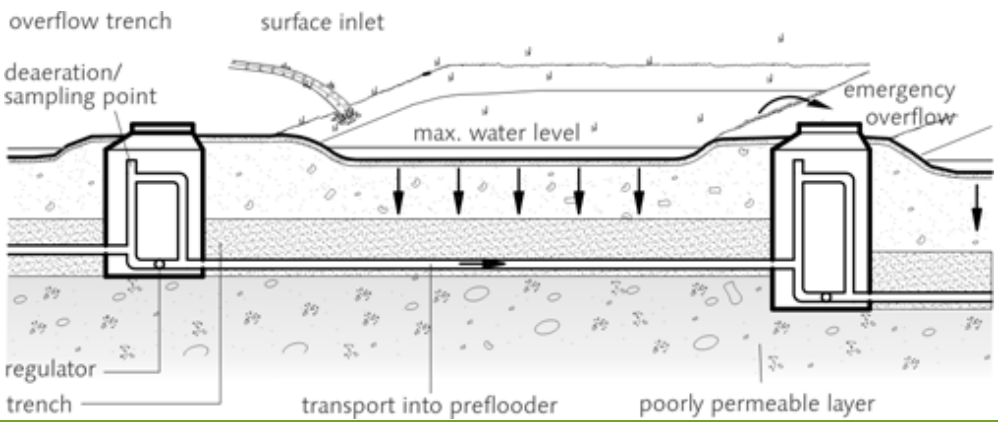


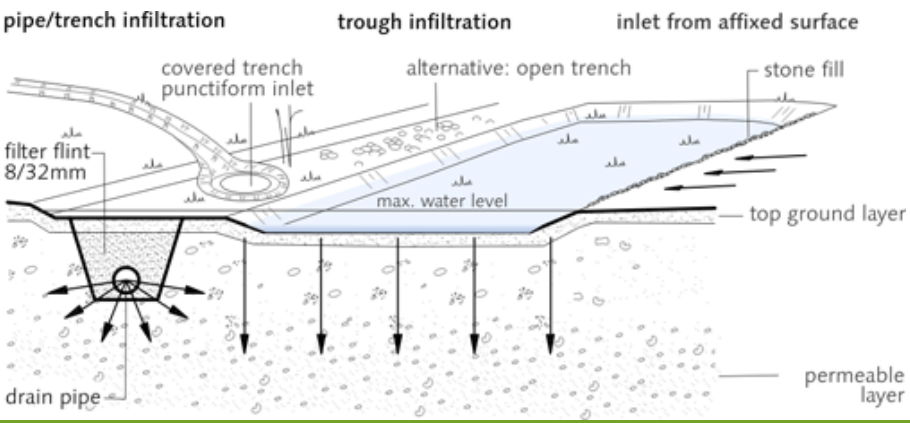
inlet by means of closed punctiform trench

Quelle: http://ecologic-architecture.org/main/

Water - Rainwater management
Rainwater percolation – Trough-french drain system (combined system)

A combined infiltration/percolation system allows a delayed percolation of surface water. If the soil is sufficiently permeable, the combination of both systems can serve as an extended infiltration system. The low trough retains the water to a degree until it percolates into the soil. The French drain and drainage pipe distribute the seepage water or collected water across a larger area of the soil. If the permeability of the soil is insufficient for direct percolation a combined system can then serves as a retention system. The percolation is delayed and the run-off water is cleaned to a limited degree prior to discharge into a body of water.





Quelle: http://ecologic-architecture.org/main/

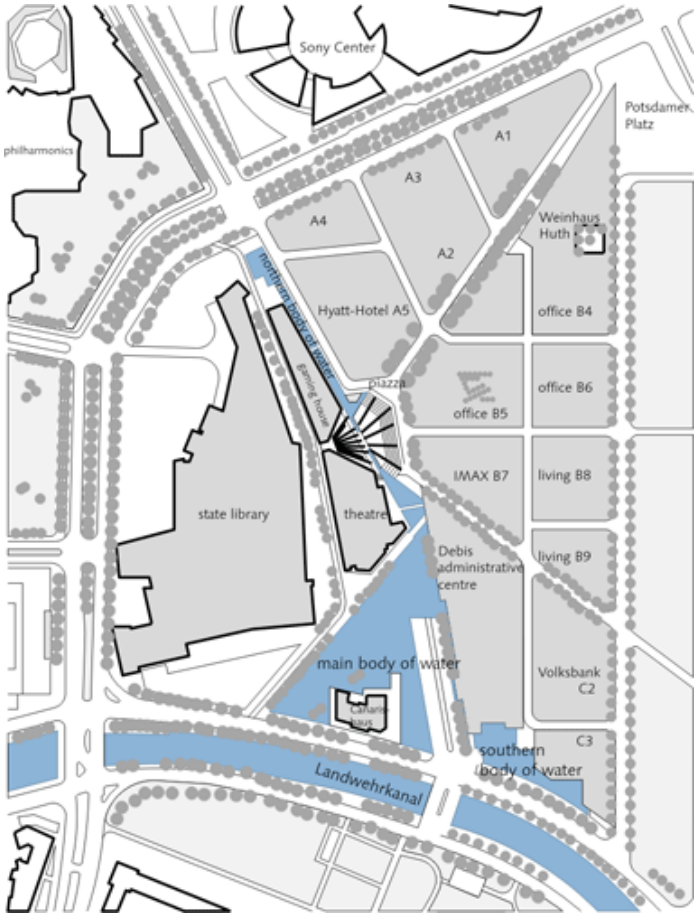
Water - Examples

Potsdamer Platz, Berlin - Studio Dreiseitl, Überlingen/Lake Constance

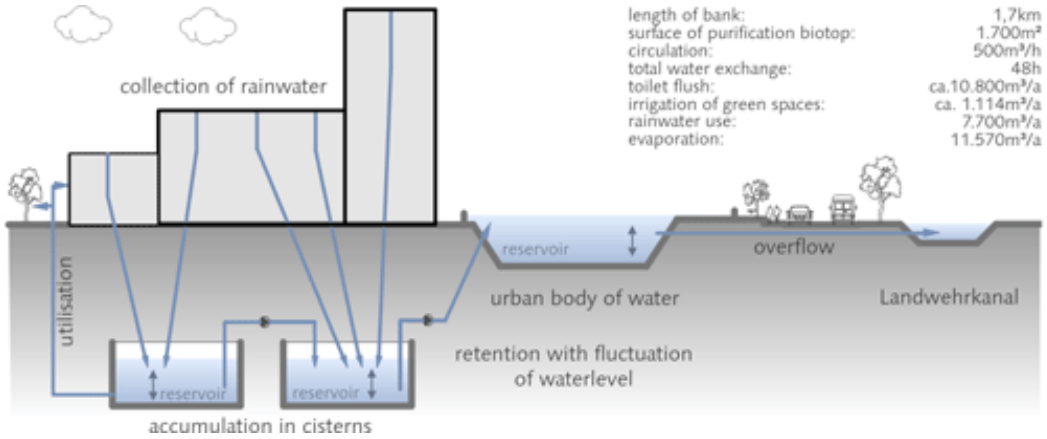
- Use of rainwater
- Water retention - the rainwater is collected in cisterns and is channelled via pumps into man-made backwater ponds
- The backwater pond is designed to fulfil the function of urban water, people can experience standing and flowing waters
- The backwater pond could be used as flood protection, the peak runoff water from heavy downpours can be collected in a pond; this water can be later conveyed into a canal
- Occasional algae formation is removed by maintenance

Quelle: http://ecologic-architecture.org/main/

Potsdamer Platz, Berlin - Studio Dreiseitl, Überlingen/Lake Constance



Ground plan Potsdamer Platz



Water system of Potsdamer Platz

Green Building

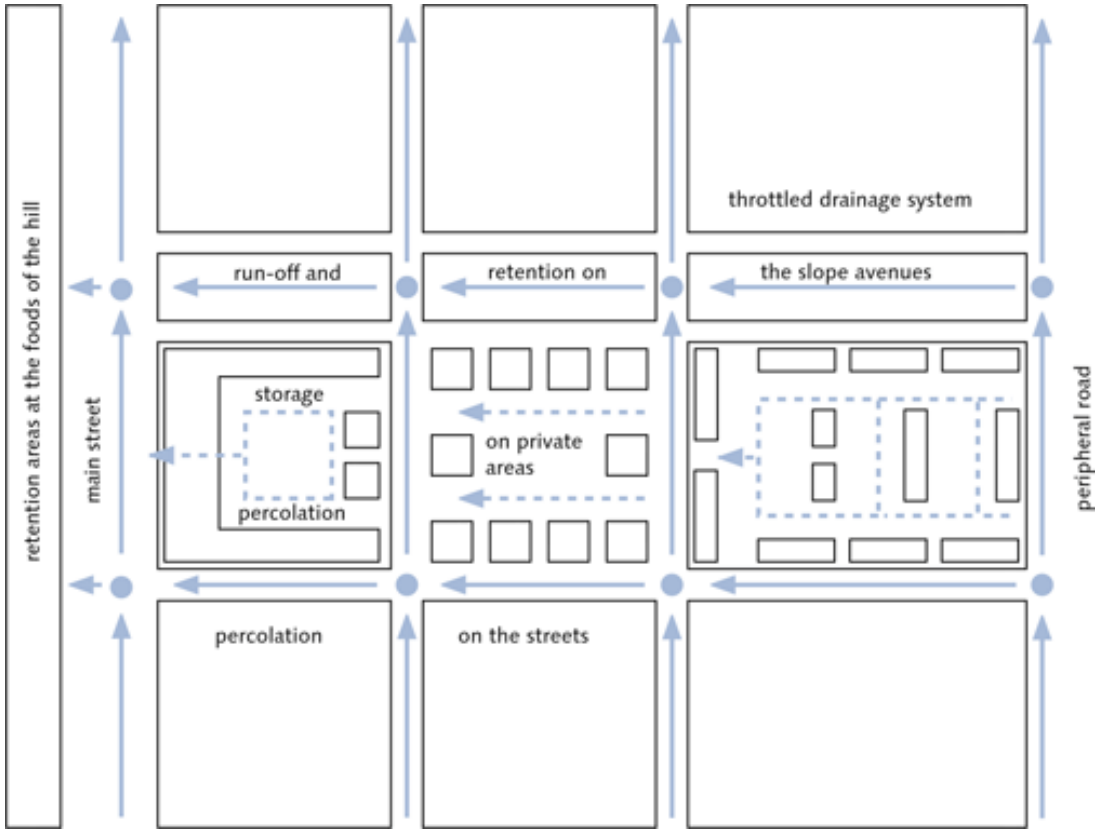
Quelle: http://ecologic-architecture.org/main/

Hanover-Kronsberg - ARGE Dreiseitl/Company for Urban Hydrology

- the water concept of Kronsberg consists of 3 sub areas and these are environmentally friendly rainwater systems, surface area measures for saving drinking water and the raising of awareness amongst people thereof
- an awareness means that water becomes an urban design feature that can be experienced, strengthening the connection between water and people
- the maximum possible rainwater retention and the delayed conduction into local streams - rainwater from the streets is channelled into the French drain system, which allows decentralised percolation
- the two sloped-avenues that cross Kronsberg, with their green corridors, act as cascade retention and percolation areas, the water may slowly evaporate, seep through the soil or is collected in retention areas at the foot of the hill
- all flats are equipped with water breakers, flow limiters and water-saving toilets
- some buildings collect and use rainwater for toilet flushing and garden irrigation

Quelle: http://ecologic-architecture.org/main/

Hanover-Kronsberg - ARGE Dreiseitl/Company for Urban Hydrology



Rainwater concept

Green Building

Quelle: http://ecologic-architecture.org/main/

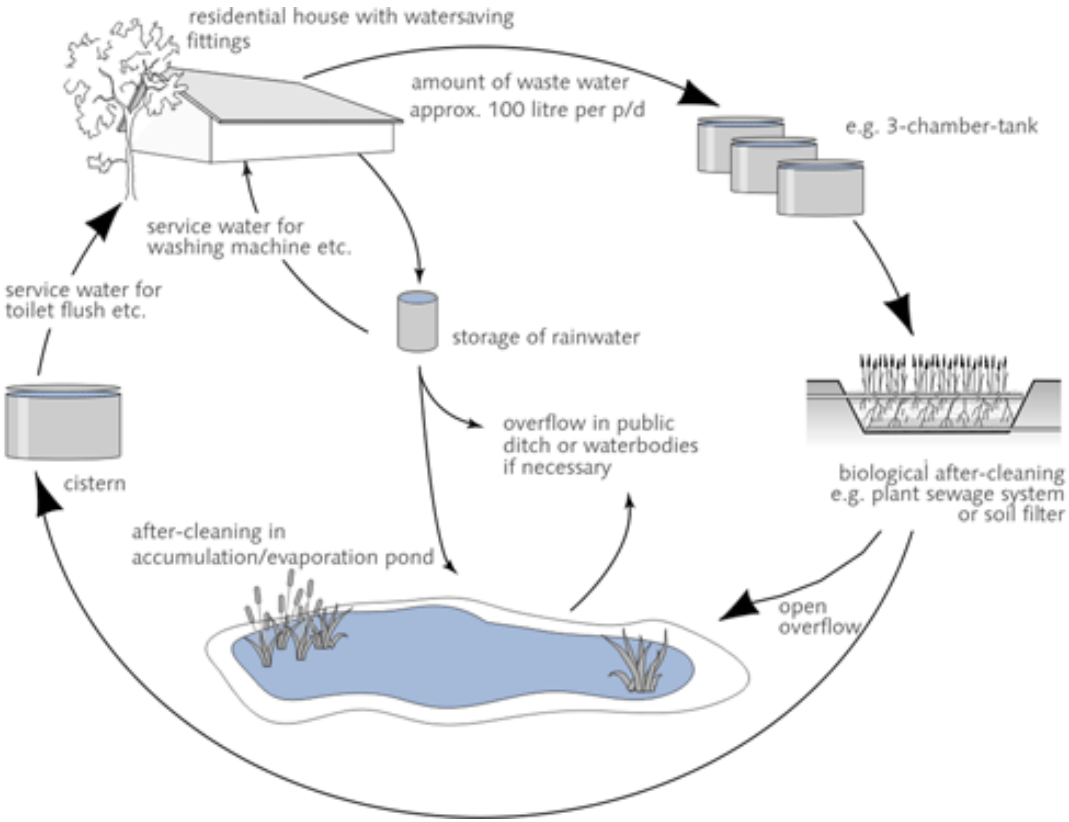
Einbeck-Avendshausen - Detlef Glücklich, Buchholz

- the project “Environmentally Friendly Water Cycle Einbeck” arose from a citizens' initiative against the enforced connection to a centralised waste water treatment plant in 1995
- it became an exhibited project at EXPO 2000, promoting of decentralised environmentally friendly wastewater treatment systems, the main objectives were the formation of local water cycles, its conservation and recycling
- the concept provides combinations of multi-chamber septic tanks with subsequent treatment by reed bed treatment systems or soil filter, according to local conditions, there are single and combined reed bed treatment systems
- after a process of pre-treatment in multi-chamber septic tanks, the water is then clarified in reed bed treatment systems or in soil filters, excessive water is conducted into trenches or ponds that act as biotopes
- if required, the overflow could be channeled in public trenches or in the nearby creek

Quelle: http://ecologic-architecture.org/main/

Einbeck-Avendshausen - Detlef Glücklich, Buchholz

Clarification by plants, Reed-bed filter system



Water cycle of Einbeck-Avendshausen

Polishing pond

Quelle: http://ecologic-architecture.org/main/

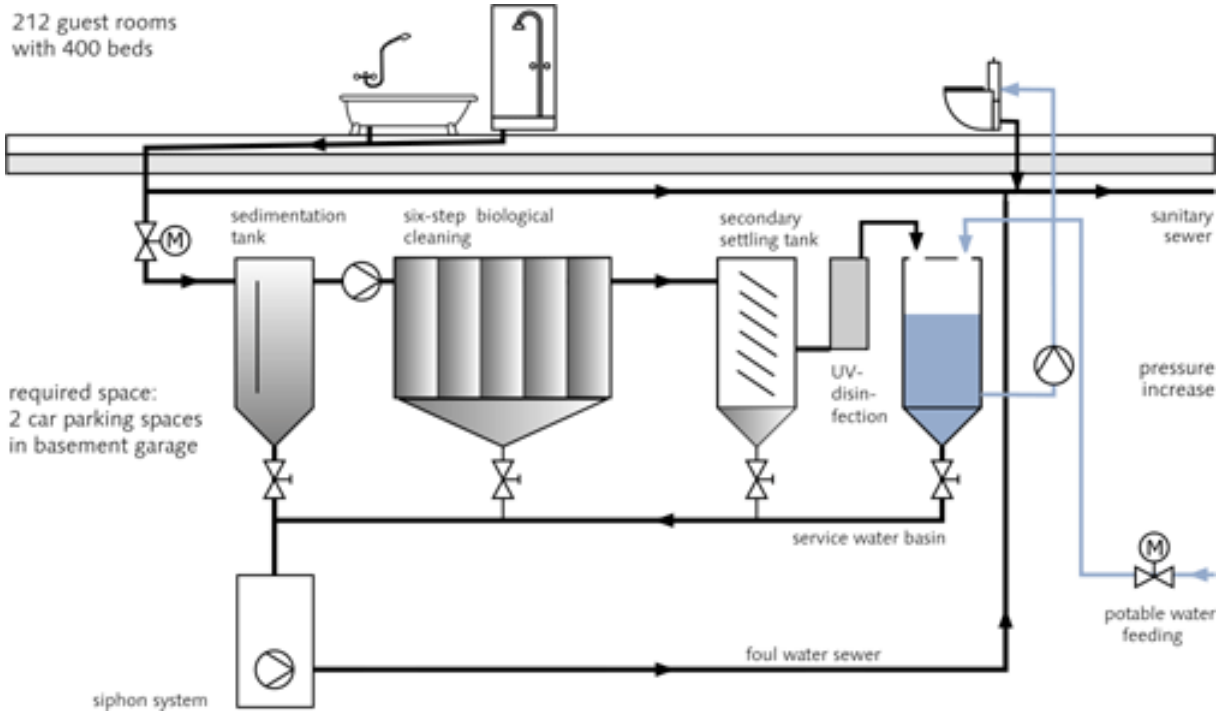
Hotel Arabella, Offenbach - Erwin Nolde, Berlin

- a six-step grey water treatment system with a clarification capacity of 20 000 litres per day, the system requires 35 m² of floor space
- the grey water treatment system provides enough water to flush 225 toilets, showers and bathtubs provide the required amount of grey water
- the planning of the grey water treatment system included a water surplus feature, the surplus is collected in a rainwater cistern where it can be used for irrigation, cleaning the courtyard and for cleaning the grease separator
- the considerable quantity of grey water and the high demand for recycled water in the hotel justifies the technical effort, microfiltration treatment systems have been competing against the system of hotel “Arabella”

Quelle: http://ecologic-architecture.org/main/

Hotel Arabella, Offenbach - Erwin Nolde, Berlin

Sedimentation tank of the greywater treatment system



Scheme of the greywater treatment system

Group of trickling filters with recirculation

Quelle: http://ecologic-architecture.org/main/

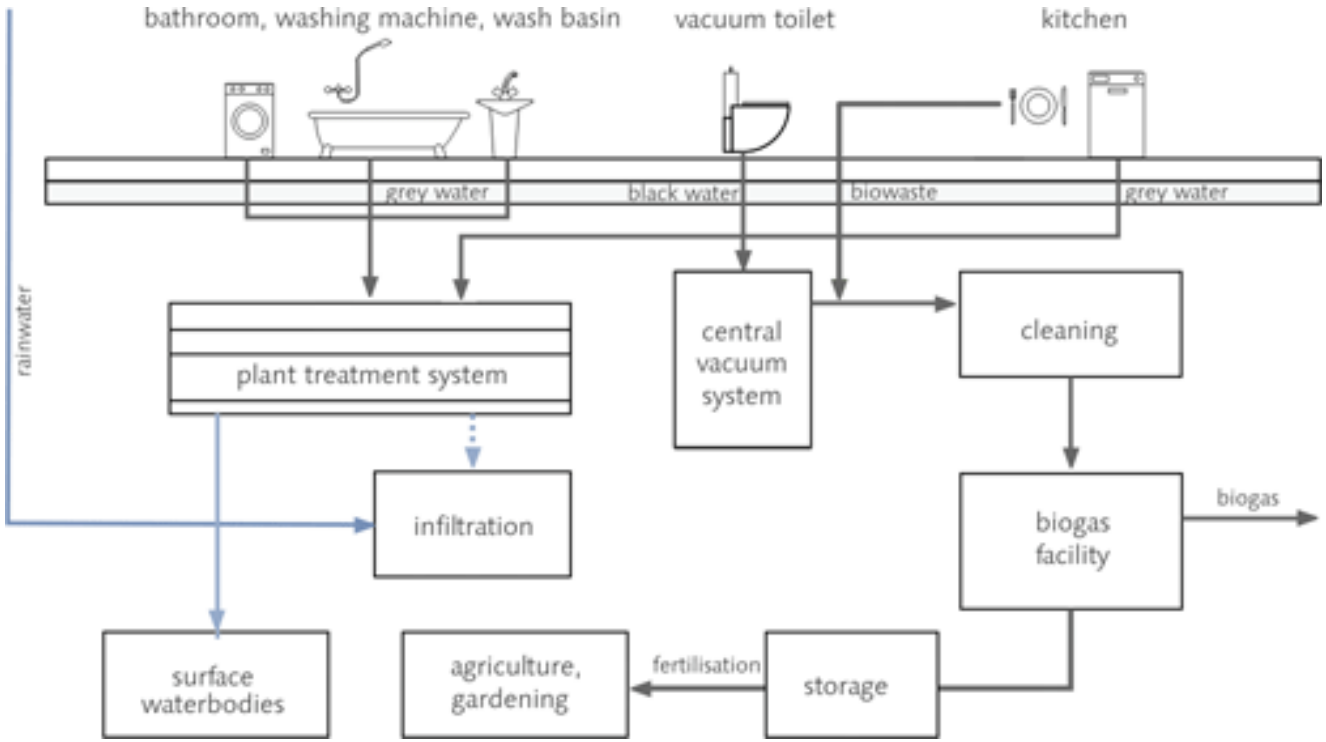
Lübeck-Flintenbreite - OtterWasser GmbH, Lübeck

- the settlement is not connected to the municipal waste water system, has an independent waste water system with wastewater separation
- the rainwater is fed into the local water cycle through the aid of percolation troughs, the flow of rainwater was integrated into the open space design
- the grey water is treated in vertical flow reed bed treatment systems and than is taken out into a trench
- through the implementation of vacuum toilets (0.7–1.0 l per flush), the black water is not diluted but is rich in nutrients and can feed the biogas plant
- the black water is used for biogas production, the nutrient-rich and sanitised end product could be used as liquid fertiliser agricultural companies
- in the combined heat and power plant (CHP) of the settlement, the biogas is used for electricity and heat production
- solar collectors with a receiving area of 250 m² conduce to domestic water heating and grid-connected photovoltaic systems feed the energy into the grid

Quelle: http://ecologic-architecture.org/main/

Lübeck-Flintenbreite - OtterWasser GmbH, Lübeck

construction stages of the reed-bed treatment system



Waste water scheme of Flintenbreite

Quelle: http://ecologic-architecture.org/main/

Lambertsmühle, Burscheid - OtterWasser GmbH, Lübeck

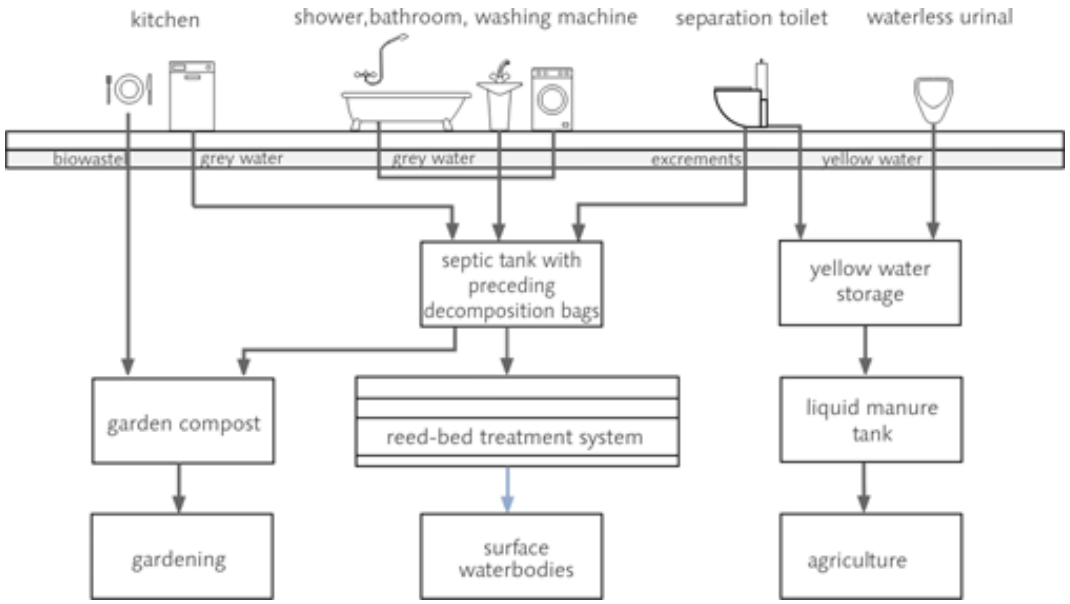
- pilot project for potential inexpensive and low-maintenance solutions in isolated buildings and small settlements in rural district
- the objective of this idea is nutrient recycling, the protection of the natural water cycle and energy savings in terms of waste water treatment work
- it includes water-saving separation toilets, which allow separated treatment of yellow water, brown water and grey water
- low polluted grey water is pre-treated in a sedimentation tank and it clarified in a planted vertical flow soil filter, the treated grey water is conducted into the creek or could be also used for irrigation or percolation
- the yellow water is used as concentrated liquid fertiliser in the agricultural sector
- the brown water is conducted into decomposition containers where the faeces are dehydrated and collected in cisterns, because of the separation of yellow water, this water can be treated together with the grey water in RBTS
- the content is composted together with bio-waste from the kitchen and garden, which results a high-quality humus with long-lasting fertiliser effect

Quelle: http://ecologic-architecture.org/main/

Lambertsmühle, Burscheid - OtterWasser GmbH, Lübeck

Composter of Lambertsmühle

Reed bed sewage treatment system in Lambertsmühle



Flow scheme of the waste water concept

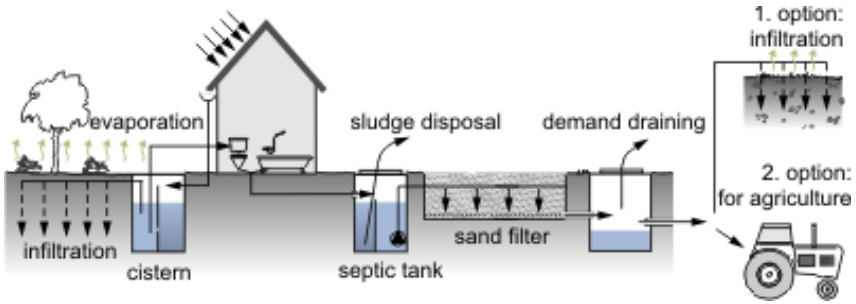
Decomposition bag

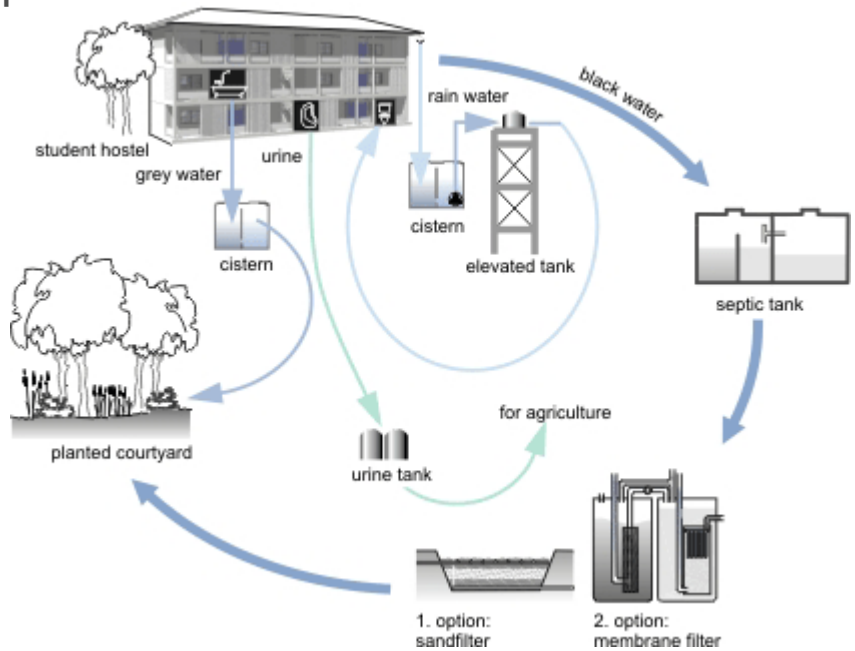
Quelle: http://ecologic-architecture.org/main/

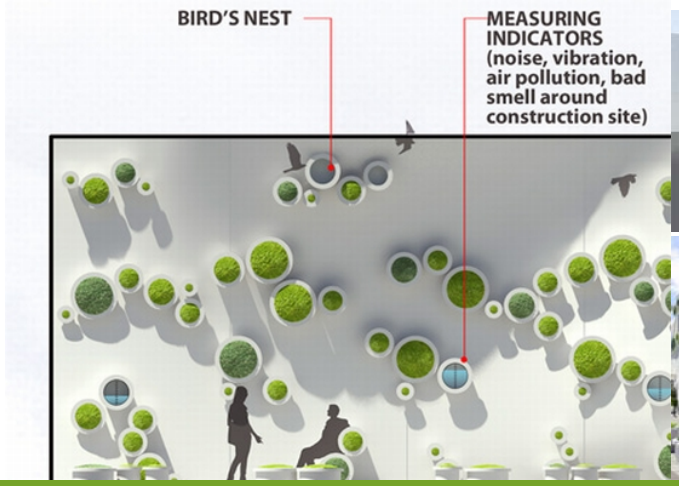
Ecological development of valley view university, Accra, Ghana

The main aspects of the concept are:

- conservation and saving of drinking water
- reduction of waste water
- retention of rainwater to improve bioactivity
- ground water replenishment through percolation





The symbiotic green wall - Kooho Jung and Hayeon Kelly Choi

The concept represents a double-layered wall system that gathers, filters and then allocates rainwater and wastewater. Two layers of the wall serve as heat and noise absorbers. At the same time they also help store water, which is used to decrease the amount of construction dust and grow grass in pods attached to the wall. The eco-friendly construction also acts as air cleaner system. In addition, the symbiotic green wall provides relaxation areas that are used by construction workers. Taking advantage of a number of natural systems, the wall has the goal of making construction sites