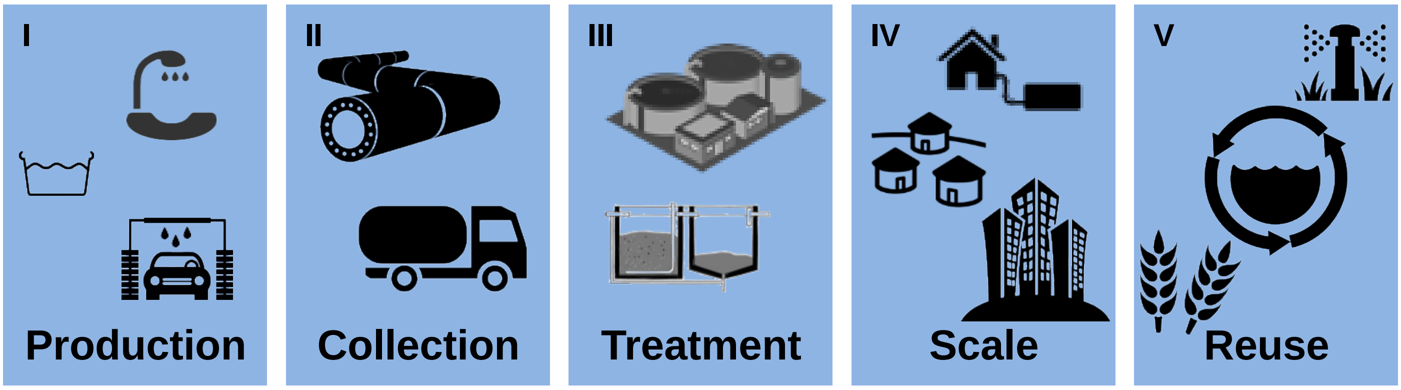
WASTEWATER TREATMENT & REUSE

Water is one of the most valuable, yet scarce, resources in the MENA region. Especially in arid and semi-arid regions protecting and conserving the current water resources as well as identifying unconventional sources of water is of imminent importance. Wastewater treatment and reuse is amongst the measures that can help sustain water resources.



Schematic diagram of the wastewater treatment and reuse cycle.

Technical background on water treatment and reuse options

WASTEWATER is a product of water consumption, usually through household or industrial water consumption, during which water is contaminated and thus not ready for further use, such as drinking water, water for irrigation, cooling water, etc. (see schematic diagram, step I). Wastewater is then collected for treatment. In the worst case, however, it is disposed untreated. Untreated wastewater contaminates the environment and even threaten valuable (ground)water resources by infiltrating into groundwater aquifers or water bodies, that are commonly used for drinking or irrigation water [1].
In the following, different components of the water treatment and reuse cycle are highlighted.

II Collection
Wastewater needs to be transported to the treatment plant. In case of centralized treatment plants this is done by (i) pipeline systems, or (ii) tanker solutions. In countries with low connection degrees (number of households connected to the sewer network) and centralized treatment plants, wastewater is transported to the plant by tanker trucks [2]. In the case of (semi-) decentralized solutions the transport, as the most cost-intensive factor in water treatment, is reduced by locating the treatment plant as close as possible to the production (e.g. household plants or cluster systems, such as for villages or urban districts) [3].

III Treatment
The treatment process contains different stages, which are classified as follows: primary, secondary, tertiary, and sometimes quaternary.
The primary stage includes the sedimentation, where solid material (sludge) settles. Whereas the sludge settles other material like grease or oil float and can, at this stage, be separated as well.
During the secondary treatment stage microorganisms degrade the organic matter in the sewage.

There are different technologies that ensure this treatment:

- Activated sludge
- Aerated lagoon
- Aerobic granulation
- Constructed wetland
- Membrane bioreactor

- Rotating biological contactor
- Trickling filter

The tertiary treatment is often the final stage at which almost drinking water quality is produced. Usually secondary treatment plants are upgraded to remove additional phosphorus and nitrogen.
The quaternary treatment is a relatively new concept and in most cases does not differ from tertiary treatment. It is sometimes defined as a disinfection treatment, e.g. by an ultraviolet system [2].

The selection of the treatment technology depends on:

- the type of wastewater, such as household, industrial, medical, etc.
- the required treatment degree which is linked to reuse [4],
- the efficiency towards energy use, water use, and space requirements, and
- the national regulations (technology/ plant certification as well as operation & maintenance availability).

IV Centralized and (semi-)decentralized

Wastewater can be treated (i) in large centralized plants that service large cities, and (ii) in semi decentralized plants (< 50.000 PE[1]) that service villages, household clusters, or urban districts, and down to single households from 4 PE onwards.
Both centralized and decentralized systems have advantages and disadvantages. Large centralized plants tend to be more cost effective in terms of their operation and maintenance. However, the highest costs in water treatment are often associated with the pipeline network transporting wastewater to the treatment plant. Centralized treatment plants are connected to extensive pipeline networks that generate high costs in construction but also in operation and maintenance. At the same time both systems, plant and pipeline network, are designed towards a certain capacity and especially pipeline networks feature particular problems with both overload as well as with very low loads This is especially problematic when being confronted with large population fluctuations, both increase and decrease, or temporary settlements, such as refugee camps or mining towns.
(Semi-)decentralized plants are often used for villages or rural regions with scattered households in general. Due to the large costs associated with sewer networks, however, such systems are also under discussion for cities or urban districts. Although the associated operation and maintenance costs for smaller plants are higher, they allow for more flexibility and for lower costs with regard to the sewer network. The improved flexibility, for example, allows modular setups; and the closer vicinity to the wastewater production reduces pipeline construction and maintenance costs. In case of wastewater from industry or specific contaminants such as from hospitals, decentralized solutions also allow a demand-oriented treatment. Overall, however, all systems, centralized & (semi-)decentralized do not compete against each other but instead, are to be considered complementary.

V Reuse

Common uses for water reuse are: irrigation (both for food as well as for green spaces in urban areas), recharge (both for rivers/ lakes as well as for groundwater), and drinking water. Drinking water production is possible but in most cases not feasible as the costs are too high. For drinking water usually surface water, groundwater, or seawater (desalination) is used and treated towards drinking water standards.
Even though the water is not always reused, water treatment nevertheless ensures the protection of water resources, which is an important issue. Given no treatment at all, sewage can contaminate rivers, water bodies, and groundwater aquifers that are commonly used for irrigation or even drinking water.
For agricultural reuse, treated wastewater is often preferred to drinking or desalinated water, as it contains components found in fertilizers (e.g. nitrogen and phosphorus) [4, 5]. Consequently, farmers have to add less fertilizer when irrigating

[1] PE: person equivalent or per capita loading. Both refer to the pollution load in household sewage produced by one person

with treated wastewater and thus can save costs in comparison with the use of desalinated water.

In which way water reuse is tackled often depends on the general water availability with clear differences between Europe [5] and the Middle East [7, 8] or on the culturally different handling of water resources [9]. Despite the actual water reuse discussions on the reuse of sludge [10] and the extraction of chemicals [5] are currently ongoing.

Executive summary

Water is becoming an increasingly scarce commodity, both in availability as well as in quality. Wastewater treatment and reuse tackle both the efficient use of water through reuse options, as well as the protection of existing water sources through treatment. The technical background describes the different steps from wastewater production and collection to treatment. Management options regarding scale (centralized, (semi-)decentralized), and reuse are discussed as well.

References

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