DISPOSAL OF SEWAGE

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Summary

An important use of, and impact on river and stream water is sanitation. This involves the intake of water for purposes of washing and operating flush toilets. The same water after use, has to be disposed of; usually after treatment it is returned to the same drainage system from which it originated. The article deals with several sanitation principles: sewer systems for disposal using considerable amounts of water, and on-site systems using very little water.

In the present article a brief review is given of the principal methods of disposal of sewage, sewerage, industrial effluent, agricultural run-off and solid waste. It deals with the various treatment principles and the disposal of treated effluent along waterways (streams, rivers, lakes, reservoirs and the ocean), or underground by means of septic tanks, soaking pits and French drains.

The article also includes discussion of other wastewater disposal systems, such as those for waste originating from industrial complexes, mining, manufacturing and agriculture.

1. Introduction

The removal of sewage from the inhabited areas is an important consideration in the overall concept of a life-support system. The essentials of a sustainable life-support system are not only the life-generating and -sustaining elements: air, water, light, heat, food, fluid and living space, but also the removal of waste products: carbon dioxide, effluent, ash, trash and sanitary waste, also known as sewage.

Water is consumed as an essential life-support substance by all living beings, including humans. The human body consists over sixty percent of water, and cannot exist without water for longer than three or four days. Normal adult human water consumption is two to three liters per day per capita, to replace the water lost through kidney functioning, exhalation of water vapor and perspiration. This consistent passage of water through the human system is necessary to remove waste from the body and to help control the body temperature.

The normal water intake per day per adult person is about.1.5 liters as liquid water and 0.6 liters as a direct part of the intake through food, and another 0.3 liters indirectly from metabolic water converted from the food eaten. The water thus "consumed" is again removed on a daily basis as follows: as urine 1.4 liters, as fecal water 0.1 liters, and as insensible loss by respiration and through the skin as non-visible "perspiration" 0.9 liters. Both the intake and removal amounts will increase with physical activity causing visible perspiration. Besides the water excreted, the adult human body daily produces some 150 gm (as dry weight) of solid waste, and another 1liter of intestinal gas.

To remove the said waste products in bulk, waterborne sanitary disposal systems are the general rule. To ensure adequate dilution as well as proper transport along sewers, a flush volume of 20 to 50 liters per occasion is customary, or some 100 liters per capita per day. To this figure must be added the normal water requirements for drinking, cooking washing and laundering, totaling to about 250 liters of fresh water per person per day.

To the above figures must be applied a scale effect. In isolation, a single person may get away with no water usage for waste disposal purposes, by utilizing a pit privy for example. This might still do for say ten persons, but for a hundred perhaps ten privies would be needed, and for a thousand a waterborne system becomes essential, with a daily capacity of some 250 cubic meters of water. Going via the tens of thousands to the millions of population figures for a large community, would involve more than simple multiplication of the above figures by the population, due to the confinement or space-concentration effect.

This is because the structure of urban living brings in additional water consuming points, such as public toilets in large buildings, heating and air conditioning systems, cleansing and washing facilities, fire fighting and street cleaning water reserves, all adding to the per capita water consumption figures. This is aside from the per capita water use for cooking, washing, laundry, gardening and recreation, which is also subject to a scaling-up effect.

For health reasons, most of the water used, that permit physical contact between the water and the user, is treated to potable water standards, although only a miniscule amount of it may actually be used for actual drinking purposes.

The vast quantity of water, that is necessary to support all functions of urban living in confined quarters, often necessitates the importation of water from nearby sources, such as rivers and lakes. Storage reservoirs have to be created by building dams, to provide water during dry seasons, pump stations, conduits and treatment works are also required. The used water has to be rendered safe by treatment for release back into the water cycle as final effluent.

Where use is made of rivers and streams to supply life-giving potable water, and life-supporting agricultural and industrial water, it is absolutely important to safeguard these vulnerable resources from being contaminated by the indiscriminate release of untreated waste water after its use.

2. Disposal Methods

Sewage is disposed of in several ways, mainly two: removal in a waterborne sewer systems (sewerage) or disposed via an on-site sanitation system (pit latrines or septic tanks). The former has become standard practice in built-up areas, most cities and industrial complexes. The latter still has preference in rural areas, small villages and special inhabitant areas. Public transportation generally makes use of a third system, mainly found in airlines, long distance trains, caravans, etc.: chemical toilet. Disposal at sea is generally practice after primary treatment on shipboard on ocean voyages.

3. Sewage Treatment

Sewage treatment consists generally of primary (physical) and secondary (chemical and biological) treatment. The two main communal sewage removal systems, off-site and on-site,on are described below:

3.1. Off-site or Sewer Systems

An example of an off-site sanitation or sewer system is that which is to be found in urban residential neighborhoods in general. Where houses are build on plots (stands), arranged along streets, each property is connected by a household sewer pipeline to a larger diameter communal sewer, running along the streets or along non-built-up borders of the community, to a waste-water treatment works located at a lower elevation off to one side, and from there via a main out-fall sewer to a river or an irrigation area. Figure 1 shows schematically the elements of such a waterborne sanitary sewage disposal system.

Distinction is made between dual and single sewer systems (the dual being a separate sewer for household wastes, sewage, wash water, laundry water, etc., paralleled by a storm water drainage system for street and roof rainfall run-off), the single being a combined sewage and storm water drainage network. The drawback of a single system is the need to treat widely varying amounts and combinations of sanitary waste and storm water run-off, from time to time.

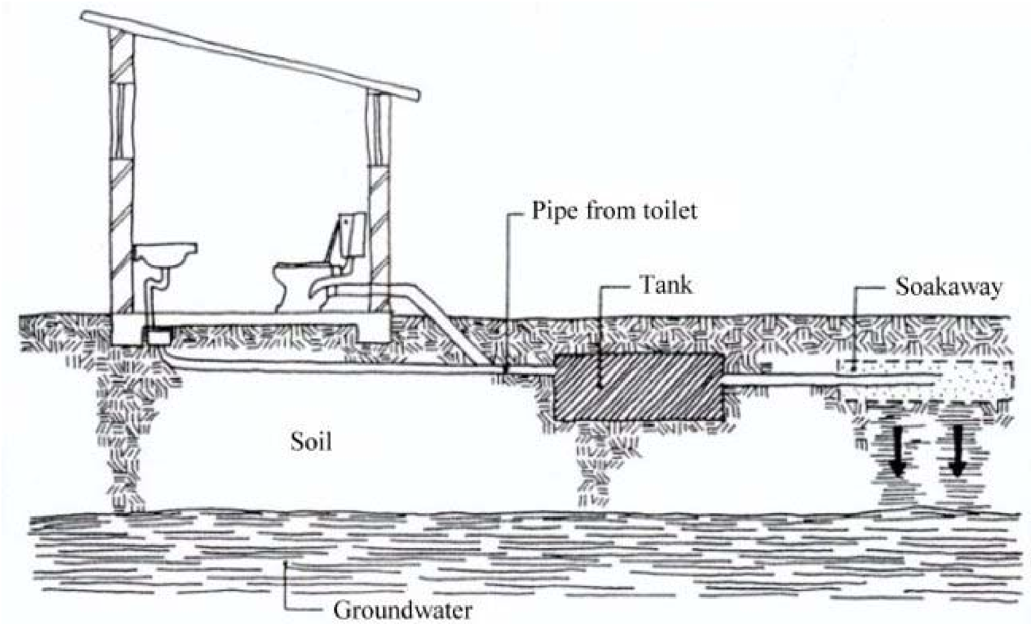

Figure 1. Regional waterborne (off-site) sanitation system
(Courtesy: ERWAT, Norkem Park, Johannesburg, South Africa).

3.1.1. Off-site Treatment Methods

The off-site treatment of sewage in a sewage treatment plant may be restricted to the *primary treatment* level (degreasing, grit removal, sludge thickening and digestion) after which the effluent is discharged into a perennial river or ocean outfall. Generally it is then still considered to be "raw sewage", although liquidized by virtue of the primary treatment, which may also include aerobic digestion and chlorination.

With *secondary treatment* the out-fall product is brought to acceptable standards, equal to natural river water, which can then be mixed and re-utilized for water supply down-river, or discharged by means of a submarine out-fall pipe to form a buoyant jet and diffusion plume in the ocean (see Hydraulics and Sustainable Waste Water Disposal in Rural Communities).

At the treatment works the waste-water is separated into supernatant liquid and sludge. The former is discharged after further treatment into waterways (rivers, the ocean, or underground-unconfined aquifers) and the latter, spread out and allowed to dry for disposal to ponds and settling beds.

Agricultural use may be made of the latter as fertilizer in some communities for cattle feed, etc. The supernatant liquid may also be disposed of in lagoons in wildlife refuges or underground via trickling filters or French drains.

3.1.2. Water Use

Sewer systems, in order to work properly, need flushing toilets at the source, at least one per home or living unit. At the same time, this requires a dependable water supply, the water of which, after becoming wastewater, needs a disposal system. The installation of flushing toilets together with bath tubs, showers, hand basins, sinks, laundries, with their water supply from a mains network, and their disposal pipe and sewer network requires a well designed and well managed infrastructure generally known as a plumbing system. Building all the components of a proper sewer system (supply pipes underground, pressure lines with plumbing fittings, as well as drain pipes and sewers) is expensive, and it is vital that they are designed, installed, maintained and managed properly. If the sewer pipes get blocked, or if the sewage treatment works is not well managed, untreated wastewater can reach rivers and cause widespread pollution of water resources that may result in epidemics and unhealthy surroundings.

The details of the design of a sewerage network, as well as an urban storm water drainage system, are presented in another theme dealing with hydraulic structures.

When the toilet is flushed, a certain volume of dilution and carrying water and the waste (sewage) flow by gravity into and along a household sewer pipe set at a certain slope or gradient underground. Bath, laundry, dishwasher water also flows along the same system. The waste water from several living units flows in diluted form, but containing also grease and soap from the individual sewer pipes into an underground sewer main, running alongside the street or outer boundary of the living units.

Street sewers gravitate towards and connect with a main out-fall sewer, which joins the wastewater treatment works. The only driving force is the water from the flushing toilets, bathtubs, and sinks, flowing under the influence of gravity and taking the wastewater with it. It is implicit that the water supply must be sufficient to activate this.

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Biographical Sketch

Jan M. Jordaan was involved in the investigations for water sources for Namibia from 1974 to 1981 as Chief Engineer Investigations in the Department of Water Affairs, Windhoek, Namibia and helped in directing the pilot plant reverse osmosis desalination project at Swakopmund in that country.

He also made a study of other water treatment and desalination processes on a European Technical Study visit. Previously he participated in ocean-related research programs at the United States Naval Civil Engineering Laboratory, Port Hueneme California, USA, as Hydraulic Research Engineer.

He also lectured in Hydraulics and Ocean Engineering at the Universities of Hawaii, Delaware and Pretoria for a total of fourteen years. He retired as Director: Design Services with the Department of Water Affairs and Forestry, Pretoria, South Africa, after a period of continuous service of twenty-eight years.