

Sanitation

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Sanitation is the hygienic means of promoting health through prevention of human contact with the hazards of wastes as well as the treatment and proper disposal of sewage or wastewater. Hazards can be either physical, microbiological, biological or chemical agents of disease. Wastes that can cause health problems include human and animal excreta, solid wastes, domestic wastewater (sewage or greywater) industrial wastes and agricultural wastes. Hygienic means of prevention can be by using engineering solutions (e.g., sanitary sewers, sewage treatment, surface runoff management, solid waste management, excreta management), simple technologies (e.g., pit latrines, dry toilets, urine-diverting dry toilets, septic tanks), or even simply by behavior changes in personal hygiene practices, such as hand washing with soap.



Example of sanitation infrastructure: Shower, double-vault urine-diverting dry toilet (UDDT) and waterless urinal in Lima, Peru

Providing sanitation to people requires a systems approach, rather than only focusing on the toilet or wastewater treatment plant itself.^[1] The experience of the user, excreta and wastewater collection methods, transportation or conveyance of waste, treatment, and reuse or disposal all need to be thoroughly considered.^[1]

The main objective of a sanitation system is to protect and promote human health by providing a clean environment and breaking the cycle of disease.^[2]

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Definition and purposes

The World Health Organization defines the term "sanitation" as follows:

"Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and feces. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal."^[3]

Sanitation includes all four of these engineering infrastructure items (even though often only the first one is strongly associated with the term "sanitation"): Excreta management systems, wastewater management systems (included here are wastewater treatment plants), solid waste management systems, drainage systems for rainwater, also called stormwater drainage.

There are some slight variations on the definition of sanitation in use. For example, for many organisations, hygiene promotion is seen as an integral part of sanitation. For this reason, the Water Supply and Sanitation Collaborative Council defines sanitation as "The collection, transport, treatment and disposal or reuse of human excreta, domestic wastewater and solid waste, and associated hygiene promotion."^[4]

Despite the fact that sanitation includes wastewater treatment, the two terms are often use side by side as "sanitation and wastewater management". The term sanitation has been connected to several descriptors so that the terms sustainable sanitation, improved sanitation, unimproved sanitation, environmental sanitation, on-site sanitation, ecological sanitation, dry sanitation are all in use today. Sanitation should be regarded with a systems approach in mind which includes collection/containment, conveyance/transport, treatment, disposal or reuse.^[5]

The overall purposes of sanitation are to provide a healthy living environment for everyone, to protect the natural resources (such as surface water, groundwater, soil), and to provide safety, security and dignity for



people when they defecate or urinate.

Effective sanitation systems provide barriers between excreta and humans in such a way as to break the disease transmission cycle (for example in the case of fecal-borne diseases).^[6] This aspect is visualised with the F-diagram where all major routes of fecal-oral disease transmission begin with the letter F: feces, fingers, flies, fields, fluids, food.^[7]

Types

The term sanitation is connected with various descriptors or adjectives to signify certain types of sanitation systems (which may deal only with human excreta management or with the entire sanitation system, i.e. also greywater, stormwater and solid waste management) - in alphabetical order:

Community-led total sanitation

Community-Led Total Sanitation (CLTS) is an approach to achieve behavior change in mainly rural people by a process of "triggering", leading to spontaneous and long-term abandonment of open defecation practices. CLTS takes an approach to rural sanitation that works without hardware subsidies and that facilitates communities to recognize the problem of open defecation and take collective action to clean up and become "open defecation free".

Dry sanitation

The term "dry sanitation" is somewhat misleading as sanitation includes hand-washing and can never be "dry". A more precise term would be "dry excreta management". When people speak of "dry sanitation" they usually mean sanitation systems with dry toilets with urine diversion, in particular the urine-diverting dry toilet (UDDT).^[8]

Ecological sanitation

Ecological sanitation, which is commonly abbreviated to ecosan, is an approach, rather than a technology or a device which is characterized by a desire to "close the loop" (mainly for the nutrients and organic matter) between sanitation and agriculture in a safe manner. Put in other words: "Ecosan systems safely recycle excreta resources (plant nutrients and organic matter) to crop production in such a way that the use of non-renewable resources is minimised". When properly designed and operated, ecosan systems provide a hygienically safe, economical, and closed-loop system to convert human excreta into nutrients to be returned to the soil, and water to be returned to the land. Ecosan is also called resource-oriented sanitation.

Environmental sanitation

Environmental sanitation encompasses the control of environmental factors that are connected to disease transmission. Subsets of this category are solid waste management, water and wastewater treatment, industrial waste treatment and noise and pollution control.

Improved and unimproved sanitation

Improved sanitation and unimproved sanitation refers to the management of human feces at the household level. This terminology is the indicator used to describe the target of the Millennium Development Goal on

sanitation, by the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.

Lack of sanitation

Lack of sanitation refers to the absence of sanitation. In practical terms it usually means lack of toilets or lack of hygienic toilets that anybody would want to use voluntarily. The result of lack of sanitation is usually open defecation (and open urination but this is of less concern) with the associated serious public health issues.

On-site sanitation

On-site sanitation, also called decentralised sanitation, is a system where the treatment of excreta or sewage takes place at the same location where it is generated. Examples are pit latrines, septic tanks, and Imhoff tanks. A septic tank and drainfield combination is the oldest and most common type of on-site sewage facility in the U.S., although newer aerobic and biofilter units exist which represent scaled down versions of municipal sewage treatment plants.

Sustainable sanitation

Sustainable sanitation considers the entire "sanitation value chain", from the experience of the user, excreta and wastewater collection methods, transportation or conveyance of waste, treatment, and reuse or disposal.^[1] The term is widely used since about 2009. In 2007 the Sustainable Sanitation Alliance had defined five sustainability criteria to compare the sustainability of sanitation systems. In order to be sustainable, a sanitation system has to be not only (i) economically viable, (ii) socially acceptable, and (iii) technically and (iv) institutionally appropriate, it should also (v) protect the environment and the natural resources.^[2]

Other

Other terms used to describe certain types of sanitation include:

- Community-based sanitation, abbreviated as CBS (often related to decentralised wastewater treatment or DEWATS)
- Container-based sanitation, also abbreviated as CBS (this is related to mobile sanitation and portable toilets)

Health aspects

For any social and economic development, adequate sanitation in conjunction with good hygiene and safe water are essential to good health. Lack of proper sanitation causes diseases. Most of the diseases resulting from sanitation have a direct relation to poverty. The lack of clean water and poor sanitation causes many diseases and the spread of diseases. It is estimated that inadequate sanitation is responsible for 4.0 percent of deaths and 5.7 percent of disease burden worldwide.^[9]

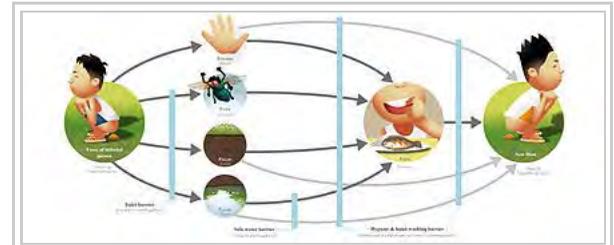
Lack of sanitation is a serious issue that is affecting most developing countries and countries in transition. The importance of the isolation of excreta and waste lies in an effort to prevent diseases which can be transmitted through human waste, which afflict both developed countries as well as developing countries to differing degrees.

It is estimated that up to 5 million people die each year from preventable waterborne diseases,^[10] as a result of

inadequate sanitation and hygiene practices. The effects of sanitation has impacted the society of people throughout history.^[11] Sanitation is a necessity for a healthy life.^[12]

Diarrhea

Diarrhea plays a significant role: Deaths resulting from diarrhea are estimated to be between 1.6 and 2.5 million deaths every year.^[13] Most of the affected are young children below the ages of five.^[14] Children suffering from diarrhea are more vulnerable to become underweight (due to stunted growth) which makes them more vulnerable to other diseases such as acute respiratory infections and malaria.



The "F-diagram" (feces, fingers, flies, fields, fluids, food), showing pathways of fecal-oral disease transmission. The vertical blue lines show barriers: toilets, safe water, hygiene and handwashing.

Numerous studies have shown that improvements in drinking water and sanitation (WASH) lead to decreased risks of diarrhoea.^[15] Such improvements might include for example use of water filters, provision of high-quality piped water and sewer connections.^[15]

Open defecation - or lack of sanitation - is a major factor in causing various diseases, most notably diarrhea and intestinal worm infections.^{[16][17]} For example, infectious diarrhea resulted in about 0.7 million deaths in children under five years old in 2011 and 250 million lost school days.^{[16][18]} It can also lead to malnutrition and stunted growth in children. Open defecation is a leading cause of diarrheal death; 2,000 children under the age of five die every day, one every 40 seconds, from diarrhea.^[19]

Malnutrition and stunting

The combination of direct and indirect deaths from malnutrition caused by unsafe water, sanitation and hygiene (WASH) practices is estimated by the World Health Organisation to lead to 860,000 deaths per year in children under five years of age.^[6] The multiple interdependencies between malnutrition and infectious diseases make it very difficult to quantify the portion of malnutrition that is caused by infectious diseases which are in turn caused by unsafe WASH practices. Based on expert opinions and a literature survey, researchers at WHO arrived at the conclusion that approximately half of all cases of malnutrition (which often leads to stunting) in children under five is associated with repeated diarrhoea or intestinal worm infections as a result of unsafe water, inadequate sanitation or insufficient hygiene.^[6]

List of diseases caused by lack of sanitation

Relevant diseases and conditions caused by lack of sanitation and hygiene include:

- Waterborne diseases, which can contaminate drinking water
- Diseases transmitted by the fecal-oral route
 - Infections with intestinal helminths (worms) - approximately two billion people are infected with soil-transmitted helminths worldwide; they are transmitted by eggs present in human faeces which in turn contaminate soil in areas where sanitation is poor.^[20]
- Stunted growth in children
- Malnutrition, particularly in children

The list of diseases that could be reduced with proper access to sanitation and hygiene practices is very long.

For example, in India, 15 diseases have been listed which could be stamped out by improving sanitation:^[21]

1. Anaemia, malnutrition
2. Ascariasis (a type of intestinal worm infection)
3. Campylobacteriosis
4. Cholera
5. Cyanobacteria toxins
6. Dengue
7. Hepatitis
8. Japanese encephalitis (JE)
9. Leptospirosis
10. Malaria
11. Ringworm or Tinea (a type of intestinal worm infection)
12. Scabies
13. Schistosomiasis
14. Trachoma
15. Typhoid and paratyphoid enteric fevers

Polio is another disease which is related to improper sanitation and hygiene.

Indicator organisms

When analysing environmental samples, various types of indicator organisms are used to check for fecal pollution of the sample. Commonly used indicators for bacteriological water analysis include the bacterium *Escherichia coli* (abbreviated as *E. coli*) and non-specific fecal coliforms. With regards to samples of soil, sewage sludge, biosolids or fecal matter from dry toilets, helminth eggs are a commonly used indicator. Viable helminth eggs can be extracted from the samples and counted.

Other industries or sectors

Wastewater and stormwater management

Wastewater management consists of collection, wastewater treatment (be it municipal or industrial wastewater), disposal or reuse of treated wastewater. The latter is also referred to as water reclamation.

The standard sanitation technology in urban areas is the collection of wastewater in gravity driven sewers, its treatment in wastewater treatment plants for reuse or disposal in rivers, lakes or the sea. Sewers are either combined with storm drains or separated from them as sanitary sewers. Combined sewers are usually found in the central, older parts or urban areas. Heavy rainfall and inadequate maintenance can lead to combined sewer overflows or sanitary sewer overflows, i.e., more or less diluted raw sewage being discharged into the environment. Industries often discharge wastewater into municipal sewers, which can complicate wastewater treatment unless industries pre-treat their discharges.^[22]



The high investment cost of conventional wastewater collection systems are difficult to afford for many developing countries. Some countries therefore promote alternative wastewater collection systems such as condominal sewerage, which uses pipes with smaller diameters at lower trench depth with different network layouts from conventional sewerage.

In developed countries centralised treatment of municipal wastewater is now quite widespread. In developing countries most wastewater is still discharged untreated into the environment. For example, in Latin America only about 15% of collected sewage is being treated (see water and sanitation in Latin America).



Sewage treatment plant, Australia.

In many suburban and rural areas households are not connected to sewers, and they rather use on-site sewage facilities or decentralised treatment if they are connected to piped water and use flush toilets. They discharge their wastewater into septic tanks or other types of on-site sanitation systems (e.g. Sequencing batch reactors or constructed wetlands). On-site systems include drain fields, which require significant area of land. This makes septic systems unsuitable for most cities.

The reuse of untreated or partially treated wastewater in irrigated agriculture is common in developing countries. The reuse of treated wastewater in landscaping, especially on golf courses, irrigated agriculture and for industrial use is becoming increasingly widespread.

Solid waste disposal

Disposal of solid waste is most commonly conducted in landfills, but incineration, recycling, composting and conversion to biofuels are also avenues. In the case of landfills, advanced countries typically have rigid protocols for daily cover with topsoil, where underdeveloped countries customarily rely upon less stringent protocols.^[23] The importance of daily cover lies in the reduction of vector contact and spreading of pathogens. Daily cover also minimises odor emissions and reduces windblown litter. Likewise, developed countries typically have requirements for perimeter sealing of the landfill with clay-type soils to minimize migration of leachate that could contaminate groundwater (and hence jeopardize some drinking water supplies).



Hiriya Landfill, Israel.

For incineration options, the release of air pollutants, including certain toxic components is an attendant adverse outcome. Recycling and biofuel conversion are the sustainable options that generally have superior lifecycle costs, particularly when total ecological consequences are considered.^[24] Composting value will ultimately be limited by the market demand for compost product.

Food industry

Sanitation within the food industry means the adequate treatment of food-contact surfaces by a process that is effective in destroying vegetative cells of microorganisms of public health significance, and in substantially reducing numbers of other undesirable microorganisms, but without adversely affecting the food or its safety for the consumer (U.S. Food and Drug Administration, Code of Federal Regulations, 21CFR110, USA). Sanitation Standard Operating Procedures are mandatory for food industries in United States, which are

regulated by 9 CFR part 416 in conjunction with 21 CFR part 178.1010. Similarly, in Japan, food hygiene has to be achieved through compliance with food sanitation law.^[25]

In the food and biopharmaceutical industries, the term "sanitary equipment" means equipment that is fully cleanable using clean-in-place (CIP) and sterilization-in-place (SIP) procedures: that is fully drainable from cleaning solutions and other liquids. The design should have a minimum amount of deadleg, or areas where the turbulence during cleaning is insufficient to remove product deposits.^[26] In general, to improve cleanability, this equipment is made from Stainless Steel 316L, (an alloy containing small amounts of molybdenum). The surface is usually electropolished to an effective surface roughness of less than 0.5 micrometre to reduce the possibility of bacterial adhesion.



Modern restaurant food preparation area.

Developing countries

Globally 2.6 billion people remain without access to any kind of improved sanitation, and sanitation-related diseases and poor hygienic conditions cause approximately 2.2 million annual deaths, mostly of children under the age of five years.

Millennium Development Goals and Sustainable Development Goals

The United Nations, during the Millennium Summit in New York in 2000 and the 2002 World Summit on Sustainable Development in Johannesburg, developed the Millennium Development Goals (MDGs) aimed at poverty eradication and sustainable development. The specific goal for the year 2015 is to reduce by half the number of people who had no access to potable water and sanitation in the baseline year of 1990. In the year 2016, the Sustainable Development Goals replaced the Millennium Development Goals.

In 2004, the Joint Monitoring Programme for Water Supply and Sanitation (JMP) of the World Health Organisation (WHO) and of the United Nations Children's Fund (UNICEF) reported that the number of people lacking basic sanitation services rose from 2.1 billion in 2001 to 2.6 billion by 2004. As the JMP and the United Nations Development Programme (UNDP) Human Development Report in 2006 has shown, progress meeting the MDG sanitation target is too slow, with a large gap between the target coverage and the current reality.

There are numerous reasons for this gap. A major one is that sanitation is rarely given political attention received by other topics despite its key importance. Sanitation is not high on the international development agenda, and projects such as those relating to water supply projects are emphasised.

In December 2006, the United Nations General Assembly declared 2008 "The International Year of Sanitation", in recognition of the slow progress being made towards the MDGs sanitation target.^[27] The year aimed to develop awareness and action to meet the target. Particular concerns are:

- Removing the stigma around sanitation, so that the importance of sanitation can be more easily and



publicly discussed.

- Highlighting the poverty reduction, health and other benefits that flow from better hygiene, household sanitation arrangements and wastewater treatment.

The Joint Monitoring Programme for Water Supply and Sanitation of WHO and UNICEF has defined improved sanitation as follows:^[28]

- Flush toilet or flush / pour-flush to a pit latrine with are connected to either a sewer system or a septic system
- Ventilated improved pit latrine (VIP)
- Pit latrine with slab
- Composting toilet

The JMP publishes a report of updated estimates every two years on the use of various types of drinking-water sources and sanitation facilities at the national, regional and global levels. For example, in March 2012, the JMP released an update.^[29] According to the definition above, 1.8 billion more people used improved sanitation in 2010 than in 1990, bringing the percentage of people using improved sanitation to 63% globally. However, the world did not achieve the sanitation target of the Millennium Development Goals in 2015. 2.5 billion lack improved sanitation.^[30] According to the JMP, if current trends continue, in 2015 2.4 billion people will lack access to improved sanitation facilities. 15 per cent of the population still practise open defecation, defined as defecation in fields, forests, bushes, bodies of water or other open spaces. This represents 1.1 billion people. Though the proportion of people practising open defecation is decreasing, the absolute number has remained at over one billion for several years, due to population growth.^[31]

This outcome presents substantial public health risks as the waste could contaminate drinking water and cause life-threatening forms of diarrhea to infants. Most cities can neither afford a sewage collection system, nor a sewage treatment system.^[32] Improved sanitation, including hand washing and water purification, could save the lives of 1.5 million children who die from diarrheal diseases each year.^[33]

Various initiatives

In 2011 the Bill & Melinda Gates Foundation launched the Reinvent the Toilet Challenge to promote safer, more effective ways to treat human waste. The program is aimed at developing technologies that might help bridge the global sanitation gap.

Research from the Overseas Development Institute suggests that sanitation and hygiene promotion needs to be better "mainstreamed" in development cooperation, if the MDG on sanitation is to be met. At present, promotion of sanitation and hygiene is mainly carried out through water institutions. The research argues that many institutions that should carry out activities to develop better sanitation and hygiene in developing countries. For example, educational institutions can teach on hygiene, and health institutions can dedicate resources to preventative works (to avoid, for example, outbreaks of cholera).^[34] There are also civil society organisations providing some of the necessary infrastructure where national governments cannot do that on their own.



Example for lack of sanitation:
Unhygienic pit latrine with ring slab
in Kalibari community in
Mymensingh, Bangladesh

History

The earliest evidence of urban sanitation was seen in Harappa, Mohenjo-daro, and the recently discovered Rakhigarhi of Indus Valley civilization. This urban plan included the world's first urban sanitation systems. Within the city, individual homes or groups of homes obtained water from wells. From a room that appears to have been set aside for bathing, waste water was directed to covered drains, which lined the major streets.

Roman cities and Roman villas had elements of sanitation systems, delivering water in the streets of towns such as Pompeii, and building stone and wooden drains to collect and remove wastewater from populated areas—see for instance the Cloaca Maxima into the River Tiber in Rome. But there is little record of other sanitation in most of Europe until the High Middle Ages. Unsanitary conditions and overcrowding were widespread throughout Europe and Asia during the Middle Ages, resulting periodically in cataclysmic pandemics such as the Plague of Justinian (541–42) and the Black Death (1347–1351), which killed tens of millions of people and radically altered societies.^[35]

Very high infant and child mortality prevailed in Europe throughout medieval times, due not only to deficiencies in sanitation but to an insufficient food supply for a population which had expanded faster than agriculture.^[36] This was further complicated by frequent warfare and exploitation of civilians by autocratic rulers.

See also

- List of abbreviations used in sanitation
- List of water supply and sanitation by country
- Sustainable Sanitation Alliance

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External links

- IRC /en/ World Health Organization overview on sanitation (<http://www.irc.nl/>)
- Sanitation, Hygiene and Wastewater Resource Guide (World Bank) (<http://water.worldbank.org/water/shw-resource-guide>)
- Sustainable Sanitation Alliance (<http://www.susana.org>)



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