

Course Name	: Water and Sanitation
Course Code	: APBSCH 1102
Course Level	: Level 1
Credit Unit	: 4 CU
Contact Hours	: 60 Hrs

Course Description

This Course deals with defining the term sanitation, the application of the concept to several variables, analysis of current sanitation, understanding the role of the health sector improving sanitation, strategies to achieve success in sanitation. The course further stipulates relevant aspects to be considered in order to manage good sanitation, determinants of health, water pollution, and chemical and other contaminants as well as noise pollution.

Course Objectives

- To enable students critically learn the various causes of pollution and numerous measures to control it.
- To provide the students with the scope of managing sanitation to promote individual and community hygiene as one major focus of public health.
- To help remind students about working hard towards protecting the environment to create its sustainability as one of the millennium development (MDGs) in order to achieve sustainable development.

Course Content

Introduction

- Definition of Sanitation
- Application of Sanitation to specific aspect, concepts, location and strategy
- Sanitation and Public Health
- Health Impacts of Sanitation
- Wider benefits of Sanitation
- Analysis of the Current Situation
- Successful approaches to Sanitation
- The role of the Health Sector in Improving Sanitation
- Constraints to success in Sanitation
- Strategies to achieve success in Sanitation

Relevant aspects to be considered in order to manage good sanitation

- Disinfectants
- Environmental epidemiology
- Environmental Health
- Environmental health concerns

Determinants of Health

- Human Biology
- Environment
- Lifestyles
- Healthcare services

Water Pollution

- Definition of Water pollution
- Point Source pollution
- Non-point source pollution

- Groundwater pollution
- Causes of Water Pollution

Chemical and other contaminants

- Organic water pollution
- Inorganic water pollution
- Thermal pollution
- Transports and chemical reactions of water pollutants
- Measurement of water pollution
- Control of water pollution

Noise Pollution

- Meaning of Noise Pollution
- Human health effects
- Environmental effects

Mode of delivery Face to face lectures

Assessment

Course work 40%

Exams 60%

Total Mark 100%

SANITATION AND ENVIRONMENTAL HEALTH SCIENCE

Contents

Introduction and Definitions

Sanitation and public health

Global access to improved sanitation

Health Impacts of Sanitation

Neglected Tropical Diseases

Acute Respiratory Infections

Wider Benefits of Sanitation

Analysis of the Current Situation

Successful Approaches to Sanitation

Approaches Specific to Urban Sanitation

Constraints to Success in Sanitation

Strategies to Achieve Success in Sanitation

Water and Environmental health

Introduction

Sanitation perhaps one of the core units of public health, Under sanitation they are numerous topics we are going to look at with the highest public health importance; explain their causation, the complications, containments and their public health strategies to improve the condition. The chapter is divided into communicable and non communicable diseases, diseases related to lifestyle and injuries.

Course work question

By the sanitation standards of Uganda, Uganda has not yet achieved it's international standard of sanitation. As a public health student what measures would you recommend for the government to adopt in order to achieve a global standard?

What are the consequences of poor hygiene and sanitation to the communities within and around?

Definitions

Adequate sanitation, together with good hygiene and safe water, are fundamental to good health and to social and economic development. That is why, in 2008, the Prime Minister of India quoted Mahatma Gandhi who said in 1923, “sanitation is more important than independence” . Improvements in one or more of these three components of good health can substantially reduce the rates of morbidity and the severity of various diseases and improve the quality of life of huge numbers of people, particularly children, in developing countries. Although linked, and often mutually supporting, these three components have different public health characteristics. This paper focuses on sanitation. It seeks to present the latest evidence on the provision of adequate sanitation, to analyse why more progress has not been made, and to suggest strategies to improve the impact of sanitation, highlighting the role of the health sector. It also seeks to show that sanitation work to improve health, once considered the exclusive domain of engineers, now requires the involvement of social scientists, behaviour change experts, health professionals, and, vitally, individual people. Throughout this paper, we define sanitation as the safe disposal of human excreta. The phrase “safe disposal” implies not only that people must excrete hygienically but also that their excreta must be contained or treated to avoid adversely affecting their

Sanitation is the hygienic means of promoting health through prevention of human contact with the hazards of wastes. Hazards can be either physical, microbiological, biological or chemical agents of disease. Wastes that can cause health problems are human and animal feces, solid wastes, domestic wastewater (sewage, sullage, greywater), industrial wastes and agricultural wastes. Hygienic means of prevention can be by using engineering solutions (e.g. sewerage and wastewater treatment), simple technologies (e.g. latrines, septic tanks), or even by personal hygiene practices (e.g. simple handwashing with soap).

Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and feces. Inadequate sanitation is a major cause of disease world-wide and improving sanitation is known to have a significant beneficial impact on health both in households and across communities. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal.

The term "sanitation" can be applied to a specific aspect, concept, location or strategy, such as:

- Basic 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.

- On-site sanitation - the collection and treatment of waste is done where it is deposited. Examples are the use of pit latrines, septic tanks, and Imhoff tanks.
- Food sanitation - refers to the hygienic measures for ensuring food safety.
- Environmental sanitation - the control of environmental factors that form links in disease transmission. Subsets of this category are solid waste management, water and wastewater treatment, industrial waste treatment and noise and pollution control.

- Ecological sanitation - an approach that tries to emulate nature through the recycling of nutrients and water from human and animal wastes in a hygienically safe manner.

Sanitation and public health

The importance of the isolation of 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 water-borne disease, as a result of inadequate sanitation and hygiene practices. The effects of sanitation have also had a large impact on society. The results of studies published in *Griffins Public Sanitation* show that better sanitation produces an enhanced feeling of wellbeing. Relevant disease include:

- Waterborne diseases, which can contaminate drinking water
- Diseases transmitted by the fecal-oral route
- Hookworm, where eggs can survive in the soil

Global access to improved sanitation

The Joint Monitoring Program for water and sanitation of WHO and UNICEF has defined improved sanitation as

- connection to a public sewer
- connection to a septic system
- pour-flushlatrine
- simple pit latrine
- ventilated improved pit latrine

According to that definition, 62% of the world's population has access to improved sanitation in 2008, up by 8% since 1990 Only slightly more than half of them or 31% of the world population lived in houses connected to a sewer. Overall, 2.5 billion people lack access to improved sanitation and thus must resort to open defecation or other unsanitary forms of defecation, such as public latrines or open pit latrines. This includes 1.2 billion people who have access to no facilities at all This outcome presents substantial public health risks as the waste could contaminate drinking water and cause life threatening forms of diarrhea to infants. Improved sanitation, including hand washing and water purification, could save the lives of 1.5 million children who die from diarrheal diseases each year. In developed countries, where less than 20% of the world population lives, 99% of the population has access to improved sanitation and 81% were connected to sewers.

Health Impacts of Sanitation

Lack of sanitation leads to disease, as was first noted scientifically in 1842 in Chadwick's seminal "Report on an inquiry into the sanitary condition of the labouring population of

Great Britain". A less scientifically rigorous but nonetheless professionally significant indicator of the impact on health of poor sanitation was provided in 2007, when readers of the BMJ (British Medical Journal) voted sanitation the most important *medical* milestone since 1840

The diseases associated with poor sanitation are particularly correlated with poverty and infancy and alone account for about 10% of the global burden of disease. At any given time close to half of the urban populations of Africa, Asia, and Latin America have a disease associated with poor sanitation, hygiene, and water

Of human excreta, faeces are the most dangerous to health. One gram of fresh faeces from an infected person can contain around 10⁶ viral pathogens, 10⁶–10⁸ bacterial pathogens, 10⁴ protozoan cysts or oocysts, and 10–10⁴ helminthes eggs. The major faeco-oral disease transmission pathways are demonstrated in the “F Diagram”, which illustrates the importance of particular interventions, notably the safe disposal of faeces, in preventing disease transmission.

Diarrheal Diseases

Diarrheal diseases are the most important of the faeco-oral diseases globally, causing around 1.6–2.5 million deaths annually, many of them among children under 5 years old living in developing countries. In 2008, for example, diarrhea was the leading cause of death among children under 5 years in sub-Saharan Africa, resulting in 19% of all deaths in this age group

Systematic reviews suggest that improved sanitation can reduce rates of diarrheal diseases by 32%–37%. While many of the studies included in those reviews could not rigorously disaggregate the specific effects of sanitation from the overall effects of wider water, sanitation, and hygiene interventions, a longitudinal cohort study in Salvador, Brazil, found that an increase in sewerage coverage from 26% to 80% of the target population resulted in a 22% reduction of diarrhea prevalence in children under 3 years of age; in those areas where the baseline diarrhea prevalence had been highest and safe sanitation coverage lowest, the prevalence rate fell by 43%. Similarly, a recent meta-analysis that explored the impact of the provision of sewerage on diarrhea prevalence reported a pooled estimate of a 30% reduction in diarrhea prevalence and up to 60% reduction in areas with especially poor baseline sanitation conditions. Another longitudinal study in urban Brazil found that the major risk factors for diarrhea in the first three years of life were low socioeconomic status, poor sanitation conditions, presence of intestinal parasites, and absence of prenatal examination. The study concluded that diarrheal disease rates could be substantially decreased by interventions designed to improve the sanitary and general living conditions of households. Further, it is not just the provision and adult use of sanitation that is important. A metaanalysis of observational studies of infants' faeces disposal practices found that unsafe disposal increased the risk of diarrhea by 23%, highlighting the importance of the safe management of both adults' and infants' faeces.

Neglected Tropical Diseases

Neglected tropical diseases, while resulting in little mortality, cause substantial disability adjusted life year (DALY) losses in developing countries. Many of these diseases have a faeco-oral transmission pathway. Thus, improved sanitation could contribute significantly to a sustained reduction in the prevalence of many of them, including trachoma, soiltransmitted helminthiasis, and schistosomiasis. Unfortunately, the current policy focus in most parts of the world is on treatment by medication, which, unlike good sanitation, is not a preferred solution because, in part, it is much more expensive.

Trachoma is endemic in many of the world's poorest countries. It is caused by the bacterium *Chlamydia trachomatis* and is the world's leading cause of preventable blindness.

Trachoma control is predominantly antibiotic-based despite the existence of the SAFE control strategy (surgery, antibiotics, face-washing, and environmental measures, namely sanitation promotion). However, a recent cluster-randomised control trial in Ghana found that the provision of toilets reduced appreciably the number of *Musca sorbens* flies (the vector for trachoma) caught on children's eyes

and by 30% the prevalence of trachoma, thus confirming the long-suspected role that sanitation could play in the control of trachoma

Soil-transmitted helminths such as the large human roundworm, the human whipworm, and the human hookworms cause many millions of infections every year and many individuals are infected with more than one of these geohelminths. Helminthic infections negatively impact the nutritional status of infected individuals, with consequent growth faltering in young children, and anaemia, particularly in pregnant women. Adult helminthes live in the human gastrointestinal tract where they reproduce sexually. Their eggs are discharged in the faeces of the infected host and thus, mainly via open defecation, to other people. Ending the practice of open defecation with good sanitation can cut this transmission path completely, but most current helminth-control programmes focus on medication, which must be repeated periodically in the absence of sanitation.

Globally, some 190 million people are infected with schistosomiasis, which can result in chronic debilitation, haematuria, impaired growth, bladder and colorectal cancers, and essential organ malfunction. Adult schistosomes live in the portal veins where they pass their eggs into the environment via the urine (*Schistosoma haematobium*) or faeces (the other human schistosomes). After passing part of their life cycle in aquatic snails where they multiply asexually, cercariae are discharged into the water where they come into contact with and infect their human hosts through their skin. Thus, sanitation (and water) interventions are essential to any long-term control and elimination of schistosomiasis, whereas the current standard intervention is repeated medication .

Acute Respiratory Infections

With 4.2 million deaths each year (1.6 million among children under 5 years), acute respiratory infections are the leading cause of mortality in developing countries. Although sanitation is not directly linked to all acute respiratory infections, a recent study reported that 26% of acute lower respiratory infections among malnourished children in rural Ghana may have been due to recent episodes of diarrhea. Thus, sanitation could be a powerful intervention against acute respiratory infections.

Under nutrition

Poor sanitation, hygiene, and water are responsible for about 50% of the consequences of childhood and maternal underweight, primarily through the synergy between diarrheal diseases and under nutrition, whereby exposure to one increases vulnerability to the other.

Wider Benefits of Sanitation

In addition to its impact on health, improved sanitation generates both social and economic benefits. Householders understand these wider benefits but scientists have only recently begun to study individuals' motivations for improving sanitation and changing sanitation behaviour.

While the main goal of agencies' sanitation programming is to improve health, householders rarely adopt and use toilets for health-related reasons. Instead, the main motivations for sanitation adoption and use include the desire for privacy and to avoid embarrassment, wanting to be modern, the desire for convenience and to avoid the discomforts or dangers of

the bush (e.g., snakes, pests, rain), and wanting social acceptance or status.

Furthermore, for women, the provision of household sanitation reduces the risk of

rape and/or attack experienced when going to public latrines or the bush to defecate, and for girls, the provision of school sanitation facilities means that they are less likely to miss school by staying at home during menstruation

The economic benefits of improved sanitation include lower health system costs, fewer days lost at work or at school through illness or through caring for an ill relative, and convenience time savings (time not spent queuing at shared sanitation facilities or walking for open defecation)

In total, the prevention of sanitation- and water-related diseases could save some \$7 billion per year in health system costs; the value of deaths averted, based on discounted future earnings, adds another \$3.6 billion per year. Furthermore, in much of the developing world at any one time around half the hospital beds are occupied by people with diarrhoeal diseases Expressed at a national scale, poor sanitation and hygiene costs the Lao People's

Democratic Republic 5.6% of its GDP per year and studies in Ghana and Pakistan suggest that general improvements in environmental conditions could save 8%–9% of GDP annually shows the cost–benefit ratios associated with achieving the Millennium Development Goal

(MDG) sanitation target (a reduction of 50% in the proportion of people without improved sanitation by 2015 from the 1990 baseline figure) and with achieving universal sanitation access in the non-OECD (Organisation for Economic Co-operation and Development) countries. Thus, one dollar spent on sanitation could generate about ten dollars' worth of economic benefit, mainly by productive work time gained from not being ill if either of these goals were achieved.

Finally, the Disease Control Priorities Project recently found hygiene promotion to prevent diarrhea to be the most cost-effective health intervention in the world at only \$3.35 per DALY loss averted, with sanitation promotion following closely behind at just \$11.15 per DALY loss averted

Analysis of the Current Situation Coverage

Currently, some 2.6 billion people lack access to improved sanitation, two-thirds of whom live in Asia and sub-Saharan Africa. 1.2 billion people, of whom more than half live in India, lack even an unimproved sanitation facility and must defecate in the open. Regional disparities in sanitation coverage are huge.

Whereas 99% of people living in industrialized countries have access to improved sanitation, in developing countries only 53% have such access. Within developing countries, urban sanitation coverage is 71% while rural coverage is 39%.

Consequently, at present the majority of people lacking sanitation live in rural areas; this balance will shift rapidly as urbanisation increases. Worryingly, over the past two decades, provision of improved sanitation has barely kept pace with increasing populations while most other social services, including water supply, have outpaced population growth.

Reasons for Slow Progress

For many years, national governments, aid agencies, and charities have subsidized sewerage and toilet construction as a means to improve access. This approach has resulted in slow progress for two main reasons. First, the programmes have tended to benefit the few relatively well-off people who can understand the system and capture the subsidies, rather than reach the more numerous poor people. Second, such programmes have built toilets that remain unused because they are technically or culturally inappropriate or because the householders have not been taught the benefits of them. In India, for example, many toilets are used as firewood stores or goat sheds and a recent study showed

that about 50% of toilets built by a large government programme are not used for their intended purpose

Even when appropriate toilets are promoted, their technical specifications frequently make them prohibitively expensive. Thus, a recent study in Cambodia found that while there is a strong demand for toilets, that demand remains mostly unrealised because people favour an unaffordable \$150 design rather than simpler but still hygienic designs costing \$5–\$10

Another reason for slow progress is that disposal of children's faeces—the group most vulnerable to faeco-oral disease transmission—is neglected and under-researched. A recent literature review that analysed a wide range of disposal practices for children's faeces and the health gains that can result from them noted that this whole topic is significantly neglected

Finally, sanitation is not an inherently attractive or photogenic subject. Before 2008, the International Year of Sanitation, sanitation specialists had failed to persuade politicians, the media, and other influential people of the importance of the subject. During 2008, however, there were many political events related to sanitation—notably regional sanitation conferences across the developing world—that resulted in Regional Sanitation Declarations, which have moved sanitation up the political agenda

Successful Approaches to Sanitation

Recently, there has been a shift away from centrally planned provision of infrastructure towards demand-led approaches that create and serve people's motivation to improve their own sanitation. Although sound technological judgment about appropriate solutions remains essential, appropriate programming approaches are now more important and contribute most to the success of sanitation work. Some of the most promising approaches that apply to both rural and urban sanitation are described below. Regarding the costs of these demand-led approaches, there are few published comparative studies, but sector professionals estimate that they cost less than traditional infrastructure provision. For example, the Water Supply and Sanitation Collaborative Council's Global Sanitation Fund allows average costs of \$15 per person for demand-led approaches, whereas governmental provision of infrastructure typically costs tens to hundreds of dollars per person.

Sanitation Marketing

Sanitation marketing uses a range of interventions to raise householders' demand for improved sanitation. The approach involves understanding householders' motivations and constraints to sanitation adoption and use. These are then used to develop both demand and supply-side interventions to ensure that appropriate sanitation products and services are available to match the demand. A successful example of sanitation marketing is described in

Community-Led Total Sanitation

Community-led total sanitation (CLTS) is a communications-based approach that aims to achieve “open defecation-free” status for whole communities rather than helping individual households to acquire toilets. CLTS was developed in Bangladesh (see section 2 in Text S1) and uses external facilitators and community volunteers to raise (“ignite”) community awareness that open defecation contaminates the environment and the water and food ingested by householders. It encourages a cooperative, participatory approach towards ending open defecation and creating a clean, healthy, and hygienic environment from which everyone benefits. CLTS has spread from South Asia to Africa and South America in the past ten years and appears to be highly successful in certain

communities. However, one recent study estimates that only 39% of ignited villages achieve open defecation-free status.

The success or failure of CLTS may relate to its cultural suitability and to the degree to which it addresses supply-side constraints to sanitation adoption .

Community Health Clubs

Community Health Clubs aim to change sanitation and hygiene attitudes and behavior through communal activities. The approach has proved effective and cost-effective in the Makoni and Tsholotsho Districts of Zimbabwe where villagers were invited to weekly sessions where one health topic was debated and then action plans formulated. In one year in Makoni District, for example, 1,244 health sessions were held by 14 trainers, costing an average of US\$0.21 per beneficiary and involving 11,450 club members. Club members' hygiene in both districts was significantly different ($p < 0.0001$) from that of a control group, and the study's authors concluded that if a strong community structure is developed and the norms of a community are altered, sanitation and hygiene behaviour are likely to improve.

Sanitation as a Business

Traditionally, sanitation has been regarded as a centrally provided service with little role for the creativity or energy of business. However, the increased demand created by sanitation marketing, CLTS, and Community Health Clubs can be met by the development of a vibrant local private sector for producing, marketing, and maintaining low-cost toilets. For example, in Lesotho the national government organised and planned workshops for people to review toilet designs and building methods in its “local latrine builders” programme. The local private sector can also be encouraged to become involved in pit-emptying, sale of safely composted human excreta as fertilizer, generation of methane from biogas toilets, and the operation of public toilets.

Approaches Emphasizing Low Cost

Many sanitation advocates now place the affordability of the toilets at the centre of the planning process. A common strategy is to encourage people to start with the simplest type

of improved pit latrine (see section 3 in Text S1) and then to progress over time towards higher-specification and higher-cost toilets—the “sanitation ladder.” The critical and most cost-effective step on this ladder, for both health and social reasons, is the first step from open defecation to fixed-location defecation; the subsequent steps up the ladder may yield smaller incremental benefits.

Approaches Specific to Urban Sanitation

Most successful demand-led approaches have been developed in rural contexts. Urban sanitation is much more complex, mainly because of higher population densities, lesscoherent community structures, and the absence of opportunities for open defecation.

Urban sanitation must extend beyond the household acquisition of a toilet to a systems based approach that covers the removal, transport, and safe treatment or disposal of excreta (see section 4 in Text S1).

For on-site urban sanitation systems, pit-emptying services are common in middle-income countries where householders can afford the cost, but less common in poorer countries.

However, in Maputo, Mozambique, a small community-based association has developed a pit emptying/septic tank desludging service using self-propelled machines to provide service

in unplanned areas of the city]. For off-site or centralised systems, simplified or “condominial” sewerage systems, in which sewers are placed inside housing blocks and then discharged into conventional sewers if there are any nearby or led

to a simple local wastewater treatment plant, can provide the same level of service as conventional sewerage but at around one-third to one-half of the cost . In densely populated low-income urban areas, community-managed sanitation blocks, used only by community members who pay a monthly fee for operation and maintenance, are an option. Public sanitation blocks that can be used by anyone, normally for a small fee per use, can be an acceptable alternative provided that they are well operated and maintained and have 24-hour access. Finally, in less densely populated low-income urban areas, onsite sanitation options of the types described in section 3 in Text S1 for rural areas are often applicable.

The Role of the Health Sector in Improving Sanitation

Sanitation promotion is one of the most important roles the health sector can have in environmental health planning, because behaviours must be changed to increase householders' demand for and sustained use of sanitation, especially in rural areas where the pressure for change is lower. Thus, two of the most promising large-scale sanitation

programmes in Africa are centred around demand creation and are both led and delivered by the Ministry of Health and its associated structures

Sanitation can be promoted by the health sector through a stand-alone programme such as sanitation marketing or CLTS or included in disease-specific control programmes such as the 'SAFE' approach to trachoma. Alternatively, it can be incorporated into a wider integrated community health package such as Ethiopia's HEP (Health Extension

Programme), which was developed in 2004 to prevent the five most prevalent diseases in the country; safe sanitation and hygiene became a major focus within HEP because of the recognition that these diseases are all linked with poor environmental health.

Promotion alone by the health sector may be insufficient, however, to ensure sanitation adoption and maintenance. A "carrot and stick" approach may be needed in which sanitation coverage is increased through a combination of community-based promotion and enforcement of national or local legislation that every house must have a toilet. In many countries, Environmental Health Officers are responsible for ensuring the sanitary condition and hygienic emptying of toilets, and have the power to sanction dissenting households with fines and court action. This enforcement role of the health sector is particularly important in urban areas where high-density living increases the risks of faecal contamination of the environment and where one person's lack of sanitation can affect the health of many other people.

The health sector also has an important role to play in advocacy and leadership. Politicians and the general public listen to doctors. That puts an onus on the medical profession to speak out on all important health issues, including sanitation. Historically, this has not

10 happened. Thus, in 2008, *The Lancet* wrote, "the shamefully weak presence of the health sector in advocating for improved access to water and sanitation is incomprehensible and completely short-sighted"

Given the huge potential health-cost savings achieved through improved sanitation, the health sector should be advocating for stronger institutional leadership, stronger national planning, and the establishment of clear responsibilities and budget lines for sanitation.

Unfortunately, although the international health community puts large human and financial resources into many low- to medium-cost health interventions such as immunization and bed net distribution, it has been slow to act on the evidence

showing that sanitation promotion and hygiene promotion are among the most cost-effective public health interventions available to developing countries. Finally, the well-honed epidemiology and surveillance skills of health professionals must also now be applied to sanitation to establish clear links between national health information systems and sanitation planning and financing, which has historically been separate from health in most countries.

Constraints to Success in Sanitation

The lack of national policies is a major constraint to success in sanitation (see section 5 in Text S1 for additional information on this and other constraints). Governments in general and health ministries in particular cannot play their key roles as facilitators and regulators of sanitation without policies that support the transformation of national institutions into lead institutions for sanitation, that increase focus on household behaviours and community action, that promote demand creation, and that enable health systems to incorporate sanitation and hygiene. Other constraints to success in sanitation are population growth and increasingly high population densities in urban and periurban areas of developing countries. Furthermore, most of the people who lack improved sanitation live on less than \$2 per day, which makes high-cost, high-technology sanitation solutions inappropriate. Finally, although macroeconomic analysis shows that sanitation generates economic benefit, the benefit does not necessarily accrue to the person who invests in the improved sanitation. So the economics at the household level remain a constraint to success in sanitation—many people are simply unable or unwilling to invest, given all the other competing demands on their money. This under-researched topic is currently under investigation by the WASH Cost Project, which is studying the life-cycle costs of water, sanitation, and hygiene services in rural and periurban areas in four countries.

Strategies to Achieve Success in Sanitation

Sanitation is a complex topic, with links to health and to social and economic development.

It affects many but is championed by few. From our analysis of the situation, we believe that three major strategies could achieve success in sanitation.

The most important of these strategies is political leadership, which is manifested by establishing clear institutional responsibility and specific budget lines for sanitation, and by ensuring that public sector agencies working in health, in water resources, and in utility services work together better. The regional sanitation conference declarations released during the International Year of Sanitation, in which many government ministers were personally involved, were an important step forward. In addition, the biennial global reports on sanitation and drinking water published by the World Health Organization and UNICEF contribute towards political leadership and aid effectiveness by publicising the sanitation work of both developing country governments and support agencies.

The second strategy is the shift from centralised supply-led infrastructure provision to decentralised, people-centred demand creation coupled with support to service providers to meet that demand. This strategy is transforming sanitation from a minor grant-based development sector into a major area of human economic activity and inherently addresses the problem of affordability, since people install whatever sanitation systems they can afford and subsequently upgrade them as economic circumstances permit.

The final strategy is the full involvement of the health sector in sanitation. The health sector has a powerful motivation for improving sanitation, and much strength to contribute to achieving this goal. The Declaration of Alma Ata in 1978 emphasised the importance of primary health care and included “an adequate

supply of safe water and basic sanitation” as one of its eight key elements. Many years have passed since this Declaration, and the body of evidence about sanitation has increased substantially. The health sector now needs to reassert its commitment and leadership to help achieve a world in which everybody has access to adequate sanitation.

Solid waste disposal

Disposal of solid waste is most commonly conducted in landfills, but incineration, recycling, composting and conversion to bio-fuels 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.[9] The importance of daily cover lies in the reduction of vector contact and spreading of pathogens. Daily cover also minimises odour 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).

For incineration options, the release of air pollutants, including certain toxic components is

an attendant adverse outcome. Recycling and bio-fuel conversion are the sustainable options that generally have superior life cycle costs, particularly when total ecological consequences are considered. Composting value will ultimately be limited by the market demand for compost product.

Wastewater collection

The standard sanitation technology in urban areas is the collection of wastewater in 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.

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

Wastewater treatment

In developed countries treatment of municipal wastewater is now widespread, but not yet universal (for an overview of technologies see wastewater treatment). In developing countries most wastewater is still discharged untreated into the environment. For example, in Latin America only about 15% of collected sewerage is being treated (see water and sanitation in Latin America)

Reuse of wastewater

The reuse of untreated 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.

In many suburban and rural areas households are not connected to sewers. They discharge their wastewater into septic tanks or other types of on-site sanitation.

RELEVANT ASPECTS TO BE CONSIDERED IN ORDER TO MANAGE GOOD SANITATION

Disinfectants

Disinfectants are substances that are applied to non-living objects to destroy microorganisms that are living on the objects.[1] Disinfection does not necessarily kill all microorganisms, especially nonresistant bacterial spores; it is less effective than sterilisation, which is an extreme physical and/or chemical process that kills all types of life. Disinfectants are different from other antimicrobial agents such as antibiotics, which

destroy microorganisms within the body, and antiseptics, which destroy microorganisms on living tissue. Disinfectants are also different from biocides — the latter are intended to destroy all forms of life, not just microorganisms.

Disinfectants work by destroying the cell wall or microbes or interfering with the metabolism.

Sanitisers are substances that simultaneously clean and disinfect.[2]

Bacterial endospores are most resistant to disinfectants, but some viruses and bacteria also possess some tolerance.

Disinfectants are frequently used in hospitals, dental surgeries, kitchens, and bathrooms to kill infectious organisms.

They are several types of disinfectants which range from air disinfectants, Alcohol, Aldehydes, Oxidising agents, Phenolics. Quaternary ammonium compounds, Silver and copper alloy surfaces among others. Phenol is the standard, and the corresponding rating system is called the "Phenol coefficient". The disinfectant to be tested is compared with phenol on a standard microbe. Those that are less effective have a coefficient

Environmental epidemiology

Environmental epidemiology is the branch of epidemiology concerned with discovery of the environmental exposures that contribute to or protect against injuries, illnesses, developmental conditions, disabilities, and deaths; and identification of public health and health care actions to avoid, prepare for, and effectively manage the risks associated with harmful exposures. Environmental epidemiology studies external factors that affect the incidence, prevalence, and geographic range of health conditions. These factors may be naturally occurring or may be introduced into environments where people live, work, and play.

Environmental epidemiology seeks to:

1. understand who is most vulnerable and sensitive to an exposure,
2. evaluate mechanisms of action of environmental exposures,
3. identify public health and health care policies and measures to manage risks, and
4. evaluate effectiveness, costs, and benefits of these policies and measures, as well as provide evidence for accountability.

Environmental epidemiology research can inform risk assessments; development of standards and other risk management activities; and estimates of the co-benefits and co-harms

of policies designed to reduce global environment change, including policies implemented in other sectors (e.g. food and water) that can affect human health.

Environmental health

Environmental health is the branch of public health that is concerned with all aspects of the natural and built environment that may affect human health. Other terms that concern

or refer to the discipline of environmental health include **environmental public health** and **environmental health and protection**.

Environmental health is defined by the World Health Organization as:

Those aspects of the human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health.

Environmental health as used by the WHO Regional Office for Europe, includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects (often indirect) on health and well being of the broad physical, psychological, social and cultural environment, which includes housing, urban development, land use and transport.

Environmental health services are defined by the World Health Organization as: those services which implement environmental health policies through monitoring and control activities. They also carry out that role by promoting the improvement of environmental parameters and by encouraging the use of environmentally friendly and healthy technologies and behaviours. They also have a leading role in developing and suggesting new policy areas.

Environmental health practitioners may be known as sanitarians, public health inspectors, environmental health specialists, environmental health officers or environmental health practitioners. In many European countries physicians and veterinarians are involved in environmental health. Many states in the United States require that individuals have professional licenses in order to practice environmental health. California state law defines the scope of practice of environmental health as follows:

The environmental health profession had its modern-day roots in the sanitary and public health movement of the United Kingdom. This was epitomized by Sir Edwin Chadwick, who was instrumental in the repeal of the poor laws and was the founding president of the Association of Public Sanitary Inspectors in 1884, which today is the Chartered Institute of Environmental Health.

Environmental medicine

Environmental medicine may be seen as the medical branch of the broader field of environmental health. Terminology is not fully established, and in many European countries they are used interchangeably.

Environmental health science

Environmental health is the branch of public health that is concerned with all aspects of the natural and built environment that may affect human health. Other terms that refer to the discipline of environmental health include **environmental public health** and **environmental health and protection**.

Environmental health is defined by the World Health Organization as:

Those aspects of human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially affect health.

Environmental health as used by the WHO Regional Office for Europe, includes both the direct pathological effects of chemicals, radiation and some biological agents, and the effects

(often indirect) on health and wellbeing of the broad physical, psychological, social and aesthetic environment which includes housing, urban development, land use and transport.

Environmental health services

Environmental health services are defined by the World Health Organization as: those services which implement environmental health policies through monitoring and control activities. They also carry out that role by promoting the improvement of environmental parameters and by encouraging the use of environmentally friendly and healthy technologies and behaviours. They also have a leading role in developing and suggesting new policy areas.

Environmental health practitioners may be known as sanitarians, public health inspectors, environmental health specialists or environmental health officers. Many states in the United States require that individuals have professional licenses in order to practice environmental health. California state law defines the scope of practice of environmental health as follows:

"Scope of practice in environmental health" means the practice of environmental health by registered environmental health specialists in the public and private sector within the meaning of this article and includes, but is not limited to, organization, management, education, enforcement, consultation, and emergency response for the purpose of prevention of environmental health hazards and the promotion and protection of the public health and the environment in the following areas: food protection; housing; institutional environmental health; land use; community noise control; recreational swimming areas and waters; electromagnetic radiation control; solid, liquid, and hazardous materials management; underground storage tank control; on-site septic systems; vector control; drinking water quality; water sanitation; emergency preparedness; and milk and dairy sanitation.

The environmental health profession had its modern-day roots in the sanitary and public health movement of the United Kingdom. This was epitomized by Sir Edwin Chadwick, who was instrumental in the repeal of the poor laws and was the founding president of the Association of Public Sanitary Inspectors in 1884, which today is the Chartered Institute of Environmental Health.

Environmental health concerns

Environmental health addresses all human-health-related aspects of both the natural environment and the built environment. Environmental health concerns include:

- Air quality, including both ambient outdoor air and indoor air quality, which also comprises concerns about environmental tobacco smoke.
- Body art safety, including tattooing, body piercing and permanent cosmetics.
- Climate change and its effects on health.
- Disaster preparedness and response.
- Food safety, including in agriculture, transportation, food processing, wholesale and retail distribution and sale.
- Hazardous materials management, including hazardous waste management, contaminated site remediation, the prevention of leaks from underground storage tanks and the prevention of hazardous materials releases to the environment and responses to emergency situations resulting from such releases.
- Housing, including substandard housing abatement and the inspection of jails and prisons.
- Childhood lead poisoning prevention.
- Land use planning, including smart growth.
- Liquid waste disposal, including city wastewater treatment plants and on-site waste water disposal systems, such as septic tank systems and chemical toilets.
- Medical waste management and disposal.
- Noise pollution control.
- Occupational health and industrial hygiene.
- Radiological health, including exposure to ionizing radiation from X-rays or radioactive isotopes.
- Recreational water illness prevention, including from swimming pools, spas and ocean and freshwater bathing places.
- Safe drinking water.

- Solid waste management, including landfills, recycling facilities, composting and solid waste transfer stations.
- Toxic chemical exposure whether in consumer products, housing, workplaces, air, water or soil.
- Vector control, including the control of mosquitoes, rodents, flies, cockroaches and other animals that may transmit pathogens.
- Air Pollution
- *Environmental Health Perspectives*
- Globalization and Health
- Noise Pollution
- Water Pollution

Determinants of health

The LaLonde report suggests that there are four general determinants of health including *human biology, environment, lifestyle, and healthcare services*. Thus, health is maintained and improved not only through the advancement and application of health science, but also through the efforts and intelligent lifestyle choices of the individual and society.

A major environmental factor is water quality, especially for the health of infants and children in developing countries.

Studies show that in developed countries, the lack of neighborhood recreational space that includes the natural environment leads to lower levels of neighborhood satisfaction and higher levels of obesity; therefore, lower overall well being.

Therefore, the positive psychological benefits of natural space in urban neighborhoods should be taken into account in public policy and land use.

Maintaining health

Achieving health and remaining healthy is an ongoing process. Effective strategies for staying healthy and improving one's health include the following elements:

Social Activity

Personal health depends partially on the social structure of one's life. The maintenance of strong social relationships is linked to good health conditions, longevity, productivity, and a positive attitude. This is due to the fact that positive social interaction as viewed by the participant increases many chemical levels in the brain which are linked to personality and intelligence traits.

Hygiene

Hygiene is the practice of keeping the body clean to prevent infection and illness, and the avoidance of contact with infectious agents. Hygiene practices include bathing, brushing and flossing teeth, washing hands especially before eating, washing food before it is eaten, cleaning food preparation utensils and surfaces before and after preparing meals, and many others. This may help prevent infection and illness. By cleaning the body, dead skin cells are washed away with the germs, reducing their chance of entering the body.

Stress management

Prolonged psychological stress may negatively impact health, and has been cited as a factor in cognitive impairment with aging, depressive illness, and expression of disease. Stress management is the application of methods to either reduce stress or increase tolerance to stress. Relaxation techniques are physical methods used to relieve stress. Psychological methods include cognitive therapy, meditation, and positive thinking which work by reducing response to stress. Improving relevant skills and abilities builds confidence, which also reduces the stress reaction to situations where those skills are applicable.

Reducing uncertainty, by increasing knowledge and experience related to stress-causing situations, has the same effect. Learning to cope with problems better, such as improving problem solving and time management skills, may also reduce

stressful reaction to problems. Repeatedly facing an object of one's fears may also desensitize the fight-or-flight response with respect to that stimulus—e.g., facing bullies may reduce fear of bullies.

Health care

One's overall well-being is the definition of health

Health care is the prevention, treatment, and management of illness and the preservation of mental and physical well-being through the services offered by the medical, nursing, and allied health professions.

Workplace wellness programs

Workplace wellness programs are recognized by an increasingly large number of companies for their value in improving the health and well-being of their employees, and for increasing morale, loyalty, and productivity. Workplace wellness programs can include things like onsite fitness centers, health presentations, wellness newsletters, access to health coaching, tobacco cessation programs and training related to nutrition, weight and stress management. Other programs may include health risk assessments, health screenings and body mass index monitoring.

Role of science in health

Health science is the branch of science focused on health, and it includes many subdisciplines. There are two approaches to health science: the study and research of the human body and health-related issues to understand how humans (and animals) function, and the application of that knowledge to improve health and to prevent and cure diseases.

Sources

Health research builds primarily on the basic sciences of biology, chemistry, and physics as well as a variety of multidisciplinary fields (for example medical sociology). Some of the other primarily research-oriented fields that make exceptionally significant contributions to health science are biochemistry, epidemiology, and genetics.

Application

Applied health sciences also endeavor to better understand health, but in addition they try to directly improve it. Some of these are: biomedical engineering, biotechnology, nursing, nutrition, pharmacology, pharmacy, public health (see above), psychology, physical therapy, and medicine. The provision of services to maintain or improve people's health is referred to as health care (see above)

Water pollution

Water pollution is the contamination of water bodies such as lakes, rivers, oceans, and groundwater. All water pollution affects organisms and plants that live in these water bodies and in almost all cases the effect is damaging either to individual species and populations but also to the natural biological communities. It occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful constituents.

Water pollution categories

Surface water and groundwater have often been studied and managed as separate resources, although they are interrelated. Sources of surface water pollution are generally grouped into two categories based on their origin.

Point source pollution

Point source pollution refers to contaminants that enter a waterway through a discrete conveyance, such as a pipe or ditch. Examples of sources in this category include discharges from a sewage treatment plant, a factory, or a city storm drain. The U.S. Clean

Water Act (CWA) defines point source for regulatory enforcement purposes.[8] The CWA definition of point source was amended in 1987 to include municipal storm sewer systems, as well as industrial stormwater, such as from construction sites.[9]

Non-point source pollution

Non-point source (NPS) pollution refers to diffuse contamination that does not originate

from a single discrete source. NPS pollution is often accumulative effect of small amounts of contaminants gathered from a large area. The leaching out of nitrogen compounds from agricultural land which has been fertilized is a typical example. Nutrient runoff in

stormwater from "sheet flow" over an agricultural field or a forest are also cited as examples of NPS pollution.

Contaminated storm water washed off of parking lots, roads and highways, called urban runoff, is sometimes included under the category of NPS pollution.

However, this runoff is typically channeled into storm drain systems and discharged through pipes to local surface waters, and is a point source. However where such water is not channeled and drains directly to ground it is a non point source.

Groundwater pollution

Interactions between groundwater and surface water are complex. Consequently, groundwater pollution, sometimes referred to as **groundwater contamination**, is not as

easily classified as surface water pollution. By its very nature, groundwater aquifers are

susceptible to contamination from sources that may not directly affect surface water bodies, and the distinction of point vs. nonpoint source may be irrelevant. A spill of a chemical contaminant on soil, located away from a surface water body, may not necessarily create point source or non-point source pollution, but nonetheless may contaminate the aquifer below. Analysis of groundwater contamination may focus on soil characteristics and hydrology, as well as the nature of the contaminant itself. *See Hydrogeology.*

Causes of water pollution

The specific contaminants leading to pollution in water include a wide spectrum of chemicals, pathogens, and physical or sensory changes such as elevated temperature and discoloration. While many of the chemicals and substances that are regulated may be naturally occurring (calcium, sodium, iron, manganese, etc.) the concentration is often the key in determining what is a natural component of water, and what is a contaminant.

Oxygen-depleting substances may be natural materials, such as plant matter (e.g. leaves and grass) as well as man-made chemicals. Other natural and anthropogenic substances may cause turbidity (cloudiness) which blocks light and disrupts plant growth, and clogs the gills of some fish species.

Many of the chemical substances are toxic. Pathogens can produce waterborne diseases in either human or animal hosts. Alteration of water's physical chemistry include acidity (change in pH), electrical conductivity, temperature, and eutrophication. Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases in the primary productivity of the ecosystem. Depending on the degree of eutrophication, subsequent negative environmental effects such as anoxia and severe reductions in water quality, fish, and other animal populations may occur.

Chemical and other contaminants

Contaminants may include organic and inorganic substances.

Organic water pollutants include:

- Detergents
- Disinfection by-products found in chemically disinfected drinking water, such as chloroform
- Food processing waste, which can include oxygen-demanding substances, fats and grease
- Insecticides and herbicides, a huge range of organohalides and other chemical compounds
- Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion byproducts, from storm water runoff
- Tree and bush debris from logging operations
- Volatile organic compounds (VOCs), such as industrial solvents, from improper storage. Chlorinated solvents, which are dense non-aqueous phase liquids (DNAPLs), may fall to the bottom of reservoirs, since they don't mix well with water and are denser.
- Various chemical compounds found in personal hygiene and cosmetic products

Inorganic water pollutants include:

- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Ammonia from food processing waste
- Chemical waste as industrial by-products
- Fertilizers containing nutrients--nitrates and phosphates--which are found in stormwater runoff from agriculture, as well as commercial and residential use[15]
- Heavy metals from motor vehicles (via urban stormwater runoff)[15][16] and acid mine drainage
- Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites

Macroscopic pollution—large visible items polluting the water—may be termed "floatables"

in an urban stormwater context, or marine debris when found on the open seas, and can include such items as:

- Trash (e.g. paper, plastic, or food waste) discarded by people on the ground, and that are washed by rainfall into storm drains and eventually discharged into surface waters
- Nurdles, small ubiquitous waterborne plastic pellets
- Shipwrecks, large derelict ships

Thermal pollution

Thermal pollution is the rise or fall in the temperature of a natural body of water caused by human influence. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. Elevated water temperatures decreases oxygen levels (which can kill fish) and affects ecosystem composition, such as invasion by new thermophilic species. Urban runoff may also elevate temperature in surface waters. Thermal pollution can also be caused by the release of very cold water from the base of reservoirs into warmer rivers.

Transport and chemical reactions of water pollutants

Most water pollutants are eventually carried by rivers into the oceans. In some areas of the world the influence can be traced hundred miles from the mouth by studies using hydrology transport models. Advanced computer models such as SWMM or the DSSAM Model have been used in many locations worldwide to

examine the fate of pollutants in aquatic systems. Indicator filter feeding species such as copepods have also been used to study pollutant fates in the New York Bight, for example. The highest toxin loads are not directly at the mouth of the Hudson River, but 100 kilometers south, since several days are required for incorporation into planktonic tissue. The Hudson discharge flows south along the coast due to coriolis force. Further south then are areas of oxygen depletion, caused by chemicals using up oxygen and by algae blooms, caused by excess nutrients from algal cell death and decomposition. Fish and shellfish kills have been reported, because toxins climb the food chain after small fish consume copepods, then large fish eat smaller fish, etc. Each successive step up the food chain causes a stepwise concentration of pollutants such as heavy metals (e.g. mercury) and persistent organic pollutants such as DDT. This is known as biomagnification, which is occasionally used interchangeably with bioaccumulation.

Large gyres (vortexes) in the oceans trap floating plastic debris. The North Pacific Gyre for example has collected the so-called "Great Pacific Garbage Patch" that is now estimated at 100 times the size of Texas. Many of these long-lasting pieces wind up in the stomachs of marine birds and animals. This results in obstruction of digestive pathways which leads to reduced appetite or even starvation.

Many chemicals undergo reactive decay or chemically change especially over long periods of time in groundwater reservoirs. A noteworthy class of such chemicals is the chlorinated hydrocarbons such as trichloroethylene (used in industrial metal degreasing and electronics

manufacturing) and tetrachloroethylene used in the dry cleaning industry (note latest advances in liquid carbon dioxide in dry cleaning that avoids all use of chemicals). Both of these chemicals, which are carcinogens themselves, undergo partial decomposition reactions, leading to new hazardous chemicals (including dichloroethylene and vinyl chloride).

Groundwater pollution is much more difficult to abate than surface pollution because groundwater can move great distances through unseen aquifers. Non-porous aquifers such as clays partially purify water of bacteria by simple filtration (adsorption and absorption), dilution, and, in some cases, chemical reactions and biological activity: however, in some cases, the pollutants merely transform to soil contaminants. Groundwater that moves through cracks and caverns is not filtered and can be transported as easily as surface water. In fact, this can be aggravated by the human tendency to use natural sinkholes as dumps in areas of Karst topography.

There are a variety of secondary effects stemming not from the original pollutant, but a derivative condition. An example is silt-bearing surface runoff, which can inhibit the penetration of sunlight through the water column, hampering photosynthesis in aquatic plants.

Measurement of water pollution

Water pollution may be analyzed through several broad categories of methods: physical,

chemical and biological. Most involve collection of samples, followed by specialized analytical tests. Some methods may be conducted *in situ*, without sampling, such as temperature. Government agencies and research organizations have published standardized, validated analytical test methods to facilitate the comparability of results from disparate testing event.

Sampling

Sampling of water for physical or chemical testing can be done by several methods, depending on the accuracy needed and the characteristics of the contaminant. Many contamination events are sharply restricted in time, most

commonly in association with rain events. For this reason "grab" samples are often inadequate for fully quantifying contaminant levels. Scientists gathering this type of data often employ auto-sampler devices that pump increments of water at either time or discharge intervals.

Sampling for biological testing involves collection of plants and/or animals from the surface water body. Depending on the type of assessment, the organisms may be identified for

biosurveys (population counts) and returned to the water body, or they may be dissected for bioassays to determine toxicity.

Physical testing

Common physical tests of water include temperature, solids concentration and turbidity.

Chemical testing

Water samples may be examined using the principles of analytical chemistry. Many published test methods are available for both organic and inorganic compounds.

Frequently-used methods include pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), nutrients (nitrate and phosphorus compounds), metals (including copper, zinc, cadmium, lead and mercury), oil and grease, total petroleum hydrocarbons (TPH), and pesticides.

Biological testing

Biological testing involves the use of plant, animal, and/or microbial indicators to monitor the health of an aquatic ecosystem.

For microbial testing of drinking water, see Bacteriological water analysis.

Control of water pollution

Domestic sewage

Domestic sewage is 99.9% pure water, the other 1% are pollutants. These pollutants although small, pose risk on a large scale. In urban areas, domestic sewage is typically treated by centralized sewage treatment plants. In the U.S., most of these plants are operated by local government agencies. Municipal treatment plants are designed to control conventional pollutants: BOD and suspended solids. Well-designed and operated systems (i.e., secondary treatment or better) can remove 90 percent or more of these pollutants.

Some plants have additional sub-systems to treat nutrients and pathogens. Most municipal plants are not designed to treat toxic pollutants found in industrial wastewater.

Cities with sanitary sewer overflows or combined sewer overflows employ one or more engineering approaches to reduce discharges of untreated sewage, including:

- utilizing a green infrastructure approach to improve stormwater management capacity throughout the system
- repair and replacement of leaking and malfunctioning equipment
- increasing overall hydraulic capacity of the sewage collection system (often a very expensive option).

A household or business not served by a municipal treatment plant may have an individual septic tank, which treats the wastewater on site and discharges into the soil. Alternatively, domestic wastewater may be sent to a nearby privately-owned treatment system (e.g. in a rural community).

Industrial wastewater

Some industrial facilities generate ordinary domestic sewage that can be treated by municipal facilities. Industries that generate wastewater with high concentrations of conventional pollutants (e.g. oil and grease), toxic pollutants

(e.g. heavy metals, volatile organic compounds) or other nonconventional pollutants such as ammonia, need specialized treatment systems. Some of these facilities can install a pre-treatment system to remove the toxic components, and then send the partially-treated wastewater to the municipal system. Industries generating large volumes of wastewater typically operate their own complete on-site treatment systems.

Some industries have been successful at redesigning their manufacturing processes to reduce or eliminate pollutants, through a process called pollution prevention.

Heated water generated by power plants or manufacturing plants may be controlled with:

- cooling ponds, man-made bodies of water designed for cooling by evaporation, convection, and radiation
- cooling towers, which transfer waste heat to the atmosphere through evaporation and/or heat transfer
- cogeneration, a process where waste heat is recycled for domestic and/or industrial heating purposes.

Agricultural wastewater

Nonpoint source controls

Sediment (loose soil) washed off fields is the largest source of agricultural pollution in the United States.[10] Farmers may utilize erosion controls to reduce runoff flows and retain soil on their fields. Common techniques include contour plowing, crop mulching, crop rotation, planting perennial crops and installing riparian buffers.

Nutrients (nitrogen and phosphorus) are typically applied to farmland as commercial fertilizer; animal manure; or spraying of municipal or industrial wastewater (effluent) or sludge. Nutrients may also enter runoff from crop residues, irrigation water, wildlife, and atmospheric deposition.[23]:p. 2-9 Farmers can develop and implement nutrient management plans to reduce excess application of nutrients.

To minimize pesticide impacts, farmers may use Integrated Pest Management (IPM) techniques (which can include biological pest control) to maintain control over pests, reduce reliance on chemical pesticides, and protect water quality.

Point source wastewater treatment

Farms with large livestock and poultry operations, such as factory farms, are called *concentrated animal feeding operations* or *confined animal feeding operations* in the U.S. and are being subject to increasing government regulation. Animal slurries are usually treated by containment in lagoons before disposal by spray or trickle application to grassland.

Constructed wetlands are sometimes used to facilitate treatment of animal wastes, as are anaerobic lagoons. Some animal slurries are treated by mixing with straw and composted at high temperature to produce a bacteriologically sterile and friable manure for soil improvement.

Construction site stormwater

Sediment from construction sites is managed by installation of:

- erosion controls, such as mulching and hydroseeding, and
- sediment controls, such as sediment basins and silt fences.

Discharge of toxic chemicals such as motor fuels and concrete washout is prevented by use

of:

- spill prevention and control plans, and
- specially-designed containers (e.g. for concrete washout) and structures such as overflow controls and diversion berms.

Urban runoff (stormwater)

Effective control of urban runoff involves reducing the velocity and flow of stormwater, as well as reducing pollutant discharges. Local governments use a variety of stormwater management techniques to reduce the effects of urban runoff. These techniques, called best management practices (BMPs) in the U.S., may focus on water quantity control, while others focus on improving water quality, and some perform both functions.

Pollution prevention practices include low impact development techniques, installation of green roofs and improved chemical handling (e.g. management of motor fuels & oil, fertilizers and pesticides). Runoff mitigation systems include infiltration basins, bioretention systems, constructed wetlands, retention basins and similar devices.

Thermal pollution from runoff can be controlled by stormwater management facilities that absorb the runoff or direct it into groundwater, such as bioretention systems and infiltration basins. Retention basins tend to be less effective at reducing temperature, as stormwater may be heated by the sun before being discharged to a receiving stream.

Noise pollution

Noise pollution (or **environmental noise**) is displeasing human-, animal- or machine-created sound that disrupts the activity or balance of human or animal life. The word *noise* comes from the Latin word *nausea* meaning seasickness. The source of most outdoor noise worldwide is transportation systems, including motor vehicle noise, aircraft noise and rail noise. Poor urban planning may give rise to noise pollution, since side-by-side industrial and residential buildings can result in noise pollution in the residential area.

Other sources of indoor and outdoor noise pollution are car alarms, emergency service sirens, office equipment, factory machinery, construction work, groundskeeping equipment, barking dogs, appliances, power tools, lighting hum, audio entertainment systems, loudspeakers, and noisy people.

Human health effects

Noise health effects are both health and behavioural in nature. The unwanted sound is called noise. This unwanted sound can damage physiological and psychological health.

Noise pollution can cause annoyance and aggression, hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects.

Furthermore, stress and hypertension are the leading causes to health problems, whereas tinnitus can lead to forgetfulness, severe depression and at times panic attacks.

Chronic exposure to noise may cause noise-induced hearing loss. Older males exposed to significant occupational noise demonstrate significantly reduced hearing sensitivity than

their non-exposed peers, though differences in hearing sensitivity decrease with time and the two groups are indistinguishable by age 79. A comparison of

Maabantribesmen, who

were insignificantly exposed to transportation or industrial noise, to a typical U.S. population showed that chronic exposure to moderately high levels of environmental noise contributes to hearing loss.

High noise levels can contribute to cardiovascular effects and exposure to moderately high

levels during a single eight hour period causes a statistical rise in blood pressure of five to ten points and an increase in stress[3] and vasoconstriction leading to

the increased blood pressure noted above as well as to increased incidence of coronary artery disease.

Noise pollution is also a cause of annoyance. A 2005 study by Spanish researchers found that in urban areas households are willing to pay approximately four Euros per decibel per year for noise reduction.

Environmental effects

Noise can have a detrimental effect on animals by causing stress, increasing risk of death by changing the delicate balance in predator/prey detection and avoidance, and by interfering with their use of sounds in communication especially in relation to reproduction and in navigation. Acoustic overexposure can lead to temporary or permanent loss of hearing.

An impact of noise on animal life is the reduction of usable habitat that noisy areas may cause, which in the case of endangered species may be part of the path to extinction. One of the best known cases of damage caused by noise pollution is the death of certain species of beached whales, brought on by the loud sound of military sonar.

Noise also makes species communicate louder, which is called Lombard vocal response.

Scientists and researchers have conducted experiments that show whales' song length is longer when submarine-detectors are on. If creatures don't "speak" loud enough, their voice will be masked by anthropogenic sounds. These unheard voices might be warnings, finding of prey, or preparations of net-bubbling. When one species begins speaking louder, it will mask other species' voice, causing the whole ecosystem to eventually speak louder.

European Robins living in urban environments are more likely to sing at night in places with high levels of noise pollution during the day, suggesting that they sing at night because it is quieter, and their message can propagate through the environment more clearly. Interestingly, the same study showed that daytime noise was a stronger predictor of nocturnal singing than night-time Light pollution, to which the phenomenon is often attributed.

Zebra finches become less faithful to their partners when exposed to traffic noise. This could alter a population's evolutionary trajectory by selecting traits, sapping resources normally devoted to other activities and thus lead to profound genetic and evolutionary consequences.

References

1. World Health Organization Report. (2000). *"Why do health systems matter?"*. WHO.
2. Princeton University. (2007). health profession. Retrieved June 17, 2007, from Princeton University
3. United States Department of Labor. (February 27, 2007). Health Care Industry Information. Retrieved June 17, 2007, from Employment & Training Administration (ETA) - U.S. Department of Labor
4. "Yahoo Industry Browser - Healthcare Sector - Industry List". <http://biz.yahoo.com/p/5conameu.html>.
5. Welcome to the United Nations: It's Your World
6. Efpia.org, Retrieved June 17, 2009
7. Stats from 2007 Europ.Fed.ofPharm.Indust.and Assoc. Retrieved June 17, 2009, from [1][*dead link*]
8. "2008 Annual Report" (pdf). *PHRMA*. http://www.phrma.org/files/PhRMA_annualreportFianl.pdf. Retrieved 2009-06-20.