WATER UK

Wastewater treatment and recycling

The world's water is a finite and precious resource. It is continually used and reused in the water cycle. This pamphlet shows how wastewater is treated and recycled for the benefit of us all and the sustainability of our environment. To obtain the full benefit we need to manage and protect it.

The water piped into our homes is collected from rivers, reservoirs, springs or wells. We use large amounts everyday for a variety of purposes from drinking and cleaning to washing and cooking. Whenever we use water in our homes, offices, schools and factories we add impurities that potentially affect future uses of that water and may damage the environment that depends on it.

So safe treatment of our wastewater and its return to the natural environment (rivers or the sea) is a key part of the water cycle. It protects the life in our rivers and ensures that all water sources are clean and may be easily used for the public supply.

In the UK each of us uses, on average, about 150 litres of water each day and in addition large quantities are used in industrial and commercial activities.

Before wastewater collection the convenient way to dispose of wastewater was to throw it away by tipping into the nearest watercourse, or even out of the window to the annoyance of passers by below. In cities toilet waste was often stored in cellars and had to be dug out at regular intervals and carted away to farms.

Not surprisingly these practices had serious public health implications as untreated dirty water found its way into drinking water wells and rivers resulting in cholera and dysentery outbreaks. Often watercourses turned into open drains and the easiest thing at the time was to cover or pipe them as they transported the wastewater to the nearest large river. These became the original sewers.

As populations in towns and cities grew the rivers could not absorb the pollution. They began to smell and became unable to support life. The situation was particularly serious in London and culminated in the House of Commons having to be suspended as a result of the 'Great Stink' from the Thames in 1859. This encouraged the construction of a new sewer system in London that set the standard for the rest of the country.

Rivers and the sea are naturally able to clean up 'organic' pollution e.g. faecal matter and food waste. Organic material is biodegradable and is food for naturally occurring bacteria and other micro-organisms which use dissolved oxygen to break it down in the respiration process. If however, there is too much organic pollution the oxygen will be rapidly used up leaving very little for other plants and animals. As cities have expanded, so has the volume of waste making more treatment necessary to prevent pollution.

Often wastewater contains other chemicals used in modern life. These include heavy metals which are not biodegradable and may accumulate in river sediments, plants, insects, and fish. They originate from both industrial and domestic sources and (above certain levels) can be toxic to animals and humans. Consequently industrial discharges to sewers must be well regulated, but householders should also consider carefully the products they use and flush away.

COLLECTION OF OUR WASTEWATER

In a modern society wastewater is carried from houses in underground pipes or sewers. Normally the wastewater (sewage) flows by gravity but sometimes pumping stations are needed in flat areas. As sewers meet and flow increases the sewer gets bigger and in large cities can be several metres in diameter.

In older parts of towns and cities sewers may also collect rainwater from roofs and roadways. In wet weather some cannot cope with the high flows and are designed to overflow to watercourses. These are called 'combined sewer overflows' and in recent years the impact of these on the water environment has been considerably reduced.

As a potent residue of human activity finds its way into the sewer system, great care has to be taken to protect the health and safety of people working there or at the treatment plant. Controls on discharges of industry and commercial wastewaters are most important but everyone should think about what goes into the sewer. Oil, petrol, waste chemicals and paint are of particular concern.

TREATMENT OF WASTEWATER

Sewage received at the treatment works is normally greyish in colour with a slight 'fruity' smell and an occasional tint of 'bad eggs'. It is basically dirty water with less than 0.1% being waste that needs to be treated. There are four main stages in wastewater treatment; preliminary, primary, secondary (biological) and tertiary treatment. The number of stages applied depends on the quality of discharge required to protect the environment.

Preliminary treatment

Sewage undergoes preliminary treatment to make it suitable for the main treatment processes. This includes screening and removing grit, oil and grease.

Screening

On entering a sewage treatment works, dirty water passes through screens to remove paper, wood and other large articles that could damage machinery or block pipe systems. Screens consist of vertical bars spaced close together

or perforated plates that are cleaned by rakes or water jets. The cleared material (known as screenings) is washed and safely disposed of at a landfill site. It is important to cut the amount of screenings which can block sewers before the treatment works with unpleasant results. Only toilet paper should be flushed down the toilet. Water companies run 'Bag It and Bin It' campaign to encourage the public not to flush cotton buds or plastic and sanitary items. In some European countries the sewer pipes are so small that not even paper may be flushed.

Grit removal

Sewage contains grit and dirt from roads or cleaning activities. This tends to be inert material that cannot be treated and it is removed by a settlement process which allows the lighter organic material to remain in suspension for the next treatment stage. The grit is washed and disposed of to landfill.

Removal of oil and grease

At some treatment works this process is thought necessary to protect the downstream processes. Materials such as oil and grease should not be poured down drains or discharged to a sewer.

Primary treatment (settlement)

After preliminary treatment the sewage flows into large round or rectangular tanks. In these the heavier organic material sinks to the tank floor and is swept by a scraper blade to a submerged outlet. From here it is pumped as slurry to a storage tank for subsequent treatment. Most of the solids in wastewater are removed in this process and concentrated into a thick slurry which has a volume less than 1% of the sewage received at the works. This slurry is known as sewage sludge and it is dealt with separately. The liquid element (settled sewage) flows over a weir to the next stage of treatment.

Secondary treatment (biological treatment)

The settlement process is very effective in removing organic material, but if the settled sewage were discharged to a watercourse, the dissolved organic matter in the settled sewage would still cause problems.

Naturally occurring bacteria in the receiving watercourse use organic material as a food source and need oxygen dissolved in the water to do this. Discharges of large quantities of organic matter will therefore result in oxygen in the water being rapidly used up with consequent harm to fish and organisms on which fish feed.

Wastewater treatment works use these same natural processes to break down and remove substances that might harm the environment but speed them up within a controlled environment. There are two main ways of doing this.

Biological filtration

In this process the settled sewage is distributed via small holes in continuously moving arms over 2 metre deep circular or rectangular beds of stones. These are typically the type of works seen when travelling on a train. This is not a true filter but the stones act as an ideal place for bacteria and other micro-organisms to live and grow. They form a biological film on the stones which remove the dissolved organic material as the settled sewage trickles downward. Oxygen from the spaces between the stones allows the micro-organisms to breathe and grow. As the bacteria grow and multiply the film reaches a maximum thickness and excess material is continuously washed off.

The flow then passes to a settlement tank (humus tank) where the excess biological film is separated and removed as humus sludge. This is normally returned to the primary settlement tanks and removed with the sewage sludge. So long as the 'humus' is effectively separated the humus tank effluent can normally be returned safely to the watercourse unless the watercourse is very small or already affected by other discharges.

Activated sludge

In this system the settled sewage is mixed with a blend of bacteria and other micro-organisms known as activated sludge and aerated by agitators or air blowers in large tanks. The amount of air is controlled according to the respiration requirement, which depends on the concentration of bacteria and the strength of the settled sewage. The bacteria grow and multiply in the aeration tanks due to the plentiful food supply and the excess is drawn off as surplus activated sludge which is mixed with the rest of the sewage sludge. The treated water is then separated from the activated sludge in final settelment tanks and is normally suitable for safe discharge to the environment.

Both these systems provide the bacteria and oxygen source that enable natural purification to proceed. The bacteria convert the organic polluting material into more bacterial mass or into carbon dioxide and water. The surplus activated sludge or humus sludge, is known as secondary

sludge and is mixed with sludge from the primary treatment process for further treatment and recycling.

Hybrid systems

These are wastewater systems where the bacteria are grown on a fixed medium (like the stones in a biological filter) but submerged in an aerated tank (biological aerated filters or BAF). Such treatment plants are intensive in operation, can be more energy efficient and have a lower land requirement than conventional systems.

Membrane separation

The key to effective biological treatment is efficient separation of bacteria (activated sludge or biological film) from the treated water. Very fine filter membranes may be used instead of settlement tanks and the resulting discharge will be of very high quality. This is a very expensive process and is normally used where the water environment would be very sensitive to the discharge.

Nutrient removal

Sewage contains both nitrogen and phosphorus that can result in nutrient enrichment of watercourses (called eutrophication), which encourages excessive growth of weeds and algal blooms that may be harmful to fish and water life. Although plants produce oxygen in sunlight they use up dissolved oxygen at night and too many plants and algae may result in de-oxygenation. Nitrogen can be removed in properly designed biological treatment plants. Phosphorus removal is achieved by addition of iron or aluminium salts

prior to settlement stages and also by using reed beds (as a natural process). In very large treatment works phosphorus can be removed by additional controls in the activated sludge process.

Tertiary treatment

Where very high quality effluents are required additional 'polishing' processes are used, including sand or gravel filters and natural systems such as ponds or wetlands. Where discharges are made to bathing waters or shellfish growing areas disinfection by ultra violet light or removal of bacteria and viruses by fine membranes is used. Effluents from wastewater treatment works contain bacteria from the treatment process and are not safe to drink.

Wastewater treatment for small communities

Septic tanks are settlement systems commonly used for treating wastewaters for single or small groups of houses. The settled effluent is normally allowed to soak away into the ground. Septic tanks provide rudimentary treatment but nowadays additional treatment in small 'package plants' is required. Septic tanks and package plants produce sludge and this is removed regularly by tanker and taken to treatment works.

RECYCLING OF RESIDUAL SLUDGE

The sludge produced from the above treatment processes consists of two forms, namely raw primary sludge and secondary sludge and this goes forward for further treatment. All sludge must be treated before recycling or disposal and the degree of treatment depends on the intended final use.

Treatment of sludges

There are several different treatment systems:

Anaerobic digestion. The sludge is passed through a well mixed closed container (digester) held at a temperature of 35°C. The process is continuous and takes 15-20 days. The organic material breaks down in the digester to produce methane gas and carbon dioxide. The gas is burnt to heat the digester or in very large plants to generate electricity through a combined heat and power plant. Digested sludge has a low odour and water is easily removed to reduce volume. The process kills potentially harmful bacteria and can be enhanced by use of high pressure or sonic systems which destroy bacteria cells

Aerobic digestion is used to pasteurise sludge. When air is pumped into the digester bacterial activity generates heat that kills off pathogens and reduces organic content.

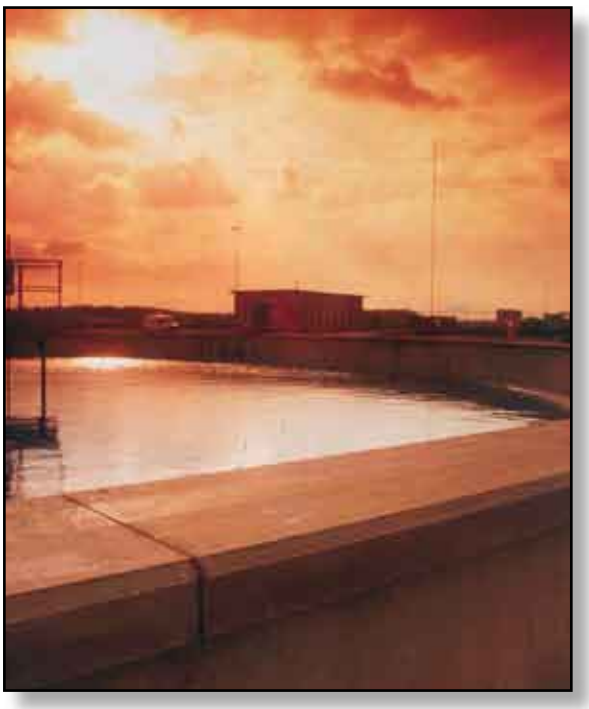
Dewatering of sludge reduces volume for transport. Processes include thickening under gravity or mechanical dewatering to produce 'cakes'. Mechanical systems normally require the addition of chemicals to flocculate particles and make separation of solids easier.

Lime stabilisation involves mixing sludge cake with lime. The lime reacts with the water in the sludge and produces heat – the increasing temperature and pH kill the pathogens and the added lime may also be useful for farmers.

Thermal drying can be used on both dewatered digested or untreated sludges. This is a heat process that drives off water and kills harmful bacteria. The low volume product can be used for agriculture and horticulture.

Incineration can be used for dewatered or thermally dried sludges. The heat produced is used to generate electricity via steam turbines. The sludge can be used in power stations or cement works as a substitute for fossil fuel.

Treated sewage sludge (usually known as biosolids) is a valuable product of the wastewater treatment works. It contains organic material and nutrients that are important for agriculture or land reclamation. The organic material is a carbon source and can also be used as a fuel to produce energy.



Use of biosolids in agriculture

Biosolids, the treated form of sewage sludge, is rich in nutrients, trace elements and organic matter. These characteristics make its most sustainable and best use as a fertiliser and soil conditioner. It enriches the soil, saves the energy required to produce artificial fertilisers and recycles phosphorus which is a diminishing natural resource. This use of biosolids in agriculture is recognised by the UK Government and European Commission as the Best Practicable Environmental Option.

The water industry, in partnership with the British Retail Consortium which represents supermarkets and other major retailers, developed a voluntary code of practice in 1999 known as the 'Safe Sludge Matrix'. This sets out the treatment required to remove harmful pathogens from biosolids, and the correct method of applying biosolids to agricultural land to ensure that public health is protected. The code has been used voluntarily since and is now given legal backing in revised UK regulations.

**To download a copy of the Safe Sludge Matrix go to www.adas.co.uk/matrix*

Biosolids have been recycled to agricultural land for many decades in the UK, Europe and the US. Biosolids are the most highly regulated and researched of organic material applied to land, forming under 5% of organic material used for this purpose.

Sewage sludge in land reclamation

Recycling sewage sludge to tip sites, coalmines and 'brownfield' areas restores derelict land to a useful purpose. The sludge provides a basis for plant growth where previously none was possible and helps to balance the soil pH. One of the most valuable properties of sewage sludge is that it can be used as a substitute for peat, thus conserving valuable peatland in the UK and Ireland.

Sewage sludge as a fuel

Sludge may be digested to produce biogas that can be burnt in engines to produce electricity and heat. It can also be dried and burnt as a fossil fuel substitute in power stations and incinerators for energy recovery.

Disposal of sludge to landfill

Where this is necessary the sludges have to be concentrated into a reasonably dewatered form. Landfilling sludge is the least sustainable option - it wastes a valuable resource by failing to recycle beneficial nutrients but also takes up landfill space.

WASTEWATER TREATMENT FACTS

- Over 95% of UK population is connected to a wastewater treatment works
- They are served by over 300,000 kilometres of sewers
- There are 9000 wastewater treatment works in UK with the majority serving populations of less than 2000
- Each person produces approx 150 litres of wastewater per day containing 60g of organic matter. A large proportion of this water is actually used to flush away waste and carry it to the treatment works.
- Each person produces on average 55g of biosolids per day as dried solids, or 20kg per annum
- Sewage is 99.9% water and the wastewater treatment process is designed to treat the 0.1% solids
- The better the treatment the more sludge is produced, As our environment has improved more and more sludges are being produced.
- UK sludge production is more than 1 million tonnes of dry solids per annum of which
  62% to agriculture (as treated biosolids)
  19% to incineration

11% to land reclamation
1% landfill
7% other (including non-food crops)

- The water industry invests millions of pounds each year in research to improve its understanding of wastewater treatment, sludge treatment and biosolids recycling to ensure protection of public health and the environment.

THE REGULATION OF WASTEWATER TREATMENT WORKS

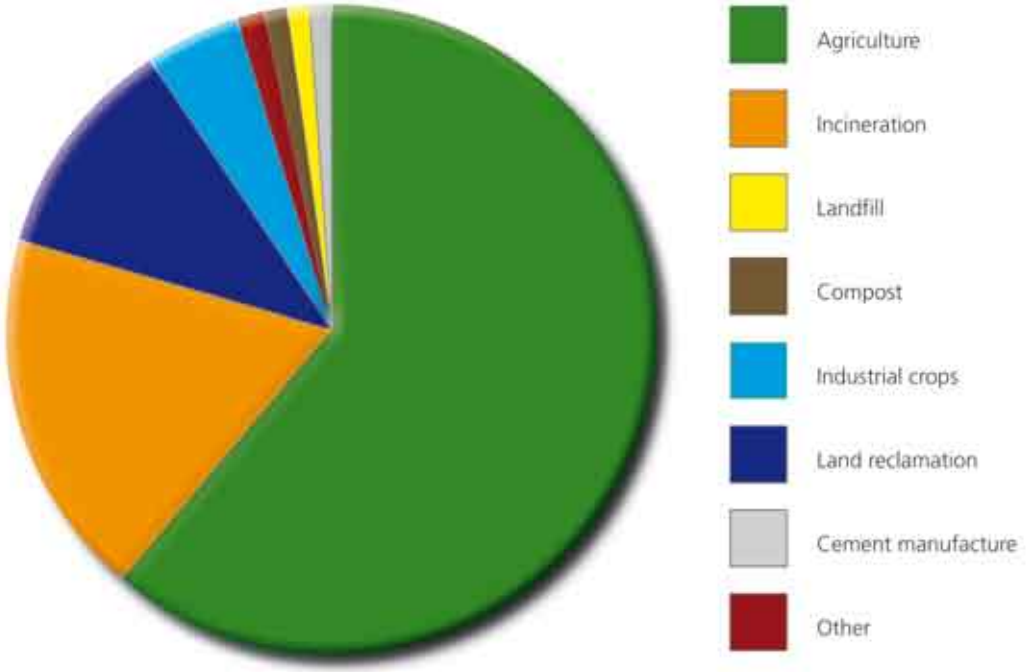
All treatment works are required to have a permit to discharge to the environment in the form of a consent from the environmental regulator, the Environment Agency in England and Wales, the Scottish Environment Protection Agency and Northern Ireland Environment and Heritage Service. The consent has conditions that are designed to protect the receiving watercourse. The larger the discharge and the smaller the watercourse the more stringent the conditions are likely to be. In addition the European Urban Waste Water Treatment Directive requires a minimum of secondary treatment for all works serving a population above 2000.

Recycling of treated sewage sludge (biosolids) to agriculture is controlled by the European Sludge Directive and this is implemented in the UK through the Sludge (Use in Agriculture) Regulations and Code of Good Agricultural Practice. The UK Sludge Regulations are currently being updated and amended to incorporate the requirements of the Safe Sludge Matrix.

Discharges from industry into sewers are controlled by consents that protect the health and safety of people working in sewers and at treatment works and also the biological treatment processes and the receiving watercourse.

The Water Framework Directive sets a target of obtaining 'good ecological and chemical status' in watercourses and will require additional investment in wastewater treatment. This Directive identifies priority substances, which must be progressively reduced in consented discharges; or must cease altogether in the case of priority hazardous substances. Continuous investments are being made by the water industry to ensure that wastewater discharged from Waste Water treatment works are well within required standards.

Principal Outlets of Sewage Sludge in the UK



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