SAMPLE

# WASTE INTRODUCTION AND DOMESTIC WASTE (SEWAGE, STORMWATER AND DOMESTIC RUBBISH)

## Lesson Aim

Learn about the concept of Environment Waste Management and explain sewage and storm water processing and disposal.

### INTRODUCTION TO ENVIRONMENTAL WASTE MANAGEMENT

In simple terms, waste is unwanted items or substances that are thrown away or that must be disposed of. Waste can be solids, liquids or gases or mixtures of these, for example, a sludge that comprises liquids and solids. The waste itself can be non-harmful right up to toxic, in terms of its impact on the world. In order to safeguard the environment in which we live and to ensure its sustainability for the future, this waste should be treated and/or disposed of, recycled, reused, upcycled or similar in an appropriate manner.

Waste management thus includes activities required to manage waste from its inception to its ultimate disposal. This involves collection, transport, treatment and disposal of waste among other activities. Waste management is therefore regulated in most places, covered by policies and procedures, and usually monitored or controlled by various regulatory and environmental organisations.

This course describes different types of waste and shows how these can be minimized. It discusses pollution from waste, how this affects the environment, how waste is disposed of through natural and industrial processes and how to harness those processes to better manage waste disposal.

### INTRODUCTION TO CONSERVATION

This course deals mainly with the management of waste, however waste management cannot be looked upon as a separate issue to the conservation of the environment. Environmental

Environment - the physical surroundings and conditions which affect the lives of living organisms; the external conditions that affect the growth of plants and animals.

Environmentalist - a person who is concerned with, or advocates for, the protection of the environment.

Ecology - the branch of biology that deals with the relationships of organisms to one another, and to their physical surroundings; the study of the interaction of humans with the environment.

## Ecoclimate - climate as an ecological factor.

## Earth

Undeniably the various environments on earth are bounded by the conditions within those environments and the resources available. The entire system is referred to as a closed cycle.

Under the laws of physics energy is indestructible, however, it can change form. It is therefore the responsibility of populations living on earth to ensure any energy changes are directed at sustaining life, and not leading to its destruction.

As a result of the extreme rate of population growth, the air and water systems which exist are being polluted by human activity. Waste materials of every kind are causing pollution, and threatening the operation of nature itself. The threat to the existence of life on earth is steadily growing. It is necessary for populations to take an active part in conservation and the reduction of waste.

## Conservation

### The Use of Resources

Conservation is the wise use of resources of the earth, to ensure they are able to support or sustain future generations. This can be done in many ways and in different situations. For example:

National Parks - the protection of the ecosystems, including endangered species.

Agriculture - permaculture techniques such as the management of soil erosion and water catchment areas.

Industry - pollution control measures should be used.

People - every person should help to collect and recycle waste.

These examples show that conservation involves the use of resources so that the environment is protected and maintained, and that the ecosystems are rehabilitated and restored.

## Ecological Value

Ecology is the study of the interactions and relationships among all living and non-living things on earth. Ecology teaches us that there is an interdependence among all living and non-living things.

The ecological reasons for conservation show the need for caring for the life support systems of the planet. For example, the greenhouse effect, gives one instance of the breakdown in a planet life support system. This is the maintenance of the carbon dioxide balance in the atmosphere of the earth. The increased combustion of fossil fuels, such as oil, coal, gas and petroleum has caused an alarming increase in the release of carbon dioxide into the atmosphere. The effect of this has been made worse by deforestation that has taken place all over the planet. The overall effect is an increase in the concentration of carbon dioxide in the atmosphere. This causes retention of heat in the earth's atmosphere, which, in turn, results in an escalation of the ambient temperatures.

## Economic Value

### Healthy Ecosystems

Many world economic structures depend on natural resources. Industries such as tourism, forestry, fishing and agriculture rely on the healthy functioning of the natural environment. There is virtually no productive industry that does not rely upon a natural resource. If this resource is damaged in any way, these industries will suffer. For example, over fishing in many areas has dramatically affected the fishing industry. This has caused dramatic drops in fish populations, reduced harvesting of fish, and major drops in incomes. This has provided profits for fishers which in turn, affected the other suppliers of goods and materials to this industry. One action can trigger a chain of undesirable effects.

### Genetic Diversity

Flora and fauna contain an untapped source of genetic diversity. This may be valuable in plant and animal breeding programs, or in the very survival of the species in the wild. Plants are also chemical factories which can manufacture many complex and unusual substances. Many of these substances are potential medicines which can benefit mankind. A few examples of existing drugs that are based on plants are:

Quinine - an anti-malarial medicine. It is made from a substance which is contained in the yellow chinchona tree

Aspirin - a common drug which has been developed from a substance supplied from the bark of a willow tree

The rosy periwinkle - this plant produces substances that have proved to be effective in treating Leukaemia.

### Aesthetic Value

Not only are there economic and ecological values to the conservation of resources, but nature also provides the beauty and adventure of the mountains, the sea, and the natural landscapes. Nature provides areas where people can enjoy their recreational time.

## OVERKILL

Overkill is the amount of destruction or the capacity for destruction exceeds what is necessary to complete annihilation.

## URBANISATION

Urbanisation is the process by which the number of people living in towns and cities increases in comparison with the number of people living in rural areas.

Urbanisation also increases with and is a direct result of economic development; the scale of urbanisation is the major differing factor when comparing trends in developed (or industrialised nations) as opposed to developing countries.

Developing countries show rapid increases in urbanisation as rural communities shrink; the trend in developed countries is for (far) slower change.

Urbanisation in developing countries contributes to the waste problem in two main ways:

1. Many of the immigrants to the towns and cities find themselves in squatter camps where there is no proper sanitation or waste removal facilities (see later section in this lesson).
2. The birth rate in urbanised areas usually shows a drop when compared to rural areas. This is because:

   There is less space to have large families.

   It is usual that the more sophisticated, educated and well off a person becomes the lower the average size of families.

   Many women who move to cities and towns from the rural areas find that working is necessary (or desirable) for them. This leaves less time for rearing children.

A country is said to be urbanised when more than 50% of the population live in the urban areas. Britain and some European countries were the first to become urbanised. This trend started during and after the Industrial Revolution, from the late eighteenth century onwards. Urbanisation in these countries was quite slow, giving the governments time to plan and provide for the needs of the increasing urban populations.

Today we have a situation where many developing countries are rapidly becoming urbanised. This has resulted in the formation of squatter communities around many major cities in the developing world. Although unskilled labour is in abundance, the economic situation and government response within these countries are (often) not keeping pace with the demand for housing, services and employment. This results in poverty, bad living conditions and disease.

World trends are also moving away from labour intensive industries to mechanisation; this further decreases employment prospects in areas other than government funded projects.

The squatter camps are also a source of widespread pollution. Due to the lack of proper sanitation, clean water supplies and ever increasing mounds of rubbish, they can become a breeding ground for such things as typhoid, cholera, gastroenteritis and many other infections.

A further complication arises because many squatter communities have built their shelters on land previously used for waste dumping. Much of this land has not been consolidated and during rainy season high scale flooding can be experienced.

Examples include Manila in the Philippines and Mexico City in Mexico.

Modern man is using the world's natural resources at an alarming rate to keep pace with demand, (as opposed to need). In order to satisfy these demands, we must either: kerb our desires or develop sustainable systems of resource management.

Laws are urban inventions; a set of norms of conduct that are devised in an attempt to curb overkill and allow people to live within a code of conduct that is beneficial to all those sharing the restricted urban environment. The pressure of modern civilisation makes it necessary to refine the rules for civilisation to flourish.

## Advantages of Urbanisation

Urbanisation does have many advantages. Two of the most important are:

1. It relieves the pressure on arable farmland that may otherwise be taken up by housing.
2. It reduces population growth. Populations tend to grow through influx rather than fertility.

Access to primary health care is usually greater thereby reducing child mortality rates. The result (in undeveloped countries) is fewer children. As mortality rates improve more children survive to take care of their aging parents and as a flow on people tend to have fewer children.

In most developed urbanised countries population growth has levelled off. In some instances, in Europe for example, birth rates have fallen below natural replacement levels, and only immigration allows for overall population increases in those countries.

## Human Environmental Impact

The impact of human beings on the environment can be likened to a geological force that is shaping the earth and its atmosphere. Mechanisation has allowed us to destroy entire worlds. Pollution, destruction of species on land and in the sea, land erosion through mass clearing of forests, damming of rivers, salinity, creation of deserts from fertile land, the greenhouse effect and overuse of earth's natural resources are all part of this force.

If human beings expect to survive, then the damage created over the previous century needs to be re-dressed. We need to implement sustainable systems of living; the earth's natural resources are finite: its ecology is fragile: its biodiversity is shrinking.

In order to understand the fragility of our environment everyone needs to be educated and aware of alternatives; it is up to the individual (particularly those in affluent nations) to implement change through their own behaviour as well as through political pressure. Our very survival depends upon the conservation of nature. In order for humanity (in general) to understand the importance of conservation we need to understand the concepts. This can only be achieved through education. It has been said that the study of nature is the study of survival!

In the 21$^{st}$ century trends are changing; governments are becoming increasingly aware of the environmental impact of past (and present) practices. Scientists are looking at ways of halting and sometimes reversing environmental damage. Farmers are being educated to work with rather than against nature. Sustainable systems of consumption, growth and use of the environment and our natural resources are being studied and implemented. The "green movement" is very active with regards the environment, ordinary people encouraging change.

This is the first generation that has become seriously worried about what the actions of today will have on the lives of future generations. Many attitudes still need to be changed but this century shows an encouraging change for the future.

## WATER MANAGEMENT

A key component of environmental waste management is water management. Fresh water is a limited resource, vital to the life of many organisms, including humans. Because fresh water is often limited in supply, it many cases it is renewed, recycled and re-used in various forms. If polluted, various waste products must be eliminated or reduced in the water, so it can be reused.

Water managers often therefore partition water into different colour-coded compartments to help them understand and control where the water comes from and how it is used. This coding may be linked to water footprints which measure the amount of water used to produce products and services we use.

Water can be coded into the following four categories:

**Blue water** is water abstracted from freshwater (lakes, rivers, dams etc.) and groundwater sources for agricultural, domestic and industrial uses.

**Green water** is that portion of the rainfall that infiltrates into the soil and is available to plants.

**Black water** is waste from toilets or urinals. It contains pathogens that can result in human or other animal illness by direct contact with it or by use of it, for example in farming e.g. of fish and shellfish.

**Grey water** is any domestic, office or building wastewater than is not black water. It does not contain faecal matter and is usually categorised as wastewater from sinks, showers, washing machines, dish washers and so on. This can be reused in some cases.

Water from all the above categories can contain impurities ranging from negligible to high levels. Physical impurities are solid particles in the water; chemical impurities are substances dissolved in the water. Biological impurities are algae and other macro and micro-organisms, ranging from non-toxic to pathogenic. Management of water to remove these wastes/impurities is covered in more detail in this and later lessons of this course.

## SEWAGE AND SEWERAGE

There is a distinct difference between the words sewage and sewerage:

> Sewage is the term that is used to describe the liquid wastes of a community. These wastes consist of the discharges from toilets, baths, sinks, lavatories and other plumbing fixtures in residences, institutions and business buildings. In some cases, waste from industries, such as manufacturing plants are included in the definition of sewage. Storm water may also enter the sewers, though it is generally the practice to provide separate facilities for the removal of storm water on all new constructions. The collection and removal of these various types of waste is generally accomplished by means of a system of underground conduits that are called sewers.
>
> Sewerage is the name given to the general process of collection and removal of these wastes. This term may include provision for a treatment plant, because the discharge of untreated sewage or industrial waste into a stream, lake, sea or any other body of water is prohibited in most countries.

## The Classification and Composition of Sewage

Sewage may be classified into different categories, according to its source, as follows:

### Sanitary Sewage

This may also be known as domestic sewage or house sewage. This is the waste that comes from residences, business buildings or institutions.

This type of sewage normally consists of water, and the accompanying solids resulting from dish washing, washing clothing, toilet flushing, showering or bathing, or other domestic purposes. Its composition is generally one to two parts per thousand of solid matter. Approximately half of the solids are suspended or floating in the liquid.

### Industrial Waste

This is sometimes referred to as trade waste. Industrial wastes vary greatly in their composition, and this depends upon the type of industry, and the characteristics of the particular factory. The percentage of solids in the sewage from a particular plant may be very small or extremely large, depending on the processes that take place within the plant.

### Storm Water

This is sometimes known as storm sewage.  It is run off during or immediately following rainfall. This type of sewage should be excluded from sanitary sewers. Storm sewers may carry large amounts of suspended material, as well as a considerable amount of organic material, including animal droppings, and oil and petrol from spills or leaking vehicles. This is especially so, if there has been a long period without rain and the first heavy rains flush considerable debris from the streets.

The organic content of sewage is important. The organic matter, in addition to being a nuisance, causes bad odours, and is a danger to health.

There are other ways in which sewage can be classified:

Strong or weak: depending upon its organic content.

Fresh or stale: referring to the state of decomposition that the sewage has reached.

Treated or untreated: untreated sewage is also referred to as crude or raw sewage.

The above factors do not enter into the design of individual sewage lines, but they may affect the broad planning on a sewerage system through their influence on the design of the treatment plants and pump stations.

## The Characteristics of Sewage

The sewage that is discharged by any community is a potential, and actually a carrier, of various disease producing organisms, If the sewage is improperly discharged, there are various diseases that may be spread. These include:

- Typhoid fever
- Various types of dysentery
- Intestinal infections

In addition it may carry viral diseases such as:

- Hepatitis
- Poliomyelitis

Sewage discharges can also cause serious nuisance problems, such as bad odours and unsightly floating material. The sewage discharge can also materially affect the quality of the water that flows into streams, if the sewage is discharged into them. In addition to health matters, this also interferes with the use of these waters for municipal or private water supplies, and for industrial and recreational purposes.

It is for this reason that there are laws regulating the discharge of sewage into water courses, and there are standards in the design of sewerage systems and sewerage treatment plants.

## Solids in Sewage

The solids in sewage consist of both organic and inorganic substances. Among the organic substances are:

1. Excrement
2. Soap
3. Small particles of garbage
4. Paper
5. Rags

Among the inorganic substances are:

1. Sand
2. Clay
3. Grit/Gravel
4. Dissolved minerals

The total amount of solid matter and the proportions of the various materials will vary considerably with the type and source of the sewage, and also with the season, and the weather.

In sewage analyses, the solid matter is usually classified as suspended solids and dissolved solids. The suspended solids are those solids that float either on the surface of a liquid or in suspension in the liquid. These usually represent from one-third to two-fifths of the total solids. Dissolved solids are those that are dissolved in sewage in the same way that salt is dissolved in water. Dissolved solids represent from three fifths to two-thirds of the total solids.

Some solids in sewage are colloidal. These are finely-divided solids that are almost too small to be seen, and also those solids are apparently dissolved but remain on the surface of a parchment filter when the liquid is passed through the parchment. Generally colloidal solids in sewage may amount to as much as one-fourth of the total solids. However, in sewage analyses, they are reported as either dissolved or suspended solids.

There is a further consideration in sewage treatment. This is the amount of settle-able solids. This is the portion of the solid material that will settle out if the sewage is allowed to stand for two hours.

The percentage of settled solids in sewage varies in proportion to the condition and character of the sewage, It is usual for something more than one-half of suspended solids, or from one-fifth to one-fourth of total solids to be settled.

## Organic Matter in Sewage

The organic matter in sewage may be grouped into the following compounds:

- Proteins
- Carbohydrates
- Fats

All of these compounds contain carbon, oxygen, and hydrogen. Some also contain nitrogen and sulphur.

Certain of the organic materials are in simple forms, but most of them are in such complex forms that several stages must be passed before a stable product is developed.

Proteins are extremely complex substances which are essential for all living matter and they are found in all uncooked animal and vegetable matter.

Carbohydrates are found in sugar, starch, cotton, cellulose and wood fibre. The sugar and starch compounds decompose very easily, but the carbohydrates that are present in absorbent papers of wood fibre and in cotton products are highly resistant to decomposition.

Fats are also difficult to decompose. Moreover, the fats, by coating particles of decomposable organic matter, protect such particles from decomposition and thus interfere with sewage treatment processes. This is one reason why oils should not be discharged into the sewers.

## The Problem of Industrial Waste in Sewage

Industries contribute to sewage wastes, and these contributions vary widely in amount. When a sewage treatment is designed, a thorough investigation should be made to determine the potential effects of these wastes on the treatment processes.

Creameries, dairies and laundries are among the more common sources of industrial wastes in small communities. In larger communities, dye plants, silver plating, brewing, abattoirs, canning, paper industries and chemical plants are large producers of effluent waste. These types of waste are very difficult to treat, either alone, or along with domestic sewage.

## Progressive Changes in Sewage

Organic matter in sewage is unstable - changes that are brought about by chemical and bacterial actions are always taking place. These changes tend towards the complete oxidation and reduction of the organic matter.

From one-fourth to one-half of organic matter may decompose in a few hours, but complete decomposition and the subsequent oxidation of the residue may require days or even weeks.

Before the process of decomposition has used the any oxygen originally present, the sewage is said to be *fresh.* When decomposition has proceeded to the stage where all the oxygen in the sewage is exhausted, then the sewage is said to be stable.

If a further process of decomposition is carried out after all the oxygen has disappeared, then the sewage becomes septic.

## The Decomposition of Sewage

According to their action, bacteria are:

- Aerobic
- Anaerobic
- Facultative

Aerobic bacteria require oxygen to carry out their activities. Anaerobic bacteria develop when there is no oxygen present. Facultative bacteria are active under both aerobic and anaerobic conditions.

Fresh sewage ordinarily contains some free oxygen, in the region of two to five parts per million.

In this case the organic matter is first acted upon by aerobic and facultative bacteria. The oxygen that is present is soon used up by combination with the other chemicals that are present, for example the change of free ammonia to nitrates.

When all the oxygen that is present in the sewage is used up, only the facultative and the anaerobic bacteria act on the organic matter. These bacteria produce putrefactive changes, in which many gases are formed, such as:

- Hydrogen
- Hydrogen sulphide
- Ammonia
- Methane - as well various intermediate compounds of these gases.

Putrefaction is a required step in the decomposition of the complex organic compounds which exist in sewage. In sewage treatment it is necessary to break down the complex compounds before the elements that make up these compounds can be formed into new compounds, such as nitrates and sulphates. Oxidation is the final step in the formation of these unobjectionable compounds. Putrefaction and oxidation are not completely accomplished during the process of sewage treatment, but they are carried far enough to prevent nuisance.

## The Nitrogen Cycle in Sewage Decomposition

The process of decomposition may be considered as one step in the nitrogen cycle. This cycle is described briefly below:

The anaerobic, saprogenic bacteria acting on dead organic matter and faeces, produce free ammonia. In the presence of oxygen, the free ammonia is oxidised by the aerobic bacteria to form first nitrites, and then nitrates. These nitrates are eventually consumed by plants that either die or are eaten by animals. These in turn die and thus complete the cycle.

Nitrates are also acted upon by denitrifying bacteria and nitrogen is set free. Some of this free nitrogen is returned to certain types of plants by nitrogen-fixing bacteria.

NOTE: Saprogenic is defined as causing putrefaction.

## The Importance of Bacteria in Sewerage Treatment

As stated previously, several of the types of bacteria that are found in sewage, are dangerous because they may produce disease. However, the large majority of the bacteria in sewage are useful as important aids in sewage-treatment processes. These bacteria assist in changing the unstable compounds in the sewage into stable forms that do not cause nuisance.

## The Classification of Sewerage Systems

The requirements from state to state regarding sewage and sewerage systems are not uniform in all details, but included in most of the regulations are factors governing such matters as:

- The number of years into the future for which the system is to be designed.
- The size and slope of the sewers.
- The joints in the sewers.
- The leakage of groundwater into the sewage system.
- Manhole design and spacing.
- The treatment of sewage.
- Pump station design.

Separate sewers are required for sanitary sewage and storm water.

At this point it should be mentioned that in many countries, it is an offence to pour noxious materials, such as old car engine, or car radiator additives, into storm water drains. Not only can this have an impact on the operation of these sewers, it can also cause spillage of these materials into waterways with disastrous effects, particularly on local wildlife.

When a sewerage system is installed, the plumbing systems of residences and businesses, and sometimes the waste or process draining systems of manufacturing plants are connected to the sewerage system.

In all new installations, one system of conduits/piping is provided to carry domestic sewage, and another separate system to carry storm water. However, in some older areas, where the sewerage system may be old, there may only be one system of pipes to carry both domestic sewage and storm water.

A sewer that is intended to carry only domestic sewage is called a sanitary sewer, or sometimes it is called a separate sewer in order to differentiate it from a sewer which is designed to carry both sanitary sewage and storm water.

A sewer which is designed to carry both domestic sewage and storm, or surface water in the same pipes is called a combined sewer.

In a sanitary sewer, provision is sometimes made for carrying both domestic sewage and industrial waste in one network of conduits/pipes. The inclusion of the industrial waste in a sanitary sewer will usually depend upon the volume strength and characteristics of the industrial waste.

Certain manufacturing processes are required to have a separate sewer line and a separate treatment system, to handle their specific wastes.

## Types of Sewers

The sewerage system must be designed to collect sewage from individual buildings and conduct it to the treatment plant. The sewage from individual buildings is conveyed to the street sewers by means of house sewers. These are small pipes usually 15 centimetres or so (6 inches) in diameter.

A lateral sewer is one that collects the sewage flow from houses on a street, but does not have other sewer tributaries to it.

A branch sewer is one that collects the discharges from one or two lateral sewers. It may also be called a sub-main, especially if it serves a small, but definite area.

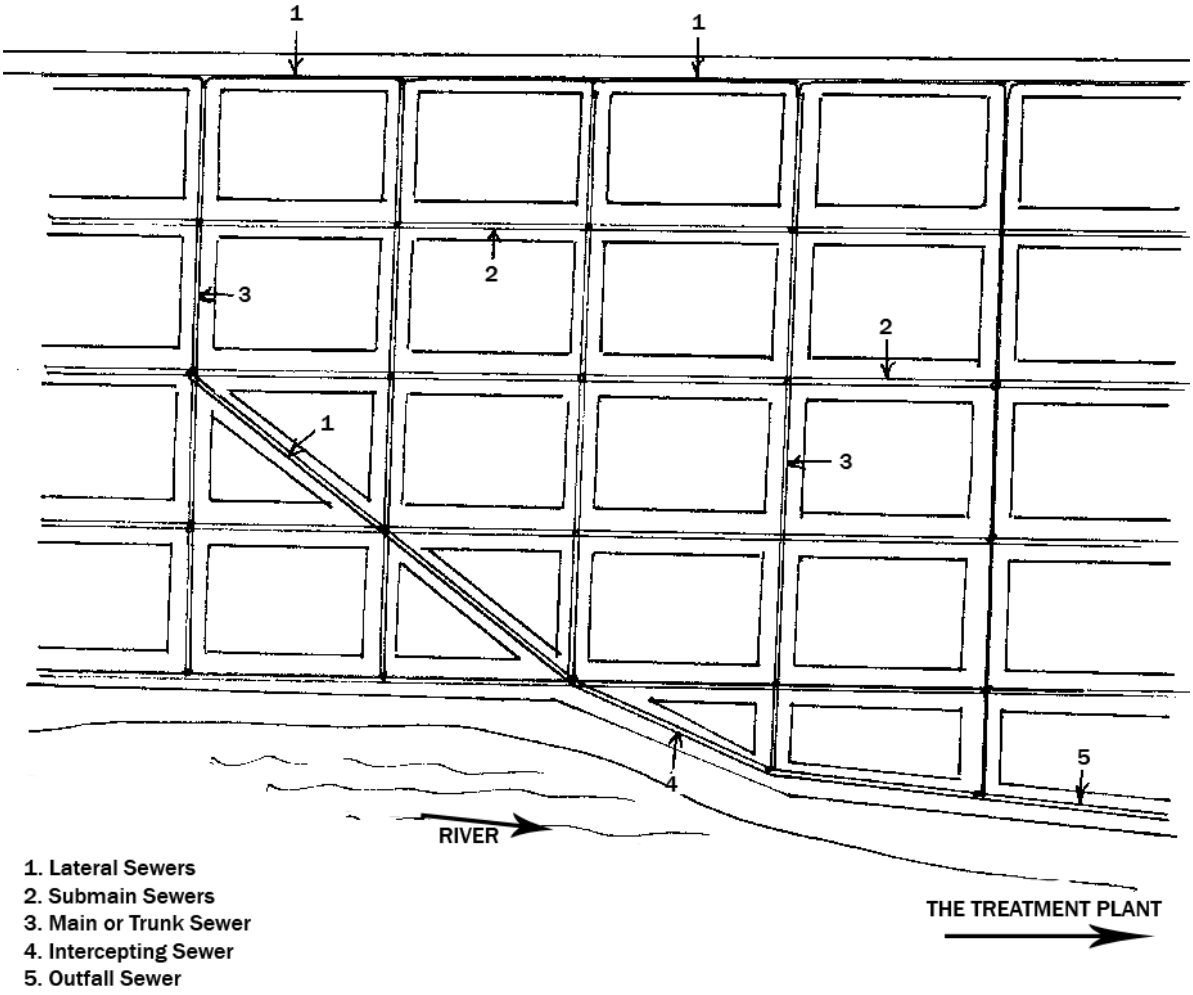
A sewer that collects the sewage flow from two or more sub-mains, serving a considerable area is called a main, or trunk sewer.

In certain circumstances an intercepting sewer may receive the flow from a number of sewers. Mainly the use of such a sewer is where a trunk sewer leads to a waterfront, and the discharge of the untreated sewage into the water must be prevented. The intercepting sewer leads directly to a sewage treatment plant.

Relief or overflow sewers may be provided to carry flows that are in excess of the capacity of the existing sewers.

## Diagram of a Sewerage System

The following diagram shows the layout for a sewage system for a portion of a city. Several of the lateral sewers are designated by the numeral 1, a few of the sub-mains are designated by the numeral 2, and the main sewers are designated by the numeral 3. An interceding sewer designated by the numeral 4 extends along the bank of the stream and collects the flow from the mains and some sub-mains. The outfall sewer, designated by the numeral 5, carries the sewage to the sewage treatment plant.




## Storm and Combined Sewers

When rain falls on the surface of the ground, some enters the ground, while the excess runs overland to natural drainage channels and from there to a river or a stream. In an urban area, however, the amount of run off is greatly increased because of impervious roofs, driveways, walks and streets. Also, because of the encroaching structures, the natural drainage channels are often blocked, altered or reduced in capacity.

A storm drain system is designed to carry off surface water, utilising a system of pipes similar to those that are used for domestic sewage. However, although less frequent, the volume of storm water is many

times greater than the volume of domestic sewage. Therefore, the storm water sewers are constructed of wider diameter pipes.

All storm water systems require appurtenances such as inlets, catch basins and manholes.

Inlets - an inlet is an opening that is installed in a street gutter or curb for the purpose of intercepting the water flow in the gutter and conducting it to a storm sewer. Inlets are usually located at low points in the streets and other low places where the accumulation of storm water may cause flooding and interfere with traffic. Most inlets consist of a casting with grates or bars. The bars must be strong enough to withstand the loadings of traffic. Curb inlets are usually only 10 to 15 cm high, and vertical bars are only required in some cases to prevent large sticks or animals from squeezing through.

Catch Basins - catch basins are sometimes used to admit storm water to the sewage system. The construction of the intake system is essentially the same as for inlets in that the grating and curb opening are usually provided. In addition, catch basins are provided with a reservoir or sump for holding the water to a depth of approximately one metre. A trap arrangement is also fitted to prevent possible emanation of odorous gas from the sewer to the atmosphere.

The catch basin was an important part of a combined sewage system, especially in the days when many streets were unpaved. Storms carried grit and debris into the catch basins and it was desirable to prevent this matter from entering the sewers. Many catch basins are still in use, and replacements are often necessary, however, very few new ones are being built. There is a maintenance problem with catch basins. Because the cleaning of them is unpleasant and costly, it is rarely done with sufficient frequency to be effective. If organic matter is left in the reservoir, odours may be created, and the water which is retained can become attractive breeding grounds for mosquitoes.

Manholes - Reasonable provision should be made for access to storm or combined sewers. On smaller sewage lines, manholes may be provided at changes in the line or grade, and at intervals of 300 - 400 metres. In the case of very large lines, other conditions may govern.

Sewage and its treatment is a complex subject and in a course detailing with all forms of waste, it is impossible to cover the subject to great depth. However, the above information is designed to give students a view of how a simple sewerage system works.

## DRY RUBBISH

### The Composition of Household Refuse

Household refuse, the waste material from houses and flats, is comprised mainly of:

- Dust
- Cinders
- Ashes
- Vegetable matter
- Paper
- Empty cans

- Food containers
- Rags
- Bottles
- Bones
- Broken glass and crockery
- Old Iron
- Electronic waste

In modern society the variation between the winter and summer content of the refuse is not as great as it was in the days when ashes and cinders accounted for a much larger share of the refuse. Before any scheme of refuse disposal is prepared, proper analysis by weight of actual refuse should be taken. Such analyses help to establish the value of any material that can be salvaged (recycled), and the percentages of combustible or material that can be composted, contained therein. It has been estimated that in some cases up to 80% of our household wastes could be composted or recycled, but this rarely occurs and as a result household waste is usually a significant component of the total amount of waste being added to our landfills.

For example, The Environment Protection Authority (EPA) in Victoria, Australia estimates that the amount of waste produced by Greater Melbourne alone could fill the world famous Melbourne Cricket Ground (which can seat around 100,000 people) to the top of the highest stand every 8 weeks. The cost to residents of the collection, transportation and disposal of this waste is at least $300 million dollars a year.

Of the total waste stream at landfills in Victoria around 35% of the wastes are from domestic sources. This included:

- Packaging waste (7.8%) of total waste
- Food (10.9%)
- Garden (7.1) - this amount in domestic waste collections
- Other paper (6.7%)
- Other garbage (2.9%).

In addition another 13.8% of the total waste stream was from gardening waste delivered privately to the landfills. Much of this waste is easily composted or could be recycled.

The City of London produces 1.1 tonne (approximately) of waste per household, municipal waste making up 26% of total waste in that city. It is also interesting to note that of the recycling waste collected 97% is reusable. Yet there are still many items thrown out that end up in landfill sites; in the UK 1.5million computers are dumped in landfill sites annually. It has been estimated that over 90% of what is actually thrown into their bins is reusable.

The City of New York with a population of 20 million produces 11,000 tons of residential and institutional refuse and recyclable waste each day. The solid waste issue created major public concern and this alone has reduced the daily waste from 13,000 tons a decade ago. A further 13,000 tons of waste is also generated by industry. During the late 1980's over two-thirds of the landfill sites in the

USA closed. This created further public interest in the incineration, recycling and waste transport programs that have taken their place. It has been estimated that most of the solid waste collected daily is made up of food scraps! Further interest is now being generated by state, local and federal government in how the waste will be treated in the future e.g. the centralised composting of the majority of these materials.

## The Nature of Refuse

The nature of refuse has undergone many changes in the last few decades. The decline in consumption of coal, and the increasing use of electricity and natural gas has reduced the necessity of removal of cinders and ashes from the home, although this may change again with current trends to the installation of combustion heaters (mainly using wood as a fuel), and a return to the use of open fireplaces.

During the same period vegetable matter content has varied very little. In some areas the amount of garden refuse has increased, but the greatest change due to the increased use of packaged goods, especially plastic bags from supermarkets.

This tendency towards increases in overall household refuse has made the standard sized garbage bin inadequate. Many municipalities have introduced the larger plastic bin with the hinged lid. Many municipalities also provide a recycling service - some providing separate bins or containers in which to place recyclable materials.

## The Placement and Protection of Bins

Bin placement is an important concept. Bins should be placed in a position where they are readily accessible from the house in order to avoid long carries of waste, with the consequent waste of time. The bins, which have wheels, and are being increasingly used by many municipalities, are ideal, because they allow the home owner to keep the bins within their property, and it is a quite easy manner to roll them out on collection days.

It is desirable to protect the bins against the weather, because lids could be left off or be displaced by cats or dogs. It is also possible that the bin may be distorted so that the lid does not fit properly. An ideal arrangement is to provide a covered alcove which forms part of the building, and is accessible under cover from the house. As an alternative, a small dustbin shed could be built.

A covered position has the advantage that if refuse is placed on the ground beside the bin, after the bin is full, it is then protected from the elements. It will not be dampened by the rain, and it will not be blown away. However, many people with private property keep their bins in the open. This allows the contents to be wetted by rain. This can produce rapid decomposition of the refuse, causing foul smells.

## Trade Waste/Refuse

Trade refuse can be defined as the refuse of any trade, manufacture or business, or any building materials.

It may be regarded as any useless material or waste that is produced in the course of manufacturing or other operations that are carried out for profit, and not being of domestic waste in nature.

In urban areas the local authority usually removes all house refuse. Each property owner pays an amount towards these collection costs as part of their annual property rates. It has generally been

considered by many municipalities that refuse of a domestic nature produced by hotels, restaurants, and other catering establishments is house refuse, and is therefore removed by the local municipality (or their contractors).

On the other hand, trade refuse is normally subject to a charge for its removal. It includes a wide range of materials, such as:

- Ashes
- Clinker
- Wood refuse
- Packing material
- Fruit refuse
- Vegetable refuse
- Fish refuse

Local authorities may be under no obligation to remove such refuse, but they usually do so in view of the highly offensive nature of much of the refuse when it is kept too long. When large factories, markets, etc. are concerned the daily collection of refuse may become a necessity. This is covered in more detail in the later lesson on Industrial waste.

Many local authorities collect garden refuse free of charge, if the refuse is placed in special plastic bags or tied in bundles. This service is separate from the normal refuse collection, and generally occurs on a set number of days each year. In addition, local council or other government authority may also have special hard rubbish collection days, where hard waste, such as old refrigerators or building materials will be collected. There are generally strict conditions placed on the types of materials, and the size and weight of materials to be collected. The cost of these "special" or "extra" collections is generally covered within the waste collection component of the annual property rates.

## The Collection of Refuse

The collection of household refuse is normally carried out by the local authority, either using labour directly employed by them, or increasingly by using contractors. Disadvantages of using a contractor may include:

- Close supervision may be required to ensure that the work is done in an efficient way, and that the bins are left in a clean state.
- The employees of the contractor may be paid according to how many bins that they empty, and so tend to sacrifice cleanliness for speed.

In some countries when traditional bins are used, the collection and emptying of the bins is often done in one of the following two ways:

- Two men go ahead and bring out all of the bins on to the pavement. The dust wagon follows about half a street behind and the bins are emptied by two men working behind the vehicle. Finally one man brings up the rear, and takes the bins back to the premises.
- A gang of men work with the vehicle and each man is responsible for obtaining a bin, emptying it and returning it.

The second system is the better because it obviates two disadvantages that occur in the first method. These disadvantages are:

- When the bins are standing in the street, the lids can be removed by children, scavengers, etc. This allows the contents of the bins to blow about.
- There is a possibility that the bins may be returned to the wrong premises.

## Systems for Refuse Collection

### The Block Load System

When this system is used, the district is divided into areas, each of which is subdivided into blocks. These blocks are estimated to contain a sufficient number of buildings to make up an average day's work for a single collecting unit, which may consist of one or more vehicles.

The collecting units are not necessarily assigned to the same blocks every day, but they may be required to work in any part of the area.

This is a rigid system, because it makes no provision for any seasonal fluctuation in the refuse output. A collecting unit may be overloaded at times of heavy refuse output (e.g. in towns with large seasonal variations in population, such as holiday resorts areas), and may have insufficient work at other times, therefore effective control is difficult.

### The Continuous System

This system has largely replaced the block system. In this method, each collecting unit is assigned to a particular area, which contains sufficient buildings to keep it busy at times when refuse output is light.

Each unit is provided with a route card, on which the collecting route is planned so that the unit commences each day at the part of the area to be collected, which is furthest from the site where waste is to be deposited. The unit then gradually works towards the deposit site, going there with each full load for tipping, and then going back to the next point on the route card.

If owing to an increase in the output of refuse, the unit cannot complete the clearing of the area, an additional unit can be put on to clear the unvisited sections.

For each unit, a progress graph is made and kept at the depot. This graph shows the number of premises cleared and is brought up to date at the end of each day for reference to the route card. This allows the progress of the unit to be frequently reviewed, and additional units can be brought in good time if needed.

This system facilitates close control, and is flexible in that the personnel can be promptly increased or reduced, and spare vehicles put in, or taken out of service as required. All premises receive a regular visit, and any complaints are minimised. Supervision by inspectors is facilitated by the progress graphs.

## Refuse Collection Vehicles

Vehicles hauling trailers can be used to convey large containers directly to the rubbish tip or incinerator, and then to substitute clean bins. However, the modern trend puts the emphasis on the consolidation of refuse into as small a space as possible, by various devices such as:

- The fore and after tipping vehicle

- The moving floor type of vehicle
- The mechanical barrier type of vehicle

The motive power of the vehicle is also subject to development, and nowadays a diesel powered vehicle is preferred to a petrol powered or electrically propelled vehicle.

Electrically powered vehicles have to carry large batteries which are charged during the night when the vehicle is not in use. These vehicles are not manufactured in large sizes, and they are more useful for other functions of public cleansing.

In cases where large quantities of refuse have to be hauled many kilometres to the tip, then transfer stations are commonly used. These depots are fed by the ordinary collection vehicles; later the refuse is sorted, and any salvageable material extracted. Larger vehicles are then used to haul the residue to the tip.

### Dustless Loading

Nowadays, the emphasis is on dustless loading, and in this system the bins are lifted by mechanical means and tipped automatically into a chute on the vehicle. The chute is specially made for the purpose and is fitted with a non-return shutter to stop any refuse from back feeding.

### Rear Loading

Generally rear loading is preferred to side loading, because there is less risk of spillage and dust on to the pavements, to the nuisance of passers-by.

Rear loading is combined with various methods of compression so that the refuse is periodically gravitated, pushed down or drawn to the front of the vehicle.

One disadvantage of rear loading is that when the vehicle is towing a small trailer, it makes access difficult, although the use of a long tow bar can alleviate this to some extent.

## Salvage of Materials

Salvageable material is best separated at the source, provided that it is clean and is easily carried by the collectors. This applies particularly to paper, rags, and in some instances, metal objects. It does not apply to tins that can be separated by electromagnet at the transfer depot, if such facilities are available.

In some countries, municipalities, provide separate bins/containers for residents to place recyclable material in, such as plastic and glass containers. Newspapers and cardboard are generally bundled and tied together and placed next to the recycle bin. These may be collected, and placed in separate deposit areas by the same vehicle that collects the general waste bin, or a separate collection may take place using another vehicle. Electronic waste can sometimes be dropped off at municipal waste sites for reuse or recycling.

The extent to which various materials are recycled/salvaged depends a great deal on the economics of the situation. Economically there is no point in salvaging un-saleable material, or matter, on which the return is not greater than the cost of salvaging it. This is why many local authorities ask the public to separate their rubbish, which then reduces the cost of salvage.

### Containers

Storage containers are being increasingly used for large blocks of flats, hotels, etc. These containers are often large galvanised steel receptacles. They are usually rectangular in form, but they are also made with a D-shape cross-section. The containers are designed for easy transportation to the special collection vehicles, and for ready loading and unloading.

The containers are particularly well adapted for use in large buildings. Each container takes the place of a number of bins, thus saving space and preventing nuisance.

Some containers are mounted on small wheels for easy transport to and from the vehicle. Others are made with feet that support the container above ground, and thus facilitate the use of self-jacking hand trucks for transport. Since large containers are very heavy when full, the latter method is preferred. When the full containers are removed empty ones are put in their place.

## STORM WATER MANAGEMENT

- In undisturbed forest about 2% of rainfall runs off the surface into creeks and streams. It may have a bit of debris in it (e.g. twigs or leaves), but is otherwise cool and clear.
- In areas where land is cleared for farming or agriculture, about 14% of water runs off. Clearing land leaves soil exposed, so it is easily eroded. Increased volumes of surface runoff erode river beds and banks, releasing even more soil into waterways.
- In urban regions there are large areas of impermeable surfaces (e.g. paving, roadways, and buildings). Around 85% of surface water runs off from these areas.
- Dirt, litter, oil, garden chemicals and animal wastes are carried with the runoff water into drains and eventually streams, and then estuaries and bays.
- For example in Melbourne, Australia there are an estimated 200,000 side entry drain pits in roadside kerbing, where litter and other debris (e.g. soil, plant matter) can enter the storm water system
- With much higher runoff, and large areas of impermeable surfaces there may be less water entering groundwater systems in lower catchment areas, although this may be offset by increases to groundwater as a result of cleared vegetation in upper and middle catchment areas.

Many major cities have two separate water removal systems:

- Sewage (this will be directed through treatment systems/plants of some sort).
- Storm water (rarely passing through any sort of treatment system). The storm water system is designed to move large volumes of water quickly to prevent flooding, but as a result it also collects and transports huge amounts of contaminants. Illegal connections of storm water pipes to sewerage pipes can cause overflowing of sewage through overflow pipes out into the environment which can cause major pollution.

### How Can We Clean Up Storm Water?

There are a number of ways in which residents can help to keep storm water clean. This includes understanding the sources of pollutants, and adopting design principles which help prevent pollution. This is also called "water sensitive design". Examples of such design include:

House and street designs that retain water on site and encourage absorption into the ground.

Creation, reclamation or enhancement of wetlands. These can help retain water on site, use up nitrates and phosphates leached from the soil or washed in surface water, provide valuable wildlife habitat, as well as being aesthetically pleasing.

Irrigated tree plantations, using runoff water, on large industrial sites.

Diverting runoff from factory, warehouse or shopping centre roofs to feed

Xeriscape gardens - this involves the use of plants that don't require supplementary watering. This reduces the need to utilise valuable water supplies, and can greatly reduce water runoff from irrigation activities.

Design for water efficient gardens, such as drip or trickle irrigation systems instead of sprinklers or hand held houses, and mulching garden beds.

Establish treatment plants for storm water as we do for sewerage. This is an expensive option.

## Reducing Pollutants in Storm Water

In response to the ever increasing litter, pollution and contaminants prevalent in the storm water system in the USA, the USEPA (United States Environment Protection Agency) has developed a storm water management program (Phase11) that has been implemented nation-wide. Each city, town, village throughout the nation are required to implement the six-part program to reduce pollutants in storm–water runoff to the maximum practicable extent. The program must include:

1. Public education
2. Public involvement programs
3. The detection and elimination of illicit and illegal connections.
4. The control of construction sites of more than 1 acre.
5. Controls for re-developments and new developments.
6. Pollution prevention and good house-keeping practices of the storm water system within each community.

### Water-borne Litter

Water-borne litter is a problem world-wide. The effect of aquatic litter goes beyond the despoiling of local environments; it has global implications - for example: thousands of tonnes of waterborne litter from London are carried by currents and tides into the North Sea and beyond annually.

Although current practices to remove litter include in London for example:  Marine Services operated driftwood collection vessels, a tug and fleet of barges, skips, baskets, rubbish containers as well as passive debris collectors in the river; Local government is still vague on where the responsibility for removal of aquatic rubbish lies.

In the USA as part of their Phase 11 program mentioned earlier systems for water carried litter have been introduced that include: Catchment nets, filters, pollution and sediment screening and water treatment i.e. UV treatment for contaminants.

In the city of Melbourne, in Victoria, Australia, for example 4.5 million pieces of litter per year float down the waterways. This doesn't include things such as plastic bags that move below the water surface. An estimated 540 million plastic shopping bags are disposed of each year in Melbourne. Even 1% of these entering Melbourne's streams amounts to 5.4 million bags. Surface booms (e.g. on the lower reaches of the Yarra River), and litter traps on storm water drains can have a big impact on the amount of rubbish reaching the bays.

In the state of Victoria alone, millions of dollars is spent per year removing litter from lakes and waterways. A lot of this money is spent removing litter from beaches. A targeted litter survey carried out in Melbourne found that 90% of the litter in the bays, rivers and on the beaches of Melbourne was washed there via the cities storm water system. It was also found that the majority of litter on Melbourne's beaches was not left there by beach users, but was washed down into the bays by streams.

Some local councils have mechanised road sweepers that periodically sweep roadside kerbs clean, but this rarely occurs at frequent intervals, so much of the debris/litter reaching the road ends up in the storm water system.

### Nutrients in Storm Water

Nutrient rich overflows from septic tanks can be a major problem in many cities. Animal droppings, plant wastes, fertilisers, and pesticides are a significant source of nutrients in storm water. Most home gardeners, for example, over fertilise, or use inappropriate forms of fertiliser. A lot of the plant waste from gardens can be composted and used in the garden as compost or mulch. In some cities, tens of tones of dog droppings are deposited and leach into storm water each year.

Although pollutants to water run-off by agricultural activities (fertilisers, herbicides etc) have a significant contributing factor urban run-off is a critical source of pollution particularly in city water-ways. Also in most cases storm water collected from urban areas is left untreated and is merely discharged into the nearest lake, river or sea.

Detergents containing phosphates that are used to wash cars are also a problem because these phosphates then also enter the waterways.

Using the City of Melbourne as an example; nutrients released from the Werribee Sewerage Treatment plant, which treats much of Melbourne's sewage, are a significant part of the nutrient load reaching Port Phillip Bay. The Yarra River puts out about the equivalent of one - quarter of the treatment plant's output, however new technologies are (and will further) significantly reduce the amount of nutrients being released to the bay by the treatment plant. In contrast the water from the Yarra is not treated, and significant efforts will need to be made to reduce the amount of nutrients carried into the bay by the Yarra river (not as easy to come to grips with). Likewise, similar problems occur with nutrient loaded discharges from sewerage farms and rivers in most major cities.

Excess nutrients can cause algal blooms. This can seriously deplete levels of dissolved oxygen in the water where the blooms occur, affecting marine organisms. The coastal waters adjacent to some of the world's cities are so polluted that there is a real health risk associated with the consumption of marine organisms, including fish, taken from them.

E.coli and other bacteria can also be a problem (particularly as a result of animal wastes entering our water bodies). Generally, levels of E-coli in bays and rivers of major cities are a problem. In the River

Thames, London for example, has highly dangerous levels of E-coli and other harmful bacteria, due to large raw sewage discharges from overflows and effluent discharges from sewage plants. In the Yarra River, Melbourne, E-coli have been dropping in the past 20 years however there are times when amounts of E. coli can reach levels that can seriously affect human health.

### Toxins in Storm Water

Other toxins can also cause major problems. These include: petroleum products, pesticides, heavy metals automotive products (e.g. tyre rubber, brake linings, rust, plating, antifreeze, etc.). Consider:

- One litre of oil is enough to pollute one million litres of water.
- Shellfish can concentrate background levels of toxicants many thousands of times.
- In many of the world's large cities, storm water is the big problem. Most industrial discharges go into the sewerage system. Illegal dumping of industrial wastes can still, however cause major environmental damage.

### Sediments

All rivers and streams will deposit sediments into the bays and estuaries they enter. Some will have naturally high sediment loads and many will have increased sediment loads due to human activity that results in increased levels of erosion, in their catchments. Sediments can cut light to aquatic plants, smother sea grass beds, clog wetlands, and reduce the flow of rivers (blocking). Oil and toxic chemicals can cling (bond) to sediments, and in doing so harm aquatic life.

## SAFE DISPOSAL OF HOUSEHOLD CHEMICALS

Household waste can be separated into three different categories requiring different disposal procedures:

Recyclable materials. This category includes paper, some metals, many plastics, glass, etc. Non-recyclable non-dangerous materials. This kind of waste can be disposed and stored safely without posing any danger to the environment or living organisms. This category includes ceramics, concrete, etc.

Dangerous chemicals. The waste in this category can be involved in chemical processes dangerous to the living organisms. The negative effect of these chemicals on plants, animals and humans can include toxicity (poisons), carcinogenic activity (causing cancer), mutagenic effects (causing mutations in cells), etc. This kind of waste includes some metals and plastics, motor oil, different kinds of solvents, sprays, cleaning agents, garden chemicals, and more. All of these chemicals should be chemically processed before disposal.

Education of the general population is an important way of protecting the environment from the negative impacts of dangerous waste. Where potentially dangerous chemicals are required in a household only the minimum amount should be kept. They need to be stored and disposed of in a safe manner. Dangerous household chemicals should not be disposed in the garbage, burned, buried, or poured down the sewer without processing.

Storage, usage and disposal of dangerous chemicals can be regulated by various authorities, be they local, national or international.

Disposal and processing of dangerous wastes is conducted by special organisations. Processing of dangerous waste can start with mechanical conversion of waste form one form to another (e.g. disassembling spray cans or mercury lamps).

The aim of processing is to convert dangerous waste into non-dangerous material that can be safely disposed using one of four methods depending on the laws and regulations in your area:

- Sewer
- Landfill
- Recycling centre
- Combustion.

## Sewer

Sewerage plants can further process some liquid or water-soluble household chemicals like bathroom cleaners, glass and tile cleaners, antifreezes, mould removers, bleaches, pool chemicals, washing liquids and powders, etc. These chemicals are poured into the sewer with a lot of water. It is important when disposing of such chemicals down the sink to pour only one chemical at a time, and to turn the tap on with plenty of water to dilute and wash the chemical down through the system.

## Landfill

Landfill can safely store solid non-dangerous materials before further processing, recycling, or burial. Some landfills will take liquid substances such as oil for disposal. These kinds of substances can then be further processed for disposal.

## Recycling Centres

Apart from non-dangerous recyclable materials, recycling centres can also recycle some dangerous chemicals like plastics or motor oil. Some chemicals like mercury are recycled without converting them into non-dangerous form. Recycling of dangerous chemicals is conducted according to specially designed safety procedures at all times. These procedures vary from country to country, so it is important to be aware of the local legislation.

## Combustion

Household waste combustion technologies are getting more popular, especially within highly urbanised territories like Western Europe and South-East Asia. For example, in Singapore about 85% of waste collected from households is combusted. In Australia this number is less than 1%, while many of developing countries don’t combust household waste all.

## SET TASK

### Activity 1

Contact the organisation responsible for the collection and treatment of sewage in your locality. Ask how local sewage is treated and what sort of sewerage system is in place. If you are not able to contact the organisation, do some research (for example on the internet) and find some relevant information.

### Activity 2

Contact or research the organisation that collects and processes domestic waste in your area.

Ask:

- Who collects the waste
- How is it collected
- Where is the waste taken to?
- Are recyclable materials collected separately?
- Are there special collections days (e.g. hard rubbish, garden wastes/prunings)
- What costs are involved for local residents who use the services?