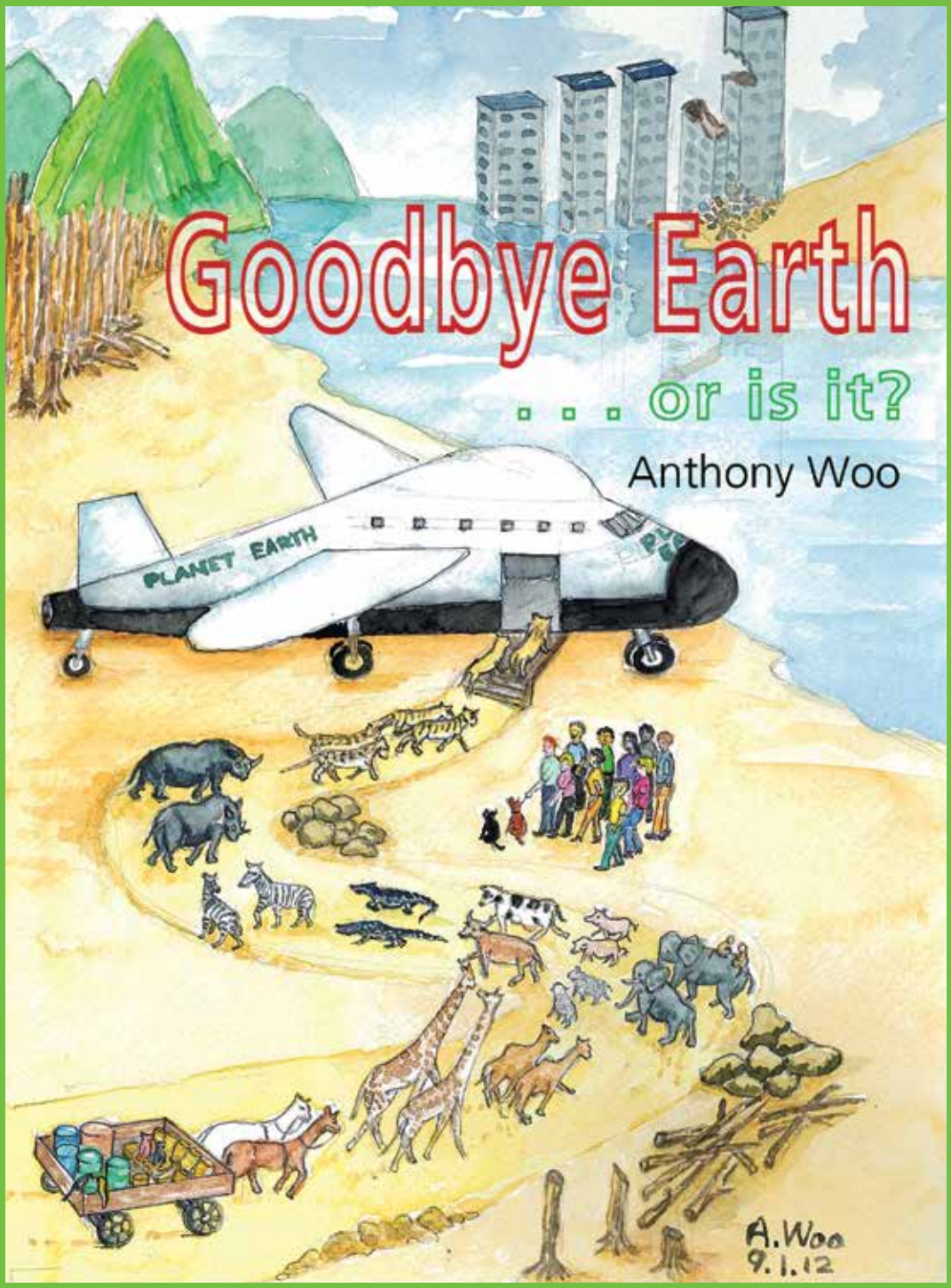
Goodbye Earth

. . . or is it?

Anthony Woo



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Finally I like to thank officials in the government environmental agency who allowed me access to publications on environmental issues. They have also put me in contact with environmental conservation enthusiasts. From them I am inspired to see to a high 'standard of simplicity' in the coverage presented in the book. I hope nevertheless readers are adequately provided to get off the starting point on a journey of environmental sustainability.

CONTENTS

COVER:

A pictorial depiction of a nightmare when Earth has been devastated with global warming, rising tide level, forest erosion, ravaged building from acid rain; and arid land. Men's survival instinct is to migrate to safer haven. Hence we see an exodus by humans bringing with them earthlings of all kinds, in search of a new hospitable planet.

1. ABOUT THIS BOOK

This book started as a personal compilation of some basic information about the environment and where it is heading, if we do not heed advice to protect it from irreversible damage. The more I delved into it, the more I thought I could make the book useful as a simple reference for all who consider taking the first step in caring for our environment. I share with you what I understand to be ozone depletion and climate change. You will get basic information on carbon footprint, Kyoto Protocol and Green Building certification. Simple notes and explanations of what all these mean are featured. I checked on plastics, heavy metals, chemicals and substances that environmentalists advised and warned of their environmental impacts and health effects. I present these in tabulated form for easy access.

I hope the people having control over production processes will constantly be wary of the impacts manufacturing has on our well being. It will serve the environment well if manufacturers are enlightened to avoid the use of harmful substances in the raw materials feeding their production.

Over the years development in life's conveniences have left us taken too much for granted, treating the environment as a bottomless sink, or a limitless space. I believe we can easily adapt to environmentally correct behavior, doing simple things to save energy, conserving precious water and avoiding too much heading to the incinerator by separating kitchen waste from recyclable items.

There are brief accounts of recent catastrophic accidents that I tried to present in simple layman terms. Our desire for life's comfort and conveniences push science and technology to the fringe where nature's wrath or human failures caught those unfortunate to be where it happened. Lives were lost and survivors will live with painful scars to the end.

I have chosen a simple title for the book. The message is that we will not see it in our life time. Our children will not see it either. But unless we put a hold on our excesses, or better to reverse the trend, sometime later our descendants will have to bid mother earth goodbye. In the meantime do not be surprised if a community suffers from unexplained sickness that medical science has to put money to investigating.

This book is easy reading. I hope you will take the first step to be more environmentally caring after reading it.

2. MAINTAINING AN ECOLOGICAL BALANCE

"Man has lost the capacity to foresee and to forestall. He will end by destroying the earth." Albert Schweitzer

When we take out more from our environment than we put back into it, we cause an ecological imbalance.

If we continue this imbalance, in time the resources we now take for granted will deplete. A stark example is in cutting trees to harvest timber from the forest. We know that animals and creatures whose existence depends on the forest will be driven to extinction, just as scientists believe probably happened to the historic dinosaurs when they were unable to adapt to drastic changes in the ecosystems. Our well being is put into jeopardy when forest gives in to urbanization. This is not difficult to understand when we think that we rely on plants to take from us carbon dioxide to grow, and give us oxygen to survive.

To meet ever increasing consumerism demand, our manufacturing activities go into high gear. The consequence of this is more wastes are dumped into the environment. From the furnace stacks more carbon dioxide is put into the atmosphere. This coupled with the cutting down of trees is a double whammy being dealt on our environment.

We need greater awareness of the impacts our living necessities inflict on our environment. To begin with it should only be necessities that we take from nature's providence and man-made convenience. Once we go past these thresholds our indulgence takes a heavy toll on the environment. One example of excesses is in the extra plastic bag you ask for in the supermarket. Another example is the 'more than necessary' consumption of electricity running our air-conditioner at full blast, and having to don warm clothing in the office. The complacency of the consumers ignoring environmental signs and messages, and the exasperation of the environment guardians urging 'save our environment' pleas are in a perpetual tug-of-war situation. Which ever side gains ground spells the future well-being or lack of it for our future generations.

"To waste, to destroy, our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them."

— Theodore Roosevelt 1858 – 1919

Source: http://www.grinningplanet.com/6001/environmental-quotes.htm

3. BEQUEATH A SUSTAINABLE ENVIRONMENT

Our future generations are heir to three valuable assets; air, soil and water which Mother Earth meant for us to preserve.

Unfortunately effects of our disregard for the environment are only very slowly manifesting in our life time, so the direct link to our irresponsible, callous behaviors is not immediately connected.

Each generation has to preserve and bequeath an environment to the next in as much a sustainable state as we know how to. In our failure to pay heed to this obligation, Mother Earth pleas on behalf of the environment guardians when the effects of our reckless disregard are felt in the changes inflicted on our surrounding. Unfortunately these effects are only very slowly manifesting in our life time and the direct link to irresponsible, callous behaviors is not immediately connected. People react skeptically when told of the threats from erosion of the ozone layer and gradual receding of ice shrouds in our mountains. When we see pictures of rotting vegetation ravaged by acid rain we relegate these to some other reason, continuing with our usual business in the false belief that this would not occur in our backyard.

4. ENVIRONMENTAL POLLUTIONS

Environmental pollution is the contamination of air, water and soil largely due to releases of waste into the environment from anthropogenic sources, meaning from man-made activities. Only over the last few decades have we come to realize we have been inflicting destruction on Mother Earth. This realization is not spurring people into taking fast corrective measures. Over time we have got used to a life style nurtured on automation and on all things of convenience. Industrialization development and technology advances are trying to keep pace with this life style and competing on drawing consumers to subscribe to more automation and heavier energy usage. The consequence is that we put into the environment a burden we expect nature to shoulder. The contamination of our air, soil and water is explained in the following.

AIR CONTAMINATION

Air contamination is caused by the discharge of harmful gases and the entrained particulates into the atmosphere. The pollutants are from power plants, steel foundries, oil refineries, chemical and cement plants, to name just a few. How are the pollutants discharged into the atmosphere? These facilities rely on heat for their processes. The heat is derived by burning fuel in furnaces. Flue gases from the burning of fuel in furnaces inevitably end up in the atmosphere. The following gases are found in the flue emission, in larger or lesser quantities, depending on the types of fuel burnt.

- Sulfur oxides (SO_x) made up especially of sulphur dioxide SO_2, is generated from burning fuel containing sulphur compounds. SO_2 in the atmosphere can further oxidize forming sulphuric acid H_2SO_4. The acid, washed by the rain results in acid rain which is a major problem to the survival of vegetation.

- Nitrogen oxides (NO_x) – amongst which are nitrogen dioxide NO_2, produced in the flue gas of high temperature furnace operation. This can be seen as a brown haze or plume spewing out of tall stacks in the distance. NO_2 is a major pollutant with a sharp, biting odor.

- Carbon dioxide (CO_2) is another flue gas component emitted from furnace stacks. It is also a prevalent contaminant from cement plants. The production of cement entails the heating of calcium carbonate at a temperature in excess of 1400^0C. At this temperature CO_2 is released, whilst the remaining lime leads onto to eventual cement output. The cement industry is second in CO_2 generation behind the highest producer due to power plants. CO_2 is colorless, odorless and is non-toxic. However it can asphyxiate and kill people exposed to an atmosphere high in CO_2. It is also a major component giving rise to the earth's green house problem.

- Carbon Monoxide (CO) is produced due to incomplete combustion of fuel such as natural gas, coal or wood. Incomplete combustion occurs when oxygen is insufficient to ensure proper and full combustion of the fuel and CO is produced in the flue gas instead of CO_2. CO like CO_2 is colorless and odorless. However, it is a poisonous gas and kills without warning.

- Particulates are fine particles of liquid or solid suspended in the gases. These are more common in the flue gases of furnaces burning coal and heavy fuel. Manufacturers of repute incorporate devices in trapping particulates from escaping into the atmosphere. These devices could be filters, cyclones or electrostatic precipitators. Electrostatic precipitators use an electric field to trap ash particles on high voltage plates.

Other air pollutant is volatile organic compounds (VOCs). VOCs are not due to furnace operations but being emitted into the atmosphere from storage tanks and where certain solid and liquid products are handled. These compounds are chemicals of high vapour pressures and are easily vaporized at ambient temperature. Some of the common VOCs are benzene, trichloroethylene (TCE), styrene, toluene, and vinyl chloride. VOC in the vapor space of storage tank is expelled when the tank is being filled from a ship during offloading of its product. Some tank operators equip their storage facility with a vapor recovery unit to recover the vapor and avoid the pollution. The same vapor recovery unit is also operated on hot days when evaporation from the tank occurs but is prevented from relieving into the atmosphere.

Source: Wikimedia Commons
Fig 4.1: Livestock is a pollution source Marine pollutant Source

In the seemingly safe haven of home and the office, VOC is of higher concentration than in the outdoors. This is when VOC emissions occur from building materials and furniture, also from office equipment such as copiers and printers. VOCs are found in glues, correcting fluids, formaldehyde and paints in which solvents are used as a manufacturing component. VOCs emitted from hydrocarbon, chemicals, household products and office equipment are categorized as non-methane-VOCs (NMVOCs) as opposed to methane. This is a critical greenhouse gas associated with livestock husbandry.

Methane is one of the gasses emitted from livestock manure; it persists for long periods of time as a greenhouse gas. It is the second most abundant greenhouse gas after carbon dioxide. Even though there is less methane than carbon dioxide its ability to warm the atmosphere is 25 times greater.

Shipping contributes considerably to the environmental woes, sending million tonnes of SO_2, NO_2 and particulates every year into the atmosphere. These are on the increase with higher demand in ocean transportation and ships burning relatively higher sulphur content (as high as 4.5% weight) in the heavy fuel it uses for propulsion. Whilst land-based combustion emission standards are easier to comply, international shipping lags behind in legislative control although ship owners and charterers are obligated to operate under the ambit of the UN International Maritime Organisation (IMO) agreements. Much is to be hoped for by year 2020 when all marine fuels sulphur content will be capped at 0.5% worldwide. This was in an agreement reached by IMO member states at the Marine Environmental Protection Committee meeting in April 2008. This should significantly reduce the SO_2 emission. There was also agreement reached on NO_x emission for new ship engines to achieve reductions by 16 to 22% by 2011 and by 80% by 2016.

Fig 4.2: "Look who's kidding us!"

Aircraft Pollutants

Apart from noise which we will not address in this book, the aviation industry contributes air pollutants no different from land-based and marine sources. The concerns in fact occur both when it is in flight and when an aircraft is on the ground. During flight, the engines operate efficiently and are normally smoke free in their exhaust. Nevertheless the major emissions are still present contributing to greenhouse problems with CO_2, NO_x and water vapor. It is believed that at flight altitude the effects on climate change from aircraft engine emissions is 2 to 3 times worse than when the emission occurs in the ground*. Landing and whilst maneuvering on the ground, also when revving up engine speed in taking off, engine efficiency is reduced which may lead to hydrocarbon being emitted in the engine exhaust. Aircraft refueling at the apron or parking area has a potential risk to spills and fume being displaced from the aircraft fuel tank. Hydrocarbons and NO_x, both components of air traffic, can contribute to photochemical smog.

Road Vehicle Pollution

Source: http://www.buckscc.gov.uk/bcc/transport/air_quality.page
Fig 4.3: Stuck in a polluted jam!

Smog is a word coined combining smoke and fog. It is pollution associated with the exhausts from road vehicles. It is ground level ozone formed by photochemical reactions involving VOC and NO_2 in sunlight.

Owning a car in large countries like Australia, United States of America, Canada and Europe is a necessity and an indispensible mode of personal transportation. Cars until recently run on gasoline or diesel. These days there are environmentally friendly 4-wheeler inventions running on electricity and cleaner liquid natural gas (LNG) fuel. Battery operated cars are not very popular because of battery service life limitation, without the mention of environmental concerns for battery charging facilities and electricity supply. LNG refueling stations if not being built at the pace of potential demand will also put a dampening hold on motorists wanting to help reduce pollutants from their vehicles. In the mean time motor vehicles (and these include trucks and 2-stroke engine motorcycles) are reputed to be the major contributors of CO_2, SO_2, (diesel), CO, NO_2, particulates and VOC into the atmosphere.

Nature's Air Pollutants

Pollutants due to natural sources are

- Wildfires producing carbon monoxide and particulates;
- Volcanic activity producing sulphur, chlorine and ash particulates;
- Vegetation emitting VOCs which react with human activities producing pollutants such as CO_2, SO_2, and NO_2 to form haze.

"Keep a green tree in your heart and perhaps a songbird will come."
— Chinese proverb

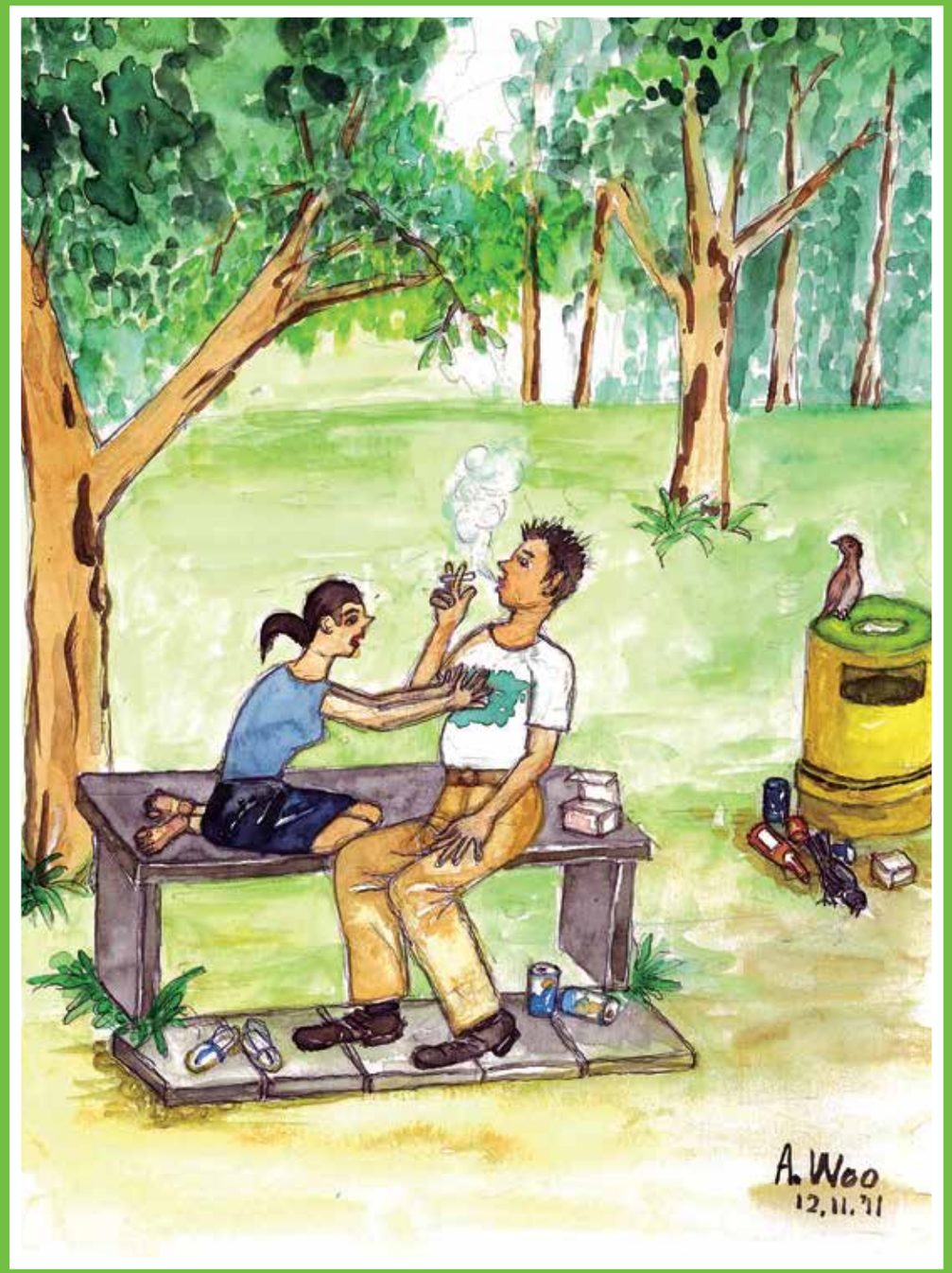

Fig 4.4: "For me 'love & fresh air' must go together!"

SOIL CONTAMINATION

Soil contamination is the result of man-made pollutants getting mixed in natural soil. These pollutants are hazardous liquids or solids physically or chemically attached to soil particles, or trapped in the space between the soil particles. The common pollutants are petroleum hydrocarbons, solvents, chemicals, pesticides and heavy metals including lead and mercury. The contaminants end up in the soil from

- Accidental spillage of chemicals or hydrocarbons from underground storage and handling systems;
- Indiscriminate or deliberate dumping of wastes from industrial sources;
- Emission of particles from furnace stacks falling in the surrounding and absorbed into the ground;
- Leaching of contaminants from landfills;
- Carried by water from a hazardous source and depositing the contaminants in the wake of its flow.

Effects on Ecosystem due to soil contamination

Rachel Carson in her book 'Silent Spring' published in 1962 raised public concerns with pollution of the environment due to DDT. This stands for dichlorodiphenyltrichloroethane. Fortunately one does not need to risk breathlessness reciting the full name instead of using the acronym. DDT was an insecticide used by spraying, sometimes from a farm plane flying over crops. This endangered wild life and human health. Carson warned that continual use of DDT was going to destroy our environment killing all insects good and harmful, and along the way large number of birds. Carson warned that unless stopped, every spring would bring people a stark reminder that it was their callous use of DDT that silenced the chirping birds for all eternity. Governments banned the use of DDT in 1972. However, to-date, less than 40 countries have supported the ban.

Soil contamination even at low concentrations can have a deleterious effect on the chemistry of the soil affecting the natural growth of the microorganism resident in the soil. The result could be the eradication of the primary food chain. On the other hand, the ingestion of contaminated microorganism by the consumer species moving up the food chain may cause the contamination to become more and more concentrated. The damage, citing the example of DDT affecting birds feeding on contaminated earth worms, is in the weakening of egg shells, increasing chick mortality and potential extinction of species.

Effects on Health due to soil contamination

Exposure to pollutants in soil is through direct contact, via breathing of air containing vaporized contaminant from the soil, or through eating of contaminated meat or food from plants. Other risks are from drinking of contaminated water. Sometimes the ground water may infiltrate from a contaminated source removed from where water is drawn for drinking. Exposure to hydrocarbon and chemicals can cause health effects such as headache, nausea, fatigue, eye irritation and skin rash. Chronic exposure to chromium, lead, mercury and other metals can lead to cancer, damage to internal organs, blood disorder and congenital disease.

A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people.
Franklin D. Roosevelt

Source:
http://www.brainyquote.com/quotes/keywords/air.html#ixzz1iwteglLZ
Extracted Microsoft Office clip art

Fig 4.5: "Oh no, don't! I'm bio-accummulated!"

WATER CONTAMINATION

Surface water seeps into the ground and combines with ground water. All streams will eventually find their paths into lakes, reservoirs and the sea. The contamination of surface runoff and ground water is caused by people who deliberately or accidentally discharge untreated waste water into these water streams. The waste water may be trade effluent from industries or runoff from non-industrial sources such as farms and public buildings, roads, parks and golf courses. The contaminants in non-industrial sources may contain detergents, insecticides (herbicides), fertilizers consisting nitrates and phosphates, and road rain washing containing oil and grease, hydrocarbons such as diesel and lubricants drips and spills from motor vehicles. Trade effluent may contain oil and grease, solvents, chemicals and heavy metals. However, oil and petrochemical industries largely operate on very high standards of technological design, operational control and good maintenance, complying with legislations in effluent quality specifications. Failures resulting in contaminated effluent getting into public water course do occur, but rare. These would be due to exigencies and lapse in staff vigilance.

Effects on Eco-system due to water contamination

Organic wastes including human and animal fecal matter dumped in the water will upon decomposition consume oxygen, depriving aqua life of the oxygen needed for their survival. Soil erosion and mining activities may cause the buildup of sediments and minerals in the water which block sunlight reaching organisms in support of their photosynthetic functions. Excessive use of fertilizers result in phosphorous and nitrates entering the river and lake which will provide nutrients for the water plants and algae causing overcrowding and depriving other vegetation species from growing. Pesticides are mobile in the soil. They are also persistent in the soil and water.

Thermal pollution of water occurs when heated water after cooling equipment and process streams in power plants or refinery and petrochemical plants, is released into streams. Warm water drives out dissolved oxygen from the water affecting fish reproduction and enhancing growth of algae.

This road side picture shows that polluted fluid had spilled from a vehicle onto the road, some apparently flowed into the drain. This could be the result of an irresponsible driver who had not taken steps to prevent this. What remained on the road surface trailed down the road for a distance, presumably by the driver of the same vehicle, wheeling over the spill? Needless to say this was a source of ground and water contamination.

Fig 4.6: Telltale spill from a vehicle

Fish and animals are killed by pollutants contaminating their habitats. Heavy metal pollutants find their way up the food chain from tiny organisms eaten by fish and shellfish, then eventually into humans. People risk having diseases such as hepatitis eating contaminated shellfish.

Source: Internet Public domain
Fig 4.7: Effects of water pollution

Effluent Containment & Treatment Strategy

Effluent systems of refineries and petrochemical plants are handled effectively according to their production source, such as:

- Non contaminated water from buildings, roads, pipe tracks, utility plants where equipment such as steam boilers, air compressors, steam turbine generator and de-aerators handle non-hydrocarbon mediums;
- Accidental oil contaminated water from coolers in case of a leak of product into the cooling water;
- Oil contaminated water, including tank compound water usually caused by leaks from equipment or spills not properly cleaned;
- Process effluent stream;
- Process drips and drains from equipment.

This manner of segregation allows effective employment of the different treatment facilities and methods. For example:

- Oily streams are first skimmed leaving water with suspended solids to be routed to an air floatation unit. In this unit air induces the solids to cling onto remaining oil and the combined pollutants are then skimmed off.
- Streams containing light hydrocarbons and solvents, especially process effluent are routed to a steam stripper where the contaminants are stripped and separated from the water to be further treated.
- All streams are cooled in their respective holding tanks before being finally treated in a biotreater where sludge is recovered and waste water treated to meet effluent quality

Effects on health due to water contamination

Water coming off the supply network if not properly managed and monitored could also open consumers to water-borne illnesses. The challenge in developing countries is to ensure fresh and clean drinking water is available for daily consumption. The following identifies the contaminants, their sources and effects on health:

- Pesticides may be present in runoffs from farms, parks and golf courses into watercourse. Apart from good management in regulating the use of pesticides, applying these at an appropriate time and not during wet seasons could help in reducing the risk of pesticide contamination of surface water. If the pesticides find their way into reservoirs and drinking water undetected, there are health risks such as cancer, low sperm counts and neurological disease. Expectant mothers in area where pesticide contaminated water occurred have been examined to harbor pesticide (DDT) residues in breast milk, with danger of passing these to new born babies.

- Excessive use of fertilisers release nitrates which contaminate ground water seeping into wells and reservoirs. High concentrations of nitrates cause blood disorders. Infants drinking formula milk contaminated from nitrates can encounter restriction of oxygen flow reaching the brain causing the 'blue baby' syndrome. Nitrates are also linked to digestive tract cancer. Good agricultural practices can help in reducing the amount of nitrates in the soil and thereby lower its content in the water.

- Toxic chemical pollutants from the refineries and petrochemical plants are for example chlorinated solvents and benzene which can cause cancer and reproduction disorders. Exposure, however, is through inhalation during normal work activities.

- Heavy metals are also pollutants from coal and gas refineries, smelting and petrochemical plants. Industrial activities which risk exposure include soldering and glazing. Drinking water contaminated by heavy metals leads to risk of damage to the nervous system, kidney failure and other metabolic disruptions

- Sewage is a major source of problem if improperly treated and allowed to contaminate streams leading to drinking water reservoirs. Leaky pipes handling sewage can contribute microbial pathogens to watercourse and spread water-borne diseases. These include cholera, typhoid, polio, meningitis, and hepatitis A and E. Children are more susceptible.

Extracted Microsoft Office clip art

Filthy water cannot be washed. ~ African Proverb

Source: http://www.quotegarden.com/water.html

Author: Bobo 12345 at the Wikipedia project
Fig 4.8: Minamata Memorial

It took one historical tragedy to raise public awareness of the effects on people's health from industrial dumping of pollutants. This occurred in Minamata, Japan during the '50s. It was only in 1968 that the root cause of the pitiful endemic infliction came to light. Methyl mercury was known to have been discharged into the bay with waste water from as early as 1906 when the acetaldehyde plant was started. The sediment wastes were ingested by organisms which were fed upon by fish and shellfish. Residents in Minamata ate fish and shellfish caught off the bay and became poisoned. Methyl mercury poisoning resulted in many people falling ill with central nervous system symptoms. People suffered gross lack of muscle co-ordination and movements, sight problem and damage to hearing and speech.

They suffered brain damage and in some cases, people became insane, paralyzed and comatose. Death followed within weeks of the onset of symptoms in serious cases. Even cats and dogs eating fish left over off the meal table were displaying identical symptoms of the disease. Unborn babies suffered worse consequence when the mother's placenta attracted the contaminant and concentrated this in the fetus development, resulting in congenital disorder (birth deformities). The awakening did well in shutting down the plant, bringing on industrial environmental pollution controls and cleaning up of the pollution.

Extracted Microsoft Office clip art

We never know the worth of water till the well is dry. ~Thomas Fuller, Gnomologia, 1732

Source: http://www.quotegarden.com/water.html

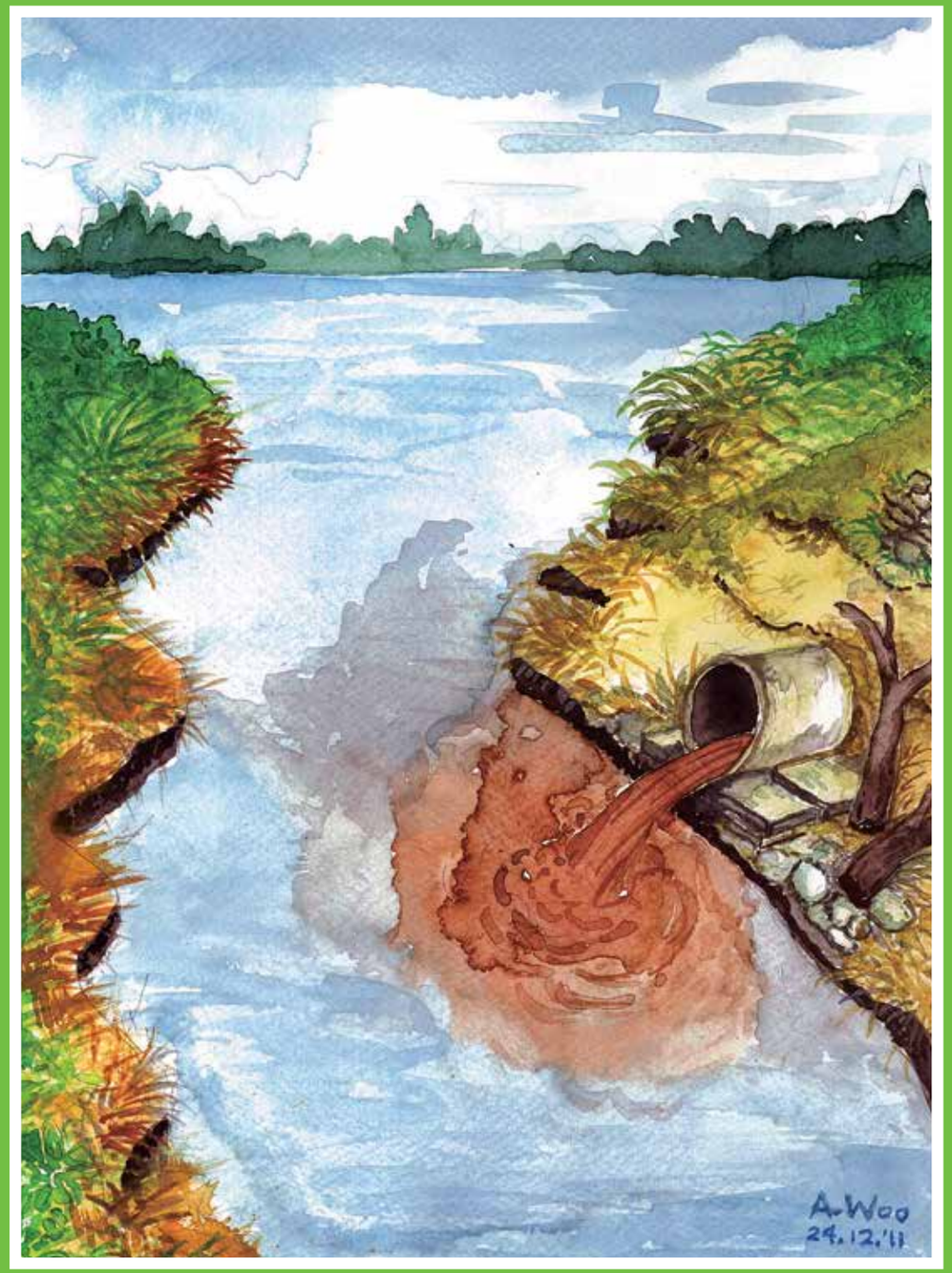

Fig 4.9: Impression of polluted effluent discharged into a river

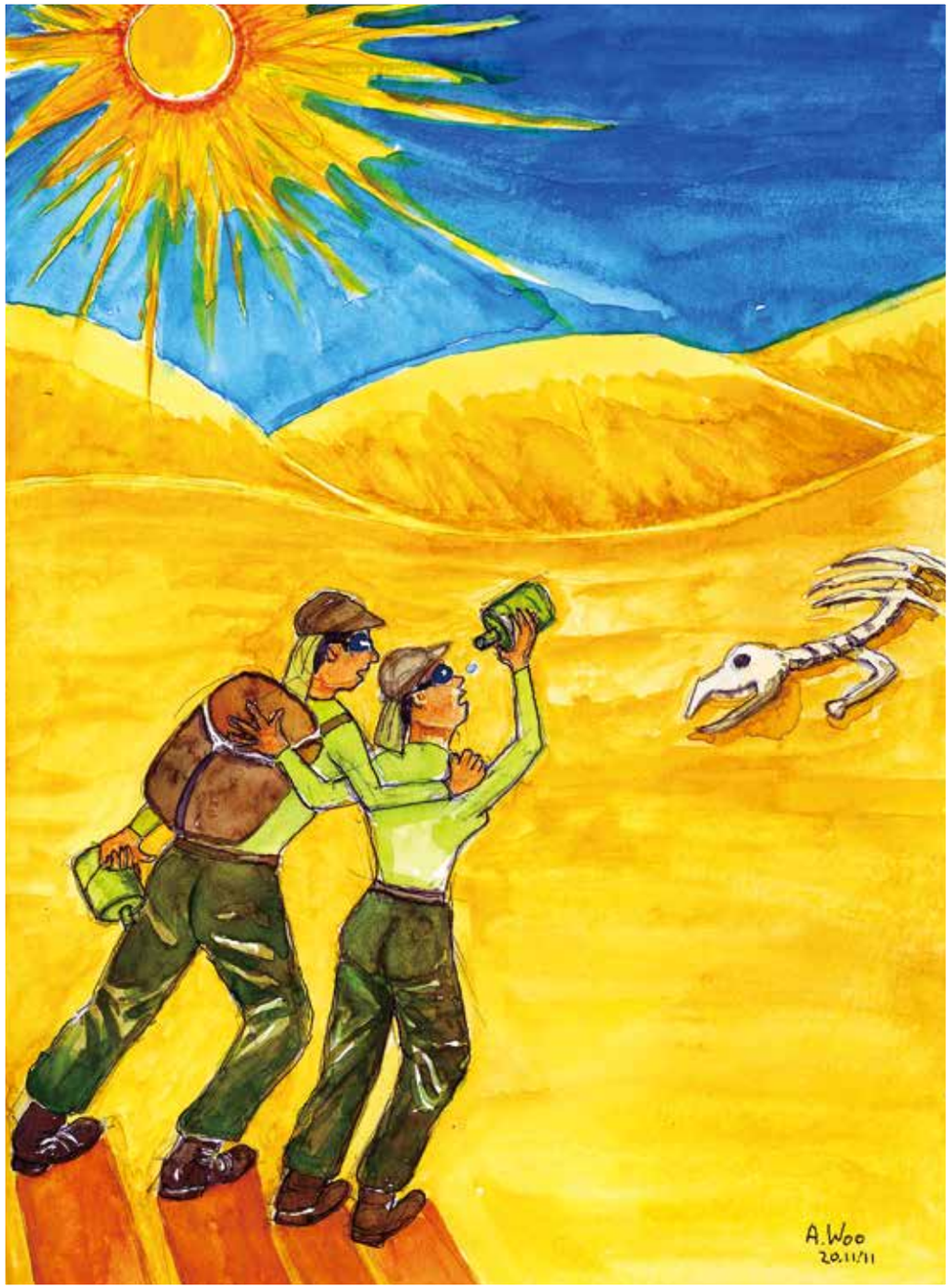

Fig 4.10: "At least when we find water it is free from human interference."

5. POLLUTION CYCLE

From human activities emitting wastes into the air, or carelessly dumping them into the ground or water stream, a full cycle of ill consequences may be created and set off to cause ecological and human suffering. People may know, but not always caring enough to take the necessary measures to protect themselves and all those around them. The example involving the use of chlorine is given here to illustrate how the three elements, air, soil and water; are linked, such that when pollution occurs in one, it can through the others be conveyed back to mankind.

Chlorine is amongst the most fearsome elements giving rise to air pollution. In the industries chlorine is used in combination with other chemicals containing carbon in the manufacturing of organochlorines. The process involves carbon and chlorine atoms being joined together. Organochlorines in turn are used in solvents, pesticides, plastics, disinfectants, forms of packaging and bleached pulp and paper products.

In the manufacture of products using organochlorine, highly toxic by-products such as dioxins are inadvertently made at the same time. Dioxins are also produced when plastics in PVC and wood treated with PCP are incinerated. The dioxins produced cling onto the soot and dust in the flue of the incinerator. These pollutants get in the atmosphere and spread over a wide area, falling on the grazing fields of livestock. Dioxin contaminated grass eaten by animals such as cows, end up in their milk and meat fats. Needless to say through the food chain these contaminated milk and meat find their way into our systems. "What is the problem?" The cynics would ask. Well, according to the World Health Organisation publication, dioxins in human bodies 'cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer'. Another toxic source of dioxin reaching the human body is from eating fish carrying dioxins. These come from airborne particles falling into the sea, or from industrial and sewerage discharges which contain dioxins originating from landfill of incinerator ash. What to do about this? Whilst entrusting the manufacturers to be organised and equipped to control emissions within legal limits, all people must avoid indiscriminate disposal into the incinerator of materials containing organochlorines such as PVC and wood treated with Pentachlorophenol (PCP).

SOIL/WATER LINK

With dioxins we have created the picture of how from the air, pollutants can be passed to the soil and then into the water course. Even if the atmosphere is left out of the link, materials that inadvertently find their way into the ground as landfills would lay dormant but quietly leach pollutants into the soil. From the soil, pollutants that readily dissolve in water would wash into streams, lakes and into the sea.
One can reasonably argue that soil contamination is all due to human activities. Where activities occur, the risk is in errors and omissions. Mishandling of petroleum and chemical storage facilities can result in spills and leaks finding their way into the ground, hence polluting the water. Uncontrolled landfill activities, involving dumping of wastes within industrial premises can give rise to heavy metal contamination such as lead, mercury and cadmium.

PREVENT SOIL AND GROUND WATER CONTAMINATION

First in the order of what should be done is to avoid indiscriminate dumping of wastes. The apparent ignorance or careless attitude in used battery disposal is an example of how the environment is put at risk, most times without the culprits' awareness in the cycle of contamination consequences. For example dry cells containing mercury, lead, cadmium and nickel should not be carelessly dumped into our household wastes and sent for incineration. Doing so may see some of these hazardous heavy metals concentrate in the ash to become a serious pollutant. Landfill will not do for such spent batteries either, for the same reason that heavy metal contaminants can leach into ground water. How should spent batteries be disposed? Refer to section on recycle.

Consumers' apathy also results in dumping of cleaning solutions in the backyard, or draining engine oil into the grass. Public awareness in the importance of protecting the environment may be promoted through sustained media messages and articles. Legislation and enforcement may be the necessary deterrent to negative attitude to environmental protection amongst individuals.

Responsible manufacturers should have an environmental commitment for the entire life of their products, from choice of raw materials, through the production process, to product packaging and deliveries. It should also be in their business principles to assume accountability for product recycle and waste disposal.

They should let it be known to the consumers what avenues are available for their used products to be recycled, at no cost to the consumers.

Grounds that are known to be contaminated should be isolated and prevented from washing into ground water streams. It is expensive effort, but necessary to create barriers to the infiltration of pollutants into the wider area. Then remedial efforts should be carried out which include excavation and removal of the contaminated soil for suitable off-site decontamination. The contaminated soil can also be treated in-situ, allowing natural process or enhanced using air and microorganisms to biologically decompose the pollutants.

Ground water monitoring wells may be drilled at strategic points in the boundary of the contaminated site. To determine if the conditions of the soil respond to remedial actions samples from these wells are taken and tested for likely decline in pollutants.

Typical tests are done on the following:

- pH – to check the acidity of the ground water. Influence of pollutants, including acid rain will show a pH below 5. Recent spill (7th Oct 2010) of high pH (12) red sludge from a burst Hungarian metals reservoir which reached a tributary of the Blue Danube River, killed a few persons, injured many others and destroyed fish and plant lives in the tributary. pH test indicated that flow into the Blue Danube was diluted and the effects were less in the River.
- Biochemical oxygen demand (BOD) –standard test for assaying the oxygen-demanding strength of waste waters in microbial oxidation. BOD is an indication of the seriousness of the presence of pollutants in the waste water; the higher the BOD, the greater the amount of oxygen in the water consumed to support the biochemical actions of the bacteria. Reduction of oxygen level faster than it can be reabsorbed into the water affects the survival of fish and other living organism in the water.
- Chemical oxygen demand (COD) – the test is commonly used to indirectly measure the amount of organic compounds in waste water, or in natural waters contaminated by industrial or domestic wastes. The higher the indication of COD, the higher is the oxygen to be consumed in the decomposition of the organic compounds.
- Heavy metals – the common being copper, cadmium, zinc, lead, selenium and mercury. Heavy metals are dangerous because they tend to bio-accumulate when taken into the systems of living things. They store more

readily than they are broken down or excreted. Refer to 'About Heavy Metals' for the health impacts of heavy metals on humans.

- Oil and Grease – is an indication of petroleum pollutants resulting from irresponsible dumping of sludge or processing wastes and failure of the operator's effluent treatment plant.
- Total petroleum hydrocarbon (TPH) – another indicator for petroleum product pollutants arising from spillage or leaks from storage facilities.
- Pesticides – checking against excessive use on vegetation and crops.
- Nutrients (nitrate and phosphorus) – indicating excessive use of fertilisers.

We can no longer afford to consider air and water common property, free to be abused by anyone without regard to the consequences. Instead, we should begin now to treat them as scarce resources which we are no more free to contaminate than we are free to throw garbage into our neighbor's yard.

Richard Nixon (1913-1994), 37th President of the United States, State of the Union Message, 22 Jan 1970

ACID RAIN

What is acid rain? It is the effect of sulfur dioxide (SO_2) and nitrogen oxides (NOx) pollutants reacting with moisture, oxygen and other chemical pollutants in the atmosphere, resulting in an acidic mixture. The sulphur and nitrogen oxides are emitted into the atmosphere mainly from the burning of coal and fossil fuels; less from volcano activities and occasionally from wild fires. (See 'Air Contamination' in the foregoing) The oxides can travel hundreds of kilometers to cause widespread harms. Along the way the oxides are converted into sulphuric and nitric acids by intermolecular reactions in the sunlight involving oxygen and hydroxyl (OH), remaining in the gas phase until coming in contact with moisture to become acids. Acid rain is actually the popular term referring to acid depositions, both in wet (when it is entrained in rain, fog, sleet and snow) and dry (carried by gases and particles) forms.

Both wet and dry deposition can be carried by the wind sometimes over long distances.

They fall on buildings, trees and soil, the effects of which are described:

- Acid rain falling on trees destroys the waxy surface and leaches the nutrients from the leaves, rendering the trees susceptible to frost (cold temperature on high grounds), fungus and insects. The roots grow slower and fewer nutrients are taken up to keep up with losses from the leaves. This stunts the growth of trees. The trees are also slowly killed by what happens in the soil due to acid rain.
- Acid rain trickling down the tree leaves reaches the soil, causing the soil biology and chemistry to change and lower the pH into the acidic level. Some microbes are unable to tolerate this drop and they die. Toxic metals such as lead, zinc, chromium and aluminum are carried by acid rain and deposited in the soil. At the same time, nutrients such as calcium and magnesium are leached from the soil. The presence of toxic metals and the loss of nutrients stunt the growth of trees and other ground organisms such as mosses, algae, nitrogen fixing bacteria and fungus, deprive the forest of protection against harmful bacteria.
- Groundwater bringing along its acidity flows into the river, into the lakes and the sea, turning these acidic with a drop in the pH to as low as 5. The lower pH in the water can kill adult fish and affect the hatching of fish eggs. Biodiversity is reduced affecting other aquatic animals.
- Buildings and statures, some of these are of historical values and are irreplaceable, are corroded by acid rain, especially those of limestone and marble containing calcium carbonate. The acids react with calcium compounds forming calcium sulphate which is soft and is soluble in water, hence easily washed off. Even gravestones have not been spared where the inscriptions become illegible after years of acid rain attack. Acid rain also increases the oxidation of copper and bronze. Statues sculptured in these metals are not protected against the ravage of acid rain.

Health problems

Dry acid deposition in fine particulates of sulfate and nitrate are inhaled by people contributing to health problems including asthma and bronchitis

6. POLLUTANT BEHAVIORS

The behaviors and consequential state of the wastes or pollutants which find their way into water, soil or the atmosphere may assume one of the following:

Biodegradable – it can be rendered harmless by natural processes or effects of microorganism, hence no permanent damage is expected from the wastes. These are generally organic materials such as from plants and animal matters.

Non-biodegradable - pollutants which cannot be destroyed by bacteria action and will remain whole over many years. Landfills involving plastics, metals, glass, plastic grocery bags, Styrofoam (polystyrene), pvc, and ceramics which are all non-biodegradable should be disallowed into landfills; as they will not breakdown for a thousand years, if they do breakdown at all.

Bioaccumulation – a build up over time of chemicals in an organism faster than they are metabolised (broken down) or excreted. The dynamic process of bioaccumulation is understood when we think of waste being absorbed by algae or plankton, is increased in concentration as it moves up the food chain through small fish, shrimps, big fish and likely into humans when we eat fish from polluted water. One example of bioaccumulation is mercury. This can evaporate into the air and is washed by rain into rivers, lakes and the sea. Mercury entering by the gills of fish is absorbed into its flesh and consumed by birds and humans. The ravage of mercury poisoning on humans eating contaminated shellfish in Japan (1950's), was the early days when bioaccumulation of toxins up the food chain became a painful lesson eventually.

Bioconcentration - is the specific bioaccumulation process with reference to the aquatic environment. Through this process the concentration of a chemical in an organism becomes higher than its concentration in the water around the organism.

Biomagnifications – these are situations when the levels of toxins become increasing higher as these are taken into the organism and moving up in the food chain. In the study of DDT used as insecticides finding its way into the soil, the environmental impact was multiplied several folds as it was picked by earthworms, then by birds and other animals. At the height of the food chain in larger animals it may be high enough to cause severe health, reproductive disorder and even death.

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Water, air, and cleanness are the chief articles in my pharmacy - Napoleon Bonaparte
Source: http://www.brainyquote.com/quotes/keywords/air.html#ixzz1iwt2Yogw

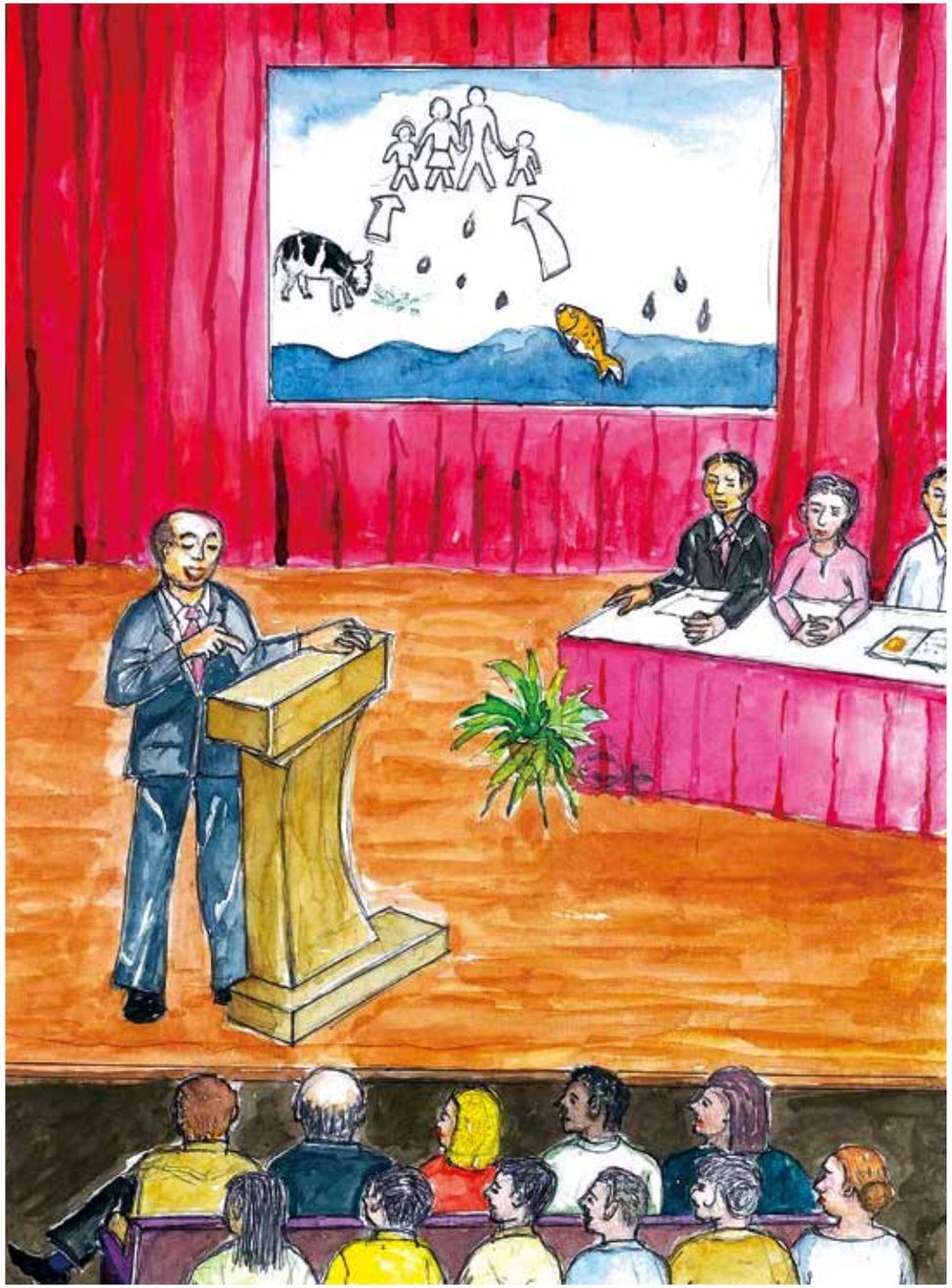

Fig 6.1: "In Bioaccumulation, ladies and gentlemen, the bug stops with me and you!"

7. DEFINITIONS OF POLLUTANT EFFECTS ON HEALTH

The terms used to describe health effects due to pollutants in our environment are as follows:

Carcinogenic – describes the threat of a chemical or substance in causing cancer. Carcinogens, apart from the well known ionizing radiation, are vinyl chloride, benzene, asbestos (now banned), cadmium, inorganic chromium, inorganic mercury, polycyclic aromatic hydrocarbon (PAH), etc.

Teratogenic – describes the threat of a substance (teratogen) in causing harm to the development of foetus, resulting in physical abnormalities, growth deficiency and/or mental retardation. Examples of teratogens are:

- Methylmercury which can cause cerebral atrophy (loss of cells in the brain), spasticity (which is altered skeletal muscle performance, due to disorders of the central nervous system,) and mental retardation. This was the chemical pollutant that caused the Minamata tragedy during the 1950's.
- Lead which causes pregnancy loss and Central Nervous System (CNS) damage.
- Polychlorobiphenyls (PCBs - ingested) which causes low birth weight and skin discoloration

Methylmercury is converted from inorganic mercury by the action of anaerobic organisms that live in the natural environment of aquatic systems including lakes, rivers, wetlands, sediments, soils and the open ocean. Note: Anaerobic organisms are those that do not require oxygen for growth and may even be destroyed in the presence of oxygen.

Allergenic – Substances that cause an allergic reaction are known to be allergenic. Contact with allergens triggers our body immunity system to fight against it. Reactions to allergens may be skin rashes, swelling, itch, running nose and in rare situations conditions that are life-threatening. Normal encounters of allergens may be due to dust, insect bites, food such as peanuts, cow's and goat's milk, egg yolk, etc.

Chemicals in the industries known to be allergenic are:

- P-tert-butylphenol formaldehyde resin used as waterproof glues found in leather goods, furniture, rock wool, hard board and glossy fabrics;
- Formaldehyde (N-hydrnxymethyl succinimide) found in glues, textiles, plastics, hardboard and some types of paper;
- Penicillin causing anaphylaxis which is severe and acute. People who are allergic to this drug must inform the doctor prior to receiving any treatment.

Mutagenic – Chemicals known to be mutagenic are capable of changing the genetic make-up of an organism, increasing the frequency of mutations, some becoming cancerous. Mutagens may be chemical compounds such as bromine and benzene, or ionizing radiation such as X-ray and Gamma rays.

8. EARTH'S ATMOSPHERE

Earth's atmosphere consists of 5 layers, namely troposphere, stratosphere, mesosphere, thermosphere and the exosphere. Each of the layers has its own significance to mankind and our activities. They are described in the following as they occur in ascending altitudes:

Troposphere

This is the layer immediately above earth's surface going up to an altitude of 10 to 15 km (highest over the equator) above sea level. The lower region of this layer is where life on earth exists, relying on air to survive. The atmospheric air which envelops earth consists of (by volume) 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. These gases among which are the greenhouse gases, consisting carbon dioxide, water vapor, methane, nitrous oxide, and ozone. This atmospheric air as we know it is only found in the troposphere. The air gets thinner as altitude increases through troposphere. For this reason mountain climbers sometimes need bottled oxygen to breathe. Earth's temperature is warmest close to the ground and decreases as altitude climbs, reaching -55°C near the top of the troposphere layer. Nearly all the water vapor and dust particles in the atmosphere are found in the troposphere. This is the reason why most clouds are formed in this layer It is also where all weathers occur.

Fig 8.1: Pictures taken of the troposphere from a commercial flight at 10,000m

Stratosphere

The stratosphere is the layer above the troposphere. This layer reaches a height of around 50 km above the sea level. In this layer the temperature increases with altitude. The ozone is found in the upper part of stratosphere. The ozone is a thin blanket consisting of a reactive form of oxygen which is responsible for absorbing the ultraviolet radiation from the sun. Read section on Ozone – Earth's Umbrella.

Tropopause

This part of the atmosphere between the troposphere and the stratosphere layers is the tropopause. This zone or boundary is characterised by a sharp change in temperature drop, averaging not higher than 2°C/km. The height of the tropopause varies according to latitude, season, day or night. Over the equator, it can be up to 18 km in height but only 7 km at the poles. The temperature is also varied, measuring around -50deg C at the pole and -80deg C at the equator. The air in the tropopause is almost completely dry.

Mesosphere

Above the stratosphere is the mesosphere. This reaches an altitude of from 50 km to around 80 to 90 km. The temperature of the air contained in this layer of Earth decreases with increases in heights. The mesosphere is the coldest layer of our atmosphere where the temperature can be as low as – 90°C. This is because the air in this layer is very thin and there are few molecules to absorb the radiation heat from the sun. Furthermore, the behaviour of CO_2 bouncing and colliding with other molecules, releases energy as photons. These photons travel upwards, carrying heat away from the mesosphere and help to lower its temperature. Most of the meteors and rock fragments from space burn up in the mesosphere before they can enter the Earth's lower atmosphere.

Thermosphere

Above the mesosphere is the thermosphere extending in altitude from about 80 km to 500 km. Temperature increases with altitude in this layer due to absorption of solar radiation by the small amount of residual oxygen still present at this altitude. The temperature can rise to 1500^{0}C. However, one would not feel the heat because the atmosphere is so thin in the thermosphere that there is not enough contact with the few atoms of gas to transfer much heat. Space shuttles orbit in the thermosphere. The International Space Station was the eleventh artificial satellite launched and being manned since November 2000. Its purpose is to provide a microgravity environment for research in preparation for space expeditions to the moon and mars.

Exosphere

The name exosphere literally means the sphere which is outside. This is the upper limit of the earth's atmosphere which meets the outer space. It ranges from about 500-1000 km up to 10,000 km. This layer is where atoms and molecules escape into space. The Earth's atmosphere becomes very thin in this layer. It mainly consists of hydrogen and helium. In the thermosphere molecules travel 1 km before they collide with other molecules. In the exosphere the particles are so far apart that they can travel hundreds of kilometers without colliding with one another. Communication and observation satellites orbit in the exosphere. The life of satellites functioning in this layer is likely to last for hundreds of years, compared to if they are launched in the lower layer (thermosphere) where the effect of heat and gravitation pull mean higher maintenance and additional energy to stay in orbit.

Ionosphere

Scientists refer to the upper reach of the atmosphere as the ionosphere. This extends from an altitude of about 85 km to 600 km, and covers part of the mesosphere, thermosphere and exosphere. The ionosphere is subject to ionization by the sun's radiation. This is the formation of ions through the breaking apart of molecules and particles in the atmosphere by the sun's radiation energy, freeing electrons which float about to recombine with positive ions. Since the ionosphere activities depend on the sun's radiation, it changes in density from daytime to night-time. The ionosphere provides the function amongst others, in the propagation of radio waves. Radio transmission, say from a communication tower at some point on earth is reflected in the ionosphere back to other parts of the earth, hence serving long distance radio communication.

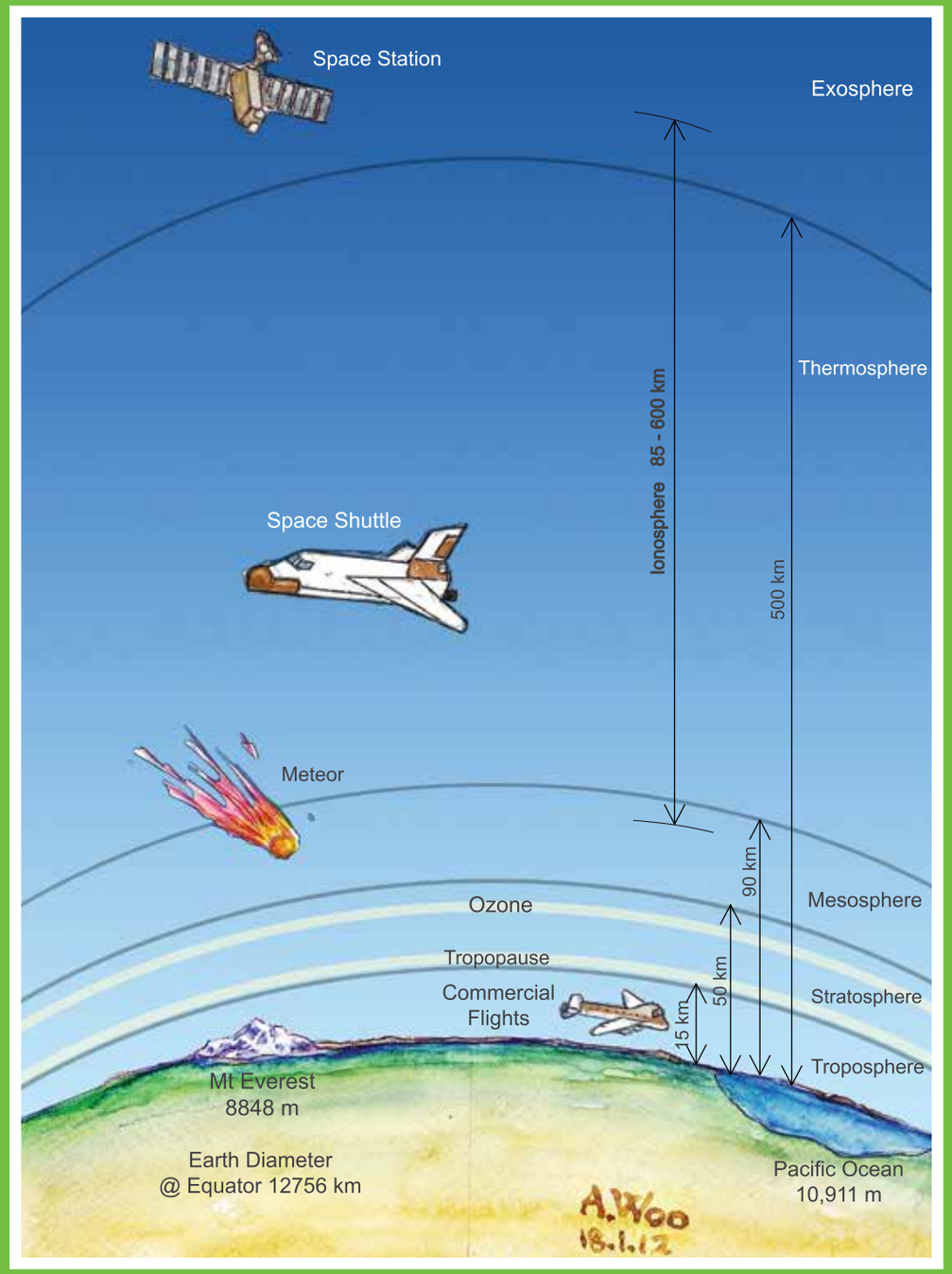

Fig 8.2: Impression of the 5 layers of atmosphere

Fig 8.3: "Now we know using the 'sky as the limit' is not high enough target when there are more layers & greater heights above the sky!"

OZONE – THE ATMOSPHERIC UMBRELLA

Historically, up to as recent as only a century ago, we have been fully sheltered by an umbrella in the atmosphere from the full ultra-violet (UV) radiation. This umbrella is known as the ozone layer – the good ozone hovering in the upper region of stratosphere (at about 80km above the sea-level.) Ozone is a colourless gas, which is a form of oxygen O_3 (triatomic oxygen) It is formed when oxygen molecules absorb ultraviolet photons and undergo a chemical reaction known as photo dissociation or photolysis, where a single molecule of oxygen breaks down to two oxygen atoms. The free oxygen atom (O), then combines with an oxygen molecule (O_2) and forms a molecule of ozone (O_3). The ozone molecules, in turn absorb ultraviolet rays perform the function of preventing these harmful radiations from entering the Earth's atmosphere. In the process, ozone molecules split up into a molecule of oxygen and an oxygen atom. The oxygen atom (O) again combines with the oxygen molecule (O_2) to regenerate an ozone (O_3) molecule. Thus, the total amount of ozone is maintained by this continuous process of destruction and regeneration.

Some people are now saying that in our industrialisation we send into the atmosphere gases which puncture holes in the umbrella, thereby opening up a window which allows UV radiations to blast through unhindered. Worse, the window is getting bigger as we send more and more ozone depleting substances (ODSs) into the atmosphere unabated. ODSs are widely used in refrigerators, air-conditioners, fire extinguishers, in dry cleaning applications, as solvents for cleaning, electronic equipment and as agricultural fumigants. The applications of the following chlorine and bromine containing chemical compounds are controlled and being phased out in some countries, in commitment to the Montreal Protocol (1987):

- Chlorofluorocarbons (CFCs) – Compound consisting chlorine, fluorine and carbon is used as a refrigerant
- Bromofluorocarbon (Halon) – used in fire extinguisher
- Carbon tetrachloride (CCl_4) – used as a cleaning agent, fire extinguishing and catalyst for polymer production
- Methyl chloroform (CH_3CCl_3) – used as an industrial solvent

- Hydrobromofluorocarbons (HBFCs) – used as solvents, cleaning agents, fire suppressants and sometimes as refrigerants.
- Hydrochlorofluorocarbons (HCFCs) – replacement of CFC
- Methyl bromide (CH_3Br) - used as a pesticide

When the ozone depleting gases get into the stratosphere they are subject to the sun's strong UV rays which break them down, releasing chlorine atoms which react with ozone molecules O_3 to form chlorine monoxide and a molecule of oxygen. The chlorine monoxide attacks the ozone molecules to form chlorine atom and two molecules of oxygen. The process continues to the eventual depletion of the ozone gas. Bromine behaves the same way as chlorine in destroying the stratosphere ozone, except it is 40 times more efficient than chlorine.

Chlorofluorocarbons sold under the trade name 'Freon' and bromofluorocarbon compounds contained in 'Halons' have stopped production since 1995 and 1993 respectively in industrialised countries. However, essential users are exempted and production may even be allowed in developing countries for their domestic applications. Even with a total ban in production and consumption from today, ODSs' capacity to cause harm remains in the stratosphere for the next 100 years!

The Depletion of the ozone layer exposes humans to the ultra violet rays of the sun causing skin cancer, immune system impairment and eye cataracts. UV rays can also damage sensitive crops such as soybeans, and reduce crop yields. Even the creatures in the sea will not be spared. UV lights will destroy planktons. Marine life such as fish will starve and needless to say human lives will also be affected.

At the ground level, within the troposphere is found the 'bad' ozone. This is formed as an effect of sunlight on NO_x and VOC from pollutants due to motor vehicle exhaust and industrial emissions, gasoline vapours and chemical solvents. Ozone has the same chemical structure whether it occurs miles above the earth or in the troposphere. Ground-level ozone is the primary constituent of smog. The gases aggravate health problems such as asthma, bronchitis and emphysema which is a chronic respiratory disease causing breathlessness. These gases also contribute to the greenhouse effect giving rise to global warming and climate change. These changes cause damage to the ecosystem, vegetation, agricultural crops, commercial forests, and tree seedlings.

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Montreal Protocol

This is the international treaty for protecting the ozone layer from depleting substances. Countries began signing from 1987 for the Treaty to be enacted on 1st January 1989. It aims at the reduction and interruption of production, consumption, importation, and exportation of a list of ozone layer depleting substances (ODSs) which contain either chlorine or bromine. A timetable was set for phasing out and eventually having the respective ODSs eliminated. Since that first meeting, the Treaty has been revised through several meetings on bi-annual intervals. This treaty was hailed as the unprecedented international treaty to achieve complete ratifications from 196 states!

The timetable set for chlorofluorocarbons (CFC) in developed countries was in having its consumption phased out from end of 1995 (with the exception of essential uses critical to health and laboratory test procedures. Halons – a compound consisting, bromine, fluorine and carbon was phased out from 1993. Consumption level of Hydrochlorofluorocarbons was frozen from 1996, with staged reductions through 2004 to 2010 and a complete phase out by 2020.

Developing countries were allowed to phase out CFC and Halon by 2010, whilst HCFC was timed for complete phase out by 2030.

9. GLOBAL WARMING/CLIMATE CHANGE

GREENHOUSE GASES & EFFECTS

The concept of growing plants in a greenhouse started in Italy during the 13th Century. This method of providing warmth and keeping out the cold (and pests) for crop farming in temperate countries for most part of the year soon spread through Europe and England. The greenhouse was built with a glass roof and walls to allow solar radiation heat from the sun to shine through. Nowadays translucent plastics may also be used. The heat is absorbed by the plants, soil and interiors and warms up the air in the greenhouse. In return the plants and interiors re-radiate some of the thermal energy in the infrared range. Part of this energy is retained in the greenhouse because the glass roof and walls are partly opaque to infrared radiation. The retained infrared radiation adds a small increase to the air temperature inside the greenhouse, most of the increase being due to the sun's radiation energy.

The atmospheric greenhouse phenomenon is the result of the accumulation of greenhouse gases (GHGs) which nature produced in a layer. This layer firstly insulates the earth from the cold of space. It also allows the sun's radiation energy to pass through and be absorbed by the surface of the earth, warming it in the process. The solar radiation is re-emitted from the earth surface in the form of infrared energy. The GHGs prevent the heat from escaping, thereby warming up the earth surface further. Ever since mankind existed, up to 200 years ago, this natural atmospheric greenhouse layer has been the safeguard to keep all lives protected, including ours, from freezing in extreme cold temperatures. Earth's temperature began to change from when industrialization commenced. This was from when the greenhouse layer began to take on more GHGs due to industrialization.

What constitute greenhouse gases? GHGs are mainly water vapour, carbon dioxide, methane, ozone and nitrous oxide. Amongst these, CO_2 and nitrous oxide (NO_x) are prevalent in the flue gases from burning fuel oil and diesel in power stations, and on ships. Other contributors are from the firing of diesel, gas and petrol in running our trucks and cars; and jet fuel (kerosene) in flying our aircrafts. These have seen drastic increases over the last few decades. Biomass burning which is burning of forest intentionally for land clearing, or sparked off by lightning or spontaneous combustion of dry vegetation during prolonged hot weather, releases pollutants such as carbon particulates and carbon dioxide gas. Burning of forests not only produces carbon dioxide as a product of combustion, but also releases carbon dioxide which is produced through photosynthesis over many years and stored in vegetation acting as a carbon dioxide sink. This sink is permanently destroyed if vegetation is not restored.

The pollutants together with clouds and water vapour in the atmosphere render an increased greenhouse effect on our planet, leading to gradual increased warming. This is referred to as global warming.

GLOBAL WARMING

Global warming is the projected rise of the earth's atmosphere temperature and the sea temperature. According to the 4th Intergovernmental Panel on Climate Change (IPCC) Assessment Report an increase of at least 0.6^0C has taken place over 50 years from 1956 to 2005. This was double the increase observed over 100 years, from 1906 to 2005. The more alarming indication in the 4th IPCC Assessment Report is that the global average surface temperature could rise between 1.1^0C and 6.4^0C by the end of the 21st Century

The direct effect of global warming is in the rise in sea level. This is due to temperature increase and expansion of sea water together with more water coming from the melting of ice cap. Based on the 4th IPCC Assessment Report, the rise in global mean sea level is projected to be 18 to 59 cm by the end of the 21st Century. With the rise in sea level, low lying lands will be submerged; vegetations and trees will be destroyed causing a migration of living creatures and animals for survival. In the fight for a piece of high ground, and what little food can be found there, the weaker species will risk being relegated to extinction.

If some countries are feeling the increased sweltering heat in summer, other places are reporting longer and increasing bitter winters. The different ways the weather is being felt in different parts of the Earth are adding to the controversy of greenhouse gases and what they do to our climate. Global warming, or global cooling, as some would assert, are best just being referred to as climate change. Climate change is what people should recognise as being part of the earthly phenomena which were not with us just last year and now, not unique to Europe, the Caribbean or the Southern Hemisphere, but creeping in to surprise us in no small measures. We should be looking at climate change and its shifting trends. As long as we continue the debate based on regional events, we may miss seeing the bigger picture and not realising how the human activities all add up in the environmental equation. We should not be using short term weather extremes to explain favourite theories whilst relegating others to disbelief. We should come to terms with the potential harms to Mother Earth due to our modern excesses which we did not recognise 100 years ago. We should take positive steps cutting back on these excesses as a sure safeguard against effects on our environment and hence climate getting worse.

VITAL SIGNS OF CLIMATE CHANGE

From satellite measurements of glaciers and ice caps in Alaska, South America and the Himalayas it was possible to determine ice mass lost over 7 years (2003 to 2010), and estimate the rise in global sea level. These are undeniably vital signs of what happens on our planet due to what we send into the atmosphere.

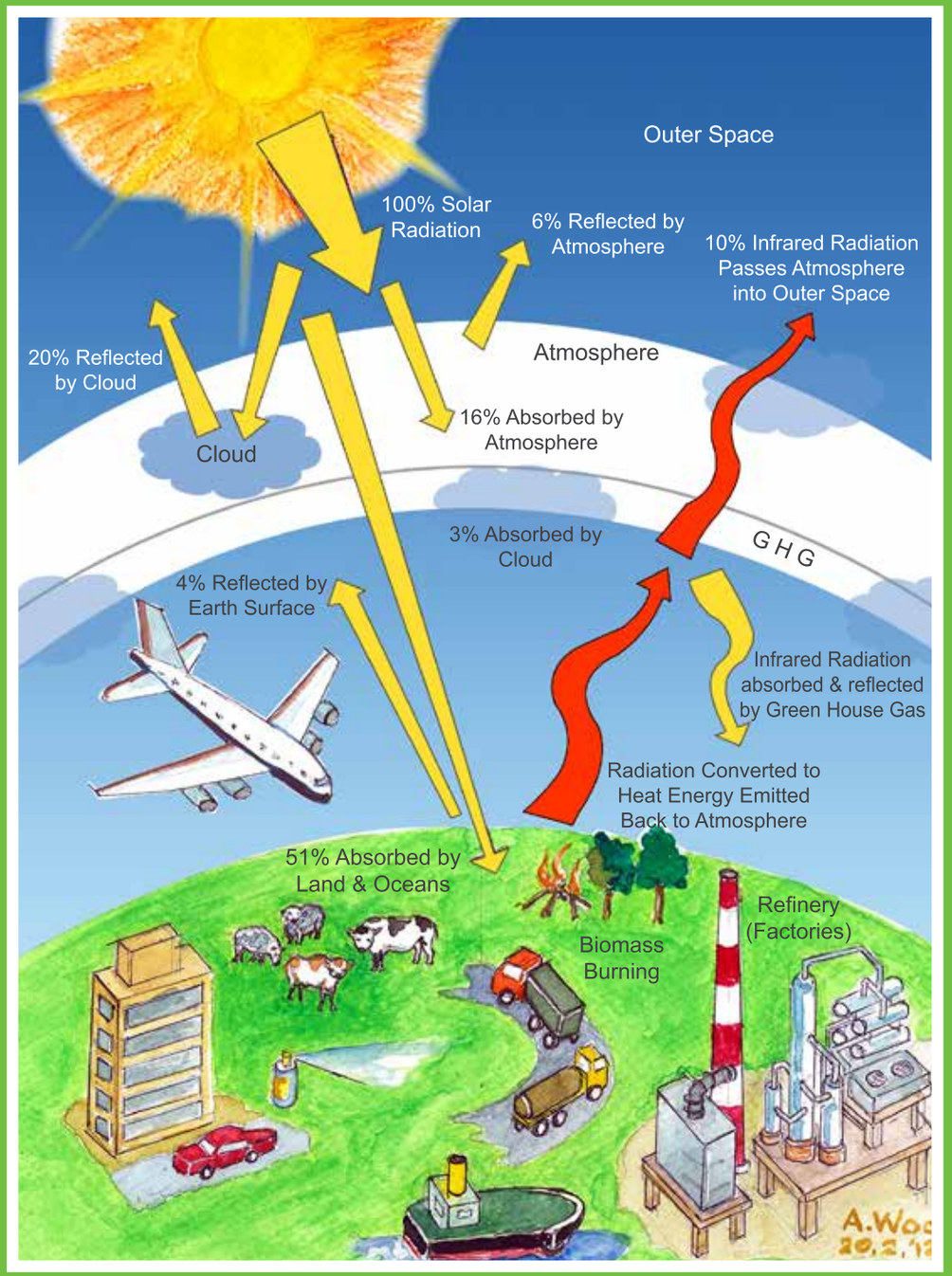

Fig 9.1 Radiation and emission distribution

10. CARBON FOOTPRINT

A carbon footprint measures the impact of human activities on the environment, in relation to the amount of greenhouse gases generated in providing the energy and products to support our daily needs. The measurement may be expressed in tonnes or kilograms of carbon dioxide equivalent of all emission gases (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride (SF_6), Hydrofluorocarbons (HFCs), and Perfluorocarbons (PFCs). Carbon footprints are accounted for according to the following defintions:

- Primary footprint is the direct emissions of carbon dioxide and other gases from fossil fuel burning. This occurs in power stations, refineries, petrochemical manufacturing facilities and other industry manufacturing operations. It is also accounted for in petrol, diesel and jet fuel combustions serving our transportation needs;

- Secondary footprint is due to indirect emission of CO_2 from products and services we use, or food we consume. It includes production, delivery and disposal of the products and services. The more we buy of these the more our individual carbon footprint counts. Granted the secondary footprint may be double counting of the primary footprint due to the burning of fossil fuels in making products we use as individuals, it nevertheless is useful as a direct measure of our individual responsibility for putting CO_2 into the environment.

THE KYOTO PROTOCOL

Industries have the main role in reducing the primary carbon footprint. Whilst responsible manufacturers continue to apply energy efficient technologies, legislations and enforcement are needed to keep desired practices in check. However, not all countries have it as their national priority to support the global agenda, when boosting export and providing employment for their voters are necessary to fulfil their electoral promises.
The United Nations Framework Convention on Climate Change facilitated a treaty amongst countries when they convened in Kyoto, Japan in 1997.

The Treaty was referred to as the Kyoto Protocol which was adopted on 11th December 1997 and ratified on 16th February 2005. The main feature of the Treaty binds 37 industrialised countries and the European Community to targets in reducing greenhouse gas emissions. The targets amount to a collective reduction against the 1990 emission level by 5.2% to be achieved over the period 2008 – 2012. Within the collective target, the Protocol assigns higher individual targets to developed countries that contribute a larger share of the emission quantity. For example a target to reduce by 7% is set for the United States and for the EU it is targeted at 8%. There are also credits in the target allocation, again taking into account their 1990 emission performances. For example Australia and Iceland are assigned targets of -8% and -10% respectively. Developing countries do not have Green House Gas (GHG) emission reduction targets under the Kyoto Protocol. Other variations or mechanisms in the Protocol which help nations in achieving their targets are briefly described as follows:

- Emission Trading – countries that have savings in carbon emissions, or assigned emission limits not used, may sell these to other nations that are in excess of their commitments. This practice is also known as ‘carbon trading’.
- Clean Development Mechanism (CDM) – a country assigned a carbon reduction target or commitment is allowed to gain credit through implementation of an emission-reduction project in developing countries. Each project so completed realises a credit of 1 tonne CO_2 counting towards meeting its own target.
- Joint Implementation (JI) – earns emission reduction units for the developed country investing in an emission removal project for another developed country with the latter benefiting from foreign investment and technology transfer.

Performance Monitoring - Each developed country has to report their yearly performance in meeting their targets by submitting their emission inventories to the UN Climate Change Secretariat, based in Bonn, Germany. Precise accounts are needed in reporting transactions which are kept in the International Transaction Log.
Beyond 2012 – Continuity is essential in this global commitment in reducing

the greenhouse gas emissions when the target period ends in 2012. A new international framework is needed to have intergovernmental agreement and support to deliver on-going protection against severe climate change.

INDIVIDUAL RESPONSIBILITY IN CARBON FOOTPRINT

It has been stated that the worldwide individual carbon footprint should be targeted at below 2000 kg CO_2 per year per person, to achieve environmental sustainability. This is a tough call considering that the current emission per capita averaging worldwide is more than twice that amount at 4250kg. Individuals can calculate (using calculator in the internet) their own carbon footprint, to see how they compare with this global average and view their actual against the target of 2000kg. For someone used to the life style of a developed country, an average 12-month period carbon footprint is about 11000 kg.

An easy reference of 1 kg of CO_2 (0.27kg of carbon) being produced for the various activities gives us a perspective of our contribution whenever we

- Travel by car for each 6 km distance (compare this to twice the distance if travelled by bus);
- Work with the computer for 32 hours;
- Shower 5 minutes every time;
- Use 5 plastic bags;
- Drink 2 bottles of mineral water

The aggregate of CO_2 emission from the above activities over the whole year does not leave much room for other daily living necessities such as:

- Our household electricity kWh usage which is shared with all members of the family for the footprint calculation;
- Our heating fuel requirements (if you are in a temperate country) also shared with all members of the family;
- Gas fuel needed for cooking, shared with all members of the household;
- Our food consumption, gaining some credit if organic food products (not subject to use of fertilisers and pesticides) are consumed;
- Air travel counting for one or multiple trips

- Other life style indulgences, scoring high if subject to excesses; e.g.
    - Recreational pursues resulting in CO_2 emission such as go-karting and health clubs with exercising machines instead of cycling and walking;
    - Household furnishing replaced on impulse compared with replacement only when broken;
    - Fashion (clothes) bought on trendy urge versus only changing for new when what is in the wardrobe is becoming worn and tattered;
    - Goods bought insistent on good packing instead of declining and going for simple or without packaging.

Individuals can contribute to lowering the secondary carbon footprint by taking the following actions:

- Adjusting heating and cooling temperatures by 1 or 2^0C is the first thing individuals can make to cut back on energy dependence and electricity bill;
- Replacing aged equipment (e.g. old fridge) with energy efficient appliances for household applications;
- Taking public bus, mass rapid train, coupled with cycling to work, or car pooling instead of driving singly reduces fossil fuel burnt per capita;
- Making prudent buying choice, for example giving preference to local products, especially fruits that are in season; rather than those imported, saving on freighting and transportation across countries;
- Eating less meat, since farm livestock such as beef cattle, produces methane from their body waste;
- Drinking tap water if safe preferred over bottled water;
- Preferring drying clothes in sunlight to operating dryer, except during persistent wet period;
- Operate dish washer only with a full load;
- When travelling, cooperate with hotel management by switching lights and air conditioning off when one vacates the room. Also, agree to less regular change of bed sheets and towels.

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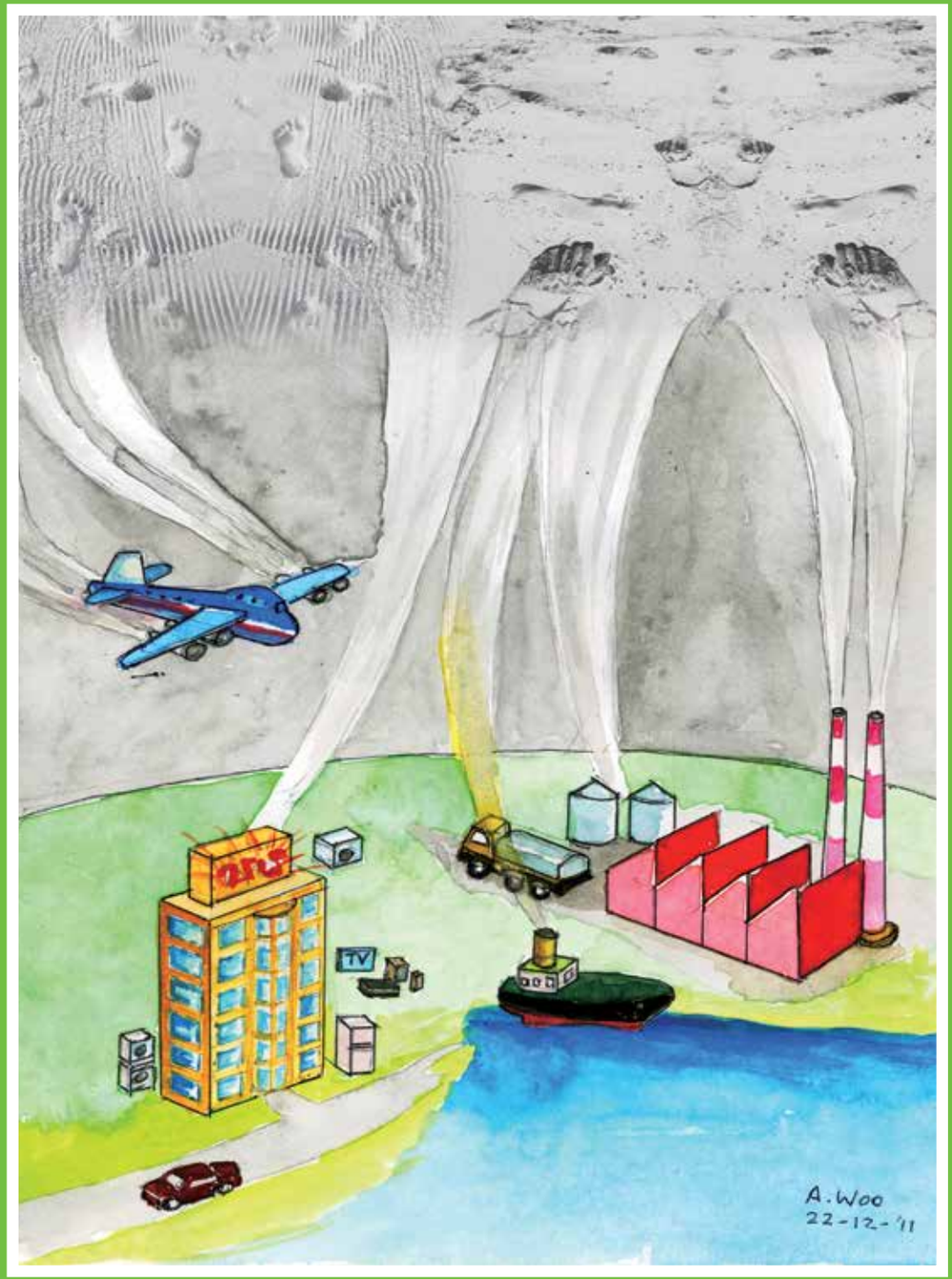


Fig 10.1: Gases contributing to carbon footprint

11. ABOUT PLASTICS

Plastics are made from raw materials in resin or liquid forms, produced from petroleum and natural gas in chemical processes that transform their molecular structures. As the word suggests, plastics are materials that are malleable and will allow casting, pressing, extruding into various forms and shapes; becoming bottles, cups, bowls, sheets, bars, boxes and many life convenient appliances. Depending on the malleability, plastics may be classified into two types:

- Thermoplastics – these can be subject to repeated heating and moulding over and over again;
- Thermosetting plastics – can be melted and moulded once. Once set it cannot be reheated for remoulding.

We have got so used to plastics that apparently life cannot do without it. Yet, other than the people who make plastics and extend these to enhance other products, people are unaware of the origin, usage and the potential harm plastics inflict on the environment and the health on humans and other living things.

Prior to the mid 1800's life was without plastic. The first man-made plastic was invented by Alexander Parkes (29 December 1813 - 29 June 1890) from Birmingham, England in 1856. Parkes was soon overtaken by other inventers moving from use of natural plastic materials such as chewing gum and shellac to chemically modified natural materials such as rubber, nitrocellulose, collagen and galalite. Then in 1907 Leo Hendrik Baekeland, a Belgian-born American used a mixture of phenol and formaldehyde which began the process of plastic manufacturing based on synthetic polymers. Through the decades following the two World Wars, chemical technology advancement created new forms of plastics. Among the earliest examples in the wave of new plastics were polystyrene (PS) and polyvinyl chloride (PVC). Nylon was produced by Du Pont in 1935. This was used as tooth brush bristles and replacing silk for women's stockings as well as for parachutes.

People need to know the different types of plastic and their basic constituents, as identified by their resin codes. The resin codes are numbered from 1 to 7, each of these numbers is placed in the centre of the recycle triangle. The code is normally embossed on the base of or printed on the products. From the codes consumers can identify with the plastic types and relate these to the buying decisions, with awareness on disposal avenues and options.

Extracted Microsoft Office clip art

For the first time in the history of the world, every human being is now subjected to contact with dangerous chemicals, from the moment of conception until death.
Rachel Carson (1907-1964), Silent Spring, 1962

In the table of plastic resin codes shown in the following pages, different plastics are described under their respective codes 1 to 7. Their applications and recycling options are also given. The product images in the table indicate that PET and HDPE are both used for plastic bottles. Plastic bags are both made from HDPE and LDPE. Someone wanting to know the origin of the plastic by just looking at the containers without the coding will often not readily be able to do so. Under others in code 7, it is not possible to tell whether the origin is Acrylonitrile-butadiene-styrene (ABS), Polycarbonate (PC), Polyurethane or recycled Polyolefins. Again, PP used for the caps of plastic bottles and hard covers of tubs may be mistaken with PVC. The exception to the foregoing is Polystyrene (PS), code 6, used for cups and disposable bowls which are easily identified as very light, soft, white in colour and break easily.

Fig 11.1 Railing of metal & PVC

Spot the difference! Rainling around the drain is both of metal (old) and PVC (new)

TABLE OF PLASTIC RESIN CODES

Plastic Resin Codes	1 PETE
Plastic Type	Polyethylene terephthalate (PET or PETE)
Application	Plastic cookie jars; bottles for soft drink, mineral water, mouth wash and detergents. Medicine containers. Also filling for sleeping bags and pillows; textile fibres.
Application Images	  PET are clear, tough plastics (Caps & covers are PP)
Recycle Options	Soft drink bottles, detergent bottles, clear film for packaging, carpet fibres, and fleecy jackets.

Plastic Resin Codes	02 HDPE
Plastic Type	High Density Polyethylene HDPE
Application	Heavier containers for shampoo, hand wash, cloth detergents and motor oil. Also used for plastic bags, toys
Application Images	  Very common plastic, usually white or coloured. HDPE is often opaque or cloudy.
Recycle Options	Compost bins, detergent bottles, crates, mobile rubbish bins, agricultural pipes, pallets, recycling boxes and rope.

High-density polyethylene (HDPE) is a polyethylene thermoplastic prepared from ethylene by a catalytic process. HDPE is commonly recycled.
The mass density of HDPE can range from 0.93 to 0.97 g/cm3 which is slightly higher than that of LDPE. It is also harder and more opaque and in application can withstand temperatures of 120 °C for short periods, 110 °C continuously.

Plastic Resin Codes	3 V	
Plastic Type	Un-plasticised polyvinyl chloride UPVC	Plasticised polyvinyl chloride PPVC
Application	Food wrap, non-food bottles, pipes, fencing and window grills	Blister packaging, shower curtains, garden hose, shoe soles
Application Images	 PVC pipes	 PVC shower curtain
	 Window grill	 Hose reel
Recycle Options	Plastic lumber, deck timber, mud-flap for trucks, roadway gutters.	Hose inner core, industrial flooring.

Plastic Resin Codes	4 LDPE
Plastic Type	Low Density Polyethylene (LDPE)
Application	Wrapping films, grocery, bread and sandwich bags, 6 pack rings and black plastic sheet. Lids of ice cream containers, Squeezable bottle and rubbish bins
Application Images	 PSoft, flexible plastic
Recycle Options	LDPE is not recycled in the main stream (kerb side) program. However, some recycling outlets are becoming available. Recycling produces trash can liners, packaging and plant nursery bags.

Low Density Polyethylene (LDPE) was originally prepared some fifty years ago by the high pressure polymerization of ethylene. It is translucent to opaque, robust enough to be virtually unbreakable and at the same time quite flexible. Chemically LDPE is unreactive at room temperature although it is slowly attacked by strong oxidizing agents and some solvents will cause softening or swelling. It may be used at temperatures up to 95° Celsius for short periods and at 80° Celsius continuously.

Plastic Resin Codes	5 PP
Plastic Type	Polypropylene (PP)
Application	Ice cream, yogurt and margarine containers, potato crisp bags, drinking straws, hinged lunch boxes, bottle caps and Tupperware. Polypropylene has a high melting point, and is suitable as containers for hot liquid.
Application Images	 Hard, but flexible plastic - many uses
Recycle Options	Recycled into: Lights and battery cables; brooms, brushes, car battery cases, landscape borders, bicycle racks, rakes, bins, pallets and trays.

Plastic Resin Codes	6 PS
Plastic Type	Polystyrene Also known as Styrofoam
Application	Yogurt containers, egg cartons, fast food trays, disposable plastic forks, knife and spoon; imitation crystal “glassware”. Hot drink cups, takeaway food carriers
Application Images	  Rigid, brittle plastic (e.g. bowl in right picture). Foamed, lightweight, energy absorbing, thermal insulation (left picture), and foam cups in the right.
Recycle Options	Clothes pegs, coat hangers, office accessories, spools, rulers, video/CD boxes and rigid foam insulation.

Plastic Resin Codes	7 OTHER
Plastic Type	Plastic resins which do not fit into 1 to 6 are classed as 7. They including acrylic, acrylonitrile butadiene styrene, fiberglass, nylon, polycarbonate, and polylactic acid
Application	Three- and five-gallon water containers, small water bottles, certain food containers, ‘bullet-proof’ materials, sunglasses, DVDs, iPod and computer cases, signs and displays, plastic lumber applications,
Application Images	  Water bottles, paste tubes
Recycle Options	No recycling. Best to return to manufacturer or supplier of the product

Plastic resin codes were designed by The Society of Plastics Industry (SPI) in 1988

SPECIFIC PLASTIC TYPES

Polyvinyl chlorides (PVC) - Amongst all plastics, polyvinyl chloride (PVC) plastics, assigned resin code 3, are deemed the most environmentally problematic throughout its life cycle, especially during its production. During production, chlorine and dioxin are released which pollute the atmosphere. Dioxin is carcinogenic. In PVC production, additives such as phthalates are used to soften the hard plastic. These are known as plasticised PVC. Phthalates when released as vapour pose considerable health hazards, risking damage to the human reproductive system. Recycling of PVC is not a simple task due to the chlorine and additive contents. Burning of PVC in waste disposal must be avoided as dioxin will again be released into the environment.

Next in the order of environmental concerns are the group coded 7 (Others) consisting of

Polyurethane (PU) – Polyurethane is a versatile material which can assume many characteristics. These may be hard, flexible, bouncy, squishy and sticky. It can therefore be used as substitutes for metal, wood, rubber, paint and glue in thousands of applications. The manufacture of polyurethane uses several hazardous materials. Amongst these are the ozone-depleting gases methylene chloride and CFCs, as well as halogenated flame retardants and pigments. The burning of PU releases numerous hazardous chemicals such as isocyanates, carbon dioxide, hydrogen cyanide, polycyclic aromatics hydrocarbons (PAH) and dioxins.

Acrylonitrile-butadiene-styrene (ABS) - ABS is used for pipes, car bumpers and toys (building blocks). The production of ABS involves the use of a number of hazardous chemicals. These include butadiene and styrene and acrylonitrile. Acrylonitrile in vapour and liquid forms is highly toxic and considered a probable human carcinogen. It is readily absorbed by humans through inhalation and by direct contact through the skin. Styrene and butadiene are also known to be probable carcinogens.

Polycarbonate (PC) - PC is used for products like CDs and refillable milk bottles. Its production uses highly toxic phosgene derived from chlorine gas and solvents such as methylene chloride, a carcinogen. Other solvents used may include chloroform, 1,2-dichloroethylene, tetrachloroethane and chlorobenzene. It is understood by scientists that bisphenol-A is leached from the PC bottle into hot beverages raising fear of this affecting the human hormones. Consequently PC bottles are losing favour with consumers.

PE & PP - In comparison with PVC, from the perspective of additives used in their production processes, Polyethylene (PE) and Polypropylene (PP) may be said to be less problematic. These are coded 1, 2, 4 & 5. The use of fewer problematic additives could mean less leaching effects in landfill, reduced probability of the toxic dioxin by-product during burning and easy, cost effective recycling processes. On the other hand, if PE and PP, or any other plastics should use brominated/chlorinated flame retardants and heavy metal stabilisers, the effect on the environment will be no less severe than PVC.

BIO-BASED PLASTICS

Instead of plastics made from fossil fuel and petrochemical bases, bio-based plastics are made from renewable biomass sources, such as vegetable oil, corn starch and cellulose. Cellulose is the cell wall of plants (wood and cotton) which can be used to produce paper apart from bio-based plastic. The advantage of bio-based plastics is its readily bio-degradable characteristics. One example of this bio-degradable plastic is from Corn Ware.

According to the supplier, *'Corn Ware is a range of safe & eco-friendly tableware. Made from corn & yam., Corn Ware not only biodegrades after 90 days upon discard, they are also carbon neutral, reducing carbon dioxide emissions by up to 68% when burnt.'*

Fig 11.1 Biodegradable plastic bowls

Other Types of Bio-Plastics

There are other types of bio-plastics to cater to other applications. These are explained as follows:

Starch-derived polymers – Starch from plants can be modified chemically to replace plastics from petrochemical sources. Whilst biodegradable and combustible they are brittle and tended to absorb water. They are therefore not suitable for use as bottles but acceptable for one-time, short-lived use such as in foam packaging, eating utensils, plates and shopping bags.

Polylactic Acid (PLA) – Lactic acid produced in the fermentation of fungi and bacteria is used for polymers having physical characteristics similar to polyethylene terephthalate (PET). PLA can be used for bottles, films, diapers, electronics and eating utensils. Its lower melting point and higher gas permeability however, could limit its application.

Bio-based Polyethylene (PE) – This has its base in ethanol produced from fermentation of sugar. The resulting ethylene is identical to the petrochemical originated PE used in packaging, automobiles, construction and electronics. Bio-based PE can fully substitute for petrochemical-based PE. It is not biodegradable but is recyclable.

Polyhydroxyalkanoates (PHAs) – These are produced through bacterial fermentation of sugars, vegetable oils and fats. This biodegradable product is a likely substitute for PVC and may be used in packaging, cutlery, household products, toys, textiles and building materials. An important application is in medical uses such as for orthopaedic devices, orthopaedic implants, and other implantable medical devices; the items can degrade after being implanted.

Draw-backs with Bio-plastic

Opinions are not all affirmative in the environmental goodness of bio-based plastics. Critics are ready to point out problems such as:

- Not all bio-based plastics are capable of composting. Hence, recycling is an option to meet environmental commitments. However, bio-plastics may not be mixed with conventional plastics as it would complicate the latter's recycling process.
- The use of bio-plastics is only a small percentage (less than 5%) of the global plastic demand. It is therefore economically not viable to invest in recycling facilities for bio-plastics, nor setting up commercial composting facility necessary for corn-based plastics as these require the hot humid conditions to render composting effective.
- Corn-based plastics production takes corn harvested from farms that would otherwise be allocated to food growing to feed growing population.
- More research is needed to bring bio-based plastic technology to a level where costs become attractive to manufacturers.

Composting is a process of using micro-organism to break down a material in the presence of oxygen, to a point or state where it is safe to let into the environment. For example household wastes composted can be used as a natural fertilizer.

BURNING PLASTIC

In general, plastics should not be burned, especially in one's own backyard. Some examples of the effects of burning plastic are given in the following:

- Burning halogenated plastics will produce toxins. These are plastics made from chlorine, bromine and fluorine which we know will affect the ozone layer.

- Burning PVC plastic will result in tetrachloro-dibenzo-dioxin, abbreviated TCDD, which we already know is highly toxic and tend to bio-accumulate.

- Burning of Polystyrene (PS) such as foam cups, meat trays, egg cartons, yogurt and deli containers will release styrene. This can be absorbed through the skin or get into the lungs. Styrene gas can affect the eyes, damage the mucous membranes. Long term exposure has the effects on the central nervous system with headaches, weakness and depression.

RECYCLING PLASTICS

Recycling is the option with plastic wastes. Recycling centres are equipped to separate the plastic types, and if burning is an approved method, this is done under controlled conditions such as burning it as a fuel supplement in steam and power generation. An example of this is polyethylene waste which can be grounded and mixed with other fuels.

Different plastics require different formulation and processes in their recycling into other products. Of the plastics shown in the table above, polyethylene terephthalate (PETE) and High Density Polyethylene HDPE; assigned resin codes number 1 and 2 respectively, are readily recycled. Polystyrene, PS code number 6 is also readily acceptable for recycling into many items (see table).

Plastics of resin codes 3, 4 and 5 tend to be less recyclable as recycling outlets may not be available locally. The plastics classed under code 7 constitute various combinations of all plastics, or from a unique formulation. This is the most difficult to recycle and are best returned to their manufacturers for their proper handling after use.

Plastic lumbers are the material (substituting as timber) made of 100% recycled plastics. The product is used as building materials for outdoor applications such as deck floors, railing, fencing and landscaping timber look alike. These are of better performance than natural timber, are more durable from the corrosion view point.

"Those who contemplate the beauty of the earth find reserves of strength that will endure as long as life lasts."
- Rachel Carson

Source: Environmental Quotes – http://www.favorite-inspirational-quotes.com/environmental-quotes.html

12. ABOUT HEAVY METALS

Heavy metals are chemical elements that are metals and both those having metal and non-metal characteristics. They have a relatively high density of >5g/cm3. They are natural substances found in the Earth's crust. They can neither be degraded nor destroyed. They are toxic even at low concentrations. Examples of heavy metals are

- Copper
- Cadmium
- Lead
- Zinc
- Selenium
- Mercury

Cadmium, lead and mercury are the three heavy metals known to be of great concern to public health. Others such as copper, selenium and zinc are essential to maintaining the metabolism of the human body at low concentrations. However, at higher concentrations they lead to poisoning.

Heavy metals enter our body through food intake, drinking contaminated water and breathing polluted air. The pollutions are resulted from human activities such as mining, smelting in foundries and coal burning in factories and power plants which affect the natural distribution of the heavy metals. Human activities also alter the natural geological and biological redistribution of heavy metals which release chemicals to the environment. The pollutants resulting bioaccumulate in plants and animals, bioconcentrate in the food chain and pose serious health risks to humans. Health effects due to heavy metals include allergic reactions, neurotoxicity (affecting the nervous system), nephrotoxicity (damage to kidneys) and cancer. Specific heavy metals and their health effects are described as follows:

- Copper in excess to the body's needs cause anaemia, liver and kidney damage, and stomach and intestinal irritation. Copper toxicity can occur from eating acid food that has been cooked in un-coated copper pots, or from drinking water through corroding copper pipe.

- Cadmium - Long term exposure to cadmium in low doses may cause loss of sense of smell, cough, shortness of breath, weight loss, and tooth staining. Chronic cadmium exposure may cause damage to the liver and kidneys; damage to respiratory systems, lung disease and even lung cancer.

- Zinc – whilst a small amount of zinc is necessary to balance the human dietary requirements, poisoning can result from excessive (up to ten times recommended requirements) intake. Zinc is an intestinal irritant. Symptoms of zinc poisoning are vomiting, nausea & diarrhea. Other symptoms are low blood pressure, jaundice, fever and coughing. .

- Lead poisoning causes acute or chronic damage to the nervous system on humans. Exposure may be due to contact with things containing lead in their manufacturing; for example leaded paint, toys, painted dishes, water pipes in old buildings and even canned food. Lead taken into the body is distributed into the blood stream and ends up in the bones. It harms the production of blood cells causing anaemia and affecting bone development.

- Selenium is found as a trace mineral in the soil from which it finds its way into plants and animals through the food chain. Selenium intake into humans is through eating vegetable and meat containing the mineral. Selenium is essential to good health in a small quantity. Excessive selenium through eating grains, nuts and meat with high content selenium risks health problems such as damage to circulatory tissue and the nervous system.

- Mercury causes damages to the brain and the central nervous system, causes psychological changes and makes development changes in young children. Normally Mercury is a toxic substance which has no known function in human biochemistry.

- Chromium – low level exposure can cause skin irritation and ulceration. Long-term exposure can cause kidney and liver damage, and damage to circulatory and nerve tissue. The risk in human exposure to chromium may occur through eating fish which is carrying high concentration of chromium which tend to bio-accumulate in aquatic life.

Aznalcollar Spillage

On 25th April 1998, the lead-zinc mine at Analcollar in Spain spilled 5 million cubic meters of heavy metal polluted slurry into the Rio Agrio and the surrounding land. This occurred due to a burst tailings dam of the Boliden-Apirsa Mine. The spillage threatened agricultural areas, fisheries, tourist resorts and the Donana National Park.

The cleanup entailed collecting the polluted sediment and depositing in an open pit at the mine. The operations took 3 years at an estimated €240millions.

In a recent study (12 years later) of the Donana soil condition comparing it with soil from unpolluted areas, researchers concluded that the polluted soil recovered 'reasonably well', although effects from the spill were still present. According to the expert, *"It could take tens of years for the soil to recover."*

13. LABELING PRODUCTS OF LOW ENVIRONMENTAL IMPACTS

Our daily consumables may harbor harmful ingredients without our knowledge. Manufacturers if they know the effects of undesirable ingredients used may be unprepared to make a production switch to healthy and environmentally preferred components. There have also been producers that put sales and profit ahead in priority to people's health and environmental concerns. In 2008 China shocked the World when they reported that melamine was added into milk formula by a number of milk companies. Melamine is a chemical having the formula $C_3H_6N_6$. The high nitrogen level gives it similar characteristics to protein. This prompted the Chinese producers of infant milk formula to resort to the unscrupulous act of adulterating the milk and disguise it with false high protein content. According to the Safety Data Sheet (SDS) for melamine, its toxicology is described as 'harmful if swallowed, inhaled or absorbed through the skin. Chronic exposure may cause cancer or reproductive damage.' Perhaps the country's report was testament to the harm unwary parents unfortunately subject their babies to. An estimated 300,000 infants were affected. Six died of kidney failure and many across the country were hospitalized. The repercussion across the World was a ban of Chinese produced daily products. It would be difficult for them to regain the trust in these products in the few years to follow. The good coming out of the scandal was the enlightenment of people to the criticality of health and environmental criteria not met in food produce and manufactured goods. The World has become more wary of the possibility of unscrupulous individuals or organizations that would not stop at selling products with substances detrimental to people's health to reap quick profit.

GREEN LABEL PROGRAM

Countries have encouraged manufacturers to work with government oriented environmental councils to develop product environmental standards. Green labels are awarded to manufacturers in recognition of their compliance in the requirements of product environmental standards. Countries like Singapore, Australia, New Zealand and Europe have develop their environmental standards which require

- Use of raw materials that will not burden the environment, e.g. no materials that will result in air, soil and water pollutions across the product life cycle from production, through application and return;

- For each product category the avoidance of materials that will harm the health of humans and all living organism; e.g. use of materials which cause cancer such as PVC, phthalates and adhesive with formaldehyde;

- Compliance with legislations in environmental protection and worker occupational health and safety in the production activities;

- Remunerating workers reasonable wages and benefits.

- The manufacturer to adopt the policy and practice of recycling their products at the end of useful life.

RECOGNITION AND DISPLAY OF GREEN LABELS

Recognition for compliance of the foregoing requirements is established through the green-label program modeled to ISO14024 Type I Environmental Labeling Principles and Procedures. The program covers the following

- Third party auditing & verifying compliant evidence in
    - Production and product environmental aspects,
    - Manufacturer's product life cycle provisions,
    - Compliance to environmental regulations,
    - Compliance to labour, occupational health & safety regulations;
- Documenting audit outcome & confirm this with the manufacturer;
- Recommending award of label from green-labeling body.

The display of a green-label on the products serves the following objectives:

- Products widely recognized to be of reduced environmental impact across their life cycle;
- It differentiates products as consumer preferred choice;
- The label qualifies the manufacturer to bid in product supply tenders which require production and products that are environmentally compliant.

To ensure that manufacturers sustain their commitment, green-label programs require them to subject their processes and products to regular review and recertification. Similarly green-label standards maintained by the standards body are also regularly updated to be aligned with new requirements.

Could the Chinese milk formula scandal be prevented through green-labelling? The answer is more positive than no. This is because the program is principled on voluntary participation. Producers of goods do not always list down ingredients used in production, hiding these under 'trade secrets'. With green labels a greater transparency in production recipes and methods are conditional to qualifying for the recognition. Where confidential production data is implicated, the company responsible person will sign an undertaking that specific harmful ingredients are excluded in the production process. Obviously where producers are reluctant to participate in green labeling for their own reasons, people have to be self-reliant in checking out what is not good for them.

PRODUCTS OF DAILY CONTACTS

It may be the first time you are made aware of green labels being carried by products we are in daily contact with. These are simple things that are large volume consumables such as detergents, papers and many more that are part and parcel of life. Two examples are listed here to give you an insight of the practical considerations to make the products more health protective and environmentally friendly.

Detergents, shampoo and soap

Our daily domestic needs in detergents, shampoo and soap refer to fluids and substances produced as cleaning chemicals whether for washing dishes, clothes, floor or body. For easy reading 'detergents' in this part of the book are taken to mean common cleaning chemicals including washing liquids, soap powder, hair shampoo and body soap It is important to know that some ingredients used in producing these cleaning chemicals may be harmful to health and the environment. In usage consumers must be aware that washing end up as waste water which bear detergent chemicals and

these have to be neutralised before letting out into the public water course. In the following notes some of these chemicals are highlighted for their resistance to treatment and will be hazardous to the environment.

Green labelled detergents require the exclusion in their production chemicals that are carcinogenic, allergenic or teratogens. Specifically, the following are considered unsuitable:

- Phosphate – Waste water with phosphate getting into streams promote algae bloom which is short-lived. The algae upon dying decay and in the process consume dissolved oxygen, thereby depriving other aqua living things oxygen to survive. The blue-green algae (cyanobacteria) release toxins that can kill other organisms and make the water unsuitable for humans, livestock and wildlife. For these reasons wastewater containing phosphate detergents should be directed to the sewerage system and not be allowed to wash into the storm water drain.

- Alkylphenol ethoxylate (APEO) – APEO does not biodegrade readily going through the sewer treatment plant. Fish pick up the contaminants which pass the health risk to humans. Contamination may also be in the streams not purified before piping into household supply. APEO is an unclassified carcinogen.

- Ethylene diamine tetraacetic acid (EDTA) – Causes respiratory tract, eye and skin irritation. May cause kidney damage and reproductive and foetal effects

- Nitrilotriacetic acid (NTA) – Other than it being a chelating agent there is little information on the toxicity of NTA in humans.

- Sodium Perborate – Hazardous in case of ingestion. Exposure and contacts cause respiratory tract, eye and skin irritation.

- Chlorine Bleach – This chemical solution consists of 3 to 6% sodium hypochlorite. It can damage clothing, burn skin and damage eyes in case of contact. It is also dangerous if swallowed. Mixing ammonia with chlorine bleach is very dangerous because it produces a toxic gas.

- Halogenated Hydrocarbons – Halogens are elements such as bromine, chlorine, fluorine, iodine, and astatine. Hydrocarbons containing halogen elements are known as halogenated hydrocarbons. Halogens especially bromine and chlorine are hazardous to health and environmentally damaging.

- Formalin – This is the generic term for a solution of formaldehyde gas dissolved in water. Formaldehyde is a noxious gas and carcinogenic. It is sensitive to temperatures, becoming more toxic at both high and low temperatures.

- Sodium hypochlorite – this should be excluded or reduced in concentration in bleach solutions as it can corrode, irritate and burn the skin and eyes; and cause nervous, respiratory, digestive system damage.

- Sodium acid sulfate, oxalate or hypo-chloric acid if found in toilet bowl cleaner can be corrosive; toxic in nature; it burns skin and causes digestive and respiratory system damage.

- Sodium/potassium hydroxide (lye) – if found in oven cleaner can be corrosive, toxic in nature; it burns skin, eyes and causes damage to nervous and digestive systems.

Detergents are also required to comply with having

1. Biodegradability with at least 90% being biodegradable;
2. pH value not exceeding 11
3. No fragrance containing the compounds such as moskus-xylene because of their cancer risk.

Environmental friendly detergents

Use of detergents cannot be fully environmental problem-free. However detergents can be made more environmentally suited when use of additives such as perfume, color and brightening agents is reduced. This would also help reduce its toxicity. Reduced packaging will also lower the waste disposal, recycling load.

For these reasons consumers must be attentive to product labeling and avoid less environmental friendly detergents and soap.

Paper

Some people would remember 40 years ago when business and inter-office correspondence was never without a hard copy to be filed away. The resource that was needed in paper production and the manpower required in sorting out and filing documents kept generations of employees busy. What happened to the filed copies some years later were a different matter. Incinerators worked at high capacity too. It was also about that time when people became aware of the environmental erosion due to uncontrolled cutting of forests for the pulp paper productions. As computerised mails and filing help offices to become less reliant on papers, environmentalists can heave a big sigh of relief. But the environmental problem will not be lessened unless the paper industry conforms to green labelling recommendations.

Green label standards for paper require a recycled content of at least 50%. Producers are to state their source of wood pulp certifying 100% from sustainable plantation forests. The production process is to be comprehensively described, confirming that recycled paper treatment does not pose any environmental threat in terms of emission and effluent qualities. The use of bleach, surfactants and chemical additives is subject to control, either through total omission, substitution or limitation in quantities.

One additive of concern in colored paper production is the dye. This should be chemicals that are not carcinogenic, not harmful to aquatic organisms and does not contain heavy metals.

Product packaging

Products that are green labeled would also have their packaging meet health and environmental protection requirements. Where plastics are used, these should bear plastic resin identification codes and recyclable in the country where products are sold. Any process in labeling or coating or treating of the packaging which prevents recycling will not be acceptable. PVC or chlorinated materials must not be included in the packaging.

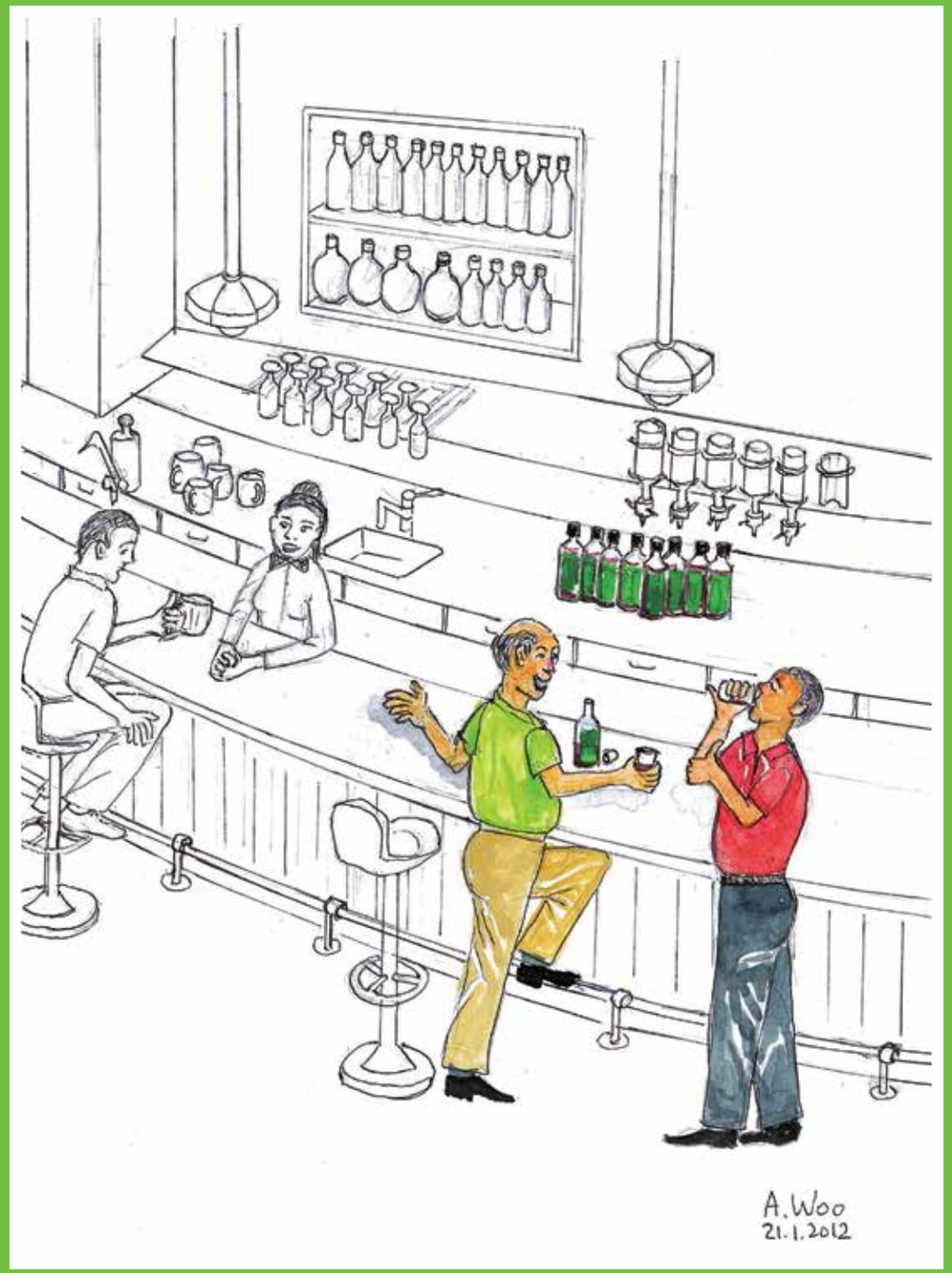


Fig 13.1:"I'd say they carry this whiskey green label too far if not for the 'oohm' that comes with it!"

14. GREEN BUILDINGS

Green buildings are recognised as achieving energy efficient criteria. This means they are built or modified to achieve a significant contribution to environmental protection as indicated by a reduction in carbon footprint. It also provides safer, healthier and productive surroundings for occupants by leaning on nature without undermining its sustainability. Green buildings are also promoted in parallel with eco-labelling programmes, requiring appliances and fittings to be those certified to environmental standards.

Countries have encouraged the industry participation in green building councils which have as their mission to promote green building design, technologies, products and practices in pursue of environmental sustainability and personnel well-being. Under the certification scheme assessment criteria are formulated by industry professionals, which are applied to accord recognition of new and existing buildings at different performance levels. An example of the green building assessment criteria applicable to commercial buildings, with points awarded for results achieved in key areas is as follows:-

- Building layout – best result against undesirable heat ingress is achieved for buildings in a north-south orientation. This is not always easily met for existing buildings due to urbane building planning in years gone by. Notwithstanding, designers and architects may find innovative solutions such as providing solar panels for water heating and electricity generation, creating sun shielding barriers planting shady trees or reorientation of space usage within the building. Another solution may be through induction of natural wind draft through the building with a solar chimney strategically positioned in the roof.

- Energy Efficiency – apart from investing in electrical equipment with energy saving features such as new design lifts, escalators, central air conditioning unit with automatic condenser tube cleaning system, and lights; innovative solutions like the following also gain merits:
    - Solar panels to harness sun's energy for water heating and electricity generation
    - Thermal energy storage for hot water and battery cells
    - Natural lighting harnessed through reflective panels and mirrors
    - Motion sensors for lights in low human traffic area such as in amenities
    - Roof insulation to minimise solar heat impact and reduce air conditioning need
    - Glazing windows to reduce sunlight penetration into the building also reduces air conditioning load.

- Water efficiency achieved through installations of water saving fittings. Other improvement initiatives are :
    - Adjusting water pressure and flow rates to avoid wastage;
    - Installing cisterns of conservative flush design;
    - Collecting rain water for non-portable use such as washing and lawn, plant irrigations;
    - Using industrial quality, non-portable water for cooling towers.

- Environmental Protection:
    - Use of recycled materials, e.g. concrete aggregates for road kerbs, drains and car park reverse wheel stoppers;
    - Use of demolition concrete aggregates for reconstruction site landfills saving on transportation CO_2 emissions and costs;
    - Installing equipment and use of products with green label certification preferred over others. This ensures materials and substances of low environmental impact and health effects have been used in their manufacturing and recycling is assured at end of product life.

- Indoor Environmental Quality:
    - Air quality monitoring to optimise fresh air/recycled air ratio in air conditioning;
    - Use of ecolabeled products with low volatile organic compound in their surface coatings;
    - Application of photo-catalytic titanium dioxide self-sanitising wall coating in toilets, to neutralise odours and improve air quality for users.

- Other Green Features
  - Landscaping provided on void-decks and roof top in addition to ground compounds;
  - Tree planting and greenery creations in outdoor relaxation area;
  - Cafeteria well ventilated and provided with hand sanitation facilities;
  - Cafeteria crockery and utensils issuing and returning systematically controlled to maintain a pest free environment;
  - Food hygiene maintained to high standards meeting health inspection criteria;
  - Smoker corner allocated with effective natural ventilation.

The foregoing listing is not exhaustive. Green building designers and engineers have a vast field of possibilities in the drive to reduce greenhouse gas emissions from all human reliance in man-made machines and products to provide living comfort. The green building councils continually seek out best practices to attain zero energy buildings, and share these across the building industry.

"What is the use of a house if you haven't got a tolerable planet to put it on?" - Henry David Thoreau July 12, 1817 – May 6, 1862

Source: Environmental Quotes – http://www.favorite-inspirational-quotes.com

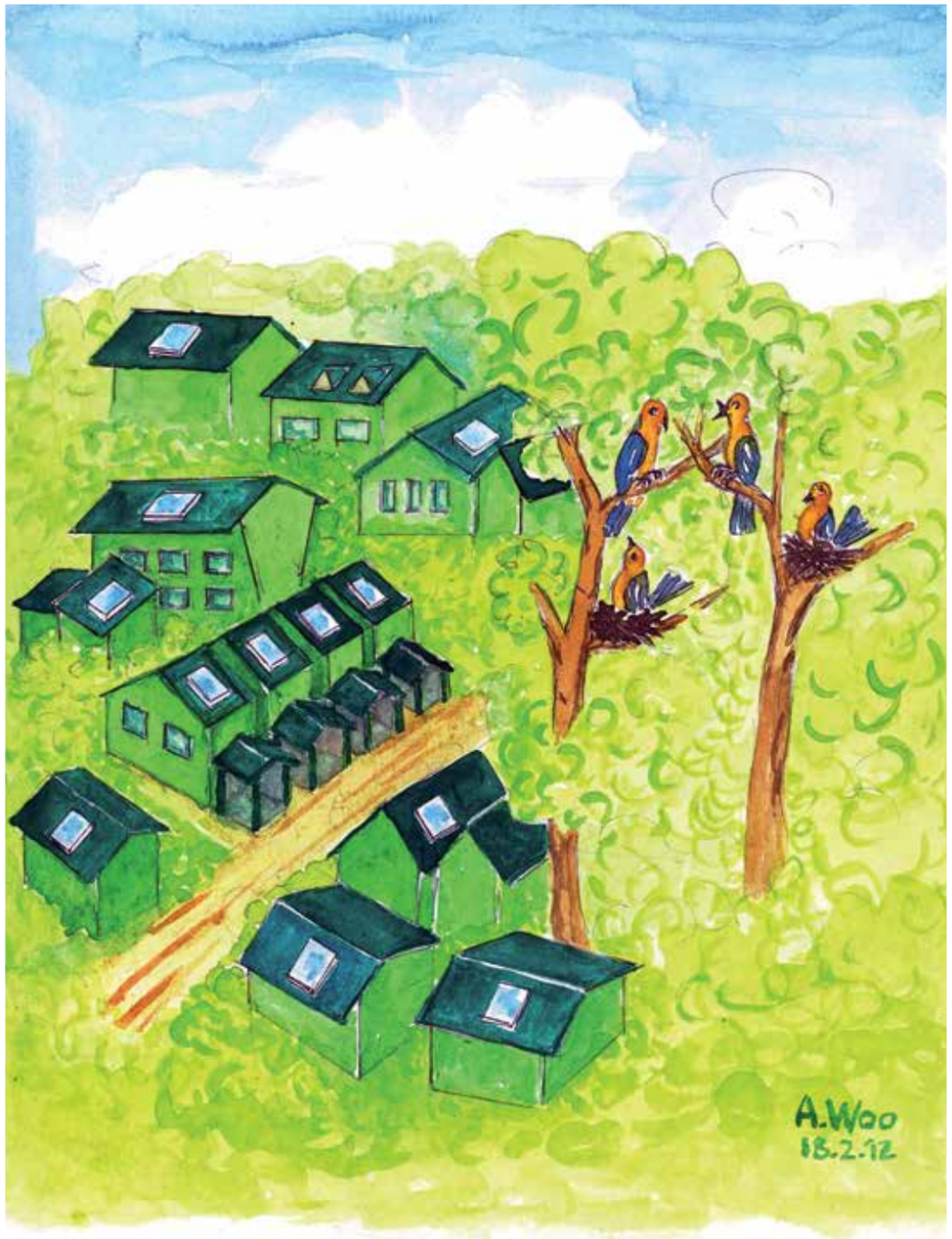


Fig 14.1: "Our homes are 100% recycled brown material, but they are no less green!"

15. PEOPLE POWER FOR THE ENVIRONMENT

This section is written at the risk of repeating points that have been made under the sections on carbon footprint and green building. Nevertheless it is fitting to sum up what people must do to make a positive impact on the environment.

CONSUMERISM IS KEY

People as consumers play a major role in environmental conservation. They can do this in a holistic way by choosing products and using energies and supplies discretionally. The choice should be based on the product materials being non-threatening and non-detrimental to the health of humans, life-support to the living organism and to the conditions of air, soil and water. The choice should also be preferred to product energy and water efficiency, renewable, recyclable and otherwise safe treatment and disposal at end of life/after use of products. This is the consumers' environmental statement that is immensely powerful to influence manufacturers and service providers to be environmentally caring in order to stay in business. In developed countries where consumerism is threatening the environment instead of helping it, governments supposedly having a good environmental regulatory and protection framework, need to work harder in educating the populace to be party to the environmental statement. In some countries the seeds are sowed by bringing environmental teaching into the primary school social study/science curriculums. But the populace at large who has worked hard and contributed in the countries development needs to be reminded, in not over indulging in the fruits of success but to save the environment from tail spinning to a crash landing. They need to cut back on life's excesses which burden the environment with activities that put greenhouse gases into the air. Education of the common folks could do with an evangelical effectiveness to rouse them out of their indifferent stance. The government budget on environmental conservation must include incentives at the individual level. Tax rebate and the ways to gain it by decreasing personal carbon footprint must become a government priority. The education process needs to be looked into in helping the populace at all levels; workers, professionals and retirees must all be rallied to understand the what, why and how not to burden the environment any further.

Here are the recommendations in helping consumers become more selective and responsive to good environmental outcome:

MAKE RIGHT CHOICE IN PURCHASES

Examples of the type of purchases are as follows:

- Check product label, avoid product with description "chloro…"
- "Chloro ,,," means product is organochlorine which is harmful;
- Avoid correcting fluids, disinfectants, paint removal; etc containing organochlorine solvents;
- Select alternative water-based correcting fluids and paints;
- Avoid packaging materials and bottles of organochlorine.
- Avoid PVC packaging labeled with a "V";
- USE paper wallpaper instead of vinyl wallpaper which is PVC;
- Ask for Totally Chlorine Free (TCF) paper products;
- Clothes washable preferred over dry cleaning, especially if perchloroethylene is used.

CUT CONSUMPTION/REDUCE & RECYCLE WASTES

There are practical ways to lower environmental impacts in our daily lives. Some examples are as follows:

- Use less paper. Do not print unnecessarily;
- Use recycled paper;
- Send waste paper for recycling;
- Conserve home and work place electrical energy, switch off cooling and lights when not needed;
- Avoid using plastic cups and cutlery.

SUPPORT RECYCLING PROCESS

Most packaging, be it paper, carton or plastic will have the logo encouraging recycling. The logo is in the form of a triangle, with arrows pointing in a clockwise continuing pattern:

Recycle Symbol

Products and packaging bearing the green recycle logo should be segregated and binned into receptacles meant for the recycling plant. In every household it is important to avoid throwing all and sundry wastes into one container. When plastics are thrown with food wastes, the rubbish sorting centre has a difficult job. Any omission or neglect in sorting plastic and treated timber from food and paper wastes for the incinerator may end up sending dioxin into the atmosphere.

If you are unsure of segregating the different items for recycling, the simple guide is to separate papers from all others. However, remember to rinse the bottles, cans and cartons of their contents to avoid spreading the ravage of insect pests. The recycling contractor will do the rest, under approved methods from the environment protection authority.

Fig 15.1 Kerbside Recycle bins

Fig 15.2 Separate bins for paper, bottles, plastics and metal containers.

Fig 15.3 Littering in the Environment

A Recycling Success Story

Have you ever thought of doing something no one has done before, and in the process amass a fortune?

Ms Zhang Yin did just that from not so long ago in 2002. Today she is amongst the wealthiest women in the world with a fortune of US$5.6 billion. Through her remarkable foresight and entrepreneurial drive she created the Nine Dragons Paper Holding Company based in China which dealt in paper recycling.

Her company collected waste paper from the United States and Europe to ship into China and recycled into corrugated cardboards. These are made into packing boxes for toys, electronics and furniture which are shipped right back to the Western Countries. The packaging thrown away is collected again and recycled.

Source: New York Times January 15, 2007

"Recycling just seems like the right thing to do, I mean really, it makes us responsible for the messes that we make. It's all about just picking up after yourself, not shoving our trash in our oceans and streams. We might as well reuse it before we lose it." - Ed Begley Jr. (1949-) Character actor and environmentalist

Source: http://famousquoteshomepage.com/Environmental_Quotes_Support_Preservation_of_Our_Natural_Environment.htm

HANDLING AND DISPOSAL OF SPENT BATTERIES

Batteries are now made safer for handling and disposal once they are spent. The old dry cell batteries containing mercury oxide are being replaced by nontoxic zinc oxide and zinc air batteries. Batteries using nickel cadmium are now made rechargeable and recyclable. Some countries have imposed limits on the mercury content in batteries and allow disposal of household alkaline batteries of AA and AAA types used in for example in toys, torch lights, remote control units, clocks, radios and many others, through the normal household waste system. Other countries have more stringent requirements to disallow mercury oxide in these batteries before they are considered non-hazardous waste.

For rechargeable, recyclable batteries, manufacturers and retailers must provide the means for collecting spent batteries. Batteries used in laptop computers and communication equipment such as two-way radios, cellular and cordless phones, remote control toys, hand held scanners, digital cameras, camcorders, and cordless power tools such as drills and screwdrivers are recyclable. Manufacturers of these electronic equipment are actively promoting the awareness of their recycling programs, and locations of their collection bins. In the absence of collection centres and when consumers are not directed to properly dispose of spent batteries, these may be conveniently dropped into regular garbage and end up incinerated or earth-filled, both end results are formidable environmental woes.

Batteries intended for recycling should be fully discharged before putting them into collecting bins. This is to avoid short-circuiting and sparking which is a fire hazard in buildings. The following types of batteries are recyclable:

- Nickel Cadmium (Ni-Cd)
- Nickel Metal Hydride (Ni-MH)
- Lithium Ion (Li-ion)
- Small Sealed Lead (2 pound maximum weight per battery)

Button batteries used in car door switches, watches, small torch lights and the like may not have been improved and still contain mercury. Such items to be discarded should have their batteries removed for recycling. Multiple button batteries sent for recycling should be kept from being in contact to avoid sparking and fire.

Consumers' contributions in environmental care concerning batteries are:

- Look for recyclable purchases;
- Know what recycle arrangement is offered by battery vendor;
- Avoid throwing spent batteries into household or office waste unless certain they are non-hazardous.

16. CATASTROPHIC ENVIRONMENTAL INCIDENTS

The world had suffered a number of catastrophic incidents resulting in either loss of lives, or painful human health consequences, or damage to the ecological landscape; or a combination of these disasters. Some of these may be identified as

- Bhopal gas tragedy: 2nd/3rd Dec 1984 – 2259 deaths and over 500,000 injuries due to exposure to spilled methyl isocyanate (MIC) gas from a pesticide factory;
- Exxon Valdez oil spill: 24th March 1989 – up to 42,000 m3 of crude oil spilled from Exxon's crude ship Valdez and polluted 2100 km of coastline and 28,000 m2 of ocean;
- Nuclear disasters at Chernobyl – 26th April 1986 and Fukushima 11th March 2011 are covered in the following passage;
- Oil Spill in the Gulf of Mexico – 2010 is also covered in the following passage.

NUCLEAR POWER PLANTS

An introduction is given here on nuclear power generation to help readers appreciate the nature of nuclear power plants and their potential to become an environmental disaster.

Electricity generation using nuclear technology first started in the United States on 20th December 1951, at Arco, Idaho. The technology involves producing heat to boil water and make high pressure, high temperature steam which drives a turbine which in turn drives a generator to generate electrical power.

The heat produced in nuclear reactors occurs during nuclear fission. This is when one atom is split into two lighter atoms thereby releasing heat energy. This nuclear fission is started when a neutron is fired and absorbed into a nucleus, splitting the atom and in turn releasing two or three other neutrons which sustain the nuclear reaction.

The material responsible for this is Uranium. Specifically the type commonly used is Uranium 235, or U235 enriched onto pellets of 25mm lengths and diameter not larger than a coin. The U235 coated pellets are packed together in rods inserted in the nuclear reactor. These fuel rods are submerged in water which acts as a coolant. In the absence of this water, heating continues which ultimately leads to melting of the uranium fuel rods and danger of over-pressuring the reactor. The coolant now heated to a very high temperature may be circulated through a steam generator where the steam for driving the turbine is produced.

Operators manning the nuclear reactors are given means to control overheating. These are in the form of control rods made of a material that slows down the nuclear reaction by absorbing neutrons produced by the fuel rods. The control rods are inserted into the uranium bundle using a mechanism that can raise or lower them. When an operator wants the uranium core to produce more heat, the control rods are lifted out of the uranium bundle (thus absorbing fewer neutrons). To reduce heat, they are lowered into the uranium bundle. Pressure in the reactor which is completely filled with water is controlled by a pressure regulator. Hydraulic pressure surge in the reactor is regulated by buffering or compensating with a nitrogen cap, venting or admitting according to pressure variance in the reactor. In the event of emergency or for maintenance, the reactor may be shut down completely by lowering the control rods fully into the uranium bundle. Fig 16.2 shows the schematic line up of the various parts of the nuclear plant.

Radiation hazard from nuclear plants is a perennial concern especially amongst people residing in the view of these plants. Yet the structures that unmistakably betray the identity of such plants are designed and built for the protection of the environment and hence the people living outside demarcated limits. The safeguards are described as follows:

- The reactor core and the equipment plant workers use to refuel and maintain the operations are installed inside a concrete lined steel vessel (Building A in Fig 16.1). The concrete liner acts as a radiation shield.

- The steel containment vessel serves as a barrier to prevent leakage of any radioactive gases or fluids from the plant.

- An outer concrete building completes the safeguard, protecting the steel containment vessel. This concrete structure is designed to withstand the forces from massive earthquakes or a jet airliner crash, preventing the release of radiation/radioactive steam in such accidents.

Common features of a nuclear power plant

Figure 16.1 is an impression of the common features that loom in the countryside of a place which relies on nuclear technology for their energy supply. One readily spots the hyperboloid structures (bell shape) concrete cooling towers (labeled C) with their plumes of white smoke, which may be the only signs of life visible from the distance. The white plume is actually condensation of warm air issuing from the tower when it meets cold air in the surrounding. This occurs if the cooling tower uses air which is fan induced or naturally inducted in an updraft promoted by the shape of the tower. Steam may also issue from the tower if water is used for cooling, the water evaporating as it removes heat from the turbine condensate circulating through tubes in the tower. Very often to the public wary of nuclear hazards, the cooling tower plume is mistakenly associated with radioactive pollutants.

The illustration also shows domed shape buildings which are of steel and concrete structure housing the reactors and steam generators (Building A), as described in the foregoing. Oblong shaped concrete buildings (B) contain the turbine engines and generators. Control technicians are housed in the control room located in another part of this building. Other buildings (D & E) in the illustration are the engineering service centre and the administrative block.

A nuclear plant tends to be built in a rural part of the country, within easy reach of river or lake or the sea for water to be sourced for cooling purpose. The plant is also preferably remote from housing communities. The owners of a nuclear power plant also put attention at maintaining landscaped surrounding to enhance an environmentally conducive image.

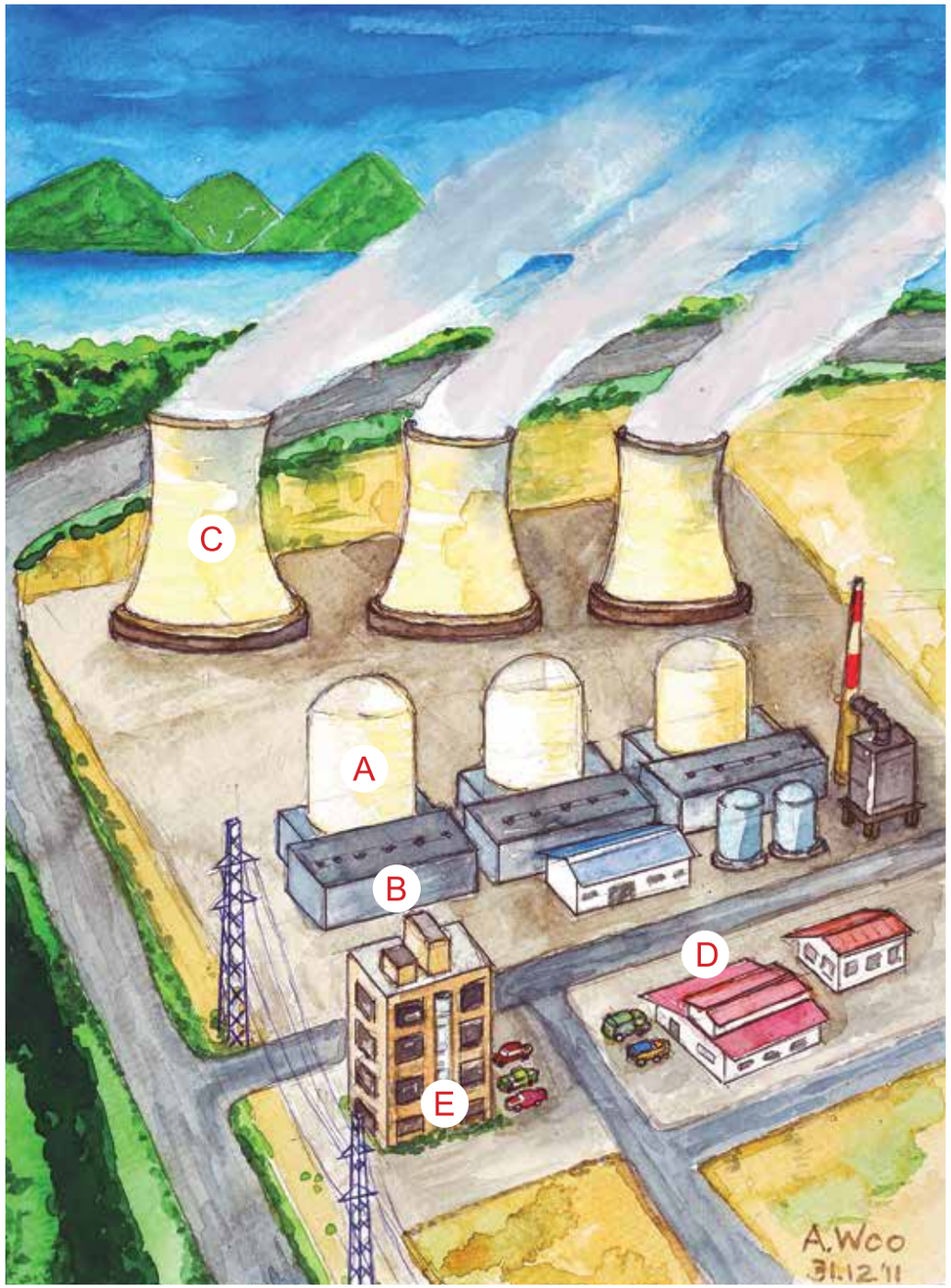


Fig 16.1 Illustration of a typical nuclear power plant landscape

Nuclear power plant pros and cons

- Power generation from nuclear plants is 'clean' compared to fossil fuel and coal fired power plants. There is hardly any CO_2, SO_2 and NO_2 emissions from nuclear plants that is a common atmospheric pollutant from fossil fuel (natural gas) and coal burning plants.

- Nuclear energy is a reliable and stable priced supply relative to other fuel generated power. The latter is sometimes subject to global political influences affecting the fuel supply.

- The disadvantage of nuclear power plants is in the production of nuclear waste which results from spent fuel removed from the reactors. The quantity produced worldwide is in the order of 2000 metric tons per annum (source: Nuclear Energy Institute - NEI). The waste has to be cooled for many years, then mixed with glass and stored in concrete containers to avoid corrosion problems. The waste has to be maintained safe and secured to avoid theft and terror intents. The waste will continue to be radioactive for thousands of years and poses a danger to nearby life forms.

- Another area of concern with nuclear power generation is in the mining of Uranium. The production and transportation of the reactive fuel no doubt bear close attention on the handling equipment and procedures put in place to safeguard personnel health and environmental protection.

Nuclear power plant safety

In a nuclear power plant, as in all other production plants, control of the operating conditions for steady, trouble-free outputs is the main responsibility of the plant operators. Where operators are unable to control or situations escape their attention span, engineering and automation would have been incorporated as a basic provision to blow whistle and sound alarms, ensure equipment reliability and in the event of the primary equipment failure, back-up facility is available to automatically activate in maintaining safe operations.

Yet accidents do occur. The International Atomic Energy Agency (IAEA) requires nuclear power plants to report all incidents and accidents arising from their operations. In 1990 IEAC introduced the International Nuclear Radiological Event Scale (INES) which plants are required to use in reporting. On a scale of 1 to 7, depending on the severity all incident/accident events are rated in the report. Scale 1 to 3 describes events as incidents, defining severity from 'anomaly' at scale 1 to 'serious incident' at 3. Above this level, events are recognized as accidents. These are reported at 4 to 7:

4 = accident with local consequences
5 = accident with wider consequences
6 = serious accident
7 = major accident

Major means the 'release of radio¬active ¬material with widespread health and environmental effects requiring implementation of planned and extended countermeasures.'

Meltdowns

Meltdown is a nuclear power plant operator's nightmare. This is the ultimate failure of his plant's response to primary breakdown recovery and activation of back-up emergency resources. The mechanism of a meltdown is such that when the normal fission heat generated from the fuel rods is not removed, this heat is self-sustaining from continual chain reaction. The water in the reactor drops in level exposing the fuel rods. They begin to melt and release gases which react with steam to produce hydrogen. Pressure build up occurs if no emergency action is taken. This could lead to a rupture of the steel reactor dome, risking the release of radioactive materials if the containment shell is also destroyed by an explosion.

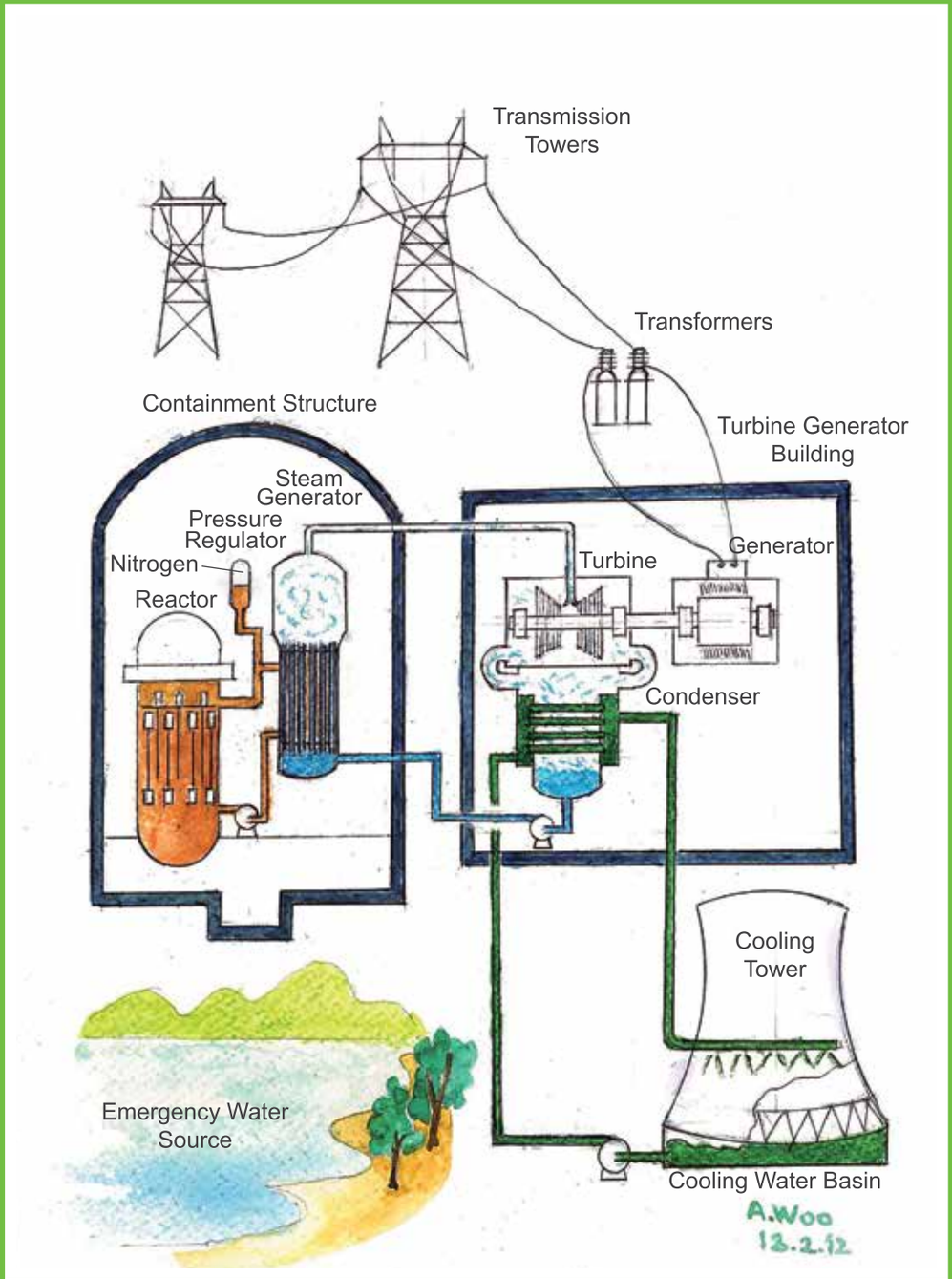


Fig 16.2 Flow scheme of a nuclear plant

The world has now experienced two major accidents i.e. of Scale 7 involving nuclear power stations.

Chernobyl – 26th April 1986

Chernobyl is in Ukraine. On 26th April 1986 whilst subjecting No. 4 reactor to a routine safety test, an explosion and fire dealt a blow which ripped open the reactor sending 50 tons of radioactive isotopes into the atmosphere. The Chernobyl plant was poorly designed and badly operated. There was no secondary containment built to protect the people and environment from the radiation release. Thirty-one people died as an immediate result. An estimated 15,000 more in the surrounding area died from cancer and other illnesses after exposure to the radiation. Millions of acres of forest were contaminated with radioactive materials spread by wind.

A 30-km radius exclusion zone was declared and 300,000 residents hastily evacuated. Today what remain are abandoned cars, tractors, buildings and homes, and survivors with memory of sweet childhood and happiness of family togetherness. Whilst the relics are still radioactive, and will remain so for hundreds of years whilst radioactive materials run out their half-lives.

At the site, 25 years after the accident, workers are still seen donning protective clothing and equipment to continue work in restoring protections. They are building concrete shields to provide for what was not there and replace those at risk of crumbling.

Fukushima 11th March 2011

Fukushima is the capital city of Fukushima Prefecture, 250km north of Tokyo. On 11th March 2011 an earthquake of scale 9 occurred causing a tsunami of more than 10 meter waves.

At the time of the accident, reactors 1, 2 and 3 (three out of six reactors) were in operation. These were shut down automatically. Although protected by a seawall of 5.7m, the tsunami which sent waves of at least 13m overwhelmed the seawall and flooded the entire Fukushima plant, damaging emergency generators, switch gear and pumps critical to supplying cooling water. The three reactors experienced full meltdown.

Early media reports indicated radioactive iodine 131 detected in milk, leafy vegetable and drinking water around Fukushima. People were also feared to have been exposed to radiation. From 13th March the government ordered the evacuation of people living within the 20 km around the plant. On 15th March, Reactor No 2 had an explosion and fire which was feared to have breached containment, sending radioactive water into the basement and seeping into pipe trenches outside the building and contaminating the surrounding seawater.

Over the weeks and months that followed the fateful 11th March 2011 date, the management and staff of Tokyo Electric Power Company (TEPCO), owner of the facilities, battled extreme odds to stem the imminent danger of radiation leak into the atmosphere and seawater. By end July 2011 TEPCO was still grappling with reactor cooling, using nitrogen to inert the reactor and prevent hydrogen explosion, and reducing the radiation levels in the plants which impeded emergency recovery efforts. In July 2011 contaminated beef was reported which caused public anxiety and prompted some governments to take precautionary bans of beef import from Japanese suppliers.

People might attribute what happened at Fukushima to the wrath of nature. The flooding which crippled the nuclear power plant was brought on by over 10 meters of tsunami waves which were unexpected when the seawall of only half that height was built. But then the Indian Ocean earthquake in 2004 brought on waves of 30 meters, 3 times that of Japan! Talk of lessons learnt. It could also be suggested that equipment redundancy policies for nuclear power plants need to be reviewed in the light of disaster of the worst kind which hitherto escaped human imagination.

TEPCO continued through August to November 2011 in shutting down and cooling the reactors, testing the water sampled from the pits and collecting the water samples from the sea to test for radioactivity. Workers have also been subject to health monitoring.

Eventually by mid-December 2011 TEPCO declared that their efforts in stabilising the reactor conditions had turned the corner and a major concern for the nation had been resolved. The Government endorsed TEPCO's position that the plant had reached a state of 'cold shutdown'. This meant that the reactors' coolant system was at atmospheric pressure, the reactor core was below 100^{0}C at which temperature nuclear reaction would not take place. This declaration signalled the possibility of lifting evacuation orders and revising the evacuation zones allowing some people to return to their homes earlier. However, it remains for decades to come that the plant and its surrounding will remain isolated and subject to arduous decontamination process to achieve a safe level of radioactivity.

Fig 16.3 Chernobyl Nuclear Plant disaster
Source: http://dearscience.org/2008/06/05/nuclear-power-disaster/

Oil Spill in the Gulf of Mexico – 2010

Reportedly one of the worst marine oil spill disasters in the history of the petroleum industry is the BP oil spill from their offshore well. The well was located 64 km in the Gulf of Mexico off the coast of Louisiana. An explosion and fire occurred on 20th April 2010 on the platform which killed 11 people and injured 17 others. The platform sank 2 days' later resulting in the seabed gusher and massive spill. It took BP three months to eventually sealing the well and stopping the spill on 15th July 2010. By then an estimated quantity in excess of ¾ million cubic meters of crude oil had been spilled.

Needless to say the impact on the ecological effect over a vast sea area and a few hundred kilometres of coast line was tremendous. Marine and wildlife habitats were damaged. Fishery and tourism industries suffered painful setbacks. Even till the end of 2010, balls of oily pollutants were washing up from under the sea surface to the shore. Some of these were found in the nets of shrimp fishermen.

BP attributed the disaster to, "…*a complex, interlinked series of mechanical failures, human judgment, engineering design, operational implementation and team interface failures, involving several companies including BP, contributed to the accident."*

Reference:
http://www.bp.com/sectionbodycopy.do?categoryId=41&contentId=7067505

Drilling for oil in deep water

Drilling for oil whether on land or offshore entails reaching into the depth of the earth where oil reservoirs formed over millions of years may still be

undiscovered. Over the first half century of the 1900's the shallow reaches have been tapped leaving only the greater depths to be explored. The world's hunger for this energy source is sustained only through technological and engineering advanced methods to drill to greater depths, and sideways directionally as well. The BP platform which sank was drilling at a depth of 1500m, although it was built to operate at 2400m depth and drill down to 9100m.

Oil people describe the search and discover of oil an 'exploration and production' business. What is involved and how does it work to enable oil and gas to be extracted from the earth? For some readers who may not have followed the news of the BP spill and related articles in the media, here is simple background information on what people do and where things can go wrong in drilling for oil in deep water.

Drilling platform

Offshore drilling operations are carried out from a platform or often referred to as an oil rig. This may be built as a structure with legs standing on the sea bed in shallow waters, or built as a semi-submersible platform with buoyancy tanks which keep it afloat. Anchor chains or the more sophisticated computer guided propeller positioning system hold the platform over the drill well. Workers live and work on this platform, isolated except for communication means and the routine helicopter visits ferrying crew changes.

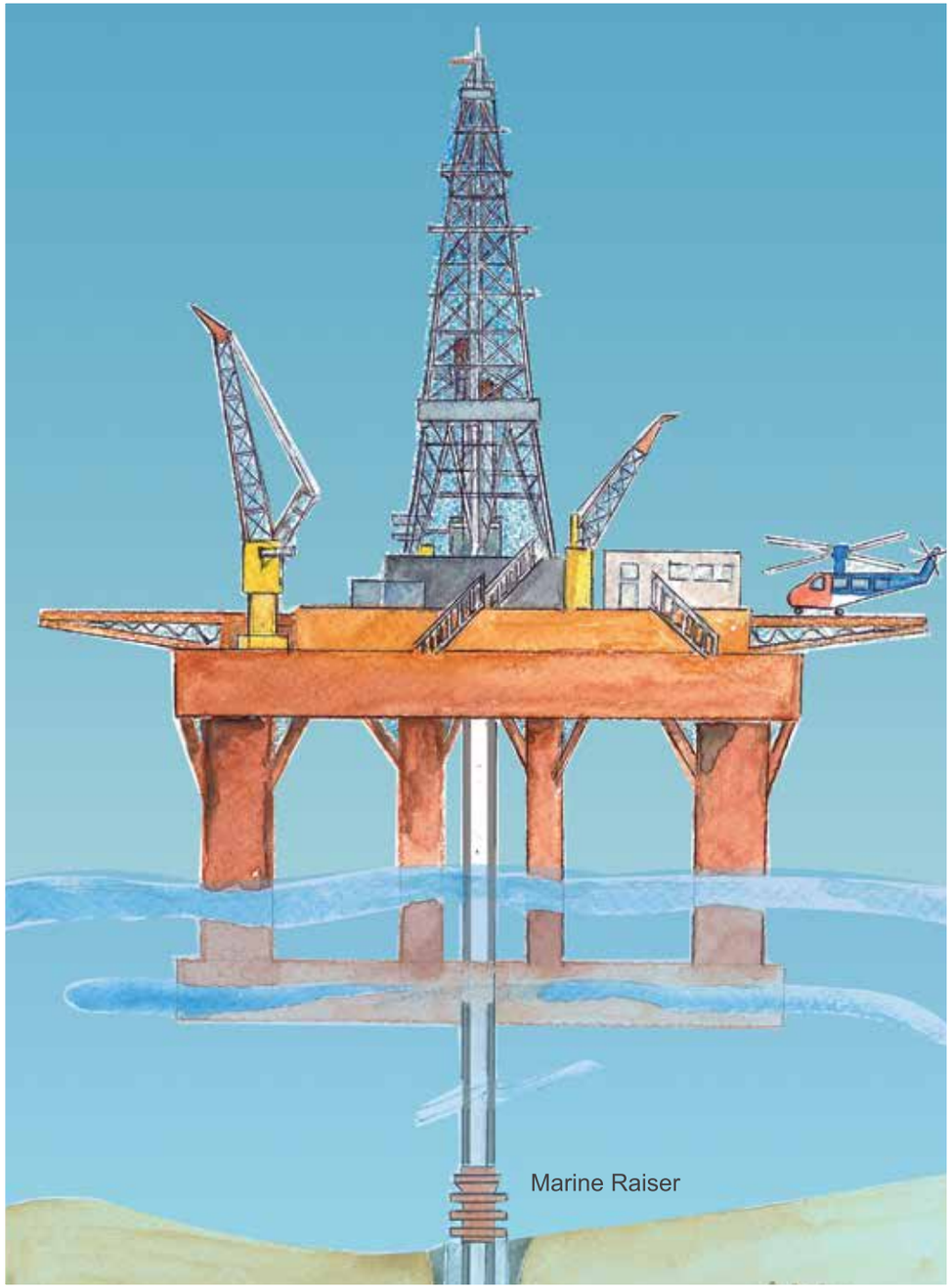


Fig 16.3 Painting of the offshore platform

Drilling into the Sea Floor

After a drilling platform has been set up by the company with the budget and the knowledge that oil is probably present and worth recovering, the first thing they do is to lay a large diameter pipe (up to 900mm diameter) vertically into the seabed. This process is known as 'spudding in'. The casing provides structural support to the wellbore, in addition to isolating the drilling fluid from escaping and preventing oil find from leaking out to pollute the sea. This large diameter casing is inserted to a depth of 100 meters. The casing is lowered to the sea floor using a 6 inch drill pipe. At locations where the sea bed is of loose sediment and silt, the casing may be lowered easily. But as additional lengths of casing are to be put in place, hammering or pounding in the 36 inch pipes with mechanical aid from the rig is necessary.

When the required depth is reached, the inside of the 36 inch casing is bored by drilling to create space for the installation of a 20 (or 24) inch casing which may reach a depth of up to 1000m. Drilling is done with a 'drill bit' fixed to the end of the small diameter pipes comprising the 'drill string' which is rotated by machinery on the rig. The drill bit consists of three cutting gears of steel or tungsten carbide teeth. The gears mesh and turn together cutting their way through the rocks, turning these into chips and pieces which are carried up to the surface by a fluid known as drilling mud. The drilling mud is continuously pumped down the drill string and ejected at high velocity through nozzles in the bit. This special mud, which contains clay and chemicals mixed with water, lubricates the bit and keeps it from getting too hot. The drilling mud which is of high density due to the weighting material barite used, may also counter pressure coming from the rock formation when an oil find is encountered. On the rig the drilling mud is recovered and the debris disposed into the sea.

The 20 inch casing is lowered and positioned within the 36 inch casing with the help of a remote operated vehicle (ROV). The combination of 36 and 20 inch casings are then cemented, this done by pumping the specially prepared cement down the drill string. The cement fills the space between the two casings and hardens within 12 hours.

Further depth is then bored by lowering the drill string through the casings. The drilling extends the wellbore which is progressively shored by casing extension of 9 meter lengths of pipes, but of stepped down diameter sections which are cemented as drilling goes deeper to the target depth. Heavy sections of drill collars (each of 10 meter length and 1800 kg) are used to add weight and stability to the drill bit as this turns in the well bore.

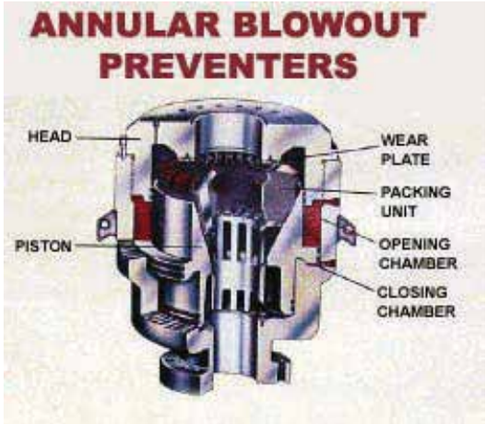
Blow Out Preventer

Towards the final stage of the drilling the Blowout Preventer (B-O-P) is installed. The BOP is fixed at the top of the well head on the sea floor. A blowout is the escape of oil and gas pressure from the seabed formations into the well bore, which if not isolated would continue to flow up the casing to endanger the platform workers, or pollute the sea. This safety device consists of BOP units which are stacked vertically on each other. The units are of different designs and equipped differently to perform separate functions. The common types are ram and annular preventers. Ram BOPs are of three types operating in a similar manner but functioning differently. All three types use 2 hydraulically actuated rams or sluice pieces that move horizontally from opposite directions. The Blind Ram consists of two rubber-lined metal sluice valves which slide in the cavity of the BOP unit and their edges butt to seal off the opening of the well bore. This is when the drill pipe is out of the well bore. The second ram type is known as the Pipe Ram. This has sluice pieces with semi-circular configuration where they butt which seals around the drill pipe. The shear ram is the third ram BOP. This has sluice pieces fitted with hardened steel shearing surfaces that can actually cut through the casing and drill pipe. This unit is activated as a last resort, reinforcing the applications of ram and annular in the event of a blowout.

The annular preventer has an elastic packing unit of donut-like rubber seal reinforced with steel ribs housed in the BOP casing. When activated, the pistons give an upward thrust which constricts the packing unit pushing it against the opening and sealing off the well bore.

Usually two or more ram preventers are stacked together topped by an annular. The entire stack is housed in a support steel frame. The assembly includes components such as electrical and hydraulic lines, control pods, hydraulic accumulators and connectors, test valve, kill and choke lines and valves. In its open position, movement is allowed of the drill string, riser pipe and flow of drill fluid through the BOP.

BOP stack of one annular unit on top of two ram typesSource: http://www.osha.gov/SLTC/etools/oilandgas/drilling/wellcontrol_bop.html



Cut-away view of annular BOP Source: http://www.osha.gov/SLTC/etools/oilandgas/drilling/wellcontrol_bop.html

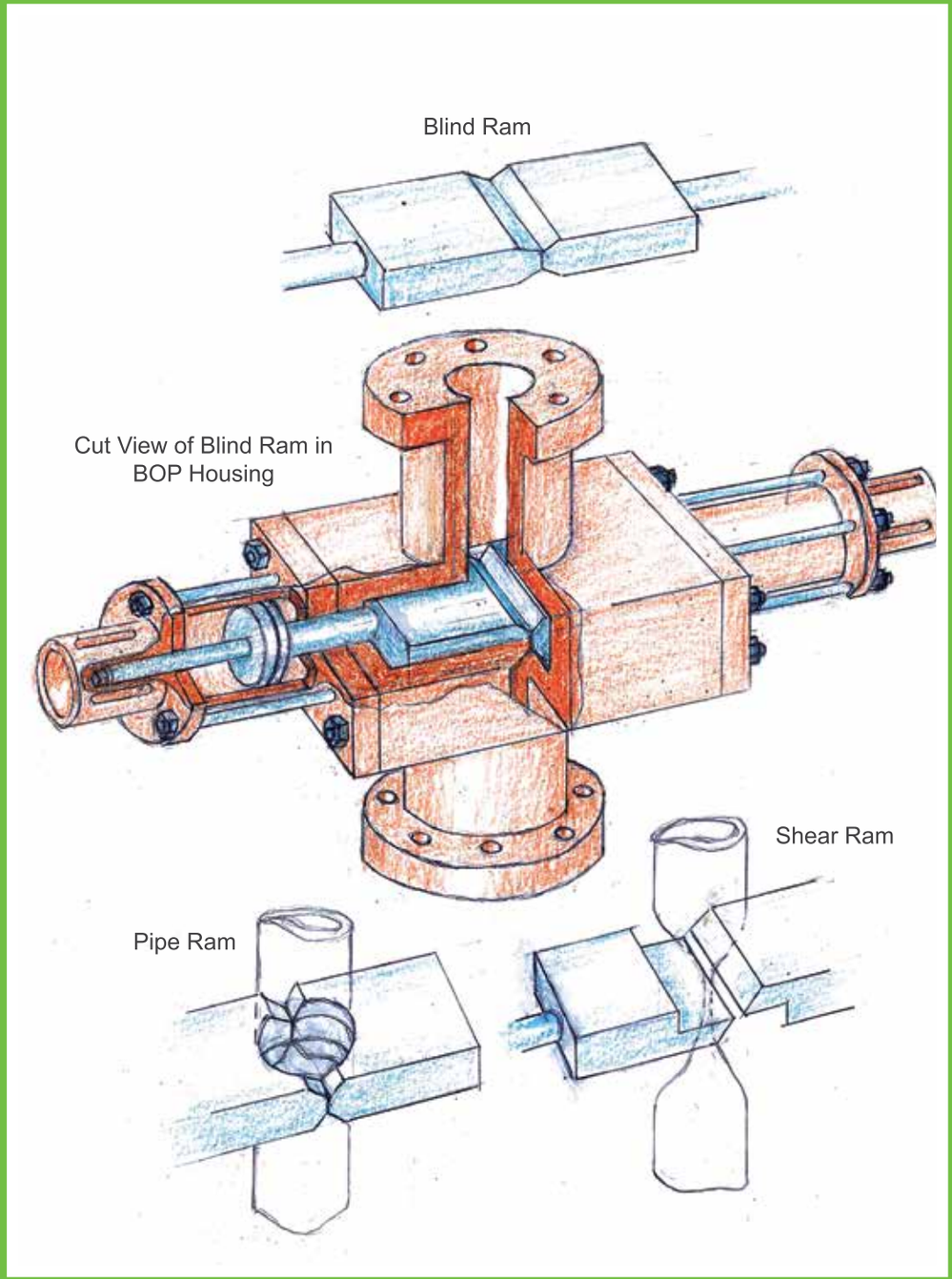


Fig 16.5 Drawing of a BOP

Actuating the BOP

The BOPs are electrically operated from separate control pods for redundancy and fail-proof design. Secondary measures using acoustic signal, ROV intervention and dead-man controls are also incorporated. Hydraulic fluid pressure for closing the ram Pumps on the rig deliver pressure to the BOP stack through hydraulic lines. Hydraulic accumulators are on the BOP stack enable closure of blowout preventers even if the BOP stack is disconnected from the rig.

Oil find

Periodically through the drilling process which may go on for weeks, samples of rock cuttings are examined and pressure reading taken to look for signs of oil find. At the discovery of positive signs the final section of casing pipe will have holes perforated to allow the flow of oil into the casing.

Completing the oil well

With the BOP in place the well is connected by a marine riser link to the platform. It is then considered complete and ready for production.

In Production

During the 7 x 24 drilling operations, the crew monitors the well for erratic pressures or 'formation kick'. The kick is a term used to describe a flow surge in well fluids which could just be water trapped in the formation reservoir being released by the drilling, coming through the well bore along with the drilling mud. It could also be gas or oil. The operators will immediately activate the BOP to prevent a blow-out. With the BOP isolated they will adjust the density of the drilling mud to counter the reservoir pressure. This is done by pumping the higher density mud down the drill string returning through the 'choke line' which bypasses the BOP to get back to the platform. Once the pressure is stabilised, drilling may resume. If the choke process fails to overcome the rising formation pressure, the 'kill' line connected to the base of the BOP stack is used which forcibly pumps very high density mud from the rig into the well and mud forcing its way into the formation reservoir to counter the high pressure there.

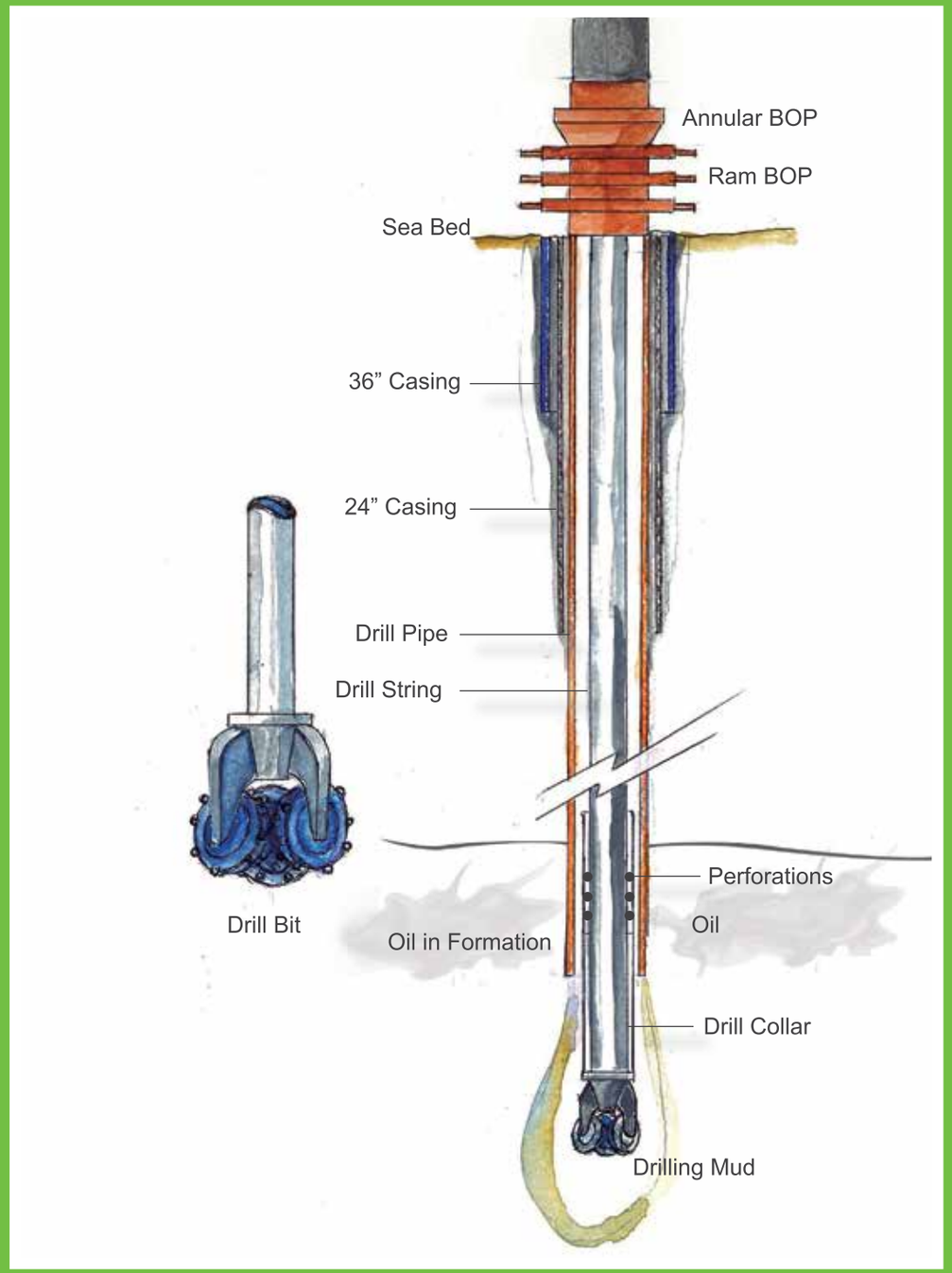


Fig 16.4 Sketch of a drill bit and well casing

What went wrong on 20th April 2010?

With the background information we may now try to briefly understand what happened at the BP oil spill disaster in the Gulf of Mexico on 20th April 2010, also known as the Macondo blow out. At that time BP, as the operator, was at the stage of installing production casing and preparing to cement this to get the well ready for the production phase. Unfortunately oil and gas found their way up the marine riser to the platform before they could be stopped. An explosion ensued and the platform was destroyed by fire. When it sank 48 hours later, oil was found to be gushing out of the damaged well head. BP reported: Fundamentally, the accident involved a loss of control over the pressure in the well followed by the failure of the well's blowout preventer, a specialized valve designed to maintain consistent conditions. After the initial explosions, the blowout preventer's emergency functions failed to seal the well, allowing the leak to occur. .Thence began the nightmare of the massive spill and the attempts at capping off the leak.

Attempts at stopping the leak

Several early attempts made by BP to stem the leak all proved unsuccessful. Attempts were first made in the use of remotely operated underwater vehicles to close the BOP. The second technique was applied early May 2010 using a 125-tonne containment dome and placing this over the leak. A syphon connection at the top of the dome was to allow oil to flow upwards to the surface for recovery. This failed when gas leaking from the pipe combined with cold water formed methane hydrate crystals which blocked the outlet. Simultaneously from early May 2010 a relief well started aiming to reach and link up with the leaking drill pipe by August in order to pump mud to overcome the pressure in the reservoir. Towards late May 2010 BP's effort to apply a process known as 'top kill' was also unsuccessful. The pressure in the oil reservoir continued to cause gushing of oil into the gulf.

Early June 2010, BP used a Remote Operated Vehicle (ROV) to cut off the riser pipe and attaché a close fitting containment cap over the leak, whilst siphoning off at the top of the cap the escaping oil into a recovery ship on the surface. This was successful in stopping over 450,000 gallons of oil a day escaping and polluting the Gulf by mid July 2010. This paved the way for BP to attempt what is known as the 'static kill'. This is a process in using a high power pump to force heavy drilling mud to overcome and force the oil back into the reservoir for cement to follow. After interruption due to the tropical storm passing through the area, in August static kill was successfully executed for the cap to be shut off.

By September 2010 one of the relief wells reached the intersection of the leaky well to allow cement to be pumped down to the bottom of the leaky well to permanently seal it off.

Environmental Impacts from an oil spill

Oil spill of any magnitude if not prevented from getting to the beaches, wetlands, and estuaries would cause damage to marine and wildlife habitats. The common methods employed to protect the wildlife environment are to contain the spill from spreading using marine floatation booms, and to recover the oil by skimming it from the water surface using a skimmer ship. Any oil escaping the boom will be dispersed by spraying with a dispersant. This latter effort is only used as a last resort to sink the pollutants and expect it to biodegrade under water. However, in the BP spill from the Macondo well, oily lumps caught in fishermen's nets and those washed up the beaches weeks later suggested that dispersing the spill was not completely effective.

Oil floats on water with part of it vaporizing leaving a sticky slick which can be widespread depending on the scale of spill. This sticky slick adheres on whatever comes in contact and is not easily washed off. This means mammals like whales and dolphins swimming near the surface will have

their blow holes coated with oil which affect their breathing. They can drown. Oily lumps which become heavy would sink to the sea floor and cover up the micro-organism living there. These suffocate and die. Fishes and other marine creatures living on the micro-organism are therefore deprived of their food. If the fishes ingest any oily deposits from the seabed, which incidentally may contain the dispersant chemicals, notwithstanding these having been approved for use, they can still be poisoned. If they survive, a channel of contaminated food chain may be in the offing, with bioaccumulation and bio-magnification of the toxins as a consequence.

Oil slicks finding its way into the estuaries and marsh land will wreck their havoc on habitats of otters and seabirds. The rising tide brings in the spill which clings to the trunks and blades of vegetation, and as the tide ebbs it leaves behind an oily carpet on the marshy grounds. The oil is absorbed into the trees which cause them to wither and die.

Fig 16.5 Sea Bird coated by oil
Source - http://www.animalsindanger.co.uk/index.htm

Amongst the mangrove trees nests are first to be destroyed and hatchlings immediately killed. Adult birds, otters and seals will have their feathers and fur coated with oil. The insulating properties of their feathers and fur are then lost and these creatures die of hypothermia in cold climate, or overheating in summer.

Even the turtle, creature of deep water, is not spared. Seasonally turtles land on the beach to lay eggs. In a polluted beach of the coast line, these turtle eggs may not hatch. Predators of turtle eggs will not be spared the effects of the oil coated shells.

If turtles from deep water are not spared, neither are the eagles from high ground. These eagles scavenged dead otters and birds on the banks. They in turn will succumb to poisoning or have their feathers coated with oil. If oil coated wings still allow the eagles to fly, they return to their roosts with their find of a poisoned chunk to feed their young. If the eagles are too heavy in oil to fly, their young would not be tended. Either way eagle chicks are not likely to survive.

The immediate effects of an oil spill on the ecological scene may be assessed by the number of dead species recovered. For example, in the Exxon Valdez spill of 1989, a total of 36,466 seabirds, 1015 sea otters and 144 bald eagles were found dead in the spill area. *(Reference: http://marinebio.org/Oceans/Conservation/Moyle/ch11.asp)* The actual number was believed to be higher because where affected wildlife died in their habitats inaccessible to people there were no means of knowing. The long term effect of the spill at Prince William Sound is still being studied. No definite finding could be established presently due to other influencing factors such as weather changes and food availability.

17. MATERIALS/SUBSTANCES HARMFUL TO ENVIRONMENT & HEALTH

In the following pages are given tables showing the various substances, their origin or production method, applications and the effects they have on our health and the environment. These substances are commonly known in the manufacturing industries, and their use has been subject to preventive control, either through legislation or voluntary measures. The list gives a quick reference for the lay persons to determine the potential environmental effects and health hazards concerning these materials/substances. This is so that where industries are slow or ineffective in switching to 'safer' production modes and selection of raw materials, consumer choice may still be exercised in contributing to a safer environment.

There will be many more substances that merit being mentioned here, as indeed the reader may eminently enlarge the list for the benefit of all, raising their awareness for the need in flagging out undesirable manufacturing practices.

And Man created the plastic bag and the tin and aluminum can and the cellophane wrapper and the paper plate, and this was good because Man could then take his automobile and buy all his food in one place and He could save that which was good to eat in the refrigerator and throw away that which had no further use. And soon the earth was covered with plastic bags and aluminum cans and paper plates and disposable bottles and there was nowhere to sit down or walk, and Man shook his head and cried: "Look at this Godawful mess."

Art Buchwald, 1970
Source: http://www.quotegarden.com/environment.html

Materials/Substance	ALKYLPHENOL ETHOXYLATE (APES)
Origin	Firstly phenols are subject to alkylation, i.e. transferring of its alkyl molecules from one group to another to become alkylphenol. This is then reacted with ethylene oxide to produce Alkylphenol ethoxylate.
Characteristics	It is a soluble liquid, almost colourless. It has a long chemical structure $C_{15}H_{24}O[C_2H_4O]_9$.
Use	APEs are synthetic surfactants used in • Detergents, such as those used for wool washing • Industrial cleaning fluids for metal finishing. • Some industrial processes, such as emulsion polymerization • Some pesticide formulations. • Lube oil, hair dyes and other hair care products.
Environmental impacts	APEs: • Do not break down effectively in sewage treatment plants or in the environment. • Accumulate where there is inadequate oxygen, e.g. in sediments. They do not biodegrade easily after they are washed down the drain. Alkylphenolic compounds taken in by living organism including fish and bird will end up with the contaminant in their organs, increasing in concentration over time to several thousand times greater than in the surrounding.

Health Effects	Human exposure to these chemicals may occur by the following routes: • Absorption through skin from shampoos, cosmetics, spermicidal lubricants and domestic and industrial detergents. • Contaminated drinking water, extracted from polluted rivers. • Inhalation and ingestion from pesticide sprays. • Contamination of food from fields spread with sewage sludge containing alkylphenols. Immediate Health Effects – if swallowed or absorbed through the skin, APEs are moderately toxic. Long-term or Delayed Health Effects - This chemical is considered an Unclassifiable Carcinogen by the World Health Organization and the U.S. Environmental Protection Agency. APEs in the forms of nonylphenol and octylphenol are suspected hormone disrupters. Hormone disruptors are chemicals that imitate our natural hormones and act to produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife.

An Unclassifiable Carcinogen belongs to Group 3 of four groups classified by IARC (International Agency for Research on Cancer). Of these –

- Group 1 is carcinogenic to humans – Substances in this Group are assessed to show enough evidence that it can cause cancer in humans;
- Group 2A & 2B substances are respectively probable and possible carcinogenic to humans;
- Group 3 substance is one for which there is no evidence at present that it causes cancer in humans.

- Group 4 substances are probably not carcinogenic to humans – as assessed to have strong evidence that they do not cause cancer in humans.

Source: IUPAC Glossary of Terms Used in Toxicology- Classification of carcinogenicity.

Materials/Substance	ANILINE
Origin	Aniline is a primary aromatic amine. It is manufactured in a 2-step chemical process involving firstly benzene being nitrated at 50^0 – 60^0C, with the aid of a mixture of concentrated nitric and sulphuric acids. Nitrobenzene so produced is then subject to hydrogenation at 200^0 – 300^0C in the presence of metal catalysts to become aniline.
Characteristics	• Aniline is a liquid • It is colourless and oily • It is a volatile organic compound (VOC) • It boils at 184^0C and melts at -6^0C • It ignites easily and burns with a smoky flame • It has a distinctive smell like rotten fish • It is toxic • It oxidises slowly forming a red-brown tint appearance after exposure to air and light • Aniline is soluble in water
Use	Aniline is used as a chemical precursor to making • Different colour dyes • Rubber • Polyurethane foam • Herbicides • Fungicides

Environmental impacts	Burning vegetation in forest fires may release aniline into the air. However, the main release is from industries using aniline in the manufacturing of other chemicals. Whilst its effect on the immediate air space is limited due to its short half-life span of up to 2 hours, as a VOC it nevertheless combines with other pollutants to contribute to a ozone destroyer in the lower atmosphere.

Health Effects	• Exposure to this toxic chemical causes
	  • Short term effects causing irritation and congestion on the mucous membrane of the upper respiratory tract
	  • Long term effects known as cyanosis which is the lowering of the oxygen carrying capacity of blood
	• Aniline is classified as a probable human carcinogen.

Materials/Substance	ANTIMONY
Origin	Antimony is extracted from its ore found in the Earth's crust. China is the world's biggest producer with 84% followed by South Africa at only 4% and others even less.
Characteristics	• Antimony is a soft metal, brittle and of shiny silver-white color. • When molten and cooled slowly, antimony crystallizes in a hexagonal cell.

Use	It is used as a flame retardant in children's clothing, toys, aircraft and automobile seat covers. To a lesser extent antimony is also used in an alloy with lead, increasing its hardness and mechanical strength.
Environmental impacts	Antimony is considered to be a Hazardous Air Pollutant (HAP) Power stations firing coal and bituminous fuels emit a small percentage of fine antimony particles

Health Effects	• Symptoms of antimony poisoning:
	  • Exposure to low doses causes headache, nausea, dizziness and depression
	  • Large doses cause vomiting, diarrhoea and abdominal discomfort
	• If left untreated, person exposed to large doses may die

Materials/Substance	AZIRIDINES (ETHYLENE IMINE)
Origin	Aziridines are monomer organic compounds with a 3-bond to one amine and 2 methylene grounps. Aziridines are produced by chemical synthesis involving several methods such as • Cyclization of haloamines & amino alcohols • Nitrene addition • Triazoline decomposition • Epoxides • Oximes

Characteristics	• Aziridines are of the following properties:
	  • Melting point: -78 ºC
	  • Boiling point : 56 ºC
	  • Flash point: -11 ºC
	  • It is miscible in water
	• It is known to be capable of permeating protective hand gloves. Care must be exercised to use gloves of suitable materials in handling aziridines.

Use	Aziridines are monomers used in the preparation of cationic polymers such as polyaziridine (polyethyleneimine). They are used as a cross-linker to improve the physical and chemical properties used in aqueous and non-aqueous coatings, inks & adhesives. The coatings are applied to wood, leather, textile and plastic films.
Environmental impacts	Its sub-zero flash point means aziridines are extremely flammable.
Health Effects	• Animals given the chemicals in laboratory tests were found to be susceptible to cancer of the liver-cell and pulmonary. • The International Agency for Research on Cancer (IARC) classifies Aziridine as possibly carcinogenic to humans. • Exposure of humans to the compound Aziridine could occur during its use in the production of cationic polymers. This could be ingested through breathing or skin contact • On exposure Aziridines cause irritation to eyes, nose respiratory tract and skin. • It rapidly penetrates the skin on contact. It causes dermatitis

Materials/Substance	BROMINE
Origin	Bromine is an element which can be obtained from seawater brines. One production source is from the evaporation pans at the Dead Sea.
Characteristics	• Bromine is a heavy reddish brown liquid • It is liquid at room temperature and highly volatile when exposed • The vapour has a sharp and unpleasant smell, hence its Greek name origin ‘bromos’ meaning stench • It is highly toxic • It is corrosive, highly reactive and produces salt when exposed to metals.
Use	• Bromine is used in an assortment of industrial compounds as organic bromines • It is used in tablet form for treating swimming pool water • Organic bromine is also used as an antiseptic agent and sanitizer • Bromine is also found in dyes, fumigants (insecticides), flame retardants on clothing and anti-knock additives with lead in automobile fuels (though these have now been banned)
Environmental impacts	Bromine being a member of the halogen group is an ozone depleting gas. The effects on the environment of bromine used in organic bromine, such as flame retardant and fumigants are being detected on the ground and surface water. The pollutants are not very biodegradable and can contaminate the food of farmland animals and fishes and other life forms in the water.

Health Effects	• Humans can absorb organic bromine through food intake, breathing and contact with the skin • Brominated flame retardant particularly polybrominated diphenyl ethers (PBDEs) are being detected in human blood and mothers' milk. • Liquid bromine is corrosive to human tissue • Bromine vapour irritates the eyes and throat • Recent reports have indicated that exposure to low concentrations of PBDE may result in irreparable damage to the nervous and reproductive systems. • Organic bromines can also cause damage to liver, kidneys, lungs and milt. They can cause stomach and gastrointestinal malfunctioning. • Some forms of organic bromines, such as ethylene bromine, can even cause cancer.

Materials/Substance	1.3 BUTADIENE
Origin	1.3 Butadiene is a by-product from ethylene and propylene manufacture in a petrochemical plant.
Characteristics	• 1.3 Butadiene is a gas which condenses at minus 4.5^{0}C • It is colourless and non-corrosive • It has a mild aromatic odour • 1.3 Butadiene has low-water solubility.

Use	1.3 Butadiene is used as a monomer in the production of synthetic rubbers and latexes, which in turn are used to make • Tyres • Plastics • Carpet and paper coatings It is also used for the production of neoprene and nitrile rubber from which gloves, wetsuits, foam, gaskets and seals are made.
Environmental impacts	When Butadiene leaks into the environment, it vapourises into the atmosphere and does not persist in it beyond two hours. It is mildly toxic to aquatic organisms but has low potential to bioaccumulate.
Health Effects	Studies on the effects of butadiene on human reproductive and developmental functions are not conclusive. However, at acute high exposure, people may expect to suffer damage to the central nervous system; have distorted blurred vision, vertigo, general tiredness, decreased blood pressure, headache, nausea, decreased pulse rate, and fainting.

Materials/Substance	CHLORINE
Origin	Chlorine is an element which has always existed on earth.
Characteristics	It is harmless when present in a compound such as sodium chloride which is common salt. When it is used in forming artificial chemical products the result has devastating effects on the environment.
Use	• Chlorine is used with other chemicals containing carbon to form organochlorines. • Organochlorines are used in solvents, pesticides, plastics, disinfectants, forms of packag ing and bleached pulp and paper products. • Organochlorines compounds had been used in Polychlorinated biphenyls, (PCBs), chlorofluorocarbons (CFCs) and DDT.
Environmental impacts	• Polychlorinated biphenyls, (PCBs), chlorofluorocarbons (CFCs) and DDT have now been banned, but their effects on the environment may still be felt through accumulation in the body-fat of fish, animals and ultimately humans, through the food chain. • In making organochlorine products, highly toxic by-products such as dioxins are inadvertently made at the same time. Dioxins accumulate in the same way as PCBs in our body fat and in the environment generally. • Major pollution problems also arise when chlorinated products such as plastics and solvents are burned or incinerated as rubbish. The resulting polluted air affects the surrounding area, falling on agricultural land and accumulating in the food chain, putting food such as dairy products at risk from high levels of dioxins.

Health Effects	Studies in the US have shown that the presence of dioxins and PCBs is linked to nervous system damage in babies, with effects on memory and co-ordination.

Materials/Substance	CHLOROFLUOROCARBON (CFC)
Origin	CFC is an organic compound that contains carbon, chlorine, and fluorine, produced as a volatile derivative of methane and ethane.
Characteristics	It is of low toxicity, low reactivity with other chemicals, and low flammability.
Use	Owing to its harmless characteristics, CFC had its popular uses as refrigerants, propellant in medicinal applications, and degreasing solvents. However, its use has now been stopped due to its harm to the environment.
Environmental impacts	Chlorofluorocarbons (CFCs), along with other chlorine- and bromine-containing compounds, have been implicated in the accelerated depletion of ozone in the Earth's stratosphere
Health Effects	These substances are considered non-toxic.

Materials/Substance	DIOXINS
Origin	Dioxins come mainly from the burning of material containing organochlorines such as PVC and wood treated with Pentachlorophenol (PCP). Note: PCP is of high toxicity and slow biodegradation. Dioxins are also by-products of chemical processes that use chlorine to produce plastics and pesticides.
Characteristics	• Dioxide oxidises at high temperature; • Production of dioxin is high at low temperature combustion, such as wood burning stoves and charcoal grill; • Dioxins are fortunately not translocated into plants, i.e. they do not move from the soil into plants; • Dioxins have low water solubility; • Dioxins do not vaporise but remain bound to particulate matters.
Use	Dioxin as Agent Orange had been cruelly used in the Vietnam War by the Americans. Agent Orange contained 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin), the most toxic of 75 different forms of dioxin.
Environmental impacts	Pollution problems occur when chlorinated products such as plastics and solvents are burned or incinerated as rubbish. The dioxins actually adhered to particles of soot and dust which are then spread efficiently into the air as the hot gases rise from the fire. The resulting polluted air affects the surrounding area, falling on agricultural land and accumulating in the food chain such as dairy products and fish in dioxin contaminated water. Dioxins taken into our system accumulate in our body fat.

Health Effects	People exposed to dioxins are at risks of a hosts of health problems such as • Damage to immune system especially in children; • Harm to liver, kidney and digestive tracts; • Miscarriage, birth defects or sterility; • Damage to nervous system; • Cancer.

Materials/Substance	2-ETHYL-1-HEXANOL
Origin	It is produced using the 3-step OXO process involving hydroformylation of propylene to N-butyraldehyde followed by an aldocondensation and reduction.
Characteristics	It is a clear, colorless liquid that is nearly insoluble in water, but soluble in most organic solvents. 2-Ethylhexanol is a combustible liquid above 60°C.
Use	It is a fatty alcohol, an organic compound primarily used in the manufacture of the diester bis(2-ethylhexyl) phthalate (DEHP), a plasticizer. It is also used as a solvent in the formation of lacquers and coatings. It is an excellent antifoaming agent for use in photographic, varnish, rubber latex and textile printing and ceramic industries.
Environmental impacts	It is a marine pollutant.
Health Effects	It causes skin, eyes and respiratory tract irritation. It can also cause nausea and headache after inhalation. If ingested it causes diarrhea and vomiting. Long-term or repeated exposure can result in dermatitis of the skin.

Materials/Substance	ETHYLENE DIAMINE TETRAACETIC ACID (EDTA)
Origin	EDTA is mainly synthesised from chemicals consisting of ethylenediamine (1,2-diaminoethane), formaldehyde, and sodium cyanide, first produced as a salt but converted in a subsequent step to an acid.
Characteristics	• EDTA is a colourless, water-soluble solid. • Contact of EDTA salt with metals such as aluminium results in generation of hydrogen gas to form an explosive hazard. • EDTA as chelating agents is not flammable, but under fire conditions, the water evaporates from the aqueous solution and the EDTA residue burns. Combustion smoke may contain toxic substances including nitrogen oxides, carbon monoxide, carbon dioxide and ammonia. • A chelating agent is a material that tightly binds or captures metal ions.
Use	• Its chelating function scavenges free metal ions makes it a useful chemical in a number of applications. • EDTA used in laundry applications softens hard water and improves the bleaching and cleansing performance of laundry water. • One industrial use is in removing residue and scale left on industrial equipment that operates under high temperature, such as boilers. • EDTA is commonly used in food and beverages as a preservative and stabilizer which protects food from discoloration and oxidation. • In medical applications EDTA is useful in treating patients with heavy metal poisoning such as mercury.

Environmental impacts	• EDTA biodegrades slowly in soil and water. However, the salt dissolves readily in water and is subject to photo degradation • At normal low levels found in the environment, there is no evidence of bio-accumulation of EDTA in aquatic organisms.
Health Effects	• EDTA is not known to cause cancer in laboratory animals. • Exposure at low concentrations affects humans causing irritation to skin, eyes, nose and lungs. No long term effects are expected provided immediate protective actions are taken. • Swallowing of EDTA in excess amounts may result in gastrointestinal irritation or ulceration and burns of the mouth and throat. Provided the person is conscious, give 240ml of water to drink and seek medical treatment immediately. • Avoid beverages with EDTA, Vitamin C and sodium bicarbonate listed in its ingredients. EDTA has a higher propensity to form benzene which is carcinogenic.

Materials/Substance	FORMALDEHYDE
Origin	Formaldehyde is a common chemical, found primarily in adhesive or bonding agents for many materials found in households and offices, including carpets, upholstery, particle board, and plywood panelling. It is also a by-product of combustion and certain other natural processes. Formaldehyde is also called methanal and is formed by oxidising methanol. Its chemical formula is CH_2O.
Characteristics	Formaldehyde is a colorless, pungent-smelling gas. It is rarely found in its original state because it has a short half-life in air. This is mainly caused by its decomposition in light to form a toxic substance. In water it is very unstable and it easily dissolves which is the form that it takes when it is transported commercially. Its melting point is -92 °C and Its boiling point is ~ 20 °C.
Use	Formaldehyde, by itself or in combination with other chemicals, serves a number of purposes in manufactured products. It is used: • To add permanent-press qualities to clothing and draperies, • As a component of glues and adhesives, • As a preservative in some paints and coating products. • As an adhesive in pressed wood applied in furniture shelving, in-door wall paneling
Environmental impacts	Dissolves in water and becomes a marine pollutant.

Health Effects	It causes watery eyes, burning sensations in the eyes and throat, nausea, and difficulty in breathing in some humans exposed at elevated levels (above 0.1 parts per million). High concentrations may trigger attacks in people with asthma. Formaldehyde has also been shown to cause cancer in animals and may be carcinogenic to humans causing respiratory system damage. For these reasons formaldehyde must not be used in air fresheners & deodorizers. Note: Singapore National Environment Agency recommends that the maximum threshold level for formaldehyde should not exceed 0.1ppm, based on *"Guidelines for Good Indoor Air Quality in Office Premises".*

Materials/Substance	HYDROCHLOROFLUOROCARBONS (HCFC)
Origin	HCFC was made intended as a substitute to CFC.
Characteristics	• HCFC possess the features and characteristics similar to that of chlorofluorocarbons, i.e. low toxicity, low flammability and reactivity. • Whilst considered to be of low flammability it is advisable to take precautions in its handling, for instance when doing welding work on the vessel of pressure which contains or has contained the mixture of any of these compounds. Under heated and high pressure conditions a rupture of its storage container can have disastrous consequence. • It is heavier than air, so when released into the open ensure adequate ventilation is provided to prevent its accumulation at the low areas around its container.

Use	Like CFC, HCFC is used for refrigeration, aerosol propellants, foam manufacture and air conditioning.
Environmental impacts	• HCFC still contain chlorine atoms, but the presence of hydrogen makes them reactive with chemical species in troposphere - the lowest part of the atmosphere. It therefore poses a smaller risk to the ozone layer in the stratosphere. However, in spite of its low concentration in the atmosphere it is still considered a greenhouse gas. Furthermore, potential effects of fluorine in HCFC on ozone destruction are being evaluated. • Production and usage of HCFC are being phased out.
Health Effects	It has low toxicity.

Materials/Substance	HYDROFLUOROCARBONS HFC
Origin	This is a compound of hydrogen, fluorine and carbon made to replace CFC and substitute for HCFC.
Characteristics	• HFC does not contain chlorine. • It is odourless and colourless. • It is not flammable.
Use	HFC is used in replacement of CFC/HCFC as propellants for aerosolized solutions and as refrigerants in cooling systems such as refrigerators.
Environmental impacts	Although HFCs are not ozone-toxic, they nevertheless contribute to the greenhouse effect.
Health Effects	No known health effects.

Materials/Substance	METHYLENE CHLORIDE, AKA DICHLOROMETHANE
Origin	• Methylene chloride does not occur naturally in the environment. • It is prepared by reacting methanol with hydrogen chloride. Hydrogen chloride gas is bubbled through boiling methanol with or without a zinc chloride catalyst. It can also be produced by passing combined methanol and hydrogen chloride vapors over an alumina catalyst at 350 °C.
Characteristics	• Methylene Chloride is a colourless liquid heavier than water • It is toxic • It is flammable • It has a characteristic narcotic odour. • It is completely miscible with almost all organic solvents but less with water. • It has excellent solvency power to most organic chemicals and materials.
Use	• Methylene chloride is used as an industrial solvent for petroleum refining • It is also used as a paint stripper. • It may be found in some aerosol and pesticide products • It is used in the manufacture of photographic film.
Environmental impacts	• It is considered as a volatile organic compound; • The environmental concerns are related to health exposure from the use of the compound in buildings.

Health Effects	• Exposure to methylene chloride is most likely by breathing contaminated air. • Exposure to high levels of methylene chloride is likely if methylene chloride or a product containing it is used in a room with inadequate ventilation. • Breathing in small amounts lead to inattentiveness and poor hand-eye coordination in performing tasks; • Inhalation of large amount of methylene chloride causes unsteady posture with numbness of fingers and toes, dizziness, and nausea. • Breathing in large amounts of methylene chloride also risks damage to the central nervous system. • Contact of eyes or skin with methylene chloride can result in burns and redness of skin.

Materials/Substance	NITRILOTRIACETIC ACID (NTA)
Origin	NTA is produced from ammonia, formaldehyde, and sodium cyanide or hydrogen cyanide
Characteristics	NTA are white odourless solids.
Use	Nitrilotriacetic acid is a chelating agent. It is used for water softening and as a replacement to sodium triphosphate in detergents, and potassium triphosphate in cleansers. However, it is not deemed suitable for the environmental and health effects as listed below.

Environmental impacts	It has an adverse environmental impact because of its chelating characteristic which causes metals that have already settled out to be re-mobilized back into the liquid waste stream in wastewater treatment plants.
Health Effects	• NTA is irritant to eyes, lungs and skin when contacted. • NTA is classified as a possible carcinogen. • It may be toxic to kidney. Long term exposure could lead to organ damage.

Chelating

Chelating is the process of using an organic molecule to ‘claw’ or grab a metal ion and firmly hold it in a ring structure.
One chelating agent applied in soap and detergent is ethylenediaminetetraacetic acid (EDTA). EDTA chelates calcium and magnesium in hard water which interfere with the cleaning action. EDTA binds to the metal ions and prevents them re-settling back onto clothes.

EDTA is often used for treating heavy metal poisoning in a person. This is given to the patients intravenously so that it can circulate in the patients’ bloodstream to sequester the metal for the chelate to be eliminated by the body.

Materials/Substance	PHOSPHATE
Origin	This is a natural resource which is mined from phosphate rock deposits from around the world.
Characteristics	Phosphate is non-flammable.

Use	• Phosphate is mainly used as a fertilizer • Phosphate used in detergents softens hard water, increases its alkalinity and helps to suspend dirt in water after it has been removed from the clothes or dishes or hair being washed.
Environmental impacts	The fertilizing ability of phosphate causes algal bloom in the water. Algae have detrimental effects on aquatic life because it takes up oxygen as well as all the nutrients and deprives other living things of the oxygen and food to survive.
Health Effects	• Contact may cause eye irritation and prolonged contact with skin may cause some irritation. • If it is inhaled, it may cause irritation of the nose and upper respiratory tract with sore throat and coughing. • If it is ingested in small quantity it is not likely to cause toxic effect. Large quantities may give rise to gastro-intestinal disorders. • No adverse chronic health effects are known.

Phosphate quarry
Source: John Matel

Materials/Substance	PHTHALATES, such as • n-butyl benzyl phthalate (BBP) • Di-n-butyl phthalate (DBP) • Di-ethylhexylphthalate (DEHP) • Dibutyl phthalate (DAP) Phthalates are a class of widely used industrial compounds known technically as dialkyl or alkyl aryl esters of 1,2-benzenedicarboxylic acid.
Origin	Phthalates are produced by the reaction of phthalic anhydride with appropriate alcohols from methanol up to isodecanol (C_{13}), in the presence of concentrated sulphuric acid as a catalyst. The different alcohols determine the type of phthalates being produced. There are many phthalates with many uses. Each has its toxicological properties.

Characteristics	Phthalates evaporates from the product it is mixed with. Over time in the environment leaching also releases it to become a pollutant with health risks. The upholstery and dashboard in cars especially when they are new, present an undesirable condition that car owners may be ignorant about. They would sense a peculiar smell distinct of the car's newness. This smell is the phthalates which emit from the upholstery, especially after the car has been left for a few hours in the hot sun. Unfortunately the unwary driver and his passengers may become exposed to the vapour in the 'indulgence' of the smell of a new possession, without realizing its harm potential. If the car is not driven but left idle over night, it cools down allowing the vapour to condense out of the inside air of the car to form an oily coating on the windshield. The evenly spread stain left on the windscreens ought to prompt car owners at this time of the unwelcome trace evidence of pollutant in the confined atmosphere of their new car!

Use	• Phthalates, or phthalate esters, are mainly used as plasticizers which soften plastics and make them flexible for their applications. For example, when added to PVC it increases the flexibility, transparency, durability, and longevity of the material.
	•
	• The types of phthalates and their different uses are as follows:
	  • BBP – used as a plasticiser for polyvinyl and cellulosic resins.
	  • DBP - used as plasticizers for a wide variety of applications, such as cosmetics, safety glass, insecticides, printing inks, paper coatings, adhesives, elastomers (rubber like properties) and explosives. It is used as a solvent in polysulfide dental impression materials, solvent for perfume oils, perfume fixative, textile lubricating agent and solid rocket propellent.
	  • DEHP - used as a plasticizer for resins, elastomers and PVC used in making medical devices. It is a solvent in erasable ink and dielectric fluid. It is also used in acaricide, an agent used in the orchards for killing mites. DEHP is also used as a component in cosmetic products.
	  • DAP – used as a plasticizer for PVC and cellulose esters. It is also used in place of styrene to make GRP products with greater heat resistance than styrene-based materials.

Environmental impacts	Phthalates move to the surface of plastics from which they evaporate or leached into the environment. This phenomenon is due to there being no molecular bond between the phthalates and plastics in which they are mixed. As plastics age and break down, the release of phthalates accelerates. This weakens the plastic which become brittle. Phthalates in the environment are subject to biodegradation, photo-degradation, and anaerobic degradation; therefore, in general, they do not persist in the outdoor environment. Outdoor air concentrations are higher in urban and suburban areas than in rural and remote areas
Health Effects	• Exposure at high levels causes cancer • Occupational exposure to phthalates such as dibutyl phthalate (DBP) and diethylhexyl phthalate (DEHP) leads to adult infertility. • Latest studies also indicate sperm DNA damage • Other health issues cited were diabetes and obesity.

Note: Use of DEHP, BBP and DBP are being banned by the European Commission from 2011.

Cosmetics

Soft plastic toys

Materials/Substance	PENTACHLOROPHENOL (PCP)
Origin	PCP is produced by the chlorination of phenol in the presence of a catalyst such as anhydrous aluminium or ferric chloride, at a temperature of up to approximately 191 °C. The product purity achieved through this mode of production is only 84 – 90% due to incomplete chlorination.
Characteristics	• Pure pentachlorophenol consists of light tan to white, needle-like crystals. • It has a pungent odour when heated. • It is relatively volatile even at ambient temperature. • The substance decomposes on heating in the presence of water, forming corrosive fumes (hydrochloric acid). • Pentachlorophenol is non-flammable and non-corrosive in its unmixed state, whereas its solution in oil causes rubber to deteriorate. • Formulated products may be flammable.
Use	PCP is a chlorinated hydrocarbon insecticide and fungicide. Owing to its high toxicity, PCP is banned in some countries and not available to the public. However, it is still in use under control by the authorities in the treatment of utility poles and railroad ties, in protection against fungal rot and wood-boring insects.
Environmental impacts	PCP will leach from treated wood, evaporate from treated surfaces and may get into waterways. PCP in the water leads to the widespread contamination of all environmental sectors. It is highly toxic to aquatic organisms affecting worms, fish and algae even at concentrations of PCP below 1 mg/l.

Health Effects	Contact with PCP vapour through inhalation can irritate the skin, eyes, and mouth. Short-term exposure to large amounts of PCP can be harmful to the liver, kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract. The person may experience symptoms such as elevated temperature; profuse sweating, uncoordinated movement, muscle twitching, and coma. Long-term exposure to low levels particularly in the workplace can cause damage to the liver, kidneys, blood, and nervous system. Exposure to PCP is also associated with carcinogenic, renal, and neurological effects.

Materials/Substance	POLYBROMINATED DIPHENYL ETHERS (PBDES)
Origin	There are 3 groups of PBDEs identified under deca, penta and octa formulations. Of these, production of penta and octa formulations has been discontinued since 2004. Production of DecaBDEs continues as a chemical additive.
Characteristics	Under sunlight PBDEs breakdown into penta and tetra forms which become environmental concerns. PBDEs are persistent, fat soluble and have toxic properties.
Use	It is used as a flame retardant used in paints, computer and television cabinets, electronics, fabrics, reinforced plastics and polyurethane foam. PBDE is mixed into the product to raise their flammability temperature.

Environmental impacts	PBDEs is a brominated flame retardant which evaporates from the products in which it had been added as an additive. It is persistent and does not breakdown readily. It biomagnifies and bioaccumulates in fatty tissues of living organism.
Health Effects	The ubiquitous PBDEs with its tendency to bioaccumulate and biomagnify pose serious health threats, especially for personnel in manufacturing, recycling and repair plants of PBDE-containing products. People are also exposed to these chemicals in indoor dust at home because of its prevalent application in common household items. Exposure to PBDEs may be from evaporation when TV and computer sets get heated up during operation, or even when people are sleeping on mattresses. Due to bioaccumulation, PBDEs have been found in food such as salmon, beef, butter and cheese. PBDEs are being detected in human blood and mothers' milk. It is feared that PBDEs are carcinogenic, cause thyroid problems, low fertility and neuron-developmental effects.

Materials/Substance	POLYCARBONATES
Origin	Polycarbonate is produced through a multistage synthesis with several components; firstly with bisphenol A and the aid of sodium hydroxide, then through reaction with phosgene for the end product.

Characteristics	• Polycarbonates are thermoplastics • They are easily moulded and formed without cracking or breaking unlike most other thermoplastics • It has high impact resistance but scratches easily unless given a hard protective coating • Compared to glass, it has higher transparency property, lower glass transition temperature of about 150^{0}C • It is light in weight relative to like materials such as glass and acrylic • It is a good electrical insulator with heat and flame resistant properties
Use	• Electrical and communication hardware • Automotive exterior components • Construction materials for roof and sound walls (noise barriers) • CD and DVD blanks • Food containers, drinking bottles and glasses • Safety eye glasses • Bullet proof windows
Environmental impacts	Polycarbonates are recyclable. It does not decompose in landfill. In combustion it also does not emit harmful substances..
Health Effects	Polycarbonate containers are believed to be incompatible with Sodium hypochlorite bleach and some types of cleaning fluids such as ammonia, acetone which leach bisphenol A off the container. Alcohol is the safer cleanser for removing grease and oil from polycarbonate. Health effects of bisphenol are a controversial issue. Studies indicate that the amount released from polycarbonate containers/bottles is too little to be of concern.

Materials/Substance	POLYCHLORINATED BIPHENYLS, (PCBS)
Origin	Polychlorinated biphenyls are man made chemicals that became available only from the 1900s.
Characteristics	• PCBs are available as oily liquids or solids • They are of clear to yellow colour • They have no smell or taste • They are not flammable • They have high resistance to current • They have good insulating properties • They are a stable material and is resistant to high temperature and pressure
Use	• Its high electrical resistance and good insulating properties made PCBs most suitable as dielectric fluids and as insulators for transformers and capacitors • Its low reactivity to temperature and pressure changes made PCBs suitable as hydraulic fluids, heat transfer fluids, lubricants and plasticizers • The use of PCBs has been banned since the late 1970's. However, it might still be in use in pre-1970s products

Environmental impacts	The production and use of PCBs have been banned since 1977. The risk of an environmental incident due to PCBs remains due to its existence and use in equipment of the pre-1977 vintage. Release into the environment can still occur through spills and leaks from such equipment. It could also be caused by irresponsible and ignorant improper disposal and storage. Once in the environment, PCBs travel long distances and they bind strongly to soil and sediment so they are not biodegradable. The higher the chlorine content in the PCB, the more it is stable. In spite of the ban PCBs have been found in air, water, soil, and sediments throughout the world.
Health Effects	• People are exposed to PCBs by eating or drinking contaminated food and water. • As PCBs are bio-accumulative in the body fat of fish and animals, it can expose humans to a high level of health risk through the food chain • It can also enter our body through breathing or skin contact • Studies of animals have shown that PCBs can affect their immune, endocrine and reproductive systems. Some animals also developed cancer. However, it is not certain that humans would be similarly affected.

Materials/Substance	POLYURETHANE
Origin	Produced by a catalytic chemical reaction process combining di-isocyanate and diol (glycol). Depending on the different di-isocynates and diol constituents, as well as use of additives, the product may assume the form of a liquid, solid or as foam.
Characteristics	Polyurethane is immensely versatile and flexible. It is resilient and durable. It may be made hard, soft, spongy, bouncy and sticky. It can take the place of wood, metal, rubber, glue and even cotton. It is combustible, decomposing at about 240^0C
Use	It is used in various products including upholstery, car seats, hard plastic parts of equipment, automobile suspension bushings, adhesives, sealants, gaskets, rigid foam insulation panels and many others.
Environmental impacts	Decomposition of polyurethane, such as in a fire, can produce isocyanates, carbon monoxide, oxides of nitrogen, and hydrogen cyanide. It is therefore hazardous to firemen who should be protected with positive air breathing apparatus when tending to such fire.
Health Effects	Polyurethane polymers can cause irritation to the eyes, chest tightness and difficulty in breathing. The isocynate compounds in polyurethane are classified as potential human carcinogens.

Materials/Substance	POLYVINYL CHLORIDE (PVC)
Origin	Manufactured through the synthesis of Ethylene Dichloride and Vinyl Chloride.
Characteristics	• Biologically and chemically resistant, useful when corrosion is a problem to metal pipes. • 3rd largest produced plastic, after polyethylene and propylene. • Can be made softer and more flexible by the addition of plasticizer such as phthalates.
Use	• Clothing, e.g. rain coat; • Upholstery, • Hoses and tubes, • Flooring and roofing membranes, • Electrical insulation

Environmental impacts	• The production of PVC constitutes considerable environmental impact as hazardous organochlorine by-products are released into the environment throughout the different stages of manufacturing.
	• From the synthesis of its feedstocks Ethylene Dichloride (EDC) and Vinyl Chloride (VCM), to the use of phthalates (to soften the hard and brittle PVC plastic) and metal stabilizers (to extend the life and applicability of the PVC), environmental hazards are encountered:
	  • Synthesis of EDC & VCM releases large quantity of chlorine into the atmosphere
	  • Use of phthalates – these are moderately persistent and bioaccumulative. They leach out and vaporize from the PVC.

Health Effects	Vapour from phthalates used in PVC pose considerable health hazard, risking damage to the human reproductive system.

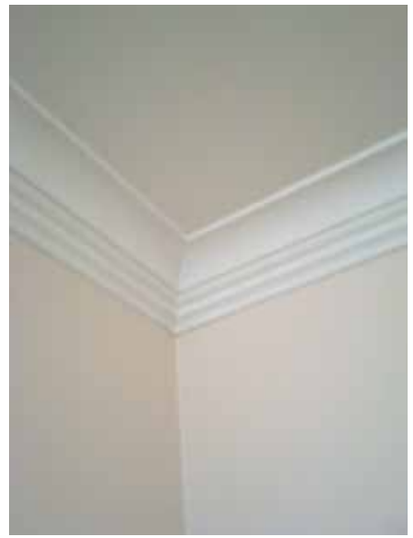
Distinguish between PU and PVC

How does one identify between these two materials when they can both be used in manufacturing a range of similar products? Common of these are pipes. PU is used in pipes that need to be resistant to gasoline and petroleum-based products, whereas PVC is commonly applied in plumbing.

In appearance, PVC tends to be opaque, lightly coloured, white and cream or a light grey. PU tends to be translucent and brightly coloured. The latter also bends easily and returns to its original length when released. PVC is rigid and bends only when heated but would be hard again upon cooling down.

In furniture upholstery application, PU is fixed to a layer of thin leather back and its surface stamped to look like real leather. The product feels soft with a texture quite like good real leather. PVC made the same way against cotton or polyester backing, however, does not feel as good.

PVC pipes



Polyurethane moldings for ceiling cornice

Polycarbonate water bottles

Materials/Substance	TAR OILS (BENZO [A] PYRENE)
Origin	Benzo [α] pyrene is a well-known polycyclic aromtics hydrocarbon (PAH) found in tar oils. It occurs as a product of incomplete combustion of organic materials
Characteristics	• It is colourless; • It is a solid or crystal at room temperature; • It may react violently with oxidising agents; • It emits toxic and irritating fumes on decomposition.
Use	Tar oils used for wood preservation. However, its use has to meet the maximum limit in benzo [α] pyrene content.
Environmental impacts	It is environmentally hazardous manifesting as a persistent organic pollutant, slow to degrade in the environment.

Health Effects	Exposure is by inhalation of polluted air, or by ingestion through drinking of contaminated water, or eating food containing minute quantities of benzo [α] pyrene. Occupational exposure may occur in tar production plants, coking plants, coal gasification sites, bitumen and asphalt production plants, road and roof tarring operations. Long term exposure can cause a decrease in lung function, chest pain & irritation. Long term skin contact can cause dermatitis and warts. Benzo [α] pyrene is probably a lung and skin carcinogen to humans.

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