DIECTORATE OF DISTANCE EDUCATION
AND
CONTINUING EDUCATION

WASTE TREATMENT

M.SC. ENVIRONMENT STUDIES

அறிவே அனைத்தும் ஆற்றலும்
KNOWLEDGE IS POWER

MANONMANIAM SUNDARANAR UNIVESITY
TIRUNELVELI

Contents **Page No.**

WASTE TREATMENT

Syllabus

UNIT I :

Solid Waste : types, sources, physical characterization, chemical composition collection methods quantitative assessments hauling precautions, transit points, sampling procedures qualities of hazardous wastes and precautions, leachate problems. Vectors, hog feeding

UNIT II :

Liquid wastes : sources, quantification characterization – cationic and anionic components-BOD, COD, CN ratio. Wastes load, impacts on lands, drinking water.

UNIT III :

Waste treatment : minimazation, zero discharge. Process modification, Anaerobic and aerobic decomposition pathways, coagulation flocculation, sedimentation, maturation. Sterlization, incineration.

UNIT IV :

Resource recovery : rag picking, composting, vermicomposting, mushroom culture, fish culture, algalculture, waste heat extraction

UNIT V :

Chosen treatment designs : Compost pits, mushroom sheds, sewage farm designs, filter systems, flash mixers, contact filters, fabric filters, trickling system, settling tanks, Biogas plant; Incinerators.

WASTE TREATMENT

UNIT – I

SOLID WASTE TYPES, SOURCES, PHYSICAL AND CHEMICAL CHARACTERIZATION

A waste can be defined as a wrong thing in the wrong place at wrong time. "Solid waste" is the term that denotes non liquid wastes arising from domestic, trade, commercial, agriculturals and mining activities. The recovery of solid urban waste certainly has the potential to contribute to solutions of twin problems namely disposal and unemployment. Many materials are categorized under the broad heading viz., "Solid waste". The urban solid wastes can be considered to incorporate three categories namely Domestic or household refuse, institutional waste (arising from schools, hospitals, universities and offices) and commercial waste arising from restaurants, hotels, markets, agricultural and industries.

Municipal refuse can be divided into two types organic or biodegradable, non organic or non biodegradable waste. Organic waste includes kitchen waste, food left mess, rotten fruits, vegetables, vegetable peelings, straw, hay, garder trimmings, crop residues, rags, paper, animal excreta, bones and leather. Typical industrial organic wastes include coffee husks, tea waste, coconut wastes, pressmud, sludge and saw dust. The non organic components of solid waste include Ash, stone and bricks, demolished wastes, coal, glass, plastics, rubber, ferrous and non ferrous metals. It is to be notes that nearly 75% of urban solid waste comes from domestic sources, 15% from commercial and industrial sources and the rest from industrial sources. This clearly shows that the bulk of organic wastes is generated from household which constitutes an invaluable source for recovery because of its huge quantity, easy collection (since it is stored in bins at particular locations) and unlikely to be contaminated. An important difference between the urban waste generated by low income industrialized countries is in the percentage of organic material. In industrialized countries, 20.50% of the urban waste is organic compared to 40.85% in low income countries. The abundant organic waste in less developed countries could therefore form an important source for recovery. The following table I gives the composition of municipal refuse generated from low-middle and high income countries.

Table-I Patterns of Municipal refuse quantities and characteristics of low-middle and high income countries.

	Low	**Middle**	**High**
Waste generation (kg/capital/day)	0.4 – 0.6	0.5 – 0.9	0.7 – 1.8
Waste density (wet wt basis kg/m^3)	250 – 500	170 – 330	100 – 170
Moisture content % wt at point of generation	40 – 80	40 – 60	20 – 30
Composition % by wet weight			
Paper	1 – 10	15 – 40	15 – 40
Glass, ceramics	1 – 10	1 – 10	4 – 10
Metals	1 – 5	1 – 5	3 – 13
Plastics	1- 5	2 – 6	2 – 10
Leather, rubber	1 – 5	__	__
Wood, bones, straw	1 – 5	__	2 – 10
Textiles	1 – 5	2 – 10	2 – 10
Vegetables / Putrescible	40 – 85	20 – 65	20 – 50
Miscellaneous inert materials	1 – 40	1 – 30	1 – 20
Particle size (mm)	5 – 35	__	10 – 85

It can be seen from table-I that the municipal refuse generated in the three groups of countries differs in their physical characteristics. The mostly organic waste generated in low income countries has a higher moisture content and waste density, making it heavy and unsuitable for incineration or for long distance transport and it contains substantial amounts of dust and dirt, giving relatively small particle sizes. In choosing appropriate methods of treatment, the composition and characteristics of waste must be taken into account as well as access to households, traffic conditions and land availability.

PHYSICAL AND CHEMICAL CHARACTERISTICS

The aim of solid or liquid waste treatment is removal of pollutants from such wastes to the extent necessary to achieve the desired quality in the effluent. The characteristics of importance in establishing waste quality are the following physical characteristics.

Suspended solids

Suspended solids are those removed in filtration through a standardized fine medium. They are classified into two types viz., fixed and volatile. The later being organic are more amenable to biological degradation or incineration. The fixed solids may be settleable or non settleable. The former can be removed by introducing the wastes in sedimentation tanks whereas the later require some additional treatment biological or chemical to remove them from waste waters. The suspended solids content is important in design and disposal because it determines the sludge handling requirements of the treatment plant that includes dewatering and drying as well as for its final disposal. Total suspended solid contents vary from 600-800 mg/l in waste water.

Dissolved solids

These are the solids in the filtrate obtained after removal of suspended solids. Dissolved solids are important wherein waste waters are to be reused after treatment. Dissolved solids vary between 275 – 675 mg/l.

pH

The pH is a measure of a acidity or alkalinity which indicates whether there is need for pre treatment. The pH of the domestic sewage is nearly neutral and that of industrial waste acidic or alkaline. Generally speaking pH of domestic sewage is nearly neutral.

Dissolved oxygen

The Dissolved oxygen can be important in the operation both of sewerage system and of treatment plant. Water supplies are normally saturated with oxygen but this becomes depleted fast with addition of organic waste/as BOD level i.e. biological oxygen demand level increases.

CHEMICAL CHARACTERISTICS

Nutrients

Waste waters contain significant concentrations of nitrogen and phosphorus – the building blocks of living organisms resulting in what is called eutrophication. Where wastes are to be discharged into relatively clean water bodies such as lakes or estuaries these nutrients may enrich such waters to the extent the excessive algal growth will be stimulated and water bodies will be subsequently harmed due to eutrophication.

Biological Oxygen Demand

* BOD- BOD is the amount of dissolved oxygen (DO) consumed by micro organisms for the biochemical oxidation of organic and inorganic matter. The sample must be diluted if the BOD exceeds 8 mg/l. The BOD is a measure of organic matter persent in waste water. It is also referred to as biochemical oxygen demand. BOD is an indicator of waste water quality. The more the BOD value the lesser will be the waste water quality. In general the degree of treatment to be provided for waste water is selected based on BOD level of sewage or any such type of waste waters so that BOD level is reduced in receiving waters below that of the waste water BOD level (8.0 to 10.00 mg/l) necessary to enable the best use made of them. BOD value varies from 280 – 340 mh/l.

Chemical Oxygen Demand

* COD – COD is the amount of oxygen necessary to oxidize the organic carbon completely to co_2 and H_2O and ammonia. COD is defined as chemical oxygen demand is also a measure of the strength of waste waters. It is a measure of the oxygen requirements of a sample under prescribed conditions as determined by using chemical oxidant. This is particularly useful when industrial wastes are concerned.

BIOLOGICAL CHARACTERISTICS

The indicator organisms include *Escherichia coli* which originates in the intestines of warm blooded animals. They provide presumptive evidence of the presence of pathogens both bacterial and viral. Since human faces contain about 1×10^2 coliform organisms per capita per day, all sewage is heavily contaminated with these organisms. MPN value of coliform organisms range from $0.5 – 3.0 \times 10^3$.

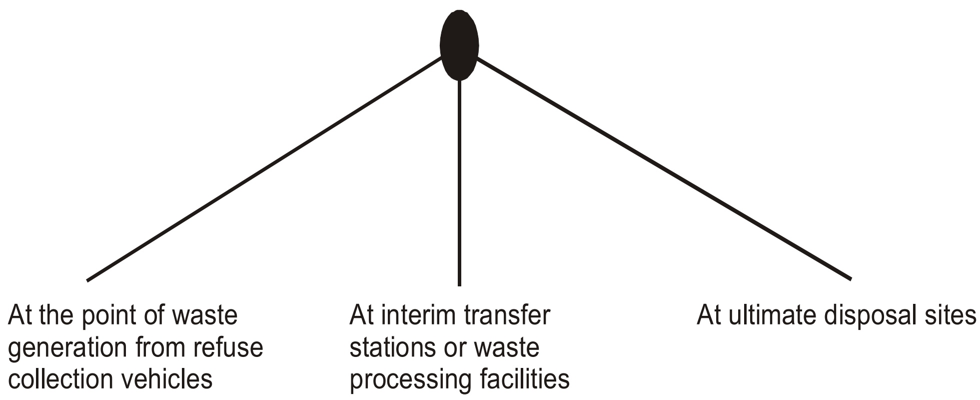
The aim of waste water treatment plant design is the removal of pollutants from waste water to the extent necessary to achieve the desired quality in the plant effluent. In order to determine the degree of treatment required and is necessary to know the quality of raw waste waters to be expected at the treatment facility.

SOLID WASTE COLLECTION AND SORTING

In low income countries municipal solid waste consists predominantly of organic materials. Because of its bulk, the transportation of municipal waste to land fills is expensive, so that recovery activities that reduce the volume of organic urban refuse represent attractive alternatives.

Before organic waste can be used, it needs to be collected and sorted out. There are several points within a solid waste management system where wastes can be retrieved for recovery : at source, i.e. at the point of waste generation : at designated pick up points (usually along the street) from refuse collection vehicles; at interim transfer stations or waste processing facilities and at ultimate disposal sites.

Waste collection points at the source (3 points)



In many countries waste is collected from all of the above mentioned points or collection centers either by municipality or by informal scavengers – all play vital roles in waste collection treatment and disposal of wastes. More and more, approaches to the development of sustainable solid waste management systems are attempting to include the informal sector and to focus on the community level. This chapter deals with some sociological and organizational aspects of collections and treatment at neighborhood level. Separation of different categories of waste improves the quality of end products as well as working conditions of the labourers.

Separation at source

The growing amounts of non-organic material in waste have made many farmers reject urban wastes as soil conditioner. In many parts of Asia, for e.g., the presence of thin plastic bags in waste has reduced the quality of compost. In mechanical composting systems the plastic bags frequently cause operating materials in compost may also cause problems. For e.g. broken glass can cause injuries while handling the wastes whereas hazardous wastes may prove to be toxic to the soil when used as compost.

The separation of waste at source has been defined as setting aside recyclable waste materials at their point of generation for segregated collection and transport to the secondary materials dealer, or to specialized waste processing sites for recycling or final manufacturing markets. In economically less developed countries, the major benefit of waste separation at source would be the retrieval of valuable items such as bottles and plastic from the valueless fraction before they enter the mixed stream. Scarcity of these products and marginal incomes encourage reprocessing activities and direct reuse. The practice of retrieving valuable items from waste is actually widespread in low income countries – whereas the separation of waste into organic and non-organic fractions is gaining ground – for environmental and health reasons, and in particular to improve the quality of compost. Systems are now introduced specially for this purpose. After separation of amalgamated wastes into organic and non-organic – the wastes can be further sorted to retrieve items such as glass, paper, plastics, used batteries etc.

Separation of wastes at source is an environmentally sound option and a technically cheap procedure. However, a number of logistical problems need to be addressed, both at the household and municipal level. In hot climates the storage of waste can be a problem within the household. As the organic fraction rots in can cause unpleasant odours and attract insects and rats. In such cases special attention should be paid to cleaning the storage bins and for frequent collection. Other precautions include wrapping of food left mess in paper, recycling of dry organic material and rejection of meat and fish left mess.

HAZARDOUS WASTES, QUALITIES AND SAMPLING PROCEDURES AND PRECAUTIONS

The most important feature of industrial and mining wastes is that a significant proportion is regarded as hazardous and as such, requires special treatment and disposal. The hazardous wastes arise from process industries, the main sources being chemical sector – which requires special treatment and disposal. Hazardous wastes arise not only as by products of industrial processes but also when consumes discard empty chemical packaging and other items at the end of their useful life. Radioactive wastes arise derived from military sources and a variety of uses in medical, industrial and university establishments. Biomedical waste refers to any waste that includes anatomical waste, pathological waste, infections waste, etc.

It is recommended that the colour coding system to adopted so that all biomedical waste can be immediately identified. The use of the colour – dose should be exclusive to biomedical wastes to preclude public exposure during general purpose disposal.

Characteristics of hazardous wastes

1. Reactive and irritating – e.g. explosive, tear gas etc.
2. Ignitable – flammable or combustible material
3. Corrosive
4. Radioactive
5. Dangerous
6. Poisonous
7. Organic peroxide
8. Explosive
9. Oxidiser

Sampling procedures, transport and precautions

Ensuring the safe transportation of hazardous materials is a complex activity. The accidental release of hazardous materials posses serious threat to human safety and property and to the environment. The classification of a hazardous substance affects packaging, marketing, labeling and placarding.

Reconditioned Drums

Hazardous wastes are accumulated in drums and containers. Historically these waste drums have been stored to corrode and pose a threat to human health and environment. Any wastes in drums that are either damaged or leaking must be recontainerised. The drum reconditioning industry uses hazardous waste to industry as a potential source of drums.

Bulk Transport

Cargo tanks are the main carriers of bulk hazardous materials are the roads – cargo tanks are made up of steel or aluminium alloy but can be constructed of other materials too – such as titanium, nickel or stainless steel – size varies from 4000 – 12000 gallons. The life of cargo tank is 20 years and beyond.

Rail Transport

The two major types of rail tanks are pressure and non pressure (for transporting gases and liquids) 90% made of steel followed by aluminium.

Water Transport

The largest bulk containers are ships, tankers and tank barges – all of which represent 91% of all marine shipping of hazardous materials. Tank barges range from 300000 – 600000 gallons – tankers 10 times larger than this. More than 90% of the tonnage in bulk marine transport consist of petroleum products and crude oil.

Non bulk Transport

Materials used in non bulk transport include fibre board, plastic, glass, fibre glass and metal. Combination containers i.e. packaging within packages – for e.g. glass bottles in fibre board boxes – are used. Composite packaging can be used for multi wide waste.

LEACHATE

The proper design of a landfill ensures an operation that protects the public from leachate, fires, odors, insects, and rodents. There are numerous technologies and techniques that are available to minimize the risk to the environment and human health. All residues that must be landfilled should be studied in order to optimize the properties of the waste and minimize its ability to migrate should the landfill begin to leak.

From a design and engineering perspective, the hydro geological characteristics of the site are the first important parameters to be considered. These characteristics include the proximity and quality of the groundwater and its depth flow rates and the withdrawal rates of the nearby users of that resource. Major geological features of the site, including faults, should be identified; these features should be seriously considered in devising plans to reduce the risks of leakage from the landfill. The landfill should also be designed in such a way as to prevent runoff from either storm water or accidental spills.

The site topography, along with surface water and climatic conditions and soil characteristics, must be incorporated into the landfill design. A major concern might be potential contamination of a nearby aquifer should the TSD facility begin to leak. The possibility of leachate from the landfill contaminating an underground aquifer will aways exist. Should the leachate escape from the landfill, a contaminated groundwater plume could develop that would adversely affect the health of nearby residents who may be using the local aquifer as a drinking water source. In order to monitor the landfill site for possible leakage, the general site requirements should include observation wells in aquifers and surface monitoring on land and waterways that are in the vicinity of the landfill site. Sufficient monitoring devices up-gradient from the site are necessary to provide baseline data for later comparison with down-gradient monitoring.

The individual containment cells must be properly sized, and appropriate quantities of soil cover must be made available to minimize leachate formation and transport through the landfill.

Wastes which may be either reactive or water soluble will tend to migrate downward through the landfill as leachate. The amount of leachate produced in a landfill is highly dependent on the amount of water that infiltrates through the soil cover and the hazardous waste layers. This quantity of leachate could be further increased if the hazardous wastes have substantial moisture content. The leachate from this water migration will contain a wide variety of chemical and biological constituents. Because of the variety to predict all of the chemical reaction products that may be produced in a TSD facility. For example, both organics and inorganics may be subject to oxidation, reduction, combination, and decomposition reactions involving landfill constituents. Complicating these reactions is the biological activity occurring on-site that will differ from landfill to landfill. The landfill pH and temperature will be important parameters in determining both the biological and chemical reaction rates; as such they can help determine both the rate of production and the complexity of the hazardous leachate produced. The use of sorbents, cement and other types of fixation materials should minimize the release of hazardous material from landfills.

In order to protest against leakage from the landfill, any leachate must be collected and treated so as to render it environmentally safe. Proper design of the leachate collection system is necessary to ensure that it can handle the anticipated volumetric form of contaminated liquids. The surface runoff, which would be primarily from rainfall, must also be collected. The treatment of all surface runoff and underground leachate must then be designed so as to permit their discharge in an environmentally acceptable manner.

VECTORS

There are number of hazards – such as pathogenic organisms, insects, rodents, birds, airborne litter, fire and water pollution – which have to be controlled in a sanitary landfill.

Insects

The main source of insects will be the eggs of flies which have been deposited in the wastes before they arrive at the site. Most of these will be buried deep in the wastes and will succumb to the temperature increase. Near the surface, however, the rise in temperature will not be so great and the eggs will hatch into larvae; only the provision of any adequate layer of suitable covering material, well compacted, will prevent their emergence and pupation. It is the importance of providing an effective barrier of this kind which has caused the British Government to recommend a covering thickness of 25 cm. Another obvious advantage of covering is that it denies access to the wastes to flies that are already at the site and thus avoids a major problem of open dumping; continuous cycles of bredding in exposed wastes at the site.

Birds

Birds are normally attracted to landfill sites and may cause risk to aircraft it there is an airport in the vicinity. This problem is exacerbated. If the birds have routine flight path between the sanitary landfill site and another source of attraction, such as a body of water, and their flight path crosses the approaches to a landing ground. Many methods of discouraging birds have been tried, from cannon to falcons. But none has been entirely successful. This problem is one that does not appear to be controllable and the solution lies in the selection of sites which avoid creating the risk of birds-strikes on aircraft.

The pollution of static water, ditches, river or the sea occur when a sanitary landfill adjoins a body of water. The normal source of the leachate causing this pollution is rain falling on the surface on the fill, percolating through it and passing over an impermeable base to water at a lower level. Only a proportion of total precipitation emerges as leachate; some is lost by evaporation and transpiration.

UNIT – II

LIQUID WASTES – SOURCES QUANTIFICATION – CHARACTERIZATION

Water is one of the most important constituents of Life Support Systems. It is indeed a wonderful chemical medium which has unique properties of dissolving and carrying in suspension a huge variety of chemicals. Thus it can get contaminated easily. Natural surface water bodies often have impurities from various sources. The impurities, may be suspended particles, colloidal materials and may also dissolve Cationic and Anionic substances. Various kinds of natural and man made activities like industrial, domestic and agricultural and others create day by day pollution problems especially in fresh water bodies. Time has come to work together in combating water pollution challenges to give our children clean and safe water.

Potential sources of Liquid Wastes

A rough estimate of oil (Liquid hydrocarbons, oil and grease) discharged into the sea would be around 5 million tones per annum of which 50% is from industrial wastes and the rest from marine operations. The lighter fractions of oils dispersed on surface wastes may evaporate whereas heavier fractions persist on the surface. Some compounds containing sulphur, nitrogen and oxygen may get dissolved in water. The gulf was has resulted in 3 major oil slicks in the Persian Gulf which are considered to be the biggest oil slicks in the world history till now. The biggest oil slick of the three in the Gulf was estimated to be 294 million gallons and spread over an area of 165 sq.km and the other two are reported to be 125 sq.km and 65 sq.km in spread of polluted area. These oil slicks affected seriously the desalination plants and other industries using sea water besides affecting marine ecosystem.

The other sources of liquid wastes include domestic and industrial wastes in addition to soil erosion whose suspended solids, silt and colloids silt up rivers and lakes that change the flow rate affecting the uninterrupted flow of water in the rivers. As silt contains high quantity of organic matter has high BOD demand above mg/l causing deoxygenation of receiving bodies of water.

Excess of nutrient load in water bodies lead to algal bloom the alarm signal of eutrophication or excessive nutrient load. Organic materials from domestic sewage, livestock wastes and various agro industries for e.g. Pulp & Paper Mills, Sugar factory, Food industries also contribute to liquid wastes that pollute aquatic bodies. Major sources of industrial chemical discharges are Pulp and Paper Mills, Iron and Steel Works, Petroleium refineries, Petrochemical industries, Fertilizer factories, Leather industries, Refineries, Pharmaceutical plants etc.

These discharges are varied and complex in nature and without treatment and properly sited outfalls are very much harmful to Flora and Fauna of aquatic ecosystems. For certain wastes particularly organic materials in liquid form, the least damaging disposal option may be destruction by incineration.

Major lakes, rivers, and reservoirs of the world are now getting polluted beyond redemption due to varied types of liquid waste discharges especially in urban areas where the quantity excels that of rural areas due to affluence, fast life and excess. It is said often “Affluence leads to effluence”. Of all types of liquid wastes domestic sewage and industrial sludges top.

Sewage

Sewage is the used water or prime liquid waste of a community rural or urban the later assuming greater responsibility. Sewage includes human and household wastes, street washings, cowshed washings, industrial wastes and ground and storm water as may be mixed with it. The constituents of sewage are

1) Domestic sewage – human excreta as well as discharges from kitchen, bathromm, lavatories etc.
2) Industrial wastes from manufacturing process – Tanneries, slaughter houses and various trades, distilleries, mils, laundries, chemical plants etc.
3) Ground water entering sewers through leaks.
4) Storm water which is rain water from houses, roads along with surface water.

Sewer is an underground conduit used for removal of sewage and sewerage is the general process of removing sewage by municipalities and corporations. The entire system of conduits and appurtenances involved is called sewerage system or sewer system. The term "municipal wastes" applies to those waste generated by households and to wastes of similar character derived from shops, offices and other commercial units such as laundries, slaughter houses, dairy farms etc.

Acidification

The type of acids found in rain water viz., sulphuric, carbonic and nitric acids which are of course more prevalent in industrialized countries due to toxic gases emanating from various industries will stimulate leaching by disassociating into H^+ and their component anions which can displace cautions from the soil exchange complex that leads to soil acidification.

The main anthropogenic (man made) causes of acidification include certain land use practices such as excessive use of nitrogen fertilizers, land drainage and acid deposition from urban and industrial pollution.

Agrochemical wastes

In recent years the use of inorganic fertilizers has increased dramatically at the expense of more traditional organic nutrient treatments. In the recent decades levels of nitrate in water supplies have increased dramatically particularly in intensively cultivated areas where N_2 inputs have been quite higher. In terms of land use, nitrate leaching tends to be greatest when there is no crop cover to utlize the NO_3 released from fertilizers and organic reserves. Fertilizers are applied in a variety of forms – solution, suspension, emulsion and solid. In addition to the environmental problems associated with fertilizer application, a number of problems arise from use of pesticides which go on accumulating in every food chain stepwise upward – a wide range of pesticides has been developed – nearly 450 compounds – of which the types most commonly used being insecticides, fungicides and herbicides. These pesticides may be degraded or adsorbed by organic matter, clay poisoned irrigated water by leaching especially compounds with solubilities – 10 mg such as simazine, bromacil and aldicarp and through surface run off.

Urban and industrial liquid wastes

Constructions and demolition wastes, metalliferous materials, power generation emissions, chemical and organic wastes contribute to water pollution and consequently leading to generation to liquid wastes.

Agricultural wastes

Wastes produced by agricultural activities comprise animal slurries, silage effluents, end of spray residues and tank washing following pesticide sue, industrial and domestic sewage sludges. Animal manures and silage effluents are the main components of agricultural wastes.

Mining wastes

Industrial process wastes encompass a wide range of materials and chemicals which comprise organic acids, alkalies and metalliferous wastes. Mining wastes arise as by products of extraction process and may include top soil rock and dirt and may be contaminated with metals and coal mining wastes. Coal mining and distillery wash are also major contributions of diverse organic compounds.

LIQUID WASTE CHARACTERISTICS

BOD

BOD is an indirect test and is important in evaluating the performance of waste water treatment plants and predicting impacts on receiving streams. The BOD is a measure of the organic matter present in waste waters. It is determined by measuring the amount of O_2 absorbed by a sample of waste water in the presence of micro organisms during a specific period of time usually 5 days period at a specified temperature say 20^0C. BOD is the primary measure of the strength of waste water and also an indicator of the waste treatment undergone by waste water by way of reducing the O_2 content. BOD of polluted water goes up beyond 200 mg/l and that of pure water ranges from 5-10 mg/l.

COD

COD is also a measure of the strength of waste waters. It is measure of the oxidation requirements of a sample under prescribed conditions, as determined by using a chemical oxidant. This is generally useful where industrial wastes are concerned. As COD is able to give a direct value of the O_2 demand of the waste and several organic compounds present in wastes from refineries, petrochemical complexes and similar industries another test called Total Organic Carbon is employed.

TOC

The total organic carbon content (TOC) of a sample represents all the organic compounds present in the waste water is determined by combustion of the organic compounds and by estimating total CO_2 produced.

Coliform organisms

These indicator organisms include *Escherichia coli* which originates in the intestines of warm blooded animals. They provided presumphine evidence of the presence both bacterial and viral. Since human faces contain about 1×10^{12} coliform organisms per capita per day, all sewage is contaminated with these organisms. The coliform index is measure of the coliform organisms of *E.coli* in a water sample. It may be defined as the reciprocal of the smallest quantity of a sample (in ml) which would give a positive *E.coli* test. M.P.N. or Most probable number may be defined as the bacterial density which if it had been actually present in the sample under examination, would move frequently than any other, have given the observed analytical results.

Other impurities in Natural waters

The dissolved impurities include positive ions such as hydrogen, negative ions such as Bicarbonate HCO_3 + Sulphate SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}, iron, Fe^{2+} and Mn^{2+} all arising from mineral soil and rock except H+ from atmosphere. Dissolved negative ions include Bicarbonate HCO_3^-. Sulphate SO_4^{2-} from atmosphere and Cl^- (chloride), Floride F^- carbonate CO_3^{2-} and NO_3^-. Natural surface water bodies often have impurities from various sources.

On the whole the quality of water is degraded by a number of reasons, the principal reasons being and clearing, removal of riparian vegetarian, grazing, irrigation, intensive animal production and intensive agriculture operations resulting in agrichemical invasion in fresh water bodies. Is it not disheartening to note that already potable mineral water used for drinking water has become costlier than milk – which is considered a balanced food for children as well as adults and aged. Multinational companies only flourishing at the expense of tropical countries. Should we allow this or take remedial measure in order to save the environment, animal, plant and human health.

WASTE LAND AND ITS IMPACT ON LAND FILLS

Historically, land fill has been the most commonly practiced method for disposal of waste materials all over the world. Prior to more restrictive regulations, land fill was generally the best method of choice of disposal, even of hazardous wastes.

Refuse, trash and garbage are bio degradable in a sanitary landfill. For this reason, municipal land fills that have accepted only sanitary wastes should not present severe long term threats to human health and environment. But disposal of chemical substances is entirely different. Because of their persistence many hydrocarbons and synthetic chemicals require further treatment before disposal if they are to be rendered harmless. Separation of biodegradable and non biodegradable at the source itself is another option. Legislation and regulations are now in place to ensure minimal adverse impact on human health and environment from future modified design and operation.

Many domestic generations send their waste load off-sites for land fill disposal due to cost effectiveness. More recently all concerned parties have come to realize that the low initial costs of land filling are merely a small portion of the true costs to human health and environment. Solid and liquid waste disposal facilities should consider the following facts when setting minimal technical standards to ensure protection of human health and environment

- Ground water
- Flood plain
- Surface water
- Air quality
- Operational safety
- Disease transmission
- Impact on food chain

- Endangered species

In order to minimize the risk to human health and the environment, land fills criteria must address all of these concerns, and the decision about sitting of any land fill must be based on due consideration of each factor.

Perceptible impact on land

First and foremost ground water quality could be adversely impacted by leachate leaking from hazardous land fill. Location and quality of nearby underlying aquifers must be considered in site selection. Hazardous waste land fills must be located outside historic flood plains. Other sitting concerns should include proximity of surface waters and potential storm water run-off problems that may be associated with land fill site.

The air quality in the vicinity of a hazardous waste land fill must be monitored and controlled to ensure compliance with applicable air quality standards and to minimize objectionable odours. Conditions may warrant the installation of a gas recovery system in order to conserve energy and minimize emission odours form the land fill.

Careful identification of incoming hazardous wastes will greatly minimize concerns about disease hour mission, infections medical wastes must be properly characterized and treated prior to disposing off in the land fill.

The issue of endangered species must be considered in the siting process on a case by case basis. Overlays are useful in avoiding a siting adverse to an endangered species.

Above all the permeability of the top soil at the site will be the major factor that will affect the rate of contaminant transport through the soil once the land fill has started leaking. An ideal native soil in the vicinity of land fill should have a permeability that does not exceed 1×10^{-7} cm/s.

Thus the land fill must be properly sited, designed, carefully manned in order to protect human, animal and plant health, atmosphere water sources especially gound and surface water soures.

SAFE DRINKING WATER

The safe drinking water Act of 1974, as emended in 1977, set minimum national drinking water standards. Under these regulations that have been promulgated by this act, maximum containment canels have been developed for coliform bacteria and other hazardous wastes. Supplies of public drinking water are periodically monitored to assure compliane. All naturally occurring freshwater bodies contain microbes and chlorination is the most widely used cost effective means of controlling microbes in drinking water.

The standards of quality regarding the presence of physical and chemical characteristics for drinking water supply are given in the following table.

PHYSICAL AND CHEMICAL STANDARDS OF DRINKING WATER

S.No	Characteristics	Higher desirable level	Maximum permissible level
(i)	Turbidity units on	5	10

	Jackson scale		
(ii)	Colour units on platinum cobalt scale	5	50
(iii)	Taste and odour	Unobjectionable	Unobjectionable
(iv)	pH (units)	7 – 8.5	6.5 – 9.2
(v)	Total solids	500	1500
(vi)	Chloride	200	600
(vii)	Sulphates	200	600
(viii)	Total hardness (as $CaCO_3$)	200	600
(ix)	Nitrates	45	45
(x)	Fluorides	1.0	1.5
(xi)	Iron	0.1	1.0
(xii)	Manganese	0.05	0.5
(xiii)	Copper	0.05	1.5
(xiv)	Zinc	5	15
(xv)	Calcium	75	200
(xvi)	Magnesium	30	150
(xvii)	Phenol	0.001	0.002
(xviii)	Anionic detergent	0.02	1.0
(xix)	Arsenic	0.05	0.05
(xx)	Cadmium	0.01	0.01
(xxi)	Hexavalant chromium	0.05	0.05
(xxii)	Cyanides	0.05	0.05
(xxiii)	Lead	0.1	0.1
(xxiv)	Selenium	0.01	0.01
(xxv)	Mercury	0.001	0.001
(xxvi)	Gross alpha activity(pc/L)	3	3
(xxvii)	Gross beta activitity(pc/L)	30	30

Concentration are in mg/l except where noted otherwise

1. pico curie per litre.

Bacteriological standards

In many part of the world, the standard aimed at is that the coliform organisms or *E.coli* should be absent from each 100 ml, sample of water entering the distribution system – whether the sample be disinfected or naturally pure, and from at least 90% of the samples taken from the distribution system. As this regid requirement cannot be fulfilled in many cases, W.H.O. has recommened the following briefly described standards.

Treated water

In 90% of the samples examined throughout any year, coliform bacteria shall not be detected or be detected or the MPN index of colirom micro organism shall be less than 1 in 100ml samples. None of the samples shall have an MPN index of coliform bacteria in excess of 10.

An MPN index of 8 – 10 should not occur in consecutive samples. When this occurs, an additional sample or samples from the same sampling point should be examined without delay.

Untreated water

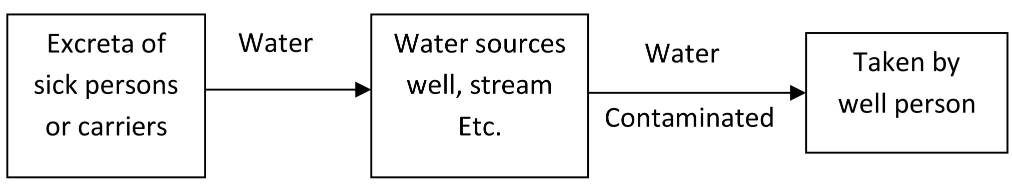
In 90% of the samples examined throughout any year, the MPN index of coliform micro-organisms should be less than 10 in 100ml samples. None of the samples should show an MPN index greater than 20.

An MPN index of 15 or more should not occur in consecutive samples. Should this happen, more samples must be examined forthwith.

Water Borne Disease

When water contains certain harmful and disease producing matter, it may lead to many diseases on being consumed by healthy persons. The so-called water borne diseases may be caused by the following factors.

a) Presence of micro-organisms which originate from the intestinal disorders of sick of infected persons. The diseases produced may be – (i) bacterial e.g. cholera, typhoid, para-typhoid, bacillary dysentery, diarrhoea; (ii) viral disease of poliomyelitis e.g. infective hepatitis (commonly known as jaundice) and (iii) disease due to protozoal infection e.g. amoebic dysentery. The part played by water in spreading these diseases is as a mechanical agent, the sequence of events being the faeces or urine of a sick person (carrier) not disposed off properly and conveyed by storm water or through other agencies to a stream, well or other source of water supply. The water gets contaminated and the persons taking it fall sick.



b) Presence of parasitic ova The eggs or the developed embryos of the eggs of round worms and type worms are generally carried by water and cause entozoal diseases like bilharziasis, nematodes, flukes, guinea worm and hook worm infections. Besides water also forms the medium to carry mosquito eggs which lead to malaria and yellow fever.

c) Presence of inorganic matter Certain diseases may result from the presence or absence or of certain minerals in water. Some minerals may be taxis by their mere presence while others become toxic when their quantity exceeds a certain limit. Of these minerals both lead and arsenic, two of the most toxic chemicals are not found naturally in water. Fluorides in quantities less than 1.0 mg/l have a beneficial effect on young teeth so that fluorine is required to be added to fluorides in excess of 1.5 mg/l cause fluorosis of erupting teeth. Presence of excessive amounts of sulphates due to magnesium generally causes disorders of the alimentary tract leading to diarrhoea. Mathemoglobinaemia or 'blue babies' is widespread in case of infants when fed with milk containing high concentration of nitrates. Because of the production of methemoglobin in the blood, nitrates are not converted to reduced forms of nitrogen and the infant turns blue. As a result , blood becomes unable to carry oxygen, the infant becomes sick, vomits and in extreme cases dies. Goiter is caused due to deficiency of iodides in water. This is manifested in human beings by the symptomatic enlargement or swelling in the anterior part of the neck. This is fairly prevalent in the hilly areas of Himachal Pradesh and other hilly states.

d) Presence of organic matter. An excess of vegetable matter in water or the entrance of sewage effluents into bodies of water may lead to diarrhoea and other gastric disturbance in the human body.

The complete control of water borne disease involves instituting an environmental health programme that incorporates personal and household hygiene, control of fly species and other insects, monitoring of food processing, immunization of populace where possible and proper, scientific waste disposal and water treatment to remove harmful constituents.

UNIT – III

WASTE TREATMENT

WASTE MINIMIZATION

Solid waste management is an all encompassing term. It can be used to describe several processes – elimination or reduction of wastes, recycling and recovery of resources, the treatment or destruction of waste i.e. physically destroying, chemically detoxifying or otherwise rendering waste permanentely harmless and waste disposal or depositing the waste in air, water or land.

Approaches to hazardous waste reduction

Waste treatment is essentially an addition to industrial production process, while waste reduction or minimization is intricately involved in all aspects of production process. People with 'end of pipe' pollution control jobs are not motivated to unilaterally reduce waste. Such efforts must involve upstream workers and facilities. For waste minimization or reduction succeeds only when it is considered pact of every day activities of all workers involved with production rather than only of those responsible for complying with environmental regulations.

Often what is called 'treatment' of waste is simply removal and transfer. For e.g. evaporation ponds and air shipping columns used for treating liquid wastes purposefully put volatile toxic chemicals from liquids and gases are generally land disposed. Statistics for industrial pollutants in waste streams sent to publicly owned water treatment plants indicate that only about half the pollutants are permanently altered. Those remaining are released into air as volatile emissions, discharged into surface waters or put into land as sludge from which they migrate into ground water. These are also concerns about air emissions of unregulated toxic chemicals from incineration of hazardous wastes.

Among all the techniques of waste management, waste reduction is the commonsense solution to the prevention of future hazardous waste problems. While waste minimization goals are both necessary and desirable, most manufacturing operations still create waste products that will ultimately need to undergo treatment to either to destroy the wastes or render these harmless to the environment. There are numerous treatments applicable to hazardous wastes that can typically be categorized as chemical, physical or biological in nature.

PROCESS MODIFICATION

Process modification is conversion of hazardous wastes to harmless wastes through various types of treatments.

Physical treatment

Physical treatment involves a wide variety of separation techniques that have been commonly practiced throughout industry for decades. Physical treatment for the separation of liquids and solids include screening, sedimentation, clarification, coagulation, flocculation etc. Each of these processes involves the separation of suspended matter from a liquid phase.

Screening

The initial solids – liquid separation step in waste water treatment involves use of strainers screens for the removal of large solids such as plastics wood and paper. The fine solids that remain in the liquid phase may then require further chemical and biological treatment.

Sedimentation

Sedimentation is the removal of suspended solids from liquids by gravitational settling. The velocity of the liquid must be reduced to the point that the retention time in the sedimentation vessel is sufficient for solids to settle by gravity. The settling rate is affected mainly by the size, shape and density of the solids particle as well as by density of liquid phase. As the particles settle they accelerate until the frictional drag on the surface against the liquid equals the weight of the particle in the liquid.

When solid particles settle through a liquid phase it settles by free fall. The settling of washed sand in water would be an example of free fall settling. As this sedimentation process continuous, particles become a dense sludge layer.

Flotation

Low density solids and hydrocarbon solids may be separated from liquids by air flotation. The air is introduced into the waste liquid in the form of finely divided bubbles, which attach to the particles to be removed. The particles then rise to the surface for removal by skimming.

CHEMICAL TREATMENT

Coagulation and flocculation

The precipitation process of heavy metals can be greatly enhanced through addition of various water soluble chemicals and polymers that promote coagulation and flocculation – both of which are used to separate suspended solids from liquids when their normal sedimentation rates are too slow to provide clarification. These are two different but related mechanisms in clarification and dewatering.

Coagulation is the addition and rapid mixing of a coagulant to neutralize charges and collapse the colloidal particles so that they can agglomerate and settle down. Colloids require coagulation to achieve an effective size and settling rate when insufficient settling time is available in a treatment plant to remove suspended solids. Hydrophilic colloids may react with the coagulant used in the treatment process and hence require more coagulant than hydrophobic colloids, which do not chemically react with the coagulant.

The determination of the nature and strength of the particle charge is needed to define how closely particles in the colloidal system can approach each other. Zeta potential is a measurement of this force. For colloids in water with a pH range of 5 to 8 the zeta potential is generally - 14 to 30 mV. This zeta potential must be reduced so that the particles approach more closely, increasing the likelihood of collision. Zeta potential is usually determined from observing particle motion under a microscope. Mixing is required to supplement addition of a coagulant to destroy stability in the colloidal system.

Flocculation

The coagulants promote flocculation too. The use of water soluble organic polymers is often more effective than the use of alum or iron salts in promoting coagulation. The coagulants also promote flocculation, which is the agglomeration of the colloidal particles that have been subjected to coagulation treatment. Flocs are promoted by slow mixing of coagulated particles under controlled pH conditions to produce large particles, thereby improving the efficiency of subsequent dewatering steps.

Flocculation requires gentle agitation to allow bridging of the flocculant chemical between agglomerated colloidal particles to form large settleable flocs. A flocculant gathers together particles into large agglomerates. Flocculation not only increases the size of the floc particles but also permits faster dewatering rates of sludges and slurries because of the less gelatinous structure of the flocs.

Alum and iron salts, which are widely used in water clarification, in fact function as both coagulants and flocculants by forming positively charges substances in the 6 to 7 pH range that is typical of clarification. The hydrolysis reaction produces insoluble gelatinous aluminium or ferric hydroxide, and the metal coagulants form flocs which trap the destabilized colloids. Aluminium sulfate is employed more frequently that iron salts in water treatment clarification because it is cheaper but iron salts are effective over a wide range of pH. In the lime soda softening process, lime serves as a coagulant to produce a heavy precipitate consisting of calcium carbonate and magnesium hydroxide, which has coagulating and flocculating properties.

The principle factors affecting the coagulation and flocculation of waste water are suspended solids, pH and the dosage and nature of coagulant. For aluminium phosphate, the waste water must be alkaline to produce aluminum hydroxide. Ferrous sulphate, ferric sulphate and ferric chloride may also be used.

Sterilization or Disinfection

The purpose of disinfecting drinking water is to destroy organisms that cause diseases. Most pathogenic and other micro organisms are removed from water by conventional treatment processes of coagulation, sedimentation and filtration but chlorination or ozanination used to sterilize and disinfect to ensure satisfactory disinfection of potable water supplies. The disinfecting ability of chlorine is due to its powerful oxidizing properties which oxidize those enzymes of microbial cells that are essential to their metabolic processes.

Chlorine is the most widely used disinfectant because it is effective at low concentration, is highly cost effective and forms a residual if applied in sufficient dosage. But chlorine additional must be a highly controlled process. Chlorine is poisonous yellow-green gas at room temperature and atmospheric pressure. Chlorine is a strong oxidizing agent capable of reaching with many contaminants in water. Oxidizing biocides such as chlorine, hypochlorities and organochlorine materials will kill all organisms in the system quickly. An efficient chlorination system provides rapid initial mixing of the chlorine solution in the waste water and contact time in a plug-flow basin for a minimum of 30 minutes.

Ozone can also be used in certain waste treatment applications to avoid the residual chloramines that result from chlorination of waste water affluent. Ozone is a powerful oxidant more powerful than even hypochlorous acid. Ozone must be produced on – site because it can not be stored like chlorine. Ozone is usually produced by an electric corona discharge through air or oxygen.

INCINERATION

Incineration is a waste disposal process by means of which solid, liquid and gaseous combustible wastes are converted through controlled high temperature oxidation of primarily organic compounds to produce CO_2 and water. The chemistry of incineration represents a combustion process applied to the destruction of unwanted hazardous substances. It is a thermal oxidation process. Both combustion and incineration refers to thermal oxidation process with a hairline difference. Combustion typically takes a valuable material like coal and oxidizes that material in the presence of a flame to produce a desirable end product – energy – and also undesirable waste products – air pollutants and solid ash waste. On the other hand incineration takes an undesirable waste – such as hydrocarbons – and thermally destroys that waste to produce desirable air emission products – such as CO_2 and water – and energy of combustion.

The design of Incinerator System

The thermal destruction of hazardous waste involves the controlled exposure of the waste to elevated temperatures, typically above 1600^0F. When properly designed and operated thermal destruction systems offer the opportunity to destroy hazardous organic wastes and significantly reduce their volume.

At present no single furnace design for municipal incinerations can be considered to be superior in all cases to any other design. The types commonly used are rectangular furnace, vertical furnace, rotary kiln furnace and fluid bed incinerating furnace. The rotary kiln is often used in hazardous waste disposal systems because of its versatility in processing solid, liquid and containerized wastes i.e. wastes stored in safe containers. Waste in incinerated in refractory lines rotary kiln. The kiln accepts all types of solid and liquid waste materials. Rotary kilns are typically 5 to 12 ft in diameter and range in length from 10 to 30 feet. Rotational speeds range from 0.2 to 1 in/s depending on the kiln periphery. High L/D ratios along with slower rotational speeds are used for wastes requiring longer residence times.

Fluid Bed Incineration

Fluid Bed Incineration for hazardous waste offers an environmentally acceptable alternative to land fill techniques. The intimate mixing in the bed and the large surface are available on the inert bed material provide a high degree of incineration with low excess air levels and a minimal temperature gradient through the bed. The residence time of fluid – bed incineration is in a high range from 5 to 8 seconds or more at a temperature of 1400 to 1600^0F and a slight positive pressure. Fluid bed incinerators offer several potential advantages including high uniform temperatures, by product neutralization low maintenance costs and DRE (Destruction and Removal of Efficiency)

The factors affecting incineration are temperature, residence time, (Destruction and Removal of Efficiency) DRE, turbulence, pressure (+ve elevated pressures), construction materials (ordinary steel to oxotic alloys) and a wide range or refractory materials such as alumina silica chromium and other oxides.

Maturation or stabilization

Stabilization or maturation systems are generally designed to reduce the ultimate toxicity of treated wastes. It is carried out in a stabilization out in where algae and bacteria work in a symbiotic way the former giving O_2 and later CO_2

causing stabilization of waste materials and making the wastes acceptable for reuse. Heterotrophs use organic matter and autotrophs inorganic matter.

Aerobic decomposition pathways

The aerobic treatment can be an efficient, cost-effective way to remove hazardous substances from contaminated waste water and ground water, land fill leachate and contaminated soil. The microbes are divided into auto and heterotrophic and according to O_2 requirement aerobic and anaerobic. The aerobic organisms are used to treat industrial waste streams – whereas anaerobic systems are usually confined to the treatment of organic wastes – from aerobic processes. Micro organisms need carbon and energy source which may come from sunlight, a reduced inorganic or organic compound. The temperature and pH must be controlled and substances that are toxic to the organisms must be removed. Unless the proper microbial consortium can be both developed and maintained, a compound may not degrade in any type of system because biodegradability is sytem-specific. The aerobic process may need other physical and chemical treatment in order to achieve desired results.

If the organics are biodegradable and if the desirable organisms can be enriched and maintained in the microbial community, then the system can be designed so that the toxin is maintained below toxic levels. If the toxin is non biodegradable microbial strains that are resistant to the toxin must be enriched.

N_2 and P_2 are common nutrients added to a biological system, since lack of these elements in sufficient quantities in an inorganic form will retard biological activity. Most of the organisms capable of treating hazardous substances grow well in the 6 to 8 pH. Many hazardous organics are readily degraded aerobically. Temperature is also as a significant factors in aerobic system.

The chief objective of aerobic systems is to develop microbes which will convert a wide variety of organic compounds a new cell material for removal by conventional separation techniques and to non hazardous substances such as CO_2 and water. Aerobic processes generally take place according to the following reaction.

Organics + O_2 ====> C_2 + H_2O + others products + energy

Other products mentioned above are dependent upon the type of organics and other nutrients present as well as upon the extent of biological activity. Many contaminated leachates, waste waters, and soils may be treated by aerobic processes.

Anaerobic pathway

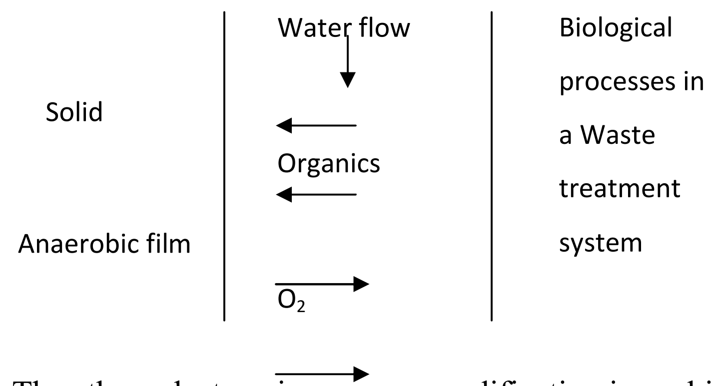
Anaerobic microbes require combined O_2 rather than molecular O_2 in order to function properly. Organic compounds generally undergo anaerobic conversion according to the following reaction.

Organics + combined O_2 =====> CO_2 + CH_4 + other products + energy

The "other products" in anaerobic processes are dependent upon the type of organics and other nutrients present, the extent of biological activity, and the elements in combination with the O_2 source. Anaerobic systems require narrow pH for efficient methane production and lesser amounts of CO_2. O_2 sources which are NO_3 result in N_2 and sulphates form hydrogen sulfide under anaerobic processes. Except for the type of O_2 source the operational parameters are similar for both anaerobic and aerobic systems.

Anaerobic bioreactors are enclosed agitated vessels that operate with a methane and CO_2 gas cap. The influent containing a high concentration of organics, is fed into bioreactor. The gas is withdrawn for combustion and heat recovery or other utilization. The digested sludge is recycled through Agri or Aqua culture operations. Anaerobic digestion is typically carried out at 90 to 95^0F for 15 to 20 days.

Biological processes in a trickling filter



Thus through stepwise process modification i.e. subjecting the untreated wastes to different types of treatment processes wastes are rendered harmless for subsequent use.

UNIT – IV

RESOURCE RECOVERY

Ther term “Resource Recovery” refers to the salvage of materials from the post consumer solid waste stream and the channeling of those materials into useful areas. Two basic strategies available for resource recovery efforts are “Source Separation” and “Centralized treatment of mixed waste”. Another way to express this is source separation denotes behavior technology while mixed waste resource recovery relies on physical technology. These are two basic strategies available for resource recovery namely Source Separation and Centralized processing and treatment of mixed waste or low tech and high tech solutions.

Source Separation

Source separation has been defined as setting aside vegetable waste materials as their point of generation for segregated collection and transport to the secondary materials dealer, or to specialized waste processing sites for recycling or final manufacturing markets. This is very much needed because the growing amounts of non organic material in waste have led many farmers to reject urban wastes for use as soil improver – the chief menace being polythene bags – the use of which has exploded over recent years – that reduce the quality of compost. Other non degradable materials include broken glass pieces, bottles, batteries etc. referred to as hazardous waste which may be harmful or may introduce toxins to the soil.

In the third world or economically less developed countries the major benefit of waste separation at source would be the retrieval of valuable items such as bottles and plastics from valueless fraction before they enter mixed waste stream. This practice of retrieving valuable items from waste is actually wide spread in low income countries – whereas the separation of organic and non organic fractions is much less common in countries like India. In many I world or industrialized countries the separation of household waste into organic and non organic fractions is gaining ground – for environmental and health reasons and in particular to improve the quality of compost. From an environmental and health point of view hazardous wastes need to be further separated for appropriate disposal.

The collections and reprocesses benefit from the separation of waste at source in a number of ways.

1) The reduction in waste related diseases
2) The recyclable materials are cleaner and fetch higher prices.
3) It takes very little time to sort various materials
4) Improves quality of compost.

At the Municipal level :

1) Less wastes has to be collected that leads to twin benefits i.e. lower transportation costs and less materials to be disposed.
2) When wet organic fractions separated heat value of the remaining portion of waste considerable increases that makes the ineration an interesting option for further treatment.

Organic or biodegradable materials include fruit and vegetable peelings, left were (including meat and fish) egg and nutshells, coffee grounds, tea leaves, husks, seeds, flowers, grass,straw, cow dung, poultry, drops, grass clippings etc. Only small amounts of paper can be included because of its poor degrading quality.

Separation of wastes at source is an environmental sound option and technically cheap and simple procedure at affordable time and money. But storage bins have to be emptied and handled over to Municipal collections when they come. It is low technology option too because source separation before disposal avoids transportation option too and other complications whereas centralized treatment of mixed wastes leads to high tech solutions that involve transportation costs as well as spread of diseases from rotting wastes. That is the reason why source separation is referred to as behavioral technology while mixed waste treatment as physical technology.

<u>Mixed waste treatment</u>

Pelletisation of mixed wastes and energy recovery is just beginning to become a technical possibility. Through adoption of variety of such innovative programmes several avenues seem to be open. These are two basic efforts open to us in Resource Recovery from mixed wastes. One is <u>Energy Recovery</u> and another <u>Raw materials recovery</u> such as glass, metals, etc. Each ton of solid waste generated has 9 million BTVs of energy. The total amount of 175 million tons of solid waste is capable of yielding 1575 trillion BTVs – a value that equals 258 million bavels of oils a year.

In addition to this energy content much of solid waste is recoverable material. Several systems have been developed to separate glass and metal that constitute major forms of inorganic fractions from mixed waste stream. In a typical system this involves shredding the waste into small pieces which may be sorted size and weight wise, the separation of ferrous metals using electromagnets or use of flotation tanks to separate glass, aluminium and other materials. Virtually all of the waste paper, aluminium cans and glass containers recoverable from post consumer wastes can be separated and routed via community collections centers or scrap dealers to the respective industrial processes.

The energy in the solid waste can be acquired by several techniques. First it can be burned to produce steam for a 'Steam District' distribution system to heat the buildings which is an useful proposition for cold countries. This is an advantages because low temperature, low pressure steam can be used in such systems whereas high temperature steam can also be produced, which can be used in factories or electricity generations to drive turbines or other machines. Second, the solid wastes can be reprocessed into a conventional fuel. E.g. Phrolysis is employed in a number of countries i.e. degradation of solid wastes (organic) using high temperature (above 60^0C) in an O_2 free atmosphere. Another environment and user friendly approach is to reamed methane anaerobically from solid organic waste which can be achieved either in land fills or in specially designed facilities.

The main disadvantages of mixed waste processing are three fold. First current technology does not yet have all the answers to the automatic separation of valuable materials from mixed waste stream. Second economically feasible efforts to generate energy are not available. In other words generation of energy should be made cost effective because mixed waste processing is currently expensive and unreliable probably because US efforts have emphasized huge plants capable of processing 2000 to 8000 tons of solid waste every day. Third many of these waste processing plants are polluting, less energy efficient than waste reduction at the source subject to market place fluctuations and hurt by successful source separation efforts.

Although efforts to devise and build automatic machines capable of extracting usable products one by one, from mixed waste collections should continue to be encouraged the same objective could be accomplished by research into methods of motivating the producer and discarder of wastes – to deposit them in a clean condition into a number of separate containers reserved for tin cans, aluminium cans, paper and cardboard, glass, garbage, garden delves, non ferrous metals, plastics and non burnable and non disposable items (Melvin First as quoted by Small 1971, PP. 107)

In source separation systems it is the user who divides waste into vegetable and non recyclable categories. At least trash should be separated into 4 categories viz., metal, glass, paper and organic mixed waste.

One we divides the wastes into categories one of the three things can happen to segregated wastes.

1. The user can deliver the waste to a central recycling area.
2. The recyclable and non recyclable waste can be picked up separately at the source of generation itself. In this two vehicles or containers may be needed.
3. All task can be picked up at the same time and placed into vehicles designed for segregated collections. This last option has the advantages of lower transportation cost and higher probable compliance.

A very exciting approach to resource recovery is the ORE RECYCLING plan it was developed at OREGON. Under this system individual households and business contract with a private firm called CLOUD BURST RECYCLING/ inc for trash collection. Consumers must sort out their trash into 6 categories viz., glass, steel cans, aluminium, cans, paper, kitchen scraps and mixed waste.

The physical technology approach to waste reduction and waste recovery is clearly one part of the solution to our resource use problems. If we want to make a significant dent in the consumption of resources, it will be through the increase of environmentally protective behaviors such as source separation of recyclable goods and the decrease of destructive behaviors such as purchase of wastefully packaged materials. However our knowledge about this behavioral technology is very much meager and slim. More than what has been done through physical technology in I and III world countries all these years, with regard to solid waste management, what can we do with a futuristic vision if a behavioral solution is the answer for waste separation is the need of the hour.

To conclude, the reduction and recovery of waste is important for a number of environmental reasons, including water conservation, energy conservation, air and water pollution. At present recycled goods are less competitive than virgin goods due to policies that artificially inflate the price or restrict the production of recycled goods. Waste reduction at the source is more attractive option and preferable to more difficult resource recovery strategies in view of cost and labour and time involved. A careful use of behavioural technology could contribute in significant ways to waste management. Yes ! Waste management is an Art by itself.

REFERENCE

Small, W.E. (1971). Third Pollution The Natural Problem of Solid waste disposal. N.Y. Praeger, 1971.

TYPICAL VERMICULTURE BED MAINTENANCE AND HARVEST OF VERMICOMPOST

Vermibiotechnology is now gaining very much importance in various fields like food, medicine and agriculture etc. The field of vermibiotechnology centers is of recent origin and employs different types of earthworms. Nature has given great potential to these tiny organisms to perform various kinds of functions, which are very useful to mankind. These capabilities make them environmentally very important.

Composting

Composting is the microbial conversion of biodegradable organic waste into a suitable humus by indigenous flora including bacteria, fungi and actinomycetes which are widely distributed in nature. But conventional composting needs more time and all composting methods are not very healthy to the environment. Here we realize the importance of vermicomposting methods.

Vermicomposting

Vermicomposting is a fast composting method. In this we use the potential of earthworms to degrade various organic residues. Vermicompost is the excreta or casts of earthworm which feeds voraciously on organic matter. During vermicomposting the wastes are processed into organic fertilizers. At the same time we are also getting rid of organic solid wastes. Solid wastes are today considered one of the major sources of pollution in the human environment. Vermiculture and vermicomposting in fact help in solid waste management, where organic solid wastes are considered as resources.

Vermibeds

The first step in starting vermiculture and composting units is to arrange for regular input of feed materials for the earthworms. These can be in the form of nitrogen rich materials like cattle dung, goat manure and pig manure. such manure can be used either in fresh form or after it has become matured and old. Poultry waste should however be handled carefully when it is fresh because it contains toxic components besides heat. Other organic materials like cowdung, agrowaste and kitchen waste can also be used as long as they are properly treated to provide a desirable C:N (carbon : nitrogen) ratio. When materials with a high carbon content is used, with a C:N ratio exceeding 40:1, it is desirable to add nitrogen supplements to ensure effective decomposition. All organic inputs should be added only as a limited layer each time to a height of 5 – 10 cm as an excess amount will generate heat. Earthworms are non-thermophilic and when temperature increase in composing units they either move away from composting beds or die.

Vermibed is medium in which earthworms grow and perform their functions which includes a layer of 15 – 20 cm thick loamy soil above a thin, 5 cm layer of broken bricks and coarse sand. Earthworms are introduced in the soil layer with little cattle dung and hay on the top as feed. The earthworms grow and multiply in this bed i.e. the vermibed function as a medium for the growth of earthworms.

Materials that can be used for the preparation of vermibeds

The best resource for composting is the locally available material. A vegetable grower or vendor can use rotting vegetables, a diary farmer can use dried cattle dung, a farmer can use agro waste, a person at home or at a restaurant can use kitchen waste, and so on. Experience has shown that in the absence of proper nitrogen input in the form of cattle dung or other nitrogenous supplements, trees like drumstick (Moringa oleifera) and subabul Luecaena leucocephala planted along the borders of composting beds contribute enough nitrogen through their leaves which naturally fall into composting units.

The composting beds can be prepared in open fields. Homes and gardeners can maintain their composting units in cement tanks or circular well rings with welded mesh plates at the base and on the top as a lid.

Preparation of vermibeds

While preparing vermibeds or worm beds, for epigeic speices, soild is not required. However if a combination of epigeic and anecic varieties are to be used as in agricultural situations, then it is advisable to have a base of not less than 15 cm of loamy solid. Composting can be done in pits, concrete tanks, well rings, wooden or brick lined growed beds wooden or plastic crates or windows (organic wastes piled in elongated rows) appropriate for a given sitution.

It is very important to select the composting bed site carefully. A site under a shade, in an area or an upland or elevated level to prevent water stagnation in pits during rains, is ideal. In regions where rainfall is plentiful it may be preferable to avoid pits. However in places like most parts of Tamilnadu and Andrapradesh in India where annual rainfall in confined only to a new days in a year, the flooding of pits by rain does not cause much harm – provided local varieties of earthworms are used

The technology which uses epigeic and anecic earthworms together is called veritech (Ismail, 1993) vermitech is carried out by first placing a basal layer of a vermibed broken bricks or pebbles followed by coarse sand to a thickness of atleast 6 – 7.5 cm to ensure proper drainage. This is topped by a layer of soil upto a height of not less than 15 cm after it is moistened. Into this about hundred locally collected epigeic and anecic earthworms may be inoculated over which small lumps of cowdung may be scattered over the soil and this is covered with a layer of hay upto 10 cm in height.

Water may be sprayed liberally till the entire set up is moist but not wet. The unit is finally covered with broad leaves like coconut or palmyrah fronds. This prevents birds from disturbing the vermibed. In case leaves or fronds are not available old jute bags may be used. A plastic covering should not be used as it traps heat and gases. Watering and monitoring of the unit should continue for thirty days. Juvenile earthworms should have appeared by this time which is a healthy sign.

Water management is the most important criteria in vermiculture as worms require moisture for their survival. Too little water kills the worms and too much chases them away. Water management, however is simple and can be learnt as soon as one starts handling earthworms. Nearly 50-60% moisture is ideal.

Organic refuse available from local resource should be added on thirty first day. It is important to remember that transferring resources from other areas may be expensive and the cost of production of compost will eventually work out to be higher and uneconomical. This refuse should be spread on the bed after the fronds are removed. The spread should not exceed 5 cm in thickness for each application. Though addition of this amount of organic matter can be done every day, it is advisable for a beginner to spread this refuse only twice a week. Watering is continued as per the requirement and the unit should be covered with fronds to keep the birds away. After a few applications of refuse, only the refuse should be turned over with a pitchfork taking care not to disturb the bed. When refuse just fills the unit, watering is continued with occasional turning over of the refuse. Forty five days after the last application of refuse, compost is ready for harvest.

As the composing process is getting ready and the change of refuse into a spongy, soft dark brown compost in noticeable, adding of water can be a stopped on the forty second day. This compels the worm to move to the bottom and facilitate easy harvesting of the compost.

Harvesting of compost

The movement of earthworms to lower lowermost layer of vermibed by stopping the addition of water facilitate the harvesting of compost without much damage to the earthworms. The harvested compost may be placed in the form of a cone on solid ground in bright sunlight. This further forces the worms which may be still present in the compost to move further down which can be recovered and may be later transferred to new composting units. The compost must be sieved through a 2 – 2.5 cm sieve and finally packed, preferable in polythene bags to retain its moisture.

Vermiwash

Vermiwash is a liquid fertilizer collected after the passage of water through a column of worm activated composted filled in a tough.

Vermiwash unit can be set up either in a barrel or a large sized bucket or even in a large mud not according to the need and economy of the consumer. Plastic or iron barrels are ideal as they are economical in the long run.

An empty barrel with one side open may be used. On the other side, a hole (preferably 1" diameter) is made to accommodate the vertical limb of a T joint tube in such a way that about half to one inch of the tube projects into barrel.

This is sealed with a washer and nut. A tap is attached to one end of the horizontal limb. The other end is closed with a dummy nut. The whole set up is mounted on bricks or on a suitable pedestral to prevent damage to the T joint as well as facilitate collection of vermiwash.

Keeping the tap open, first a 25-30 cm layer of broken bricks or pebbles or blue metal (2-4" size) is placed in the barrel or bucket. Water is made to flow through this layer. This is then followed by a 20-30 cm of coarse sand. Water is again made to flow through it. This set up is called the basic filter unit. Over this is placed a 30-45 cm layer of good loamy soil, which is kept moistened, and into this nearly 50 each of epigeic and anecic earthworms are introduced. Cattle dung pats and hay are placed on the top of the layer of soild. This is gently moistened and tap is closed after excess water is drained off. This unit is moistened every day, keeping the tap open for about 20-25 minutes. During this time epigeics produce the compost and simultaneously the anecics multiply and produce large number of drilospheres.

After the unit is ready (by the 16th day) the tap is closed and on the top of the unit a 5 litre vessel of water perforated at the base like a sprinkler, is allowed to gradually sprinkle into the unit. This water slowly percolates through the compost and the drilospheres, carrying with it nutrients from freshly formed castings, as well as washings from the drilosphere through the filter unit. The tap is opened the next day to collect the vermiwash. Tap is then closed and the suspended pot refilled with water to be collected as vermiwash the next day.

Uses

Vermi wash is sprayed on plants as foliar spray. If need be, the vermiwash may be diluted with water as a spray, or it may be diluted with 10% cow's urine which is an effective pesticide.

The casts formed on the surface of unit may periodically be cleared and cattle dung pats and hay be replaced. Vermiwash can be collected and stored as such, or can be solarised, condensed and stored. This may be diluted before use, with a dilution factor that best suits the user.

Reference

1. Sultan A. Ismail, Vermicology, TheBiology of Earthworm, Orient Longman Ltd. Hyderabad, 1997.
2. C.A. Edwards, Earthworm Biology, John Wiely and sons Publications.
3. P.K. Thempen, Organics in Soil health and crop production, Peekay trace crop development foundation, 1993.

MUSHROOM CULTIVATION

Introduction

Mushrooms are members of higher fungi belonging to the class Ascomycetes and Basidomycetes. According to Chang and Hayes (1978) edible mushroom refer to both epigeous and hypogeous fruiting bodies of macroscopic fungi that are already commercially cultivated or grown in half culture process or implemented under controlled conditions. Use of mushrooms can contribute positively in facing the challenge of world wide food shortage, originating with rapidly expanding human population at the rate of more than 2 lakh per day.

Mushroom cultivation was thought to be very simple, but in fact it is a complicated business. Yield is affected by compost, spown, temperature, moisture etc. The great value in promoting the cultivation of mushrooms lies in their ability to grown on cheap carbohydrate materials and to transform various waste materials.

Cultivation methods

The cultivation methods are

(i) Garden and field cultivation (in Europe)

(ii) Cave and house cultivation (in America)

(i) <u>Garden field cultivation</u>

There is no need of constructing houses. Small ridges are made in garden or fields. Soil inoculated with spawn is covered with leaf litter just to check from drying the mycelia of spawn.

(ii) <u>Cave and house cultivation</u>

Small tunnels are prepared in rocky areas and mushrooms farms are established. More over mines after their use are taken to develop into mushroom forms. Inside the tunnels and mines small flat beds of 16 x 16 feet size are prepared. On these beds suitable. Crops of mushrooms are raised.

Houses of different size (50 x 150 x 18 – 24 feet) are constructed which may be above ground, or partly above ground and temperature and moisture control systems. Inside the house small beds are prepared it tiers on either sides or in middle portion. Compost mixed with soil or compost along in spread over beds. The major steps of mushroom cultivation.

a) Obtaining pure culture of a suitable mushroom by tissue or spores culture method on the specific culture media.
b) Preparation of spawns e.g. grain or straw spawn.
c) Preparation of substrate i.e. composting.
d) Spawings, spawn running and cropping.

The first two methods come under laboratory methods and C and D under mushroom house method. The major steps of laboratory and mushroom house methods are shown as follows.

<u>Obtaining pure culture</u>

To get pure culture, mushroom are either isolated from nature, purified and characterized in laboratory before their use or purchased from national and international mushroom culture centers.

<u>Procedure for mushroom culture</u>

Sterilized and cooled potato-dextrose agar (PDA) or malt extract medium is poured into sterile petridishes and when solidified, they are inoculated by a piece of tissue or spores of the mushroom. In tissue culture method fresh mushroom is removed from the bed, washed in running water to remove adhering soil particles, dried with blotting paper, gently wash with 70% ethanol and finally cut off from center into two halves. A small portion of pseudo pavenchymas tissue from the center strip is transferred into petridishes. Petridishes are incubated at suitable temperature for the growth of hyphae.

<u>Preparation of spawn</u>

Spawn is a fungal growth medium impregnated with mycelial fragments of mushroom which serves as inoculum for mushroom cultivation. There is a great problem in preparing pure spawn of the particular strain of a mushroom because of fungal bacterial or viral contamination.

Raw materials used for prepartion of spawn are

rice straw cuttings,
cotton waste,
hulls of cotton seed and rice,
grains of sorghum

The physical and chemical compositions are developed in such a way that can alter the gross microbial community and promote maximum growth and yield of mushroom. No such chemicals or conditions should be present in compost that inhibit mycelial growth while formulating the substrate. Care is taken for ease in microbial degradation. The main constituents of straw or plant waste are cellulose hemicellulose and lignin. The first two are carbohydrates which upon decomposition result in glucose units.

Substrates are filled in small trays or wooden boxes to make beds use of trays of plastic bags makes air spaces. In India, tray culture is being replaced with plastic bags and shaf beds due to right cost of wood and tarry over pests and diseases. Trays or plastic bags are transferred in the room for its partial pasteurization at low temperatures. Room temperature is maintained around 50 – 55^{0}C for about 6 hours by live steam generated from a boiler. Later on it cools down to a preferable temperature for casing the compost.

It may be used alone or in combination. For selections of substrates to be used in making spawn, care is taken with regard to cost and availability of raw materials and mycelial growth on it as well. The steps of grain spawn or straw preparations are indicated below.

(i) cooking the grains in water until they swell/cutting of straw into 5 cm long pieces and soaking in water for 5 – 10 minutes.
(ii) decanatation of water, mixing of 2% lime (calcium carbonate)
(iii) transferring into glass tubes.
(iv) plugging with cotton
(v) autoclaving at 121^{0}C for 30 minutes and cooling down to 30 – 40^{0}C.
(vi) inoculating the substrate with pure culture of mushroom.
(vii) Incubation of suitable temperature for proper infestation of mycelium for their use as spawn.

Formulation and preparation of composts

Methods of preparation of composts for mushroom cultivation is known as composting. The purpose of compost preparation is to provide a medium for the rapid growth.

Casing is the covering of the compost when spread over beds with a thin layer of soil or soil like materials. It gives support to mushrooms, maintains temperature and prevents drying up of the compost. Various casing materials including farmyard manure and soil (1:1 W/W) moss and garden soil (2 : 1 W/W) have been tried.

Spawning, spawn running and cropping

Inoculation by spawn of compost in beds is known as spawning. Bed materials is inoculated by a small amount of spawn by removing it from container and spreading over bed materials. Room temperature and humidity is controlled for maximum mycelial growth and spawn running environmental conditions are necessary.

Mushroom crop matures at different intervals, producing flushes. After five to six flushes, the culture is renewed. Mature mushroom are picked up without disturbing the neighbouring ones by giving a gently twist. During this period also, environmental conditions are left undisturbed. Harvested mushrooms are sent to market or canned for their use as food.

Control of pathogens and pests

A number of harmful fungi and bacteria are encountered in composts which deplete the nutrients present for growth of mycelia and attack fruit bodies at different growth stages of crops, resulting in serious crop losses. Mycoviruses are also known to attack mushroom. Biological control of nematodes through leaf excracts and nematophages fungi leaf extracts of lastor, madder followed by neem chrysantnemum, bheng safede and marigold respectively. Incorporation of dried plant materials of above plants to compost increased yield to 7 – 12 % through favourable shilf in the compost mycoflora.

Cultivation of pady straw mushroom

The paddy mushroom *Volvariella* species prefers to grow on paddy straw and hence it is known as paddy straw mushroom. It grows at temeperature from 30 – 40^{0}C on paddy straw. The other substrates used are sugarcane bagasse, cotton wastes, water hyacinth etc. The paddy bed (prepared separately) may be spawned and covered with the third twist. The whole bed should be covered with the polyethylene sheet to maintain moisture.

The polythelene bag method followed the following steps.

(a) Cut the paddy straw and soak in water for 24 hrs.
(b) Cut waste paper into small pieces and soak for the 24 hrs.
(c) Decant water after 24 hrs.
(d) Mix thoroughly the chopped strew paper pulp and spawn.
(e) Fill the mixture in polyethylene bags.
(f) Puncture the bags with needle to facilitate the exchange of air and drainage of water.
(g) Tie the mouth of bag and keep them at 35 – 40^{0}C.
(h) Cut and remove polyethylene bag carefully to leave its contents undisturbed.
(i) Maintain the humidity of the contents to about 85 – 90% by spraying water.
(j) After 10 – 15 days of incubation small, small pins appear to grow.

Cultivation of white button mushroom

The various steps are

(a) Formulation of compost and method of compost
(b) Spawn preparation
(c) Spawning of compost
(d) Casing of compost
(e) Harvesting the crops

It requires a temperature of 15 – 18^{0}C during cropping. Therefore its cultivation is gaining much popularity in hill region.

Nutritional value

Mushroom contains 85 % - 90% water of its dry matter. However amount of water is greatly influenced by relative humidity and temperature during growth and storage. Protein in the most critical component which contributes to major nutritional value of good food. Nearly 34 – 89% mushroom proteins are digestible. Amount of protein varies from 34 – 44 % of total dry weight in Agaricus spades. The fat content ranges from 1 – 20% of total dry weight. Besides protein, a large various of free and combined fatty acids also occur in a bisporus with large or high concentration of palmitic acid, stearic acid and oleic acid.

Fress mushroom contains relatively large amount of carbohydrates say 3 – 28 % particularly pentoses, hexoses, disaceharides and treholse (a mushroom sugar). They appear as good soruce of several vitamins (thiamin, riboflavin, macin, biotin, ascorbic acid, vitamins A,B, C, D & minerals (Na, K, Ca, Fe etc.) essential aminoacids (methionin, citrulline, ornithine and several other elements (Se, Cd, Cr etc.)

Present status of mushroom cultivation in India

Since mushroom have a very short life it should reach to consumers within a short time or immediately canned. They will lead to proper marketing of mushrooms.

The cost of production in India at present in comparatively higher than other countries (Rs. 10 / kg in North Indian Plains and Rs. 15/kg in hills) and hence cannot compete in international market.

The yield obtained so far is low due to

(a) improper infrastructure of preparation of pasteumed compost.
(b) use of ordinary building lacking proper temperature control as cropping rooms
(c) use of low yielding strains.
(d) inadequate supply of quality spawn.
(e) lack of preined man power.
(f) inadequate research support.

The technology for cultivation and processing of mushroom has been developed at CFTRI (Hyderabad), RRL (Jammu) and NBRI (Lucknow). RRL and NBRI are distributing mushroom spawns in rural areas for mass cultivation. CFTRI has developed technique for processing and drying mushroom.

REFERENCE

Mushroom – The art of cultivation by Brig. Harmander Singh.
A text book of Biotechnology by RCDUBEY.
Kisan World, May 1997, 77(p).
Kisan World, Jan 2000, 65(p).
Kisan World, Oct 2001, 25(p).
Kisan World, Aug 1999, 44(p)
Kisan World, Oct 2000, 39(p), 41(p)

FISH CULTURE IN ORGANIC WASTE FED WATER

The use of organic wastes in fish culture probably predates written history. Silkworm wastes were used in pond – fish culture in China more than 4000 years ago. The earliest published work on the use of wastes in fish culture was by Fan Lai in China around 460 B.C. Fish culture in India and other parts of Asia may be equally ancient. Early Roman writers including Plivy, gave directions for the use of stable sweepings and other organic wastes in fish ponds.

To a large extent the nutrients that support fish growth in waste – fed ponds are incorporated in the natural foods that develop in the pond. Fish production can also be linked to existing waste treatment facilities to provide additional biological treatment.

Direct and Indirect feeding

A wide variety of organic wastes can be used successfully in aquaculture. Some wastes serve as direct feed for fish-agricultural and kitchen residues trash fish and agro industrial byproducts such as rice ban, oilseed cakes and distillery, slaughter and fishery industry residues.

Indirect use can be made of the wide variety of agricultural fibrous wastes. The principal wastes used in aquaculture are animal manures, a major component of which is crude fibre. The fibre and mineral components of manure serve as indirect feed by enhancing natural productivity in the pond. Decomposition of these wastes increases the production of bacteria and fungi which serve as food for a multitude of organisms in the pond such as protozoa and zooplankton. When the wastes are mineralized to their respective inorganic compounds, they enhance the growth of phytoplankton, the basis of food web.

Through this microbial activity in which low nutritional value wastes reenter the food web and are upgraded protein content, the pond performs an external function for fish similar to the internal function of the rumen in cattle or sheep.

The characteristics of wastes required for direct or indirect feeding are different. Wastes that are used indirectly should be finely divided so that they remain suspended in the water and spread through the pond. The relatively larger surface area of smaller particles also provides more sites for bacterial attack.

Fibrous residues such as rice straw can also serve as a base for the production of bacteria - protozoa complex in the pond. The straw must be supplemented with N_2 and P_2 fertilizers to provide Carbon : Nitrogen : Phosphorous fertilizers to provide Carbon : N_2 : P_2 ratios essential for the growth of bacterial cells - about 100 : 5 : 1

Polyculture

Each species of fish feeds on a more or less defined array of organisms. With indirect feeding the production of a multiplicity of organisms in the food web, such as algae, protozoa and zooplankton is enhanced.

When only one species of fish is grown, metabolic waste products can build to levels that foul the water and inhabit growth. Costly flushing and recycling systems can be used to prevent this pollution, but the use of a carefully chosen polyculture is a better solution.

Polyculture systems are commonly integrated with livestock production. Ponds are frequently located so that wastes from pigs or chicken drop directly into the pond. Another common practice is to use fishponds as production units for ducks or geese so that the mature is deposited directly into the pond. A typical pond might include silver, grass and common carp.

Catla is a surface feeder feeding on zooplankton. Rohu is a column feeder browing the sides of ponds and Mrigal is a bottom feeder. Common carp is a detritus feeder occupying the bottom layer. In scavenging pond bottom, the common carp strips up sediments - which create turbidity and help prevent excessive growth of undesirable aquatic vegetation. It has down turned mouth in contrast to Catla which has upturned mouth with closely set grill rakers. Since varied food materials found in every niche of the pond are well utilized from top to bottom by stocking the pond with a judicious combination of fishes having different food habits and their body structures modified according to feeding habit there is no competition for food space and no wastage of food occurs.

An outstanding example of the benefits polyculture on fish yields is found in Israel. Over the past 40 years average fish yields have risen from 1500 kg / ha to almost 4000 kg / ha. In illnois where the growing season for warm water fish can be as short as 170 days, the polyculture proved to be more advantageous. For e.g. for channel cat fish was feed with commercial high-protein pellets the maximum production was about 1500 kg / ha. When the same ponds were menured and stocked with a polyculture of Chinese Carp the net gain was increased to 4,585 kg / ha. The three fold increase in production was accomplished using only serine manure and sunshine. Why, at West Bengal in a polyculture pond they harvested 9000 kg / ha - a bumber harvest! Is it not?

In N. East States, West Bengal and Kerala. Paddy-cum-fish culture is a common phenomenon. Tilapia is an ideal fish to be cultured in rice fields during growing season that is capable of converting insects and other aquatic organisms to edible protein. T.nilotica appears to be harvested at Phillippines. When T.nilotica in comnbination with total yields of 290 /ha were obtained.

Industrial wastes fish culture

Industrial wastes have also been used in fish culture. In Pureto Rico, rum distillation wastes and pharmaceutical wastes have been evaluated for the culture of tilapia. Fish reared on the byproducts of antibiotic production achieved a growth comparable to that of the commercially fed control.

The rubber processing wastes in Malaysia have particular potential for fish culture. Ammonia used to prevent premature coagulation of latex is lost with other processing effluents and could be used in algal fish production.

Diluted sugar beet processing waste waters have been used for fish as feed in trout farming.

In Peru a combination of slaughter house wastes and fish meal is used as feed in trout farming.

In the USA waste treatment system using brine shrimp (Arheunia saliva) upgrade part of the effluent from a petrochemical complex. These waste streams contain small amounts of organic matter and large amounts of salt. Bacteria remove the organic material, and algae are grown in this effluent. Industrial wastes do not have the possibility of transmitting microbial disease unlike animal manures.

Thus it is clear that waste is not a waste. We use it prudently and convert waste into a Resource.

Yes, WASTE NOT WASTE!

UNIT V

COMPOST PITS

Compost is commonly prepared in pits by farmers. In rainy season Compost pits are poorly aerated. For facilitating aeration, the substrate has to be turned over every month. As the process is cumbersome, it is not usually done by farmers. As a result not only the composting period gets prolonged but the quality also gets affected. A method of aeration developed at Jabalpur is known as chimney and wall aeration technique. For wall aeration technique, 2 brick walls, 30 cm apart, 1 m high, 23 cm thick and having 40 holes at size 22 cm x 10 cm each are constructed in the center of a 3 x 4 m pit. Chimney aeration is provided in all aeration. Substrates are filled in layers with each layer consisting of 3 sublayers. In a trial carried out at Jabalpur, the sublayers were consisted of as follows:

1. Overnight water soaked paddy straw 50 kg (air dry basis)
2. Dung slurry (20 kg dung in 40 litres of water)
3. Mixture of 20 kg well pulverized soil half kg urea and 1.5 kg rock phosphate (1.5% available phosphorous, 150 mesh passed)

Total quantity of substrate in each pit was one ton. After one month the towers and chimneys were sealed with dung and mud mixture. Chimney aeration yielded 60% recovery with N_2 ranging from 1.10% to 1.70%.

Indone method

Sir Albert Howard (1924 - 26) at Indore, Madhya Pradesh, developed this method. In this, the conservation of cattle urine is effected by getting it absorbed in rice straw saw dust and other organic wastes used as bedding in cattle shed. The urine soaked material along with fresh dung serves as major source of N2 for the micro organisms involved in composting. To this material collected from cattle shed is spread evenly in a pit to form a layer of 10-15 cm thick. To this layer is added dung slurry made of 4 - 5 kg dung + 3.5 kg urine earth + 4.5 kg inoculum from 15 day old compost pit. Water is sprinkled to achieve 100% saturation. The layering is repeated to fill the pit within 7 days. The material is turned two times first 2 turnings in 15 days internal after filling the pit and third turning after one month of 1 turning. During rainy season the piling of 20 cm carbonaceous materials (leaves, hay, straw, saw dust, wood chips, corn stalks, etc.,) and 10 cm nitrogenous materials (fresh grass, weeds, digested sewage sludge, poultry litter) in alternate layers is repeated until the pile is one meter high. The recommended size of the heap is 2.4 m square at the base 2.1 m square at the top i.e. in the form of a Trapezium.

This method is labour intensive but hastens maturity period and results in substantial loss of organic matter and nitrogen.

Bangalore Method

In this method, the disadvantages of Indore method are overcome by slowing down the rate of decomposition and avoiding turnings. The substrates used for composting consist of Town refuse and Night soil which are spread in alternate layers of 15 cm and 15 cm in pits. When the pit is filled to 15 cm above the ground level it is scaled to prevent loss of moisture. After the initial aerobic decomposition. During this stage the rate of decomposition slows down taking about 6-8 months for the compost to be ready. But this method is not suited to high rainfall areas.

Farm yard manure in pits

For preparing better quality FYM the use of pit method for areas with less than 1000 mm precipitation and heap method for other areas is recommended. In the pit method the cattle shed wastes are conserved in pits of 2 m wide, one m deep and of convenient length with a slopping bottom towards are end. In this pit an absorbent layer is created at the bottom by spreading the straw at the rate of 3-5 kg per animal reared. The substrate containing well mixed dung, urine and straw is spread over the absorbent layer daily to form a layer of 30 cm thick and the process continued till the pit becomes fall. Each days layer should be pressed, moistened dry and covered with 3-5 cm layer of well ground fertile soil to hasten the decomposition and to absorb ammonia. The pit should be dry in high lying areas to avoid the entry of rain water.

Vermi composting by pit method

Compost pit of 2m x 1m x 1m or any convenient dimension with length or width according to one's convenience but depth not exceeding one metre may be dug in a suitable location which is not directly exposed to sunlight. At the bottom of pit a vermi bed may be created for earthworms. This is done by placing 15 to 20 cm thick layer of good loamy soil above thin layer of broken bricks (5 cm) and sand. Earthworms of local species may be introduced in the soil where they will inhibit and breed. In a compost pit of 2 x 1 x 1m about 1000 earthworms may be introduced and the bed kept moist by sprinkling water. Handful lumps of cow dung are placed here and there in the vermi bed so constructed. After 30 days wet organic wastes of plant or animal are spread over partially decomposed organic layer to a thickness of 5 cm within 50 days vermi compost can be harvested, shade dried, sieved and packed with 30% moisture level.

MUSHROOM SHED

Mushrooms were grown on a domestic scale in green houses in England as far back as 18th century. The object of this type was to provide mushrooms for household purpose only. Commercial cultivation is of recent origin only.

One of the early methods was to make ridge beds out of doors and hatch them with straw to protect against inclement weather. These ridges were 0.6 - 0.9 m wide and 0.45 - 0.6 m high in single rows separated by paths whereas the ridge beds in caves where mushrooms were cultivated in earlier days were half that size. This form was replaced in 1950s by shelves and bags which were made for more efficient use of space in a building that also eliminated some of the risks from pests and diseases when crops were grown on the floor.

Shelf System

A standard pattern of house evolved and used for many years consisted of 2 houses under a single pitched V root each house holding 371.6 m of bed area in 2 tiers - each of 6 shelves about 0.53 m apart, the harvest being 20 cm above the floor and are 1.5 to 1.8m wide. Gangways between about 2.1 m above the floor to serve the higher shelves. The shelf structure consists of a frame work of wooden upright posts with pairs of cross bars at each shelf level on which the shelf boards are laid.

Upright are 1.2m apart and shelf boards 2.4 or 3.6 m long. These are side boards resting on the bed boards or raised by placing blocks and held in place by the uprights to hold in the sides of the bed compost. These house are heated by hot water pipes fitted along the side walls through heating systems have become much more sophisticated in recent years. This type of shed is most suited to cultivate Agaricus or Button mushrooms.

Holland shed

In Holland there is uniformity in the type of mushroom shed constructed. The houses were built by side under a common roof so that only the end walls and outer walls of end houses are exterior walls. Because pasteurization, spawn growing and cropping are carried out in the same house they must be insulated and equipped well for all these stages. All the walls have 2 skins of 11 cm foamed concrete blocks separated by 5 cm cavity which is ventilated to allow water vapour to escape. The terlings are insulated with 10cm of mineral wool or other material of equal insulating value. The insulation value specified are : for the walls 0.74 J / m^2 sec ^oC and for ceiling 0.40 J / m^2 sec ^oC (0.13 and 0.07 BTU/$ft^{2o}F$ respectively).

Dutch type

The Dutch mushroom growers cooperative supplied compost to most of the Dutch farms and also rents conveyor units for filling the houses. These conveyors are portable and are lowed to the farm by the truck which carries compost so that a complete filing service is provided.

The Tray System (Indian)

This system, also called in various modifications the two zone, three zone or multi zone system was divised in 1934 by Knaust Brothers practiced in India too.

The fundamental change it introduced was the use of separate buildings for two or three stages of the crop. The crop material, compost was carried in trays throughout, instead of being filled into shelf beds and staying in one house throughout.

In the tray system as it is usually practiced in India trays are filled with compost and stacked in a heat room for pasteurization. Within 6 days at the end of the process the trays were removed, spawned and transferred to a “spawn growing room” (SGR). They remain there for 13 rooms” (CR). They come to cropping stage 17-21 days after casing and usual picking period lasts for 5-7 days.

Thus one heat room filled weekly with 2 spawn growing rooms used in alternate weeks can supply 10 cropping rooms used in a weekly basis and occupied for 10 weeks each time, less the day or 2 to empty, clean out and disinfect the CR before filling. The same HR and 2 SGRs can supply 9 CRs as a 9-week cycle or any other number of cycle preferred.

Mushroom house design for Pleurotus productions

The mushroom house can be constructed either with bricks and cement or with hatches more preferably. An ideal shed would be with bamboo frames, angle iron or concrete. Air vents on the upper walls and side walls are provided for ventilation. Two rooms are preferred are spawning room, other cropping room. Spawning room should be dark with no ventilation while cropping room should be ventilated properly. The walls may be covered with plastic of foam sheets to increase relative humidity to 80-85% in the cropping rooms as well as spawning room. Bamboo lines in the CR may save space while shelves with bamboo lining will occupy more space. The root may be simple with arrangement for water pipes with jets to facilitate watering and cooling. Gunny bags may be hung along sides of cropping room and sand bed may be provided down which will keep the room moist and humid. Though plastic houses are common in Europe whereas under Indian conditions a house / mud house / thatched house may be used.

TRICKLING FILTERS

Trickling filters are bed of rocks coated with biological film - the zoogloea - responsible for the natural stabilization of organic wastes. The end products are CO_2, N_2 and its oxides and water. Trickling filter was first installed in U.K. - called percolating filter that makes it possible to treat waste water continuously in tanks containing media that support large populations of micro organisms or filter slimes or what are referred to as zoogloeal films - an aggregation of microbial mass.

In Trickling - filter systems primary effluent is sprayed over a bed of crushed rock or other medium coated with biological films. The major components of the trickling bed are1 the filter medium2 an underdrain system and3 a rotary distributor.

Trickling filter →

1. ***Filter medium - bed of rocks***
2. ***Under drain system***
3. ***Rotary distributor with nozzles through sewage is sprayed that trickles down***

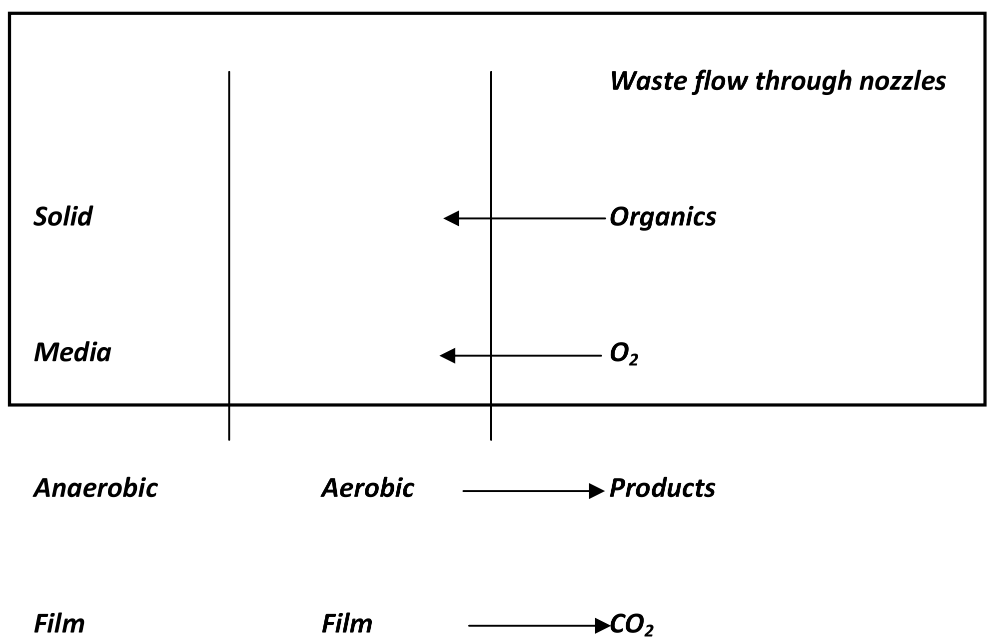
The filter medium provides a surface for biological growth and voids for passage of liquid and air. The preferred medium is 3 to 5 inches in diameter. The under drain system carries away the effluent and permits circulation of air through the bed. The under drainage system with provision made for flushing, the effluent. Channels and the effluent pipe are designed to permit free passage of air. A rotary distributor provides a uniform hydraulic load as the filter surface. The most prevalent kind is driven by the reaction of waste water flowing out of the distributor nozzles.

The biological layer consists of microbes that are aerobic to a depth of only 0.1 to 0.2mm. The zone next to the medium is anaerobic. Micro organisms near the surface of the bed where food concentration is high, are in log-growth phase while the lower zone of a bed is in a state of starvation. Dissolved oxygen extracted from liquid layer is replenished from surrounding air. As waste water passes through the trickling filter bed, microbial growth is remove an appropriate amount of organic materials for use as food. As waste water passes over the microbial growth, an amount of organic material is removed along with molecular oxygen. Aerobic processes occur and the oxidized organized inorganic and organic and products are released into the moving water film. The waste water passes through a filter, while the organic materials are retained for several hours as they undergo bio-oxidation.

Rotating biological contactors

Waste water flows through rotary biological contactor which consists of multiple plastic disks mounted as a horizontal shaft. The shaft at right angles to the waste water flow rotates with about 40% of the total disk area being submerged. The bio absorption and bio oxidation processes that occur are similar to those of a trickling filter. Advantages of such biological contactors are their low energy requirements and high degree of nitrification that takes place.

Biological processes in a trickling filter



Sedimentation or settling tanks

Whenever a waste containing liquids and solids must be treated physical separation should be considered just because it is cost-effective and least complicated to many waste management problems. Sedimentation is one of the physical processes.

Flash mixer

In a Flash Mixer, the rapid mixing is caused in a rectangular chamber, by the revolutions of a propeller fixed to a propeller-shaft and driven by an electric motor. Flash mixer is designed so that the displacement capacity of the impeller is greater than the maximum flow through the chamber so that alum solution and water are `folded' together in one quick mix. Consequently, alum consumption is held to the necessary optimum for adequate treatment. The detention period is generally ½ to 1 minute, velocity of impeller 3 to 10 revolutions per minute and the velocity of flow at the periphery less than 75 cm per second.

BIOGAS PLANT

Developing countries rely on wood, dung, straw and animal and human power to meet most of their basic energy needs. This energy is used for the preparation of food. As a consequence of fuel wood shortage, dung is increasingly being used as fuel instead of being returned as fertilizer to the soil. It has been estimated that 20% of India's energy crops produce less straw resulting cow dung. High yielding variety of cereal crops produce less straw resulting in reduction of agricultural wastes for use as fuel. Therefore with rising demand for fuels in developing countries available for the conversion of wastes to fuel are biological and thermochemical. Biological methods include production of biogas. Thermochemical include incinerators.

Biogas Production

Biogas production is gaining momentum in recent days with escalating energy cost. These processes are advantageous due to availability of organic wastes at low or no cost. The fermentation of wastes resulting in fuel and fertilizer yields a number of benefits which are as follows:-

- Produce an energy resource that can be stored efficiently and used in a number of ways i.e. in stove, lighting, power generation, etc.
- Create a stabilized residue that improve manurial value or even enhances the manurial value.
- Reduce fecal pathogens and improve public health due to anaerobic fermentation taking place in an underground digester.

Components of a Biogas plant

A typical KVIC model of biogas plant often recommended consists of a brick lines pit (5 x 5 x 6 ft deep) that serves as digester constructed below ground with an inverted steel gas holder of rotating type 6 x 6 x 3 ft resting over the digester in a water seal, an inlet tank into which cowdung and water mixed in the ratio of 4:1 that touches which gas is evolved and a hose is fitted with the outlet which is connected to stove in the kitchen or anywhere. The outlet is led into holder through which gas is evolved and a hose is fitted with the outlet which is connected to stove in the kitchen or anywhere. The outlet is led into slurry collecting tank in which slurry gets collected which has high manurial value and free form pathogens which can be readily used in agricultural or aquacultural fields. As the gas is produced after initial retention time of 21 days the drum rises that acts as a gas storage chamber. The gas can be drawn off for use as needed.

The most useful constituent of biogas or marsh gas is methane that constitutes 50 to 65% CO_2 makes up most of the remainder gas with small amount of N2, hydrogen and hydrogen sulphide.

Factors affecting methane production

The factors affecting methane production include the composition and volume of the wastes used, operating temperature, retention time, agitation, pH and most importantly C : N ratio.

1. C / N ratio

The C/N ratio of the wastes has a significant effect on the volume of gas produced. A ratio of 20 to 30:1 being best and ideal for fermentation, which depends on the composition of wastes. High Nitrogen wastes such as animal and human wastes can be added to high carbon cellulosic wastes like agri residues to during ratio closer to optimum level.

2. Total volume of wastes

The volume of wastes that can be precessed is a function of digester size and retention time. The rate of charging is important. The continuous addition of small amounts of materials is important and sporadic addition of variable amounts is not desirable. Daily addition of uniform amounts is preferred them are time bulk mixing and letting in the digester.

3. Temperature

Bacterial activity in the digester depends on the temperature of the wastes undergoing digestion the ideal range being 20-40^oC. i.e. thermophilic range - at which faster decomposition of wastes take place. Although satisfactory results can be obtained by operating at 20-40^oC faster decomposition and increased rate of gas production take place when the digester is run at 40 - 60oC. This can be accomplished by burning part of the methane to heat the digester contents, through solar heating or by any other means.

4. Retention time

Retention time varies with temperature prevailing in the digester as well as biodegradability of waste materials fed into the digester. Higher temperature, leading to faster degradation leads to leads to lesser retention time as well as result in reduction of pathogens. Biodegradability varies with the nature of waste materials used as feed stock.

Some agitation of digester is required that results from addition to or withdrawals from the fermenting waste biomass. The deliberate agitation of the digester is beneficial to gas production by dispersing some layers and breaking down particles to provide greater surface area.

pH

As digester bacteria are more sensitive to changes in pH the optimum pH range is between 7.0 and 7.2 i.e. nearly neutral pH. When the pH drops below 6.0 there is significant inhibition of methane producing bacteria and a pH of 6.2 is toxic to these bacterial organisms.

Although gas production takes place at pH 6.6 - 7.6 it will not be at expected level of production. Under balanced digestion conditions the biochemical reactions tend to maintain the pH in the appropriate range.

Biogas production takes place under 3 stages viz., hydraulic, Acelogenic and Methanogenic phase.

During the I stage i.e. hydrolytic phase the biopolymers in the waste materials are hydrolyzed enzymatically much in the same manner of human digestive system to their respective monomeric units.

During II stage i.e. Acelogenic stage the monomers are transformed into organic acids mainly Bytyric Acetic and propionic acids through the action of Acelogenic baceria.

During II stage i.e. Anaerobic or Methanogenic phase methane is generated by methanogenic bacteria using the organic acid as substrates.

The advantages of biogas production are besides yielding non polluting fuel energy in the form of methane we get nutrient rich slurry too an effective organic manure which can be utilized in fish bond to produce fish food organisms as well as in Agricultural field to enrich the soil. Biogas can be used for producing electricity, lighting a lamp, or even running a generator too and what more? We are returning cow dung back to soil instead of burning and letting into air causing pollution. To top all these biogas production paves way for hygienic and safe disposal of organic wastes - a viable alternative to traditional usage as fuel in the form of cow dung take. Is it not worth taking it up for cleaner environment?

INCINERATORS

Land filing is still practised as common method of waste disposal in developing and developed countries - especially for the Municipal and Corporation Solid wastes. Faces with growing piles of garbage and lack of landfills in recent days make the public to think of alternatives for safe disposal of wastes - especially hazardous wastes. The structure of the molecule determines the nature of hazardness. If the waste molecules can be destroyed or reduced to CO_2, water and associated inorganic substances the organics are rendered harmless. For these reasons thermal destruction is recognized as a preferred treatment technology of hazardous wastes and incineration is a most desirable disposal technology especially while dealing with large quantities of hazardous or bio medical wastes - since it ensures highly efficient destruction of organic wastes with minimal quantities of emission of gases.

Incineration is the controlled high temperature oxidation of primary organic compound to produce CO_2, water and energy. Incineration helps in energy recovery or waste to energy because the heat derived from incinerated refuse becomes a useful resource. Internationally well over 1000 waste to energy plants in Brazil, Japan and Western Europe generate energy while reducing the volume of wastes to be land filled. In the United States more than 110 waste incinerations burn 45000 tons of grabage daily.

Chemistry of Incineration processes

Incineration processes are highly complex and require control of kinetics of chemical reactions under non-steady state reaction conditions. All of the mechanisms of heat transfer - including conduction, convection and radiation - takes place among solids, liquids and gases - under high temperature reaction conditions involving high rate of heat release.

It is similar to combustion but with one distinct difference. Combustion oxidizes a valuable material say for e.g. coal and produces undesirable air pollutant besides useful energy. Incineration as the other hand produces heat energy from undesirable waste material such as hydrocarbons - through thermal destruction resulting in the release of desirable air emissions - CO_2 and water. But solid ash residue also is produced besides certain undesirable air pollutants. The thermal destruction of hazardous waste involves the controlled exposure of wastes to elevated temperature well above 1600^{o}F. When properly designed and operated the thermal destruction systems significantly reduce the volume of hazardous wastes.

RCRA and TSCA regulations specify minimum destruction temperature for a required residence time in the presence of excess O_2. Hazardous waste incineration occurs during the flow of hot, turbulent substances within a refractory lined incinerator. There are many factors in designing an incinerators.

1. Temperature

The threshold temperature to initiate thermal destruction is above 1600oF.

2. Residence time

Sufficient residence time must be allowed in order to ensure destruction and removal efficiently as well as to assure conversion to desirable incinerator products.

3. Turblence

The configuration of the incinerator will affect its ability to destroy hazardous wastes. The selection of pumps, blowers and baffles should be based upon the type of wastes to be incinerated.

4. Pressure

Most incinerators are designed to be operated at slightly negative pressured to reduce fugitive emissions.

5. Air supply

The incinerations should have sufficient air supply or O2 to ensure that products of hydrocarbon combustion ultimately result in CO2 and water.

6. Materials for construction

These include ordinary steel to exotic alloys for free operation.

7. Auxiliary features

After burners may be needed to ensure proper DRE (Destruction and Removal Efficiency). Further downstream treatment is necessary to neutralize and remove undesirable destruction products such as mineral acids.

Thermal destruction systems must be insulated with refractory materials to effectively operate at elevated temperatures. The main purpose of insulation is to contain within the unit the heat released from incinerator process. The materials (Refractory) include Fire clay, Silica, high aluminium or chrome.

Incineration offers an excellent disposal technology for all substances that have high heat release potential. Liquid and solid hydrocarbons are adaptable to incineration. The bulkier the materials and less subject to uncertainty. It detoxifies carbinogas, mutageous and teratogens. Numerous other hazardous, wastes detoxified by incineration includes pathological bio medical wastes. Another advantage is reduction of teachable wastes from landfills and elimination of long term odours that are usually emitted into atmosphere. Incineration offers the best opportunity to better manage the potential polluting air emissions at a control location as opposed to widely disposed landfill locations. Another significant advantage of incineration is the potential energy recovery of heat released and recovery of valuable products and can either be reused, recycled or marketed. One disadvantage is initial capital investment which is much more higher than that of any other treatment technologies. It also requires high trained personnel -because of the variance in the waste composition and extreme vigilance and care required to achieve desirable thermal destruction efficiencies.

*****

Question Pattern

Marks : 1OO

SECTION - A (5×5=25 Marks)

Answer any FIVE out of EIGHT.

SECTION - B (5×15 = 75 Marks)

Answer any FIVE out of EIGHT.