UNIT 17 ECONOMIC IMPLICATIONS OF CHANGED ENVIRONMENT

Structure

17.1 INTRODUCTION

You have already learnt in Unit 13 about different types of wastes, sources of their generation, and the practices generally employed to dispose them. You have also known about the adverse impact of different kinds of pollutants on health in Units 14 and 15. We shall now look at the economic aspects of wastes and the related environmental issues in a holistic manner right from 'Cradle' (source of generation) to the 'Grave' (ultimate disposal).

Every human activity, economic or leisure, does result in some kind of wastes. Since, wastes are perceived to have no economic value, they are thrown or discharged into the environment. In the past, such wastes by the large were always within the assimilative capacity of the environment. However, due to increased population and better standard of living, the wastes now entering the environment, have grown both in quantity and complexity. A situation apparently has been reached where environment is unable to digest them any more. It indeed is this 'environmental indigestion' which is manifesting itself as the plethora of environmental problems confronting the humanity today.

In this unit we will discuss the economic impact of degraded environment. The cost and benefits or potential opportunities associated with wastes generated in industrial, transport, agriculture and domestic sectors. We will also discuss how cost-effective the environmentally acceptable waste management practises are and what could be economically preferred waste management options. These are some of the key areas that we shall dwell upon now.

Objectives

After studying this unit you should be able to:

- establish the linkage between wastes and environmental problems,
- list various types of wastes from different sectors,
- understand economic implications of waste generation and waste disposal,
- list hierarchy of waste management options,
- relate through concrete cases that "wastes" indeed are "misplaced resources",
- analyse the economic constraints impeding environmental preservation efforts.

17.2 COST OF WASTE GENERATION AND DISPOSAL

In this sections we will first tell you about the linkage between waste and environment. Then we will discuss the magnitude to industrial, agricultural and domestic wastes in India.

17.2.1 Wastes and Environment

Everything-everything indeed, we use and consume—the food we eat, the clothes we wear, the house we live in, the course book you are now reading—are all essentially made of materials and energy drawn from environment—the earth's crust and surface, atmosphere or water. We never get something from nothing.

Look at Fig.17.1, when the materials extracted from environment are not in the desired usable forms, they are subjected to knowledge-based processing called 'technology'. By applying energy they are converted into useful products and services. It holds good for every activity we perform, whether, it has to do with industry, agriculture, transport services, or domestic sector both urban and rural areas.

It must be recognised here that in any technological process, all the material inputs or input resources are NOT and perhaps can NEVER be transformed into desirable products and services completely. Some amount of waste is always produced. How much of the given inputs shall finally appear as products and services at the end of processing-run-through, or how much shall go out as wastes, would depend on what is produced, the technological processes employed and how efficiently these processess are managed. One thing, however, is certain that wastes would be generated—come what may. It is inevitable.

As we have outlined in Fig.17.1, wastes are also generated when people take in food, water, air or use material to make industrial products. When waste is produced, in excess, it pollutes the environment. However, some of the wastes can be recycled.

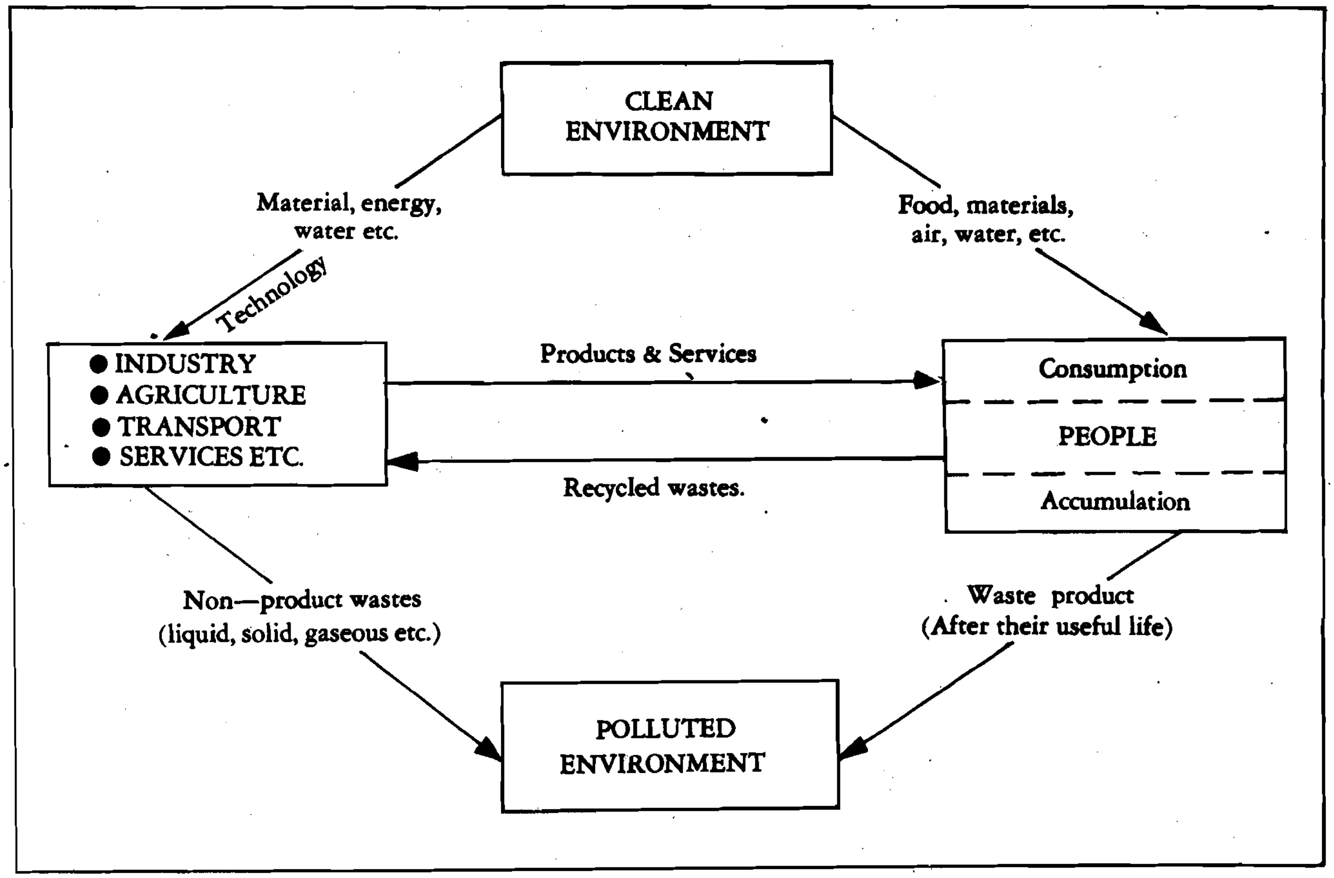

Fig. 17.1 : Human Activities and Environment

As the 'needs' and 'wants' of people increase, per capita extraction of materials from environment also increases progressively. For instance, per capita material extraction in USA during early 80s was as high as 60 kgs. per day. With increase in population the world production of goods and services has also been growing rapidly. For example, since 1950, the industrial production has grown more than seven-times and production of minerals has multiplied over three times.

Obviously, therefore, as the withdrawal of resources increases, so does the discharge of wastes back into the environment. Every withdrawal and every discharge alters the environment. What emerges, therefore, is that we are constantly disturbing the environmental equilibrium. The intensity of these disturbances, unfortunately, is escalating with evergrowing withdrawals and discharges.

It is, however, not just the quantity of discharges or withdrawals alone which is the basic bane of all the environmental problems confronting us today. There are other factors too. The form, the place and the time of discharges or withdrawals also contribute significantly to our environmental woes. Let us try to understand the importance of these factors in the context of environmental degradation, with the help of an example — the coal fired thermal power station at Delhi. The power generation capacity of this station determines the quantity of coal needed, which in fact has to be extracted from Bengal or Bihar coal mines and transported all the way. This coal when burnt in the power station results in a waste flyash and unburnt coal particles which are discharged up the chimney into the atmosphere. While, the coal was withdrawn from the environment in Bengal or Bihar, what is discharged into the environment at Delhi is flyash and a little quantity of unburnt coal. Therefore from withdrawal to discharge, form has changed, and so has the place — from Bengal or Bihar to Delhi.

Even the time-frame has undergone a change. At one point of time what was coal is now largely ash. The timings of discharges or withdrawals acquire special significance in real life situations. For instance, in certain weather conditions if the discharges are not controlled it may lead to 'smog' — a suffocating environmental condition, about which you have learnt in Unit 10.

The form, place and time of withdrawal and discharge changes at the biosphere level also. Of the total withdrawals, a very major portion is extracted from the earth's crust or the surface. Relatively, much less material is withdrawn from air or water. But, when it comes to discharges, the proportion discharged into the air and water is very much more than that extracted from them. This leads to an increasing level of pollution of the air and water. That is why water pollution problems were recognised first, followed by the air, soil and other forms of pollutions. Accordingly, the trend worldover has been that acts to control water pollution were the earliest to be enacted. Acts regulating air pollution and others followed later.

We can now sum up what we have learnt so far : wastes are inevitable and are growing both in quantity and complexity. Since, their discharge affects the environment adversely, different environmental protection or pollution control Acts have been enacted and are being enforced. Let us examine the economic aspects of wastes right from generation stage to disposal—discharge into the environment.

Excessive wastes, when generated, indicate inefficiency. They represent economic loss and therefore associate with it is a hidden cost. Under obligations and mandates of environment protection or pollution control laws, when wastes have to be arrested, treated, stored, transported and disposed off in environmentally acceptable manner, additional cost is incurred.

In the following section you will learn how much and how the wastes are generated and how much, in domestic, agriculture, industrial sectors. But before that try the follwing SAQ.

SAQ 1

a) Fill in the blank spaces in the following statements with appropriate words :

   i) We draw material, energy and water from...................... and convert them into usable form by applying..........................

   ii) The excess......................... of......................... from the biosphere increases the discharge of waste into the environment.

   iii) The three factors that determine pollution are.........................., ...and..........................of waste.

iv) At the level of biosphere the resources are withdrawn from.......................... and wastes are thrown in the...........................

v) The environmental..........................is disturbed because of increase in.........................., ... and subsequent increase in.......................... of..........................

b) Give the basic reasons for escalating disturbances in environmental equilibrium.

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17.2.2 Industrial Wastes

Industries in India, like industries anywhere else in the world generate a variety of wastes in large quantities. These wastes may be solid, liquid or gaseous. Industry-wise quantities are not accurately known in many cases. While, the large and medium industries do respond to environmental compulsions as imposed by the pollution control laws, particularly the water and air Acts, the small scale units do virtually nothing to clean-up their waste waters or air emissions. However, the solid wastes, whether generated in the manufacturing processes in small scale units or in large or medium industries, are dumped indiscriminately wherever convenient and cheap.

It is estimated that small scale units put together generate as much wastes as the large and medium industries in the country. And the entire amount is discharged almost without any treatment with very little regard to the environmentally safe disposal practise. The result is increasingly polluted environment which at places has already acquired serious proportions. The first casualty of waste discharge is our water sources, including the ground water. One such example is a city in Punjab which is wholly dependent on ground water sources. Table 17.1 shows the difference in quality of water available in some of the city's ground water sources and what it should be, if it has to be potable as per WHO drinking water standards.

Table 17.1 : The Ground Water Quality of a City in Punjab

Parameter	Value	Drinking Water Standards (WHO)
Colour	Slightly Yellowish-green	Colourless
pH	8.2	7.0
Conductivity	3000 μ Mho/cm at 25°C	—
Total Dissolved Solid (TDS)	2000 mg/l	—
Iron	1.5 ,,	0.1
Aluminium	0.1 ,,	—
Total Chromium	0.7 ,,	0.05
Cyanide	2.0 ,,	0.01
Copper	0.02 ,,	0.05
Cadmium	0.005 ,,	0.05
Nickel	0.01 ,,	—
Lead	0.05 ,,	0.1
Manganese	0.15 ,,	0.1

The Magnitude of Wastes

Even when the effluent treatment plants and air pollution control devices are put up by all the industries—small, medium or big, the wastes still have to be discharged. The only difference in that case would be that nearly all the wastes will be in the solid form. With the stricter enforcement of pollution control laws, almost all the large industries treat their waste waters and air-emissions converting generally the pollutants present into solids or sludges. Let us, therefore, look at the magnitude of industrial solid wastes in India. In Table 17.2, some of the major industrial wastes and their current annual generation figures are indicated.

Table 17.2 : Source and Annual Generation of Some Major Industrial Wastes

Waste	Quantity (Million Tonnes/year)	Source
Blast furnace slag	35.00	Integrated iron and steel mills
Fly ash	30.00	Coal based power plants
Phosphogypsum	4.50	Phosphoric acid/ammonium phosphate plants
Red mud	3.00	Aluminium industry
Lime sludge	3.00	Sugar, paper, fertiliser, tanneries, soda ash and calcium carbide industries
Kiln dust	1.60	Cement plants
Brine mud	0.02	Caustic soda industry
Copper slag	0.0164	Copper industry
Mica Scraper waste	0.005	Mica mines

It may be mentioned that the above Table lists only the wastes from some of the large industries. If one considers the wastes from other industries as well as from 2.5 million small scale units in the country, the total quantity would indeed be much larger.

Take just one sector, for example, the stone crushers. Our country has over 10,000 stone crushers. Assuming that each one of them on an average crushes just 100 tonnes of stones everyday, on a conservative side, all the stone crushers put together shall let out a minimum of 1000 tonnes of stone-dust daily into the atmosphere. If the dust emissions aren't controlled, a large portion of dust particles remain suspended in the air. You have learnt that when people breath in such air, over a period of time they get all kinds of respiratory and lung malfunction and may even suffer from serious disease Silicosis. It is, therefore, not just the quantity of wastes, but where and in what form they are discharged which determines the magnitude and seriousness of environmental consequences.

Discharge of solid wastes on land may result not only in soil and ground water pollution, but large quantities of wastes such as fly ash, blast furnace slag, etc., also pose a problem of an altogether different dimension — the space for their disposal. For example, a 1000 MW coal-fired thermal power station, using coal containing 40-45% ash and having calorific value of 3500 kcal/kg, would need in 30 year time of its operation as much as 500 hectares of land for disposal of its waste, the fly ash. Imagine the situation by the turn of the century when we would have doubled our total thermal power generation capacity to 80,000-100,000 MW. In effect, we shall be more than doubling the magnitude of our fly-ash disposal problem, if we take into account the pressure on the availability of land, we might face then, purely due to increase in population during the intervening period.

Reasons for Excess Wastes

It is generally acknowledged that outdated technologies and inefficient running of industries are mainly responsible for generating large quantities of wastes. While thermal power stations may not be classically the right example but a large segmen of our industries, specially the small scale industries do produce more wastes than what they ought to. For example, generation of wastes per tonne of the product in a small dye-intermediate industry is almost double that of a large unit producing the same item. Such a large variation in the generation of wastes is attributable to the batch operations and the type of product separation processes employed by the small scale units. In other words, the manufacturing technology plays a crucial role in both quantity as well as quality of waste generated. However, if an industry generates more wastes per unit of product output than what the manufacturing technology dictates, it indicates inefficient use of resources, ineffective management, and improper operation and maintenance of manufacturing systems or equipments. Such is indeed the case in many of our industries.

Financial Implications

Whatever may be the cause, larger and more complex the waste, greater would be the manufacturing cost. Waste production itself entails costs and in addition costs have to incurred for treatment, storage, transport and for disposal. Should the environmental protection Acts warrant safe disposal (which is not yet the case in our country), many wastes particularly the ones which are hazardous or heavy metal bearing may require thermal, biological or chemical treatment before disposal. In such a situation, industry not only has to invest on the treatment facilities but also has to incur operation and maintenance costs of such a facility on a recurring basis. Larger is the waste, greater will be the investment on the treatment system and so would be its operation and maintenance costs. Even after treatment, there would remain the residues, requiring disposal on a designated landfill. Wastes, therefore, cost again not only for the transport to the landfill site but also in terms of certain payments to the landfill operators to accept the waste and subject them to environmentally compatible landfill operations. So you see wastes always cost. They cost at every stage right from generation to their final disposal. For most industries the cost of managing wastes varies between 2-5% of the sales turnover. In certain industries, it could become as high as 12-15% of turnover.

SAQ 2

a) Why are more wastes generated by an industry than advocated by manufacturing technology?

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b) Elaborate in a few lines that wastes cost right from their generation to disposal.

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17.2.3 Agricultural Waste

The problems of rapid depletion of resources and environmental pollution are most acutely felt today in those sectors of economy that deal with non-renewable resources. Industry and transport are such sectors. Given the finiteness of non-renewable resources; oil, metal ores, coal, etc., exponential increase in exploitation of these resources and the associated-environmental repurcussion the future of these two sectors poses a serious challenge to ingenuity and technological capabilities of the entire human race. On the other hand, those segments that work with renewable resources are significantly less problematic both in terms of raw material availability and waste disposal. Agriculture is one such sector.

Range and Magnitude

Over a hundred types of reclaimable agricultural wastes are available in India. Each one of them could be and indeed are being put to a variety of uses. It is estimated that over 600 million tonnes of crop residues and agro-industrial wastes are generated annually in the country. In the year 1985-86, the availability of agricultural wastes or crop residues alone was estimated to be around 324 million tonnes. These wastes include crop residues such as paddy, juwar, wheat and gram straws, cotton sticks or linters, maize stalks and cobs, rape and mustard sticks, millet and barley straws, sugarcane trash, coconut shells etc. The quantities of these materials generated during the year 1985-86 are given in Table 17.3.

Table 17.3 : Availability of Crop Residues in India (1985-86)

Crop Residue	Quantity (Million tonnes)
Paddy Straw	147.35
Juwar Straw	20.24
Ragi Straw	3.20
Bajra Straw	7.37
Wheat Straw	68.92
Gram Straw	5.68
Cotton Linters	4.40
Pulses Straw	5.00
Groundnut Haulms	11.37
Maize Stalks	10.76
Maize cobs	2.07
Rape & Mustard Sticks	4.88
Millet Straw	1.56
Barley Straw	2.87
Arhar Sticks	3.21
Jute Sticks	4.24
Sugarcance Trash	17.17
Castor Sticks	1.37
Mesta Sticks	0.73
Coconut Shell	1.35
Total (Crop residues)	323.74
Others (Agro-wastes)	275.25
Total (Agricultural Wastes)	600.00

Utilisation of Agricultural Waste

In the normal course, these agricultural wastes are used for a variety of purposes. Some of the predominant uses are as fuel, animal feed, farm manure, construction materials, etc. A small quantity goes to industry as raw materials.

Though the conventional uses account for a very high proportion of the total crop residues, the manner in which they are utilised leaves a considerable scope for improvement. In other words, even after satisfying the need for conventional uses, some of the crop residues could be put to better alternative uses and for better economic returns. Some such potential alternatives are presented below in Table 17.4.

Table 17.4 : Present Utilization and Potential Alternative Economic Usage of Agricultural Wastes

Crop Residue	Present Use	Potential Alternative Usage
Paddy Straw	Mostly burnt, a small quantity used for mulching and roofing.	Paper, paper and straw boards, biogas, power generation
Wheat Straw	Fuel, animal feed, construction material	Straw board, biogas.
Maize Stalk	Animal feed and fuel	Paper and paper boards, particle boards.
Maize Cobs	Animal feed and fuel	Xylose, furfural, oils and acids.
Sorghum Sticks	Animal feed and fuel	Pulp and paper, Kraft paper, viscose rayon.
Sugarcane trash and dry leaves	Fodder, fuel and manure	Pulp and paper, Plastic and linoleum filler.
Cotton leaves	Compost	Organic acids such as citric and maleic acids.
Coconut shell	Fuel and fancy items	Charcoal, activated carbon, furfural.
Cashew Apple	Waste	Beverages, Syrups, Candy, Chutney, pickles etc.
Groundnut Shells	Waste	Fuel.

As the demand for industry-produced items is increasing and the pressure on availability of both non-renewable as well as renewable resources such as forests is mounting, the use of agricultural residues and agro-industrial wastes is also increasing progressively. For instance, the pulp and paper industry which has been traditionally using bamboo and hardwood as raw materials, is gradually making increasing usage of agricultural residues like wheat straw, cotton linter, paddy straw, bagasse, etc.

There are a large number of small pulp and paper mills in the country now, which produce paper out of these agricultural residues and waste-paper. Similarly, bagasse, which was traditionally used as fuel in sugar industry, is now increasingly finding its way for pulp and paper manufacturing. In fact, due to limited availability of forest raw materials for pulp and paper industry, sugar industry, these days, finds it economically more attractive to sell bagasse to the paper mills than to use it as a fuel. A large integrated paper mill producing newsprint from bagasse has already come into operation in the country. More such paper mills are likely to be set up in future. Likewise, many industries, which were using coal earlier, have switched over to rice-husk as the fuel on grounds of economy, despite the fact that rice husk storage requires huge space. If burnt in skilfully managed incinerators, rice-husk turns out to be far cheaper, (about one third), than coal as a fuel for power generation. It has substantial energy value ranging from 3,200 to 3,500 kcal/kg. The availability of paddy straw is also good. Punjab alone produces about 5 million tonnes of paddy straw per year. It can easily fulfil the bulk of power needs of the farm sector.

It is apparent, therefore, that agricultural residues and agro-industrial wastes, in fact are no wastes. All of them have some use or the other and in that sense they are a resource whose conventional use needs to be upgraded and better potential usability fully harnessed. Their generation costs virtually nothing but having generated, not to make their appropriate use is indeed costly.

Environmental Dimension

Agricultural sector also has its environmental side effects. You know that increasing use of synthetic fertilizers, pesticides, fungicides, etc., has its own environmental fallout. For example, these fertilizers and pesticides which remain unused in the fields, invariably flow out along with run-off waters during the rains. And, they find their way into estuaries, lakes, river courses and even into the ground water. Their presence beyond a certain limit pollutes water, particularly in lakes and estuaries, bunds, ponds etc.

Likewise, use of agro-residues or agro-industrial wastes in industries results in air and water pollution. For instance, use of molasses — an agro-industrial waste from sugar industry, in distilleries creates massive organic pollution of waters. Burning rice-husk in industrial boilers, pollutes the surrounding environment with ash particles thrown up the chimney. Even disposal of high silica-bearing rice-husk ash by itself is an environmental problem.

17.2.4 Domestic Wastes

The quantity and quality of wastes generated in domestic sector depend upon a number of factors such as per capita water supply, food habits, standard of living, socio-cultural values, life-style and degree of commercial and industrial activity around. From the domestic sector, the wastes are largely in solid and liquid form. Air emissions are confind to rural areas and settlements of weaker sections in the cities, where they use coal or wood as fuel for cooking purposes. While, the domestic wastes are traditionally looked at as liquid and solid wastes only, in the Indian context, however, they have to be put into four different categories :

i) human waste
ii) liquid waste
iii) solid waste
iv) air emissions

Human Waste
This category of waste is peculiar to our country and many other developing countries, where there is a wide-spread prevalence of open defecation and the practice of manual scavenging. Human waste is a serious and pervasive contributor to the environmental degradation in these countries. As you have learnt earlier sanitary disposal of human excreta does not cover even one-fourth of the total population.

Liquid Waste
It consists of what flows out as waste waters from the toilets, kitchens and bathrooms of residential houses and toilets and canteens of commercial establishments. Such waste water is termed as sewage. The most widely prevalent disposal practice is to discharge the sewage on to the ground, nearby nallahs, rivers and other water courses, often without any treatment.

In class-I cities (population > 1.0 lakh) for instance, where better sewage collection and treatment prior to disposal is expected, only about 60% of the population have access to the sewage system. Even in the metropolitan cities, only around 50% of the total waste water generated is collected through the sewer system. The remaining is let out on the surface, creating insanitary conditions, foul smell and degradation of environment.

Also, in class-I cities on an average only about 20% of the waste water collected through the sewers is subjected to some kind of treatment prior to its disposal. It may be mentioned that the treatment given is often inadequate and rarely the quality of waste waters discharged from the sewage treatment plants meets the disposal standards. As a matter of fact, the raw sewage that flows out from our cities and towns directly into the rivers is one of the major cause of our rivers getting polluted. There is hardly any river which is an exception.

The sewerage and sanitation scene in class-II cities (population between 0.5 and 1.0 lakh) presents a despicable picture of insanitary conditions. In these cities and smaller towns, not more than 5% of the total waste water generated is either collected or treated.

In rural areas, generally there is no piped water supply. As such both the generation and the consequent disposal of waste water is small. Even then, it is not uncommon to find stinking, wet streets in the villages, due to utter lack of drainage.

Solid Wastes
They comprise solid wastes as generated in the households, such as, kitchen waste, paper, plastic, glass, rusted metals, etc. In addition, such solid wastes are also generated in commercial establishments and through street and road sweepings. These wastes, often referred to as 'city garbage' after collection are usually disposed

off on designated landfill sites. These landfills are supposed to be sanitary landfills, however, due to non-adoption of scientific methods, even incompatible wastes are recklessly dumped in a haphazard manner creating not only the familiar nuisance of bad odour but also the ground water pollution through percolation of leachates.

The quantity of garbage generated is generally proportional to the affluence in the society. For instance, the per capita waste generated within the New Delhi Municipal Committee area is between 800-1000 g/day, whereas in the Municipal Corporation area of Delhi it is only about 300 g/day. On an average, however, the per capita solid waste generation in Indian cities is of the order 350-400 g/day. Table 17.5 gives an idea of the magnitude of solid waste generation in some of our cities.

Table 17.5 : Generation and Collection of Solid Wastes in a few Selected Cities

City	Population (1981)	Solid Wastes (tonnes/day)		
		Generated	Collected	Collection Efficiency (%)
Bombay	8,227,332	3200	3100	96.0
Madras	4,276,635	1819	1637	90.0
Kanpur	1,688,424	2142	1500	70.0
Coimbatore	917,155	175	113	64.6
Indore	827,071	120	100	83.3
Meerut	538,461	120	70	58.3
Jamnagar	317,037	149	89	60.0
Anand	83,815	34	17	50.0
Khopoli	32,108	6	3	50.0
Dehgam	24,817	9	4	44.4

Air Emissions

What is discharged into the ambient air from domestic sources primarily consists of :

a) smoke and soot from coal and wood fired cooking stoves and

b) to a lesser extent CFCs (chlorofluorocarbons) from deodorant spray cans and refrigeration equipment.

In cities, the discharge of smoke and soot is limited to the areas occupied by poor people and weaker sections of the society, as they don't have access to cleaner fuels such as cooking gas or kerosene, whereas, in rural areas wood and coal are predominantly used for household purposes. According to an estimate, of the total wood consumed in the country, 85% is accounted by the domestic sector for cooking purposes. Similarly, in areas close to coal mines, people often use coal for cooking purposes. For instance, in Delhi the domestic sector contributes just about 10-12% to air pollution, the remainder coming from transport and industrial sectors. But in Calcutta, the air pollution caused by domestic sources is relatively much higher, essentially because of extensive use of coal as the cooking fuel.

The problem of CFC emissions is generally confined to the cities and that, too, to the affluent section of the society. What is important to consider is that though the release of CFCs into the environment is small, its effect on destruction of ozone layer is enormous.

Release of emissions whether smoke, soot or CFCs costs both to the individual users and to the society, in general, through environmental degradation. For example, the overall thermal efficiency of the conventional 'chulhas' (stoves), where wood or coal is used as fuel, is only about 15-20%. To that extent it costs the individual users by way of higher fuel consumption, as opposed to users having improved stoves where the thermal efficiency could be easily 35% or more. If all the households in the country use better stoves, the consumption of wood or coal can be reduced to half. Imagine, the salutory effect such a scenario would have on the deforestation problem and consequent run-off of top soil.

SAQ 3

a) Write the names of crop-residues that can be put to potential alternative uses listed below.

   i) Paper. . . . .

   ii) Paper board. . . . .

   iii) Straw board. . . . .

   iv) Organic acids. . . . .

   v) Beverages, syrups, candy. . . . .

b) From Table 17.5 calculate the per capita solid waste generated in Bombay, Kanpur, Khopoli and Dehgam. Which of these cities generates more solid wastes and what does it indicate?

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17.3 ECONOMICS OF POLLUTION CONTROL

It costs to control pollution but it also costs if it is not controlled. If pollution is allowed unabated, it affects the health of the people, agriculture, archeological monuments and other structures, tourism, flora and fauna adversely. These adverse impacts can be quantified in concrete monetary terms. Similarly, investments needed for control of pollution can also be quantified. Therefore, if a cost-benefit analysis is attempted at macro or national level, it can be demonstrated that the benefits of controlling pollution far outweigh the investments required.

On an average, industrialised nations spend anywhere between 0.5% to 1.5% of their GNP on pollution control measures. Countries like Japan and Germany are even spending as much as 5% of their GNPs to control pollution.

17.3.1 Economic Damage

Let us first look at the extent of economic damage caused by pollution in some of the industrialised nations as given in Table 17.6.

Table 17.6 : Pollution-Induced Economic Damages in Some Industrialised Countries

Items	Per Capita Costs (US $)*			
	USA	Canada	UK	Italy
Health	60.0	2.5	35.0	2.5
Agriculture	0.5	0.5	10.0	0.5
Services/Tourism	20.0	10.0	10.0	5.0
Materials	24.0	49.0	14.0	5.0
Total	104.5	62.0	69.0	13.0
As % of GNP	2%	1%	3%	1%

* US $ ~ 25 Rs.

The annual damage to the natural environment in Germany is of the order of 6% of GNP and in OECD countries, it is around 3% of GNP today. Table 17.7 given below details various environmental pollution damages in Germany.

Table 17.7 : Environmental Damage in Germany

Media	Damages (In billions of DM* per year)
Air Pollution (Health hazards; material damages; animal losses; degradation of vegetation, agriculture, forests, etc.)	48.0
Water Pollution (damage of sea, rivers, lakes, ground water, etc. and consequent loss in fisheries, tourism, etc.)	17.6
Soil Pollution (nuclear fallouts, dumping of hazardous wastes, loss of biotopes and species, etc.)	5.2
Noise Pollution decline in productivity, reduction in property value, loss of residential amenities etc.)	32.7
Total	103.5 billion DM*

*** 1 DM (Deutche Mark) ≈ Rs. 12**

The purpose of the above Table was essentially to introduce you to the kind of damages a polluted environment could result in. However, such data from developing countries are not available.

17.3.2 Pollution Economics

Since, the relevant data from developing world are virtually non-existent, it is not possible to present a cost-benefit analysis based on the situations in the developing countries. However, for the sake of demonstrating the economic advantage of controlling pollution, cost-benefit data of USA are presented in Table 17.8 below. It may be noted that the data given in the Table pertain to the year 1972 and they are specifically selected with the assumption that the level of industrialisation in USA at that time, perhaps, was more or less similar to what it is in some of the developing countries today.

Table 17.8 : Economic of Pollution Control in USA (1972)
(All the figures are in billion US $)

	Water	Air	Total
Pollution Damages	12.8	16.1	28.9
Gross Savings from Clean-up	11.5	10.7	22.2
Cost of Clean-up	6.3	3.9	10.2
Net Savings	5.2	6.8	12.0

It is apparent from the above Table that in monetary terms every rupee spent for clean-up results in a benefit to two rupees to the economy. Purely from the economic standpoint, it is also evident that control of air pollution is relatively more cost effective than water pollution control. May be that historically, air-pollution control efforts all over the world were initiated much after the water pollution control activities and this delay had resulted in higher air-pollution damages.

Whatever may be the reasons, it is always prudent to control pollution and it makes tremendous economic sense to do so. In 1985, the national spending on pollution control in USA was of the order of 70 billion US, $, and in Germany the total environmental protection expenditure in 1984 was around 23 billion DM.

Since, the environmental damages in most countries are nearly 2 to 3% of GNP, it is compelling enough to spend anything between 1 to 1.5% of the GNP for control of pollution. In the context of India, 1% of GNP would mean over 3000 crores of rupees. At present, it is estimated that India may not be spending more than Rs.600 crores annually on pollution control efforts.

An argument is often advanced that poor, resource-starved countries like India, cannot afford to spend too much on pollution control, specially if one considers the other pressing priorities. The cost-benefit analysis presented in the Table above, on the contrary, clearly establishes the fact that even for a country like India it would be economically advantageous to control pollution. In developing countries if the availability of resources for pollution control is the critical issue, then let us look at the strategies by which requirement of resources can be reduced. The two most powerful complimentary strategies for national pollation control effort could be:

a) Waste Minimisation and

b) Waste Utilisation

Let us now discuss each of them in some detail.

17.3.3 Waste Minimisation

You know that wastes, hazardous or non-hazardous, generated in transport, domestic, agriculture, industrial or any other sectors, are all potential pollutants. If generation of wastes can be minimised, the investments needed to control pollution effects of the remaining wastes can be substantially reduced. Reducing wastes to prevent pollution is, therefore, a practical and sensible way to complement costly pollution control practices.

It is important here to understand the difference between pollution prevention through waste reduction and conventional pollution control. While, prevention as well as control efforts are aimed at protection of environment, the two approaches are quite different. Control is exercised either to stop further environmental damage or is extended to repair the damage that has already occurred. It is a reaction to what has happened. Prevention, on the other hand, is a response to what might happen and it is aimed at preventing the possible damages from occurring.

Irrespective of the sectors, wastes are a reflection of inefficiency, carelessness, poor quality and bad habits. It is always possible to reduce wastes—whether it is of water, energy or materials. To exemplify, how waste reduction efforts help in reducing both the initial investment on pollution control systems as well as subsequent operation and maintenance costs of such systems, let us examine a couple of case-studies from industrial sector that illustrates prevention pollution through waste minimisation.

CASE-I
The Case of the Missing Milk-Shake
The case pertains to small food-processing unit engaged in:

a) Ice-cream production

b) Cheese preparation

c) Vegetable and meat processing

These items are produced daily on a single shift basis all through the year.

Pollutants of concern : Since the unit is processing edible organic items, the pollutants of concern can be represented primarily through two pollution parameters, BOD and TSS (Total suspended solids). The total BOD load was 92 kg/day and the total TSS was 890 mg/l.

Sources of pollutant generation : Equipment rinsing and washing, and floor washings were traced as the main or major sources of polluted waste water.

In the ice-cream section, there are five vessels which are washed after every batch of ice-cream production. The practice was to fill the vessel with 400-500 litres of water, stir it so that the ice-cream or its ingredients sticking to the walls of the vessel can mix with water and then discharge the washing into the drain.

The waste water from the cheese preparation section comprises mainly of whey and the equipment washings. Similarly, in the food processing section, generation of waste water was mainly from the washing of vessels and floor-wash, uncooked vegetables and fruit peels, uncooked food, etc.

Pollution Prevention Measures : For minimising both waste water volume and discharge of polluting wastes, the following measures were evolved and implemented :

- Vessels in the ice-cream section were washed with minimum possible quantity of water as the first wash, and this wash was collected for alternative usage. Subsequent washings were with only about 100-120 litres of water and washing was discharged into the waste water drain.
- Wire screens were installed to reduce the TSS in the waste water from vegetable and fruit and processing sections.
- Whey from the cheese section was segregated, instead of discharging and was sold as a by-product for cattle feed use.

Result

- The total pollution load in terms of BOD in the waste water went down by 63% from 92 kg/day to 34 kg/day and the TSS came down by 54% from 890 mg/l to 400 mg/l.
- The capital investment cost on the ultimate waste water treatment plant declined by 43% from Rs. 6.5 lakhs to Rs. 3.7 lakhs.
- Since the unit did not have enough space, it was a constraint to put up the 'add-on control system as was conceived earlier without the prevention measures. The requirement of land then was 45 sq.m. which came down to 25 sq.m. after implementation of pollution prevention measures—a reduction of 45%.
- Segregation of the first wash from the ice-cream vessels resulted in a mixture containing just water and ice-cream which tasted like "milk-shake"! It is now being consumed by the factory workers and the children of a nearby school.

The results in pollution parameters are summarised below:

Table 17.9 : Pollution Prevention in a Food Processing Industry

	Without in-plant measures	With in-plant measures	% Reduction
Ice-Cream Section			
Flow, m³/hr	1.81	1.80	00.60
COD, mg/l	5861	2474	57.78
BOD, mg/l	3170	1220	61.51
TSS, mg/l	1590	612	61.50
BOD load, kg/d	40.20	15.40	61.70
Fruit and Vegetable Section			
Flow, m³/hr	3.30	3.30	Nil
COD, mg/l	1829	1645	10.00
BOD, mg/l	869	800	7.90
TSS, mg/l	506	294	41.93
BOD, load, kg/d	20	18.50	7.50
Cheese section			
BOD load, kg/d	27.2	Nil	100
Combined effluent			
BOD load, kg/g	92	34	63
TSS, mg/l	890	406	54

Remarks

- The case only testifies to the fact that waste reduction is not only possible but also makes tremendous economic sense.
- It also reveals that both waste elimination and waste reduction are feasible.
- That every waste is a misplaced resource, clearly emerges when wastes are put to alternative usage.
- It also demonstrates that despite the constraint of space availability which is a general problem with most small scale industries (SSIs), control of pollution is feasible.

- The case exemplifies at least two methods of waste reduction. Firstly, the plant operation practices and secondly, the reuse of wastes within, as well as, elsewhere.

CASE-II

The Case of Saving Energy

This is a case of a small pottery unit producing ceramic wares for household use. The unit had a down-draft kiln (Fig.17.2) operated batch-wise to fire the ceramic-wares. The batch-cycle time was 42 hours and the kiln was fired with coal as fuel. The hot gases from the combustion chamber rise upwards, strike the roof and pass downwards through the green ceramic-wares and go through the port holes in the floor to a duct which leads these gases to the chimney. ID (induced draft) fan was provided to maintain the requisite draft.

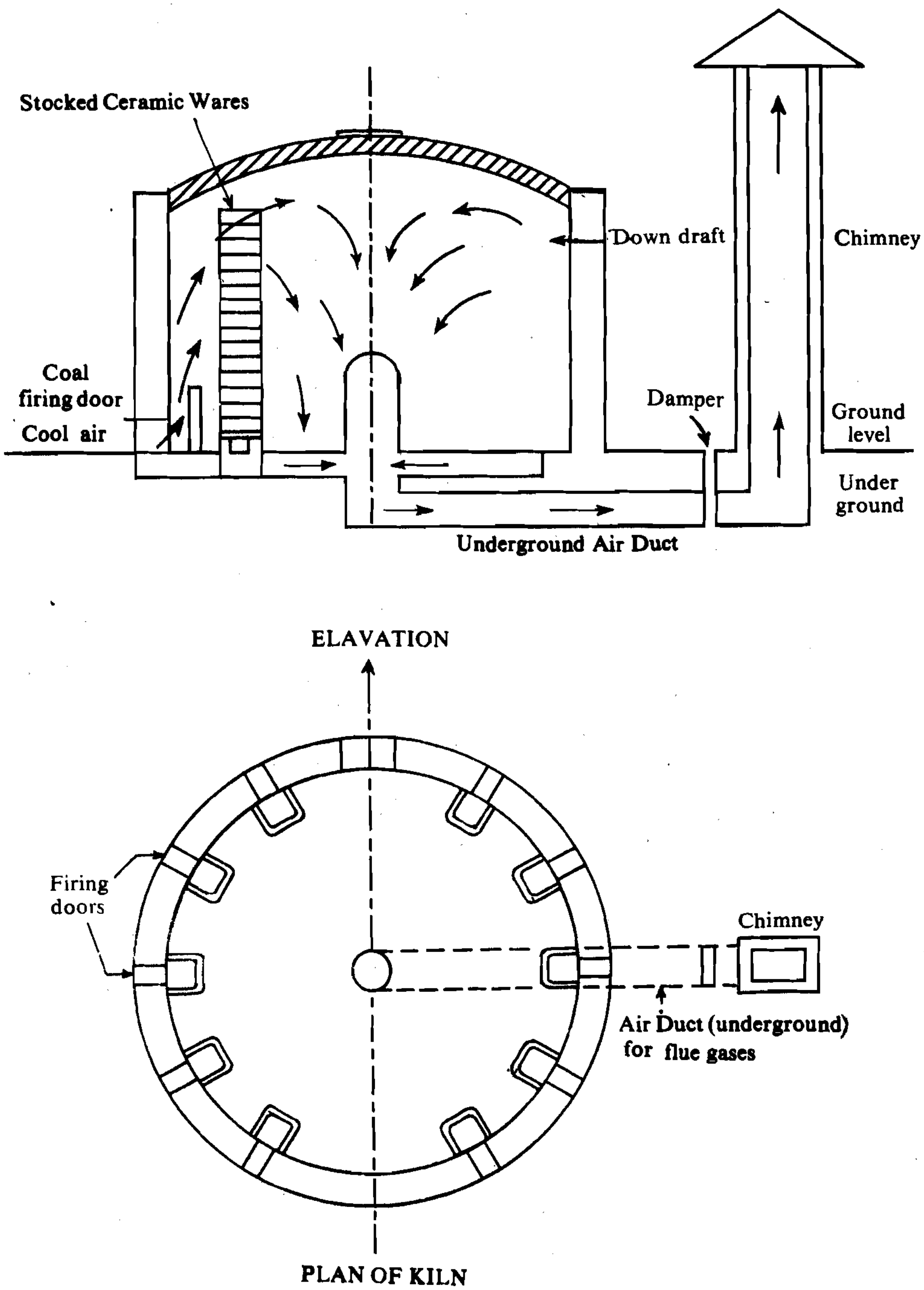

Fig. 17.2 : Sketch of Down-draft kiln leed in small Pottery unit

Pollutants of Concern : As is common with down-draft kilns, combustion of coal emanates thick black smoke. The problem of heavy smoke emission is intensified immediately after the kiln combustion chambers are stoked. The problem is specially acute in the later half of the firng cycle. Since coal was the input material, the ash escaping up the chimney was the pollutant of concern. Measurements indicated that the SPM (suspended particulate matter) in the flue gases goes as high as 3000-5000 mg/Nm^3 during peak emission periods.

Source of Pollutants : The source, obviously was coal which was burnt in the ten combustion chambers of the kiln.

Analysis and Observations : Detailed and in-depth study of the kiln operation revealed the following:

a) Emissions are very high immediately after coal has been fired and persist for a period of about 10-15 minutes.

b) The intensity of black smoke thereafter starts dropping and the stack becomes clear before it is time to fire the coal again.

c) The emissions in the later half of the cycle are more intense than in the first half.

To substantiate visual observations, operation of parameters such as draft, flue gas flow rate, CO_2% in the flue gases, etc. were measured. The variation of flue gas flow rates at different cycle times is shown by curve (A) in Fig. 17.3. The maximum draft available at the combustion chamber outlet was only 7mm W.G.

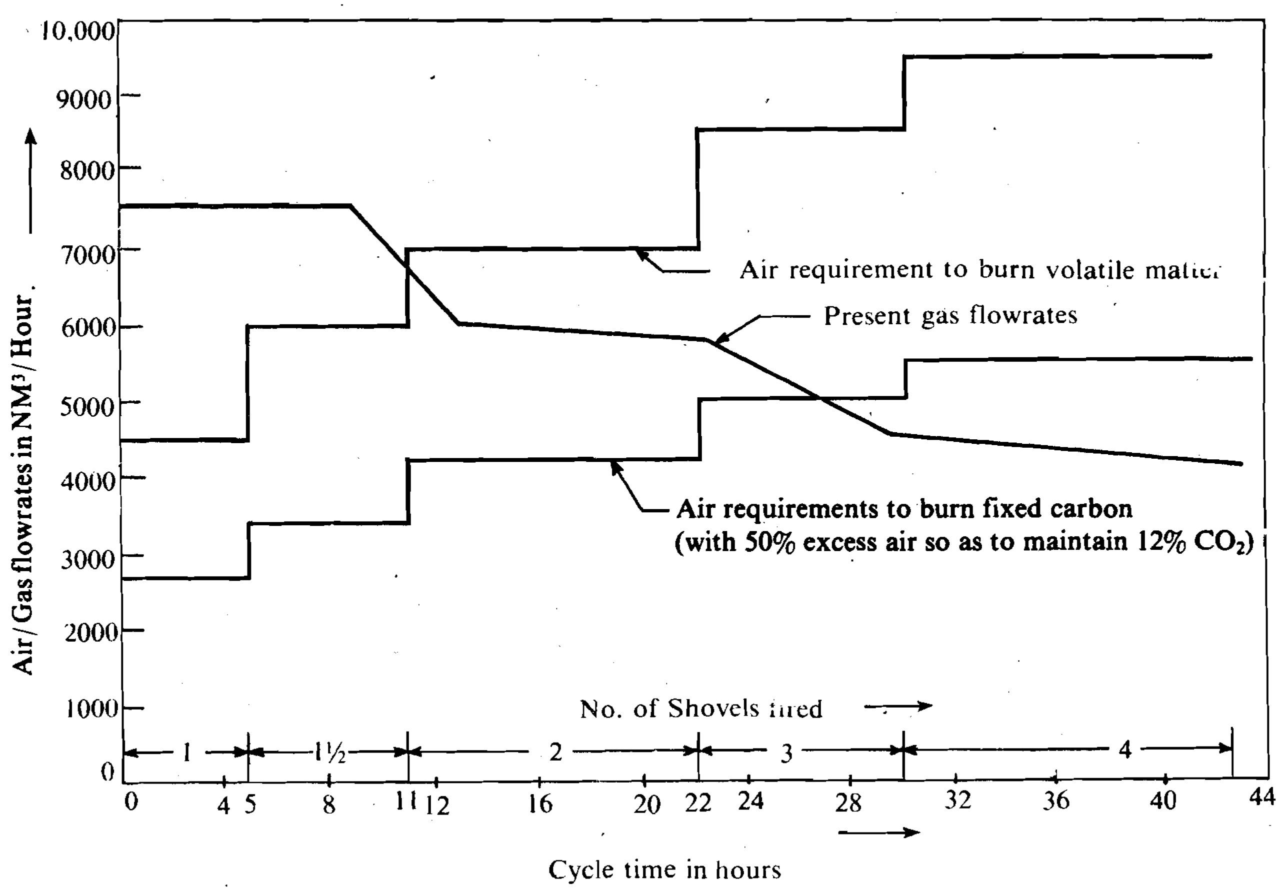

Fig. 17.3 : Combustion Air Requirement and Flue-gas Flow Rate over the Entire Cycle

It is revealed that the supply of air was not in tune with the requirements whether it was between the two firings or over the entire production cycle. The basic principle of combustion also revealed that :

a) Initially when coal is fired, volatiles are emitted requiring enough supply of air to burn them. That the kiln was starved of air during this period was evident from the high percentage of CO. Thus, during the first ten minutes, the requirements of air was high due to volatiles but the same was not available.

b) During the later half when higher kiln temperatures are maintained, more coal is fired, needing more air. Since the temperature of the flue gases leaving the kiln during this period also goes up, volume of the flue gases also becomes larger. But the ID fan can handle a fixed volume of flue gases, in terms of mass flow. So, the actual displacement of flue gases by ID fan, goes down due to increase in temperature. Thus, the air available for combustion becomes even lesser than that during the first half of the cycle.

c) Under these conditions, the kiln had also become pressurised, which was visibly noticeable as the flames leapt out from the firing boxes.

The curves (B) and (C) of Fig. 17.3, indicate the air requirements during initial stages of combustion and during the normal combustion period respectively (between two consecutive firings).

The analysis, therefore, showed that emission of thick black smoke and high concentration of SPM in flue gas is due to improper draft and inadequate supply of combustion air.

Pollution Prevention Measures

- The time gap between two successive coal firings was reduced from 17 minutes to 11 minutes and also the quantity of coal fired in each firing was reduced to half.
- The draft and air supply was regulated as per the combustion air requirement through damper adjustment.
- The unit was advised to maintain around 12% CO_2 in the flue gases.

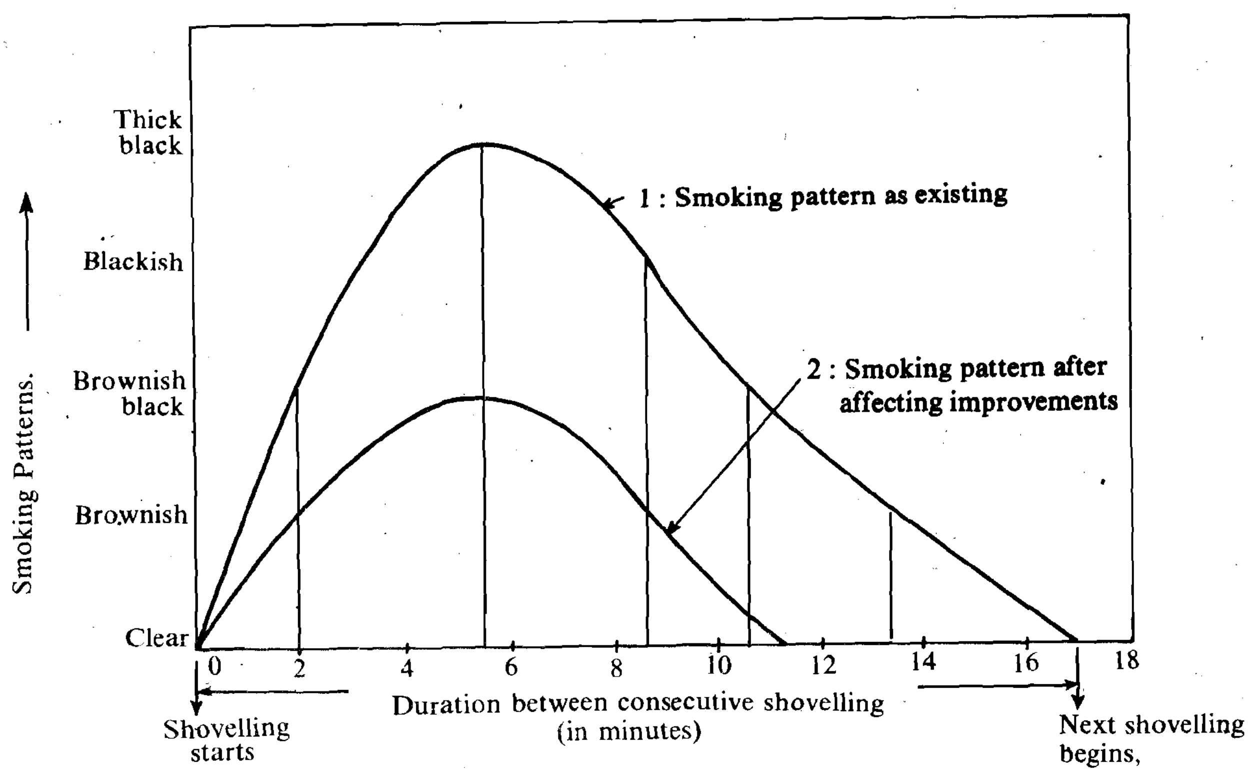

Fig. 17.4 : Smoking Pattern Between Two Successive Firings

Result

- The dust (SPM) concentration in the flue gases came down to 1100 mg from 3000-5000 mg/Nm^3 earlier. This is evident from Fig. 17.4 showing the change in smoking pattern before and after the improvement.
- The specific coal consumption per tonne of ceramic-wares fired was reduced by 28%.
- It resulted in monetary saving of Rs.40,000/- per batch, both due to reduced coal consumption and reduced rejection rate of wares fired.
- Quality of ceramic-wares produced improved.

Remarks

- The case demonstrates that air pollution can be prevented.
- It also shows that certain basic instrumentation is necessary for waste minimisation efforts to succeed.

The two cases discussed above clearly demonstrate that waste minimisation efforts cannot only bring down the investments needed for pollution control equipment by as much as 40% but they often result in greater productivity and profits also. Industries, in which bulk of pollution control investments are usually made, can adopt anyone or more of the following six approaches to minimise wastes:

i) change raw materials and other inputs;

ii) modify the production processes, equipment, operating parameters or the technology itself;

iii) improve the production efficiency and procedures;

iv) recover, recycle and reuse the wastes within the plant;

v) reformulate the product;

vi) locate a buyer and sell the wastes.

17.3.4 Waste Utilisation

It must be clearly understood that waste reduction efforts, no matter how far they are taken, cannot eliminate all the wastes. Instead of throwing away the remainder wastes and create environmental problems, it is better to find their alternative uses. Waste utilisation efforts involve

a) Research and Development (R and D)

b) Waste-Exchange Information System

c) Market Support

d) Legal, Financial and Institutional Interventions.

The Government of India, realising the complexity of the issues involved in promoting waste utilisation, has set up a National Waste Management Council, to advise the Government on different facets of this problem and its solution.

Let us recognise that many of the wastes can be put to alternative use, provided doing so is technologically feasible and economically viable. For instance, fly-ash from power stations can be used for making bricks, the blast furnace slag can be used in cement making, phosphogypsum—a waste generated from phosphoric acid, ammonium phosphate and hydrofluoric acid plants can be utilised for manufacture of gypsum boards, fibre boards, ceiling tiles, etc. While all these uses of wastes are technically feasible, they aren't widely adopted on economic grounds. This is where, appropriate intervention from the Government is necessary.

SAQ 4
What is the difference between pollution prevention and pollution control? Which of these is more beneficial?

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17.4 SUMMARY

In this unit you have learnt that :

- Wastes are always generated when matter or energy drawn from the environment are processed by technology or used directly.
- The environmental disturbances are escalating due to increase in the quality and complexity of wastes discharge. Excess withdrawal of resources ends up in generating more wastes.
- Wastes always cost. In the manufacturing process they are produced at the cost of products. Increased wastes require more money for safe disposal.
- In India, millions of tonnes of wastes in the form of slag, flyash, phosphogypsum, etc. are generated annually by large and medium scale industries. While the wastes from small scale industries have not been accounted so far it is estimated that their combined waste would amount equal the wastes generated by major industries. In India, most of the wastes are dumped indiscriminately in the environment.
- Agricultural wastes are not waste because no money is spent in their production and moreover, they can be utilised for useful purposes. Over 600 million tonnes of crop-residues and agro-industrial wastes are produced. These are used for fuel, animal feed, farm manure, construction or for some industrial purposes. Some of these can give better economic returns if utilised for making pulp, paper, paper straw boards, biogas, viscose, beverages, etc
- The conventional chulhas have only 12-18% thermal efficiency and also cause pollution. Their efficiency can be increased up to 35% by using improved chulhas. This can reduce the total consumption of coal and wood by 50%. It would amount to a lot of energy savings for the country and protect out environment by reducing deforestation and air pollution
- The economic damages in some major industrial countries due to pollution amount to 1 to 3% of their GNP. Such data are not available from developing countries including India. The cost-benefit analysis of pollution control measures indicates that, purely in monetary terms, the gains double for the money spent. However, considering the meagre resources of our country, it is proposed that instead of spending money on pollution control, it is best to minimise waste production. This is testified by case studies of the industrial sector which demonstrate that waste reduction makes tremendous economic sense and prevents pollution also.
- It is technologically feasible to recycle many of the wastes. However, economically it may not be viable, and therefore, it is necessary that the Government takes appropriate measures in this regard.

17.5 TERMINAL QUESTIONS

1) Explain with an example how changes in the form, place and time of resource withdrawal from that of wastes discharges cause imbalance in the biosphere.

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2) What is the magnitude of industrial wastes in India?

3) What are the financial implications of industrial wastes?

4) Which among the following crop-residues wastes are maximum in our country?
   - Jawar straw
   - Wheat straw
   - Paddy straw
   - Bagasse

5) What is the magnitude of agricultural wastes in India and what are their conventional uses?

17.6 ANSWERS

Self Assessment Questions

1) a) i) environment, technology, ii) withdrawal, resources, iii) form, place and discharge, iv) earth's crust, atmosphere, v) equilibrium, resource, withdrawal, discharge, waste.

   b) i) Increase in population, ii) need to withdraw more resources, iii) increase in industrial growth due to rising needs and demands of people (since 1950 industrial has grown 7 times and mineral extraction has increased three times, iv) subsequent increase in quantity and complexity of discharge of wastes.

2) a) More wastes are generated because of

   i) improper operation and maintenance,

   ii) inefficient use of resources due to outdated technology

   b) Wastes always cost. For example, industrial wastes increase due to inefficiency of the manufacturing process. This means wastes are generated at the cost of products. Moreover, the excess waste so produced costs more for dumping it in environmentally acceptable form. They are treated, stored and transported at the site of landfills. All this costs money.

3) a) i) Paddy straw, maize stalks, sorghum sticks, sugarcane trash,

   ii) Paddy straw, maize stalk,

   iii) Paddy straw and wheat straw,

   iv) Maize cobs, cotton leaves,

   v) Cashew apple,

   b) $\text{Bombay} = \dfrac{3200 \times 1000}{8{,}227{,}332} = .389 \text{ kg} = 389 \text{ grams/capita/day}$

   $\text{Kanpur} = \dfrac{2142 \times 1000}{1{,}688{,}424} = 1.269 \text{ kg} = 1269 \text{ grams/capita/day}$

   $\text{Khopoli} = \dfrac{6 \times 1000}{32{,}108} = 0.187 \text{ kg} = 187 \text{ grms/capita/day}$

   $\text{Dehgam} = \dfrac{9 \times 1000}{24{,}817} = 0.363 \text{ kg} = 363 \text{ grams/capita/day}$

4) Pollution prevention is any measures taken in anticipation to safeguard environment from possible damages by some human activities. Pollution control is the exercise to stop further damage to environment or to repair the damages that have already occurred.

   Pollution prevention is done by waste minimisation and waste utilisation by recycling. It is more beneficial than pollution control because the later requires waste treatment plants, whose operation and maintenance are costly etc. It does not disturb the environment.

Terminal Questions

1) The environmental equilibrium is disturbed because the three factors—form, place and time of withdrawal of resources change from that of wastes disposal. For instance, crude petroleum is extracted from Bombay High from beneath the earth's crust. After refining, the petrol and petroleum products are sent throughout India. Petrol burns in transport vehicles and in converted into CO_2 and water. Besides, large amount of carbon monoxide fumes are emitted into the atmosphere. Excess of CO_2 causes global warming. So the matter is extracted from the earth's crust in a different form, place and time is thrown in the atmosphere at different places, time and form. Such changes result in environmental disturbances.

2) About 75 million tonnes of wastes mainly in the form of slag, flyash and phosphogypsum etc. is generated annually by major Indian industries. Waste from many industries and 2.5 million small scale units have not been accounted so far. It is expected that it would be again many millions of tonnes. Most of this is thrown indiscriminately in the environment.

3) Wastes are produced because no manufacturing unit produces a product with hundred % efficiency. More wastes are generated due to inefficiency in operation, maintenance or in overall management. Therefore, losses occur due to lower production and subsequent increased cost for the disposal of more wastes. Hazardous or heavy metals bearing wastes require plant for thermal, biological or chemical treatment before disposal. These plants also cost for operation and maintenance. Finally, the residue waste will require transport to landfill site. In this way wastes always cost right from their generation to their final disposal. For most of the industries management and disposal of wastes costs about 2 to 5% of the sales turnover. However, in some cases the cost may be as high as 12 to 15% of the turnover.

4) Paddy straw

5) In India, about 600 million tonnes of crop-residues and agro-industrial waste is generated annually. The main crop-residues are paddy, juwar, wheat and gram straw, cotton sticks linters, maize stacks etc. They are used mainly for fuel, animal feed, farm manure, construction, and industrial purposes.

Glossary

Acidosis : condition caused by accumulation of an excess of acid in the body.

Addiction : physical and psychological dependence on a drug.

Aflatoxin : toxin produced by *Aspergillus flavus* that may pass from contaminated grain to humans in grains, milk or meat products and may induce tumors.

Allergen : substance (usually protein) capable of producing altered response of cell, resulting in manifestation of allergy.

Alveoli : the air sacs in the lungs that exchange oxygen and carbon dioxide.

Ankylosing spondylitis : a degenerative, arthritis-like disease of the spine.

Antioxidant : a substance that prevents deterioration by hindering oxidation.

Apathy : indifference, lack of interest or concern.

Aplastic anaemia : a side effect of chloroamphenicol therapy in which red blood cells are produced with little or no haemoglobin.

Autoimmune disease : a disease in which antibodies react with individual's own chemical substances and cells.

Batch-operation : a way of operating manufacturing unit where the unit is stopped at intervals to remove the product in order to start the operation all over again.

Benign tumor : a tumor in which growing cells remain localised at the site of origin.

Bilirubin : the principle pigment in the bile of humans and carnivores.

Biochemical Oxygen Demand (BOD) : the amount of oxygen required by microorganisms to decompose the organic wastes in per unit volume of water.

Botulism : frequently fatal poisoning caused by toxin produced in inadequately sterilized canned food by the bacteria *clostridium botulinum*

Bronchitis : inflammation of the bronchi of the lungs as a result of irritation : often accompanied by a chronic cough.

Bund : water collected in low-lying area.

Calorific value : the heat per unit mass produced by complete combustion of a given substance.

Cardio vascular disease : disease of heart and blood vessels.

Chemical Oxygen Demand (COD) : the amount of oxygen required for oxidation of chemicals present in unit volume of water of lakes, rivers, ponds, etc.

Cirrhosis : a severe liver disease often caused by alcohol abuse.

Coagulation : process of changing into a clot, as in heating of an egg, curdling of milk.

Coliform bacteria : gram-negative non-sporeforming bacilli usually found in the human and animal intestine. Coliform bacteria ferment lactose to acid and gas.

Congenital : existing at or before birth with reference to certain physical or mental traits.

Coronary arteries : blood vessels that supply oxygenated blood to heart itself.

Debilitate : cause weakness.

Diabetes : a disease characterised by imbalance in blood sugar : usually associated with insulin deficiency.

Disease : a change from general state of good health.

Down's syndrome : a chromosomal abnormality that produces disease characterised by severe mental retardation; formly called "mongolism".

Droplets : Airborne particles of mucous and sputum from the respiratory tract that contain disease organisms.

Dropsy : disease in which watery fluid collects in cavities or tissue.

Dyspepsia : indigestion or upset stomach.

Edema : a swelling of tissues brought about by accumulation of fluid.

Elephantiasis : swelling and distortion of the tissues, especially the legs and scrotum, commonly due to infection by certain bacteria.

Encephalitis : acute inflammation of the brain.

Emotional distress : feeling of frustration, anger, fear, anxiety, or depression that occur when emotional needs are not being met.

Emulsifier : substance that can make emulsion.

Enteritis : inflammation of the intestine.

Epidemic : of a disease which is not normally present in a population and which therefore will spread rapidly from individual to individual and infect a large number of the population because there is no natural immunity to the infection.

Etiology : Study of causes and origins of diseases.

Fetal alcohol syndrome : birth defects caused by ingestion of alcohol during pregnancy.

Fibrosis : formation of fibrous tissue in repair processes.

G-6 P deficiency : hereditory disease due to deficiency of an enzyme. No symptoms are seen under adverse condition, certain drugs e.g. the anti-malarial drug primaquine results in anaemia.

Genetic disease : a hereditary disease; one that is passed from parents to children.

Genome : a complete set of genetic material; i.e. a complete set of genes.

Giardiasis : a protozoan disease of intestine commonly transmitted by water.

Gingivitis : inflammation of the gums.

Heart attack : obstruction of the coronary arteries depriving the heart of blood and oxygen.

Hemophilia : a genetic disease, almost exclusively of males, that shows tendency of blood not to clot; as a result the person bleeds excessively when injured.

Hepatitis : an acute inflammatory disease of the liver caused by several viruses.

Holistic health : an approach to health that recognises the interrelatedness of physical, mental, emotional, spiritual, social and environmental factors in the attainment of health.

Hypertension : high blood pressure.

Illness : symptoms of ill-feeling experienced by an unwell person.

Immune responses : the production of antibodies by a type of lymphocytes in response to antigens, also direct attack on antigen by other type of lymphocyte.

Immunological deficiencies : deficiency of proteins that possess antibody activities.

Incineration : the process of placing an object direct into a flame.

Induced draft : to take out gases from the system so that air rushes in.

Inflammation : a nonspecific defence response to injury; usually characterised by red colour from blood accumulation, swelling, warmth and pain from injury to local nerves.

Jaundice : condition characterised by elevated bilirubin level of the blood and deposit of bile pigments in skin and mucous membranes, marked by yellowness of the skin and the white eyes.

Lathyrism : a crippling disease characterised by paralysis of leg muscles.

Leukemia : abnormal production of white blood cells; a cancer of the blood.

Leukocytes : white blood cells that combat infectious organisms and foreign substances of the body.

Lifestyle : activities that are a regular part of an individual's daily pattern of living.

Lymphoma : an irregular (cancerous) proliferation of lymphocytes.

Malignant tumor : a tumor in which cells grow rapidly and may spread throughout the body.

Marasmus : extreme protein-calorie malnutrition marked by emanciation especially severe in young children who receive insufficient amount of food.

Meningitis : A general term for infection of the covering layer of the brain and spinal cord.

Necrosis : cell death.

Neonatal : pertaining to new-born.

Neuroses : condition characterised by behaviours and feeling that are considered abnormal but that are not severe enough to prevent most kind of normal functioning.

Neurotoxin : a toxin that is active in the nervous system of the host.

Nicotine : a chemical constituent in tobacco that produces rapid pulse, increased alertness, and a variety of other physiological effects.

Nitrosamine : cancer causing substances that are found in some food and that can also be synthesised in the body.

O E C D Countries : organisation for economic cooperation and development. Member countries are mostly European countries.

Peptic ulcer : ulcer in the stomach.

Perinatal : pertaining to before during, or after the time of birth.

Phenyl keton uria (PKU) : a genetically caused metabolic disorder that can usually be controlled nutritionally.

Prenatal : preceding birth.

Psychoactive drugs : a substance that primarily alters mood, perception, and other brain functions.

Psychosis : condition characterised by severly abnormal thoughts, moods, or behaviours and a loss of contact with reality.

Psychosomatic illness : illness caused mainly by mental states and attitudes that change physiology and produce disease.

Rheumatic fever : a complication of streptococcal disease in which damage of the heart valves develops from the reactions between antigen and antibodies.

Rheumatoid arthritis : an autoimmune disease characterised by immune complex formation in the joints.

Schizophrenia : a particular type of psychosis characterised by highly unusual thought and behaviours.

Sepsis : poisoning by the products of putrefaction; a severe toxic state resulting from a kind of infection.

Shigellosis : Shigella bacterial injection causing dysentrys manifested by wave of intense abdominal cramps and frequent passage of smcll-volume, bloody mucoid stools.

Sickle-cell anemia : an inherited disease of the blood in which haemoglobin is altered so that red blood cells become Sickle-shaped.

Sluge : suspended material removed from water treatment processes and collected as thick pasty ooze.

Staphylococcal infection : food poisoning due to bacteria *Staphylococcal aureus.*

Streptococcal infection : bacterial infection may cause sore throat, scarlet fever (sore throat accompanied by skin rash) & other human diseases.

Stress : an extreme or prolonged disruption in mind-body harmony that can lead to the onset of a variety of physical illness.

Stressor : any condition that elicit the specific psychological and physiological responses characteristic of stress.

stroke : an obstruction of arteries of brain resulting in brain damage or death.

Susceptibility : the state of being open to disease; specifically, the capability of being infected; a lack of immunity.

Syndrome : a collection of symptoms.

Syphilis : a venereal disease caused by bacteria.

Tailing : the wastes residue of ore processing.

Thalesemia : a hereditary disease resulting in severe anaemia in children. Frequent transfusion is required. Children do not live upto the adulthood.

Trachoma : a disease of the eye due to bacteria and series of tiny, pale modules form on cornea giving it rough appearance.

Tumor : a mass of abnormal cells growing without regulation.

Ultrasonic waves : sound waves of high intensity (beyond the audible range), used in destruction of microbes or cleaning of material.

Withdrawal Symptoms : uncomfortable and sometimes life threatening reactions that occur when a person stops taking a physically addicting drug.

FURTHER READINGS

1) The State of India's Environment : The First Citizen's Report, 1982, Published by Ravi Chopra for the Centre for Science and Environment.
2) The State of India's Environment. The Second Citizen's Report, 1984-85. Centre for Science and Environment.
3) Cherunilam, F. and O.D. Heggade (1987). Housing in India. Himalay Publishing House, Bombay, Nagpur, Delhi.

We are providing you below a list of prefixes and suffixes used in the scientific terms. We hope these would help you in understanding the different terms pertaining to biology.

Prefixes

anti-, ant-. Against inhibiting.
auto-.Self independent.
bio-. Life.
cardi-, cardio-, Heart.
cyt-, cyto-. Cell.
de-. From, removal.
dermato-. Skin.
di-. Two, double.
ecto-. Outside.
endo-. Within.
exo-, ex-. Outside, without.
hem-, hema-, hemo-. Blood.
hetero-. Different.
hist-, histo-. Tissue.
holo-. Complete, homogeneous.
hom-, homo-. Like, similar.
hyp-, hypo-. Deficiency, below.
hyper-. Excessive, above normal.
inter-. Between, among.
intra-. Within, into.
iso-. Equality, similarity.
kary-, karyo-. Nucleus, nuclear.
leuk-, leuko-. White.
macro-. Large.
meso-. Middle.
micro-. Small.
mono-. One.
multi-. Many.
myco-. Fungus.
necro-. Dead.
neo-.New.
noso-.Disease.
nucle-, nucleo-. Nucleus, nuclear.
oxy-. Oxygen in a compound.
pan-. All, many.
path-, patho-. Disease, pathologic.
peri-. About, around.
pneumo-. Pulmonary, respiration.
poly-. Many, diverse.
post-. After, behind.
pre-. Before.
pyo-. Pus.
syn-, sym-. With, together.
tax-, taxi-, taxo-. Arrangement.
therm-, thermo-. Heat, temperature.
thi-, thio-. Sulfur present.
tox-, toxi-, toxo-. Poisonous, toxin, poison.
trans-. Through, across.
trich-, tricho-. Hair, filament.

Suffixes

-algia. Pain, suffering.
-ase. Enzyme.
-cide. Killer, killing.
-cyte. Cell.
-emia. Condition of blood.
-ia. Condition; abnormal or pathologic condition.
-iasis. Diseased condition.
-ism. Condition or disease.
-itis. Inflammation of a part.
-logy. Field of study.
-lysis. Dissolution or disintegration.
-oma. Tumor, neoplasm.
-osis. Process, disease, cause of disease.
-otic. Related to causing a process or condition.
-otmy. A cutting into.
-ous. Having or pertaining to.
-pathia. Disease.
-penia. Deficiency.
-phage, -phag. Ingesting, breaking down.
-rrhage, -rrhagia. Abnormal or excessive discharge.
-rrhea. Discharge.
-scope. Instrument for seeing or examining.