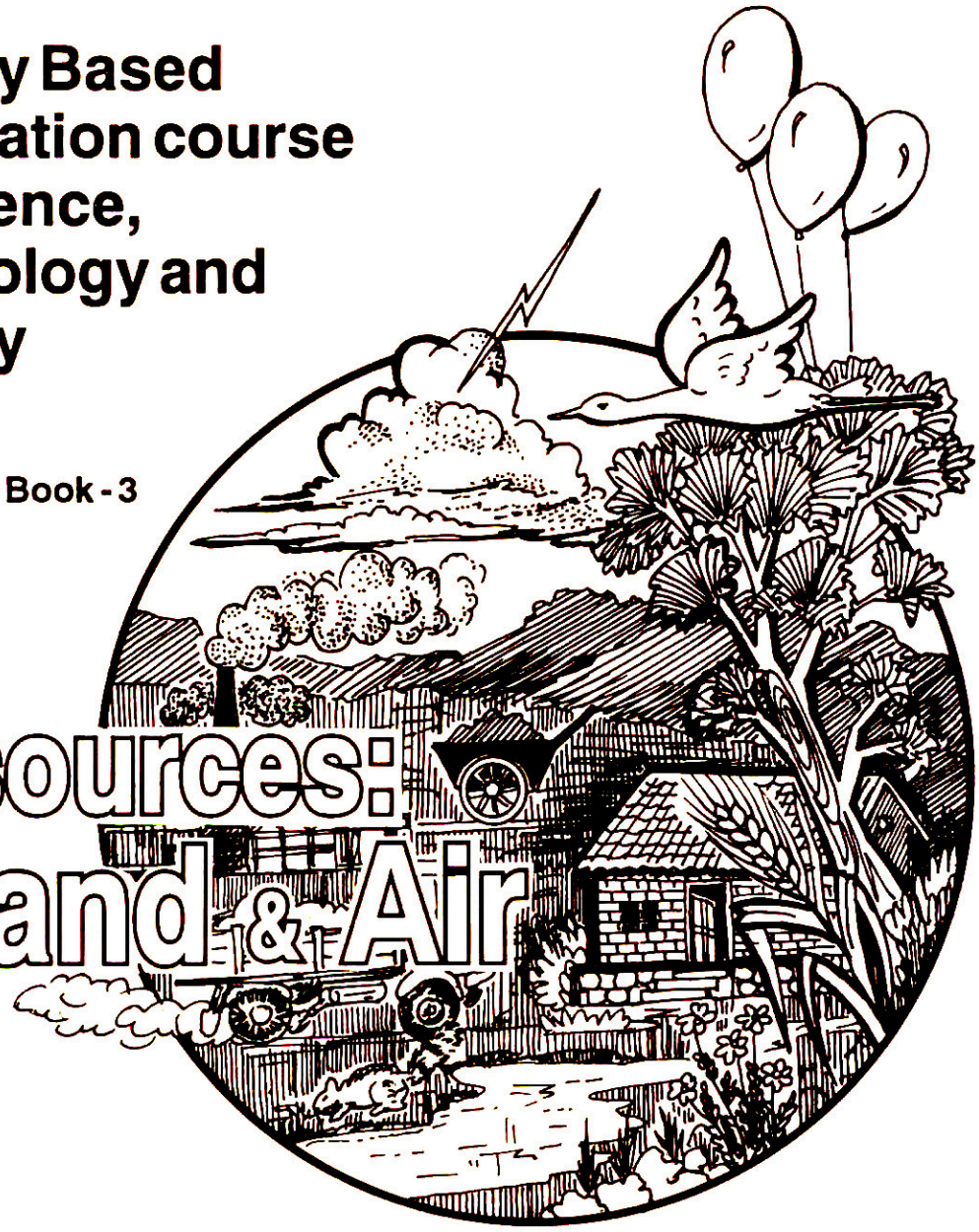
Activity Based Foundation course on Science, Technology and Society

Curriculum Book - 3



Resources: Land & Air

Chitra Natarajan

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research

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The sensitivity to current issues and concern about education of young people evinced by Mr. V.G. Kulkarni, Founder Director of HBCSE, guided the project from its inception. Discussions with Dr. Phondke and Mr. Kulkarni have enriched the content of the series. Besides deriving the benefit of his rich experiences in the areas covered by the project, I have been inspired by Dr. B. M. Udgaonkar's keen interest in the curriculum.

HBCSE Director, Dr. Arvind Kumar's commitment to enriching students' knowledge, and his participation and support in drawing up the content and format of the programme, contributed immensely to the success of the project. The series of books, of which this is one, is a direct outcome of the programme. Dr.Arvind Kumar has been actively involved in planning the overall content of the books. His encouragement and gentle nudges have been useful in bringing them out in print over a reasonable time span.

Besides Dr. Arvind Kumar, Drs. Bakhtaver Mahajan, Sugra Chunawala, G.C. Pal and Ms. Sandhya Karande conducted several sessions during the programme. Besides encouraging the project, Dr. H. C. Pradhan, through the programmes he has coordinated, has provided me opportunities to test some of the activities included in this book on selected students of secondary and higher secondary levels.

The participants of the programme in Mumbai were students from arts, com-

merce and science faculties of two junior colleges in the vicinity of the Centre. The programme was also conducted at the D. B. F. Dayanand College of Arts and Science, Solapur, by Dr. N. S. Dhayagude and his team, where it was received well by the local participants. The participants of the Mumbai and Solapur programmes performed many of the activities included in the books, and enriched this endeavour by their enthusiasm and feedback. These young people's quest for meaningful activities is the *raison d'etre* for this activity based curriculum.

Bringing out books of this kind involves a variety of tasks, like clarifying references, getting drafts printed, choosing appropriate illustrations, cover-page layout, photocopying, and so on. As in the earlier books, in referencing, wordprocessing, printing and illustrations, it is a pleasure to acknowledge Ms.Yogita Parab's help, which was often sought and willingly given. Drs. G. Nagarjuna, Porus Lakdawala and K. Subramaniam have been of immense help in providing the needed human interface in all our computer interactions. Everyone at the Centre contributed to providing a problem-free working atmosphere.

Chitra Natarajan

Contents

List of Tables

List of Figures

Chapter 1

The foundation curriculum

1.1 The need

The complex web of interactions between all spheres of human activity demand that prospective decision makers possess a repertoire of skills complemented by a reasonable capability to communicate their strengths, in oral and written form. Many of these skills are dependent on the domains of specialization: the study of biology may hone observational skills and the ability to classify and categorise; mathematics calls for logical skills, and the pursuit of sociological sciences calls for critical thinking and the ability to make complex linkages.

Both teachers and the taught readily acknowledge that science, technology and society are intimately linked. However, these linkages are complex. Hence, there is a need to adopt different methods in classrooms to encourage students to form such links. These pose problems for the teacher.

A factor that makes teaching issues at the interface of science, technology and society even more difficult is the proliferation of information. The information boom also comes in the wake of crumbling national barriers for trade and information exchange and a global notion of neighbourhoods. Societies and individuals are reacting more rapidly to global changes than they ever did before. Changing environmental perspectives in Europe have led to mi-

gration of polluting industries into the developing countries. Tension in the Middle East or West Asia becomes an immediate cause for concern in Kerala. War, destruction, concern, recovery, rebuilding, and war again - cycles that used to take hundreds of years in previous centuries, now have a periodicity of less than ten years. Contemporary issues not only affect all citizens to some extent, but also call for a systems approach to its understanding and resolution, considering among other things, the technological, economic and socio-cultural linkages. This approach requires a certain attitude to problem solving.

Appropriate training can enable students to acquire problem solving abilities. However, increasing content specialization after grade ten, and lack of an integrated approach to learning before that, are hurdles to such a training. This situation can be partially remedied through intervention training programmes, be they at the level of higher education, or during professional on-the-job training.

1.2 A programme for post-school students

Such a training formed the principal objective of the programme funded by the J.N.Tata Endowment Trust, and implemented by HBCSE over three years at Mumbai and also for two years at Solapur. Developing a sensitivity to, and an understanding of, the complex linkages between science, technology and society, was the basis for the programme that aimed at promoting 'good citizenship' qualities among post-school students. The other vital input was strengthening the comprehension and communication skills of the students.

1.3 The curriculum

1.3.1 Genesis

The success of the programme, measured in qualitative terms — heightened sensitivity of the participating students, and their sustained interest — has

inspired this Foundation Curriculum. The curriculum has been embodied in a series of books. The objectives of the curriculum preclude these books from being textbooks. Instead, these books outline a series of activities that lead from simple issues and ideas to complex ones, requiring the students to make the necessary linkages. The activities are also designed to develop the skills necessary for a practical understanding of issues at the interface of science, technology and society.

Most activities suggested in the books have been tried with post-school students during the programme. These could be used by any interested person — a teacher or leader of a forum — to develop comprehension and communication skills among members of a group of young people. They will be working on a broad canvas of issues at the interface of science, technology and society. Outlined below are the objectives of the curriculum, guidelines for interaction, and the topics, chosen for convenience, under which various issues will be discussed.

1.3.2 Objectives

The objectives of the curriculum can be summarised as follows.

- Offer guidance to students in improving their English comprehension, communication and analytical skills, besides quantitative reasoning. English has been chosen in the light of its being the language of global information flow.
- Integrate students' curricular knowledge with environmental and developmental issues of concern, thus giving a broad exposure to several disciplines.

1.3.3 Guidelines

Setting guidelines for interaction between the group of students and the teacher will go a long way in achieving the objectives stated above. A possible set of guidelines are listed below.

a. Sessions should be conducted in a participatory and interactive mode.

b. Sessions should involve thinking across disciplines, stretching the ability of participants to think beyond the obvious connections.

c. Relevance of the issues to daily life should be stressed, and participants should be guided in making decisions.

d. Weaknesses and lacunae should be assessed at intervals, through appropriate questionnaires.

e. Skills should be developed through suitably designed activities. These could include the following.

   - writing persuasive essays, poems, letters to local newspapers,
   - writing and staging street plays,
   - organised formal debates,
   - analysis of tabulated information,
   - comparison and quantification,
   - drawing charts and graphs,
   - designing games,
   - conducting interviews and surveys, and
   - visits to industries, research institutes.

1.3.4 Content

Activities designed to meet the objectives of skill development are grouped under issues of current concern. The issues are all interlinked and need to be treated that way. For convenience of presentation, these are discussed under the following topics.

- Survival of Humankind: Curricular Philosophy, and The Population Problem
- Education

- Health — Diseases, Drugs, and New Challenges
- Resources: Land and Air
- Resources: Food and Water
- Resources: Energy
- The Environment — Balance in Nature
- The Environment — Degradation, Science and Technology
- Information Revolution and the Media
- Social Conflicts, Gender Issues and World Peace

The present chapter, an introduction to the curriculum, is a part of each book, with a variation only in Section 1.4. It would be useful to revisit the discussion on *Survival of humankind* given in the book on "The Population Problem", whenever in doubt about the goals of the session.

1.3.5 Duration and target group

The activity books are designed to be adequate in content for a 2-year course in Science, Technology and Society at the Higher Secondary level. The activities in the curriculum can be completed over a span of 200 contact hours. Some of the activities require the participants to collect data by library search or survey outside contact hours. However, many activities, mentioned in Section 1.4 of the respective books are essential for giving students a flavour of the issues. These may be covered over a span of 100 contact hours, about 10 hours per book. The large number of activities given in each book allow ample scope for a flexible and innovative approach to teaching.

The activities outlined in the books can, however, be used with any group of individuals with a minimum schooling of standard X (grade 10). It has been found to be harder to work with groups exceeding 30 members. This problem can be overcome by dividing the group into subgroups of smaller size. It would certainly help to have a common language of communication within

the group. Since it is most likely that the books will be used in a classroom situation (say, higher secondary class), the participants are referred to as *students* in all the books.

1.3.6 The group leader

The objectives will be patently met if the group consists of a leader or coordinator, who has more than a cursory interest in the developmental issues of concern today, and enjoys making linkages. The students should be guided not only in making the obvious links, but also to go beyond them.

A coordinator with a formal training in cross-disciplinary thinking has a clear advantage, but a person with an open mind to the ideas of others, and one who feels that students cannot be all wrong, would do just fine. It would be useful for the group leader to be proficient in English, so as to be able to read and comprehend the proliferating information and communicate this to the group. It is most likely that the leader will be the teacher, and hence *teacher* in the books will mean the leader or coordinator of the group.

The leader plays a special role in all the activities outlined. The cardinal principles that govern the interaction of the leader with the group include the following.

i. Understand and value individual and group perceptions.

ii. Encourage listening by setting an example.

iii. While moderating discussions, support the apparently indefensible viewpoint.

iv. Attempt to raise the discussion from the level of free-standing personal statements —'I feel', 'I think', etc., with no accompanying justification — to coherent and logical arguments, with quantification wherever possible.

v. Allow for changing and evolving views during discussions and show a willingness to learn from the students.

vi. Encourage following firm rules during a debate.

vii. Facilitate and liven up discussions by introducing a new angle whenever possible.

viii. Use the 'let us find out' mode as often as is appropriate.

The role of the leader is far from a passive one. Encouraging the diffident student, guiding the overly confident one, finding loop holes in the arguments of a member without lowering self-esteem and being in control of the situation in a class full of thinking individuals is a challenging task. Yet, if viewed as an opportunity to improve one's skills of critical thinking, at the same time creating a generation of thinking individuals, the joy of such interactions can be infectious.

1.3.7 What this is, and what it is not

As already explained in Section 1.3, these books are not substitutes for textbooks, nor are they comprehensive. They are meant to give students a feel for 'real world' problems, without introducing the intractable complexities all at once.

There are very few problems of concern today that have either globally applicable, or locally unique, answers. As in any reasonable developmental approach, the answers to many questions must be sought within a local framework of society, politics and economics. In fact, increasing students' sensitivity to local needs and problems and putting these in the context of global concerns, constraints and opportunities, with examples of solutions arrived at in different contexts, is a tacit aim of the Foundation Curriculum.

Hence, it is an advantage for leaders and group members to have access to information, both local and global. The bibliography is indicative rather than exhaustive. Definitions and concepts can be sought and found in any relevant textbook available in a junior or senior college. Newspapers and locally available magazines could be additional and sometimes valuable sources of issues of debates. Many newsgroups and voluntary agencies provide information and clippings files free of cost or at a nominal charge. The group must, in

the course of the interaction, generate and catalogue its own set of clippings files on issues of concern to the group.

The important, but rather difficult, questions of evaluation have not been addressed here. In this curriculum, more than in any other, evaluation of any form is a measure not only of participant's comprehension, but also of the effectiveness of the leader. Test questionnaires have been provided in some of the books as guidelines to assess effectiveness of interaction in the course and to help take corrective measures.

1.4 This book

Most conflicts can often be traced to the use or perceived misuse of resources. In fact, resources of all kinds — energy, material, and living — are the essential ingredients of life on Earth. This book deals with two important resources, namely, *Land* and *Air*. There is no doubt that all resources are interlinked in their occurrance and use. However, it is useful to ponder a while on each one before separately attempting the complex linkages. **Resources: Land and Air**, third in a series of books on issues in *Science, Technology and Society* gives a set of activities for understanding the role of land and air in sustaining life on Earth, with special reference to human life.

This book requires the participants to interact with their material and social surroundings. Besides writing and making posters, there are surveys, and dialogues with local employers and policy makers. At their best the activities can be empowering (we can do something!). At least they are expected to be learning experiences. A completion of all activities will involve about 20 contact hours. For an awareness of local issues related to land use, Sections 2.1, 2.3, 2.4, 3.1, 4.3, 5.3 and 5.4 of Part I may be covered in about 5 contact hours. Similarly, covered over another 5 contact hours, Sections 6.1, 6.2, 7.1, 7.2, 7.3 and 8.4 of Part II will give a flavour of the issues involved in keeping air clean.

Part I

Resources: Land

Chapter 2

A treasure chest of resources

2.1 Ideas about land

Land is a resource. It is limited and finite. If human populations continue to increase at the present rate there will be twice as many people in the world in about 60 years. Even in our country, the population dependent on the land for food, fuel and employment will double within the next 25 to 50 years.

In the dawn of human occupation of earth, over 30,000 years ago, there were far fewer people and their wants were far from what our needs are today. Hence, it did not matter what each plot of land was used for. There was enough land for all people to satisfy all existing needs. This cannot be said of the present time, much less of the future. What are our present needs, and what can we say about the availability of land? In this section and the succeeding ones, you will

- focus on your own perceptions of land use,
- make estimates and measurements of land area and elevation,
- learn about the types of land use in your locality, state and country,
- recognise conflicts in land use and generate appropriate criteria to resolve them.

Table 2.1: Some uses of land: living (**L**) and non-living (**NSL**) structures.

Land use	**L or NSL**	**Land use**	**L or NSL**
Greenhouse		Shopping centre	
Planetarium		Nursery (rare plants)	
Botanical garden		Agricultural experiments	
Aquarium		Business centre	
Video parlour		Snake park	
Skating ring		Museum	
Rock garden		Medicinal plants	
Restaurant		Children's play centre	
Herbarium		Tennis court	

First, some activities to know your own perceptions about land.

1. What are the ideas, materials, thoughts and feelings that come to your mind, when you think of 'land'? Make a list that includes structures like houses and factories, human activities like cultivation and gardens, as well as natural land formations. Make your list as long and comprehensive as possible.

2. Compare the items in your lists with those of others in the class. List all the ideas on a big blackboard, or a large sheet of paper.

3. Given a plot of land, you could use a major portion of it either to build a house or to grow a garden. Of course, you could also do a variety of other things, like make a tennis court, or house an aquarium. Take the case of a house or a garden for instance. In what ways is building a house a different kind of land use than growing a garden? List all the possible differences.

4. One way to categorise land use is to see how much more 'living' the land becomes when used in a certain way. For instance, you may consider a park or aquarium a 'living' use, and a shopping centre or tennis court not so living. A few uses of a plot of land are given in Table 2.1. Against each indicate whether you consider the use as 'living' (**L**) or 'not-so-living' (**NSL**). Justify your classification.

5. How many of the 18 uses were 'living' structures?

6. Now mark as living or not-so-living the land use/ types listed in the earlier activity by the whole class. If there are ambiguities and hence conflicts of category, resolve them through discussions. This should result in an overall agreement within the group about the category of each item in the list.

7. What is the percentage of living structures given by the whole class?

8. Using the same criteria of living structures as you did for the whole class activity, calculate percentage of land use and types given by each of you as living.

9. Do you think someone living on the outskirts of a forest, or on a farm engaged in crop cultivation and animal husbandry may come up with a different list from the one given by urban school or college students? How different would the two lists be?

10. If you were offered a plot of land, as big as you would like, how much would you ask for? How would you use it?

11. Write a page on your perceptions of (ideas about) land use in your locality. You will return to this and the previous exercise more than once in this Part. Preserve your writings in a file so that you can compare the change in your perceptions as you carry out different activities.

2.2 Estimating land area

Land has a measure. For instance you could easily measure the surface area of a small and flat piece of land. However, it is often necessary to estimate large areas. You could 'visually survey the land', estimating its size by comparing it to a football field, a tennis court, or its sides to tracks of '50 metre dash'. You may count the number of fence poles, estimating the distance between two, and so on. The art of estimation is developed through practice. The activities in this section will provide you practice in estimating areas.

1. If you owned a piece of land, how would you quantify it? List as many ways as you can think of. Compare the lists made by the whole class. List on the blackboard the different ways of estimating areas, and also indicate the tools you would use.

2. How big is your classroom? Each of you can estimate its length, breadth and height. A few persons then measure the length and breadth. How would you measure the height without climbing up a ladder with a tape? List the possible ways in which you can measure the height of the classroom just sitting in a place. You will make a tool for measuring heights in Subsection 2.2.1.

3. Estimate the following areas:

   (a) Land occupied by your Institution building in square metres.

   (b) Land within the Institution compounds.

   (c) Land occupied by your residential structure — bungalow, row house or whole building in the case of an apartment or hostel.

   (d) The local 'house of God' and the land belonging to it.

   (e) Land that comes within your village, locality or suburb, as the case may be.

   (f) Land owned by a farmer nearest to you. If you live in a city, go on a picnic at the next opportunity to a typical village surrounded by agricultural farms. Estimate the size of individual plots in acres. Take a rope of known length, say 10 metres and measure out an acre of land. You need to know how many square metres make an acre. Refer to Appendix A.

4. Estimate any other plot of land that is not included in the above activities, but is a place you frequent.

5. Find out the area of your district. Look up a political map of your State and estimate the areas of the other districts in your State and hence the area of your State.

6. Find out the actual area of your State. How close was your estimate in the last activity to the actual figure?

7. Knowing the area of your State, estimate the areas of other States of India, and hence the area of the Indian subcontinent. How does this compare with the actual figure of 3,287,000 square kilometres? If the error in your estimation was about 10 to 20%, you have become very good at estimating areas!

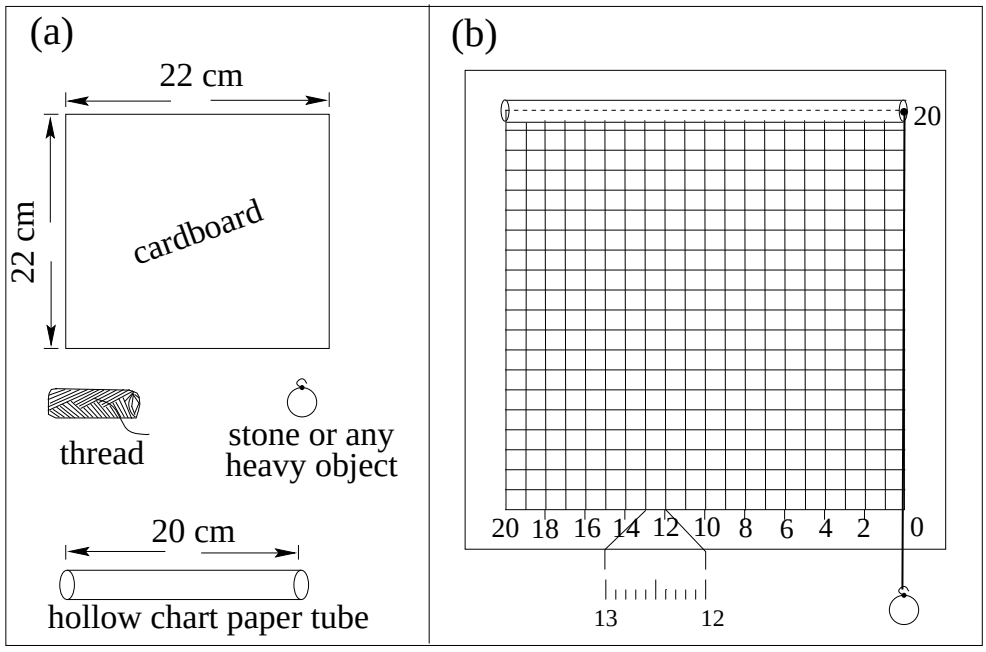
2.2.1 Make your own Hypsometer

A **Hypsometer** is a simple tool for estimating the height of tall objects whose distance from where you stand can be independently measured or estimated. This uses the property of similar triangles to estimate heights of tall objects. You can make your own Hypsometer by following the instructions given below [2].

Collect the materials shown in Figure 2.1 (a) required for the project: *cardboard, hollow chart paper tube or curtain rod about 22 cms long, string and small heavy object to be tied to the string as a bob.*

1. First cut the cardboard into a square of size 22 $cms \times 22$ cms.
2. Paste a sheet of graph paper marked in centimetres or plain paper on the cardboard.
3. Draw a 20 $cms \times 20$ cms grid on the cardboard as shown in the Figure 2.1 (b). If using a plain paper, mark graduations in millimetres on the bottom line of the grid. Mark the scale on the bottom line starting with zero at the right most vertical line.
4. Now fix the hollow tube on the top line.
5. Suspend the string with the bob from the mouth of the tube, at the right hand top corner of the grid, as in Figure 2.1 (b).
6. To use the Hypsometer, hold it parallel to the ground such that the string covers the first line (which is therefore vertical).
7. Now looking through the tube, point it to the top of the structure whose height is to be estimated. Ask your friend to note the graduation reading

Figure 2.1: (a) Materials for a Hypsometer, and (b) A ready-to-use Hypsometer.



where the string crosses the bottom line on the cardboard. This is the Hypsometer reading. This position is shown in Figure 2.2.

8. Using the following formula you can calculate the height of the object from your eye line as: $H = \frac{h}{20} \times D$, where

   (a) H = calculated height of object in metres above your eye level;

   (b) D = Distance of object in metres from your position;

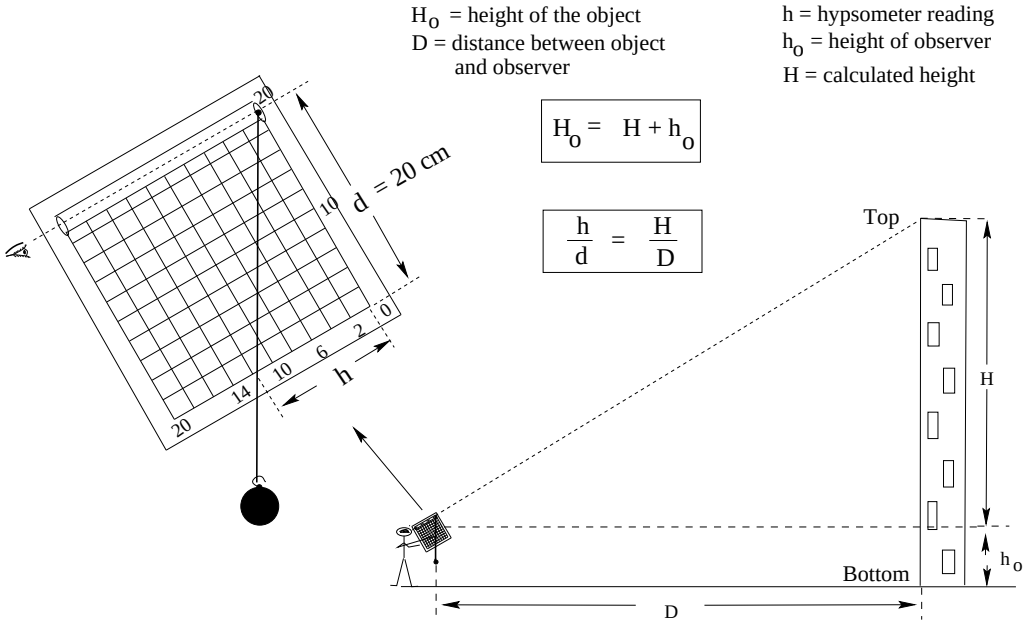
   (c) h = Hypsometer reading in centimetres;

   (d) h_0 = your height in metres to be added to the calculated H;

   (e) $H_0 = H + h_0$ = height of the object from the ground.

9. Working in pairs, estimate the height of your classroom using your new tool. Using the estimates of everyone in class, find the average height

Figure 2.2: Hypsometer in use.



(H_{ave}), and the range of height estimates (R) as,

$$H_{ave} = \frac{sum\ of\ all\ heights}{number\ of\ participating\ students}$$

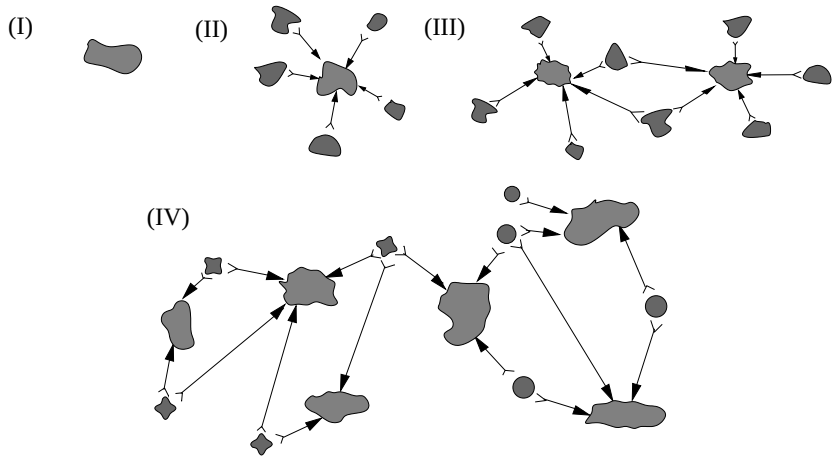
and, $R = Maximum\ height\ -\ minimum\ height.$

2.3 A picture of your locality

In the activities in this section you will all do some rudimentary cartography. You will map out your locality, be it a suburb of a major city, a society in a town, or a village. You will then know your locality like the back of your palm, or at least like a page in your book!

1. Figure 2.3 has four parts. The arrows indicate commuting routes. The heads of arrows point to places of work and the tails indicate residences.

Figure 2.3: Schematic diagram of types of urban places.



- Part I shows an isolated village, town or city centre.
- Part II shows an urban region with a city at its centre.
- Part III has two cities at the centre of the urban region.
- Part IV is a picture of an urban metropolis.

Which of these pictures best represents your locality?

2. Note down the area of your locality that you want to map. What is the shape of the locality: rectangular, square, circular, oval or highly elongated? What might be its approximate dimensions in length and breadth?

3. What scale would you have to choose to fit the map on your page? Note this scale (say, 1 $cm = 1\ km$) in the top left hand corner of your sheet of paper. Sketch the rough outline shape of the locality on the sheet. Mark the *north* direction.

4. Select 2 or more landmarks in your locality. Indicate their positions on the map by a star, numbering them as 1, 2, etc. Position each landmark relative to the other approximately in the east, west, north, south or the 4 directions between them. Estimate the distances between these landmarks and position them at those distances to scale. Include on your map historical heritages and old structures of your locality.

5. Add parks, commercial complexes, Government offices, well-known residential complexes to your map.

6. Interview an old resident of the locality. Based on the interview, sketch a new map showing the locality 10, 25, 50 and 100 years ago.

7. Compare the information collected by all members of the class. Discuss the results in terms of the changes in your village, town or city.

8. What was your locality like 10, 25, 50, 100 years ago? What will it be like 25, 50, 100 years hence? If the residence and work areas are widely separated, what changes do you expect in the land along the route? Explain your ideas in about a page.

2.4 Treasures in a plot of land

Land is a special kind of resource. The phrase, "to live off the land" has deep significance. Almost everything we use — either for survival or for luxury — traces its origins to the land. Our basic needs for food, water, fuel, clothing, and shelter are met from the resources of land. Aesthetic pleasures, beautiful sights and sounds arise from the land. Land is really a treasure trove of many resources. You will discover these and discuss them.

1. What constitutes a piece of land: the surface soil or rock, the trees and plants on it or the minerals beneath? List all the things that you could possibly find on or below a large plot of land. Compare your list with those of others. Preserve the list for activities in Chapter 5.

2. In the last activity, did anyone mention water, oil or coal? How deep would these resources lie? If you owned the plot of land, would you also own all that lies below the surface? Would you own the resources all the way to the centre of the Earth?

3. To see what it means to really own land all the way to the centre of the Earth, make a solid spherical ball, a little bigger than a cricket ball, (say 10 cm diameter) out of moulding clay. Imagine the ball you have made to be our Earth. The equatorial diameter of the earth is 12,756

kilometres. Allot yourself a generous plot of land on earth, say 50,000 square kilometres, a land equivalent to the Punjab State. What fraction of Earth's surface would your plot occupy? What would this correspond to on your solid clay ball?

4. You have discovered in the earlier activity that 50,000 square kilometres was less than a pin head on your *Earth* ball. Select a surface area of about 4 square centimetres on the sphere. Carefully cut out the sector of the sphere corresponding to the surface area. Examine its shape.

5. On this carved out pencil-point-shaped sector, estimate the portion corresponding to the earth's core, magma and crust.

6. You have now realised that the Earth's crust is merely skin deep. In practice, you do not even own the whole depth of this crust below the land allotted to you. Find out what portion of this wedge you could own. What would happen if you struck oil or coal, or one of the resources considered *a national resource*, on your plot of land? The laws related to ownership of resources vary from country to country. Find out about these laws in our country, India.

7. Leaving aside resources like coal, gold and oil, what resources of the land can you call truly yours? List them all.

8. Imagine that you have to practice 'living off your plot of land', for your entire lifetime. That is, you must use only the material and energy resources available on your land, and nothing else as long as you live. However, you can access all the knowledge in the world, and can have a companion too. Remember that access to information does not automatically mean that you will seek it and retrieve it. Write an essay describing what you would do to make your life as comfortable as you can within these means: "Your strategies for sustainable living". File your essay.

9. Each of you in the class could then summarise your strategies in 2 minutes. How many new lifestyles and strategies did you learn through this sharing of ideas? How many of you mentioned retrieval of information from libraries or peers to innovate strategies to survive?

10. Would your strategies have changed in any way if you were told that for the next 10 generations, you have to live off the same plot of land? In what ways would they have changed?

Land contains many treasures. But not all of these can be used simultaneously. It may be necessary to forego one to be able to use another. You will discuss the conflicts that arise in such compromises in Chapter 4. The following chapter will increase your familiarity with land use patterns in India and the World.

Chapter 3

Land use in India

India has vast land resources. Its land area is about 3,287,000 square kilometres. As citizens and hence potential custodians of this land, you must know how this is being used. Table 3.1 gives the land under green cover. This is the percentage of land used for plants, pasture and cultivation. It includes all purposes other than industry and housing. Discuss the issues raised below based on the data.

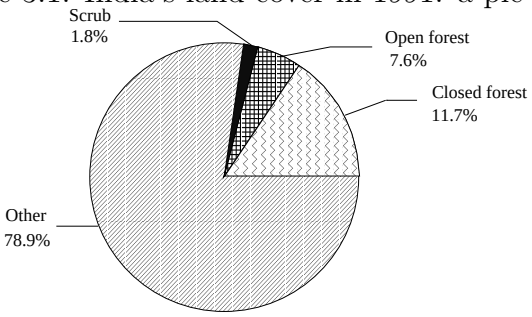
Table 3.1: Percentage of India's land used for plants, pasture and cultivation in 1991.

Purpose	**Percentage**	**Area,** km^2
Under forest	20.5	
Sown with crops	41.6	
Left fallow	7.6	
Permanent pasture	3.9	
Permanent crops like tea, fruit trees	1.5	

Source: 1992 Grolier Electronic Publishing, Inc

1. Besides items given in Table 3.1, what other types of land use are there in our country – either natural formations or human-made? List all such possible uses and types of land.

Figure 3.1: India's land cover in 1991: a pie chart.



2. What is the percentage of land neither under green cover, nor being used for growing plants, pasture or for cultivation?

3. Calculate the area of cultivated land (sown with crops) per person in India.

4. Draw a pie chart to indicate the distribution of land for plant, pasture and cultivation.

5. Figure 3.1 is a pie chart indicating India's land cover in 1991 [10]. The chart does not include mangrove forests, which form about 0.13%, and 0.58% uninterpreted land area under clouds or in the shadows. How is such information obtained? Discuss the possible ways of getting this data and the most recent technology for doing so. Where does India stand in the world with respect to this technology?

6. How is this information different from the information given in Table 3.1 and the pie chart that you have drawn?

7. What types of land are included in the category *other* in Figure 3.1?

8. Calculate the actual land area in square kilometres of closed forest. Closed forests have green cover density of 40% or more. What is the value of closed forest area per family in India? Assume an average family of 5 members. How many square metres of total (closed and open together) forest area do we have per family?

9. Interview a practising farmer about the land he would need to feed a family of 5 people; growing grains, pulses and vegetables on it, as

well as maintaining the cattle needed for their livelihood. Discuss the sufficiency of crop area in the class. You will return to this discussion in the book on *Resources: Food and Water*.

3.1 Managing the forests

Most middle class people living in urban areas do not directly perceive the benefits of forests. Most people think of forests mainly in terms of the wood for their furniture, large wild animals, and an assortment of trees they cannot name or identify. Yet, the survival of a lot of people, specially the poor, even in the urban areas, directly depends on the nearby forests. Fuelwood is one of the many important forest-produce that these people need. Decrease in forest cover would decrease their source of survival and hence increase their burden of poverty. You will discuss the important aspects involved in forest management.

It is interesting to analyse how urban centres in different States have fared in preserving the forest cover around them. Table 3.2 gives the forest cover around some of the urban centres in India in the years 1960 and 1986 [10]. Study it and engage in the activities below.

1. Calculate the difference in forest cover around the urban centres in the table between the years 1960 and 1986. Fill the fourth column. Did the forest cover increase in any case? Would you have expected it to increase? Justify your answer.

2. Which urban centre decreased the most in absolute value of forest cover? Which state fared the worst in absolute terms?

3. Which urban centre had the greatest percentage relative change in forest cover? Calculate the percentage change, **R**, in forest cover from 1960 to 1986. This is given by,
   $R = 100 \times \frac{Cover(1986) - Cover(1960)}{Cover(1960)}$

4. To calculate the relative change among the States, use the absolute values of forest cover in 1960 and 1986, which you have calculated in

Table 3.2: Closed forest cover around urban centres in India in 1960 and 1986.

Urban Centre	**1960 sq.km**	**1986 sq.km**	**loss sq.km**	**Relative change (%)**
Ajmer (Rajasthan)	259	124		
Ammathi (Karnataka)	8,275	5,625		
Amritsar (Punjab)	208	111		
Bangalore (Karnataka)	3,853	2,762		
Bhavnagar (Gujarat)	112	9		
Bhopal (M.P.)	3,031	1,417		
Bombay (Maharashtra)	5,649	3,672		
Chikmagalur (Karnataka)	7,912	6,175		
Coimbatore (Tamil Nadu)	5,525	4,700		
Delhi (Delhi)	254	101		
Gwalior (M.P.)	1,353	515		
Hyderabad (A.P.)	40	26		
Indore (M.P.)	3,770	1,070		
Jaipur (Rajasthan)	1,534	786		
Madras (Tamil Nadu)	918	568		
Monghyr (Bihar)	1,069	875		
Nagpur (Maharashtra)	3,116	2,051		
Varanasi (U.P.)	1,785	1,072		

Source: B.Bowonder, S.S.R.Prasad and N.V.M.Unni, Dynamics of fuelwood prices in India in [10], page 1218.

activity 2. Which States have less than half the forest cover left in 1986? Which two States fared the best?

5. Explain the patterns in the data that you have found in the earlier activities in terms of the nature of the forests, expansion of urban centres and the needs of poor people and industries.

6. The data given is inadequate to make all possible judgements about forest cover management. In what ways is it insufficient?

7. List the resources obtained from India's tropical rain forests and deciduous forests. Mark a cross against those resources that have a potential to

destroy the forest if their collection is unregulated. Mark a tick against those resources that will not normally destroy the forest. Against each of these, note down the category of people (rich, middle class, poor) intimately related to the resource collection and its economic benefits.

8. Arrange an appointment for a few representatives from the class to meet an official from the Forest Department of your State. Before the meeting, list the questions you want to clarify regarding forests, and the regulations governing their use in the State. Remind the official that the National Forest Policy Resolution of 1988 has set a target of total land area of 33% under forest cover. Seek clarifications on how a forest cover value of 33% was arrived at. You may also bring up the fact that an estimated 157 million tonnes of firewood are required for fuel every year by the rural population, whereas the recorded production is only 58 million tonnes. You may enquire about the steps taken to increase production.

   One or more among you could write the minutes while the meeting is in progress. Ask about the steps taken by the department to achieve its target, the difficulties encountered, and the people involved. In what ways can you, as a student and as a concerned citizen help them?

9. Report the outcome of the meeting to the whole class. Was there a mention of conflicts of the forest department officials with people — those living in and around the forest, with commercial logging companies, or with other State or Union Departments? Make special note of these. What suggestions do you, a group of sensitive young people, have to alleviate the problems?

10. Write a letter to the local newspaper suggesting alternative strategies to increase the forest cover around your town, and at the same time reduce conflicts between people, animals and forest officials.

3.2 India and the World

In the last section you discussed land use patterns in India and saw how urbanisation has increased the pressure on forests. You may wonder about

Table 3.3: Land area used for crops, permanent pasture (pasture), forest and woodland (forest) in some countries around the world in 1989-91.

Country/ Region	**Land area 1000 ha**	**Land use, 1000 hectares**		
		Crops	Pasture	Forest
World	13,041,713	1,441,423	3,357,292	3,897,998
Bangladesh	13,017	9,352	600	1,899
China	932,641	96,524	400,000	126,515
India	297,319	169,594	11,782	67,011
Indonesia	181,157	21,967	11,800	109,800
Japan	37,652	4,595	647	25,105
Malaysia	32,855	4,880	27	19,361
Pakistan	77,088	21,107	5,000	3,430
Sri Lanka	6,463	1,901	439	2,075
Canada	922,097	45,947	28,100	359,000
Mexico	190,869	24,713	74,499	42,460
U.S.A	916,660	187,776	239,172	287,400
Argentina	273,669	27,200	142,200	59,200
Brazil	845,651	59,933	184,200	493,030
Australia	764,444	48,267	417,244	106,000
France	55,010	19,187	11,381	14,817
Germany	34,931	12,002	5,329	10,403
Norway	30,683	870	111	8,330
Sweden	41,162	2,829	556	28,020
U.K.	24,160	6,665	11,186	2,391

Table 3.4: Choose two pairs of countries and compare them.

1. India and Argentina	8. Indonesia and Mexico
2. Japan and Germany	9. Malaysia and Norway
3. Canada and USA	10. Canada and China
4. India and Pakistan	11. India and China
5. Sweden and France	12. Bangladesh and Sri Lanka
6. UK and France	13. Brazil and Australia
7. Brazil and Argentina	

earthquake-prone and densely populated regions like Japan making houses of wood and yet preserving a substantial fraction of their land in the form of forests. You will discuss emerging land use patterns in the world.

Table 3.3 gives data on land area in 1989-91 of some countries of the world, and the area used for crop cultivation, for grazing (permanent pasture), and as forests and woods [10]. In other words, the table shows the green cover in these countries. Study the green cover in different regions of the world and discuss how green the earth is and who is preserving her greenery better. Mark these countries on a World map.

1. What percentage of the World's land area does India have? What percentage of the World's population lives in our country? What percentage of the World's forest area is in India? Using this data write a story on people, land and forests of India.

2. What is the per capita availability of cropland, pasture and forests in India? What is the average for the whole World? How does India compare with the world?

3. Find the relative area under cropland, permanent pasture and forests and wood (as a percentage of the total land area of each country) for the different countries given in the table. Draw up a table similar to Table 3.3 and enter your calculated values there. This is your table of percentages. Write a page describing the pattern.

4. Of what use are permanent pastures? List as many uses as you can.

5. Some of the pastures are found at the periphery of forests and woods. Some are a result of degradation of land. List the possible ways in which land becomes a permanent pasture. Imagine a land that is not a pasture at present. Write down the scenarios, either through changing human use or by natural ways, in which the land is converted into a permanent pasture.

6. Form teams of 4 students for this activity. Each team should select 2 pairs of countries (4 countries) from among the pairs given in Table 3.4. Compare and contrast the pairs of countries selected by your team in terms of the following aspects,

- Geographical location – hemisphere, latitude and longitude,
- Climate,
- Population,
- Culture,
- Food types — local consumption and export (grains, cash crop, meat, etc.), and
- Whether developing or industrial.

Consult your geography teacher, textbooks or magazines like National Geographic for this activity.

7. Did you find any pattern among the pairs of countries you had selected? Discuss the patterns in the class. Can you predict the past, present and future land use knowing the geographical, climatic and socio-economic aspects of a region?

Figure 3.2: Land use for survival.

You have seen a picture of green cover over India that is not very promising. Relative to our population, our land resources are rather insufficient. Besides, we produce less from our cropland and pastures per acre than many other countries, which you will discuss in the book titled *Resources: Food and Water*. Add to this the degradation of land due to various reasons and we

are only getting worse. Land use can be made sustainable. That is, it can benefit a maximum number of people over a long time. However, change in land use causes conflicts. You will discuss issues related to such conflicts and find ways of resolving them in the next chapter.

Chapter 4

Land use conflicts

Increasing number of people and changing needs from the land will no doubt lead to conflicts over land use. For instance, you could not mine your land for coal, build your house, plant a *Banyan* tree, all on the same plot of land at the same time.

Even where the land is plentiful, many people may have inadequate access to land or its benefits. In the face of scarcity, degradation of farmland, forests or water resources may be clear for all to see. Yet, individual land users lack the incentive or resources to prevent it. Such situations have led to new directions for land use in national policies. You will discuss these conflicts in the following activities.

1. In the decades after Indian independence, there have been numerous conflicts involving land use in the country. List the land use conflicts that have become national controversies. List as many as you can remember. Compare the lists generated by the whole class.

2. Form subgroups of 3 to 4 members. Each subgroup may select an important land use conflict, either present or past, to 'research' about. Note down your findings and file them. Collect as many newspaper and magazine clippings as you can on the conflict. Using the facts and figures you have gathered, take a stand on how the land use should have been planned. Write a page or two justifying your stand.

3. Make a presentation to the class, subgroup-wise, on the conflict you have researched. Follow this with a class discussion.

4. What were the characteristics of each conflict? What were the common features among all the conflicts discussed?

Land use conflicts must be resolved. What criteria would you use to resolve them, and ensure an equitable distribution of land? You will ponder over these issues and generate your own suitable guidelines in the next section.

4.1 Conflict resolution: setting goals

The demands for arable land, grazing, wild life, forestry, tourism and urban development compete for the limited land resources available. Hence it becomes important to be clear about local, regional and national priorities. Goals define what is meant by the "best" use of the land. They should be specified before any land use change is planned. Goals and criteria for land use may be grouped under three broad heads: efficiency, equity and acceptability, and sustainability.

You could study practical cases in terms of a few primary criteria. Each criterion given below is associated with an acronym. In the following activities, you will grade different land uses in your locality in terms of these criteria. You may add other criteria to this list if you need.

SUIT The land is suitable for this use in terms of location and composition.

ECON This land use is economically viable — gives high economic returns.

PECO This land use bestows economic benefits on a large number of people.

PAES Land satisfies the aesthetic needs of a large number of people.

PSUR Survival needs (food, fuel, fodder) of a large number of people are satisfied by this land use.

SUST Land use is sustainable. Sustainable land use is that which meets the needs of the present, and at the same time, conserves resources

Table 4.1: The 7 criteria format for rating land use in your locality.

Land type	Area m^2	SUIT	ECON	PECO	PAES	PSUR	SUST	Ave.
Park	40,000	1	3	2	2	3	1	2

for future generations. This requires a combination of production and conservation: production of the goods needed by people now, combined with conservation of the natural resources on which the production depends so as to ensure continued production in the future.

1. List the different structures and land uses that you encounter on your way from home to your institution. Write this in the first column of a table of the format given in Table 4.1.

2. Estimate the approximate area occupied by the land on which each structure stands. Fill the second column.

3. Examine the type of land occupied by each structure, park, residential building, hospital, or commercial complex. Study its surroundings. Estimate whether the location and composition of the land suits its use. Could the land have been put to an alternative use in terms of the resources contained in that land?

   On scale of 1 to 3, rate its suitability: 3 for most suitable, and 1 for least suitable. Note this rating in the column marked **SUIT**. For each land use type, you need to determine the requirements, like water, nutrients, avoidance of erosion; or noise in the neighbourhood, dust, and so on. You could also consider the physical properties in the area, like climate, slope, and soil type. Then you could compare the requirements of the land use types with the properties of the land unit to arrive at *land suitability*. For instance, the Park land had no natural water source and needed soil to be added frequently. Hence it rates low on *SUIT*.

4. Working on similar lines as in the last activity, rate each land use type for its economic viability (**ECON**), whether it benefits people economically (**PECO**), for its aesthetic quality (**PAES**), whether it satisfies

survival needs of many people (i.e. equitable **PSUR**), and for its sustainability (**SUST**). The author's perception of a park in her locality is indicated in the table.

5. After filling up the columns for each land use, add up the ratings in the row for each land use/ structure and divide it by 6 to get its average rating.

6. What type of structures got the highest and lowest ratings in your locality according to your list?

7. Compare the ratings of the whole class. Did all the lists contain similar structures? Did different members of your group rate the same structure differently? What will you conclude from this?

8. How will your Table 4.1 change if this were filled by a person living in a locality totally different from yours. If you are urban, try to fill a similar table using your imagination of rural life. If you are rural, try to fill the table as an urbanite might. It would be ideal, of course, if you could organise a class visit to the 'other' kind of human habitation!

9. Could you say that you are more likely to encounter more sustainable uses of land in the rural areas than in urban ones? Discuss this issue in class, clarifying what *sustainable* means to you.

An average rating of 3 must have been very infrequent (or absent) in the above activity. You probably wonder why this is so. Land use needs to be a planned activity in order to maximise the benefit of land to the maximum number of people in all possible ways.

4.2 Land use planning: checklist

Land use planning is the systematic assessment of various conditions in order to select and adopt the best land use options. The conditions include land and water potential, alternatives for land use, and economic and social conditions. Planning should enable the authorities concerned with the task to put into practice those land uses that will best meet the needs of the people while safeguarding the resources for the future.

Land use must change to meet new demands. Yet, changes bring new conflicts between competing uses of land, and between the interests of individual users and the *common good*. Land occupied by towns and industries is no longer available for farming. Likewise, the development of new farmland competes with forestry, water supplies and wild life. Planning should provide guidance in cases of conflict. Planning should also indicate which is the more sustainable use in the long run.

Making a checklist

You will discuss in the activities below the important steps in land use planning. The first step is setting local and national goals. By putting yourself in the shoes of the planner as well as an affected citizen, you will think about what you should do in situations of land use change. The following activities may be more fun if you formed subgroups of 2 to 3 members, and then discussed your findings with the whole class.

1. One of the first steps is to define the land area that is proposed to be changed. Write down one scenario in a land use change, where land area is not clearly spelt out. Predict its consequences.

2. All the people who are connected in any way with the change need to be contacted. Suppose a large plot of land on which wheat is being cultivated is to be converted to sugarcane cultivation. List the people or specific administrative bodies of the government, which may be concerned with this conversion. On the other hand, suppose a park in a city is to be converted to a residential complex. Who should be contacted and involved in the planning?

3. Before converting a land to a new use, you need to acquire basic information about the region in which the land is located. Table 4.2 gives a preliminary checklist containing different data needed prior to land use planning. The first column gives the heads under which information is needed. Fill the second column with an example of land use change where that information is crucial. Indicate in the third column why this information is important.

Table 4.2: A checklist for land use planning.

Information type	**Land use change**	
	Where crucial	**Why crucial**
Land resources		
Present land use		
Infrastructure		
Population		
Land tenure		
Social structure		
Government		
NGOs		
Commercial organisations		

For instance, while converting an unused land into a municipal landfill site, it is important to study underground water bodies (land resources). Can you justify that?

It would also be important to check for population density in the vicinity, and whether the land is close to ecologically sensitive sites (other land resources). You will discuss ecology and its implications for land use in another book. It might be useful to discuss with the Non Government Organizations (**NGOs**) operating in the area. They may have useful inputs about the social uses of the land even though it may be technically unoccupied.

4. Discuss the table made by all the subgroups in the class. Were there instances when an item was thought to be crucial by one subgroup, but not considered of importance by another? These are especially interesting for a class discussion. These also represent the real difficulties of land use planning.

4.3 Picture analysis: problem perception

Figure 4.1 depicts a village scene, possibly a meeting. Perhaps, a land use change is anticipated in the village. And a representative from the district

planning committee has arrived to discuss the issues with the villagers. The planner recognises as you do now, that meetings with representatives of those affected by the change, will help the planner see problems from the people's point of view. These meetings also alert the people to the fact that changes are being considered. Without the willing acceptance by the people, and their help, no land use plan can succeed in its goals.

1. Form pairs of students. Decide among you what must be happening in the picture. Let your imagination free. One of you should report the meeting in detail from the planner's point of view. Use your ideas about land use, take into account the local and national goals you would like to set. Report on what might interest you as a planner. The other partner takes the position of the villager. You are aware of local problems, the history of land use in the area, and the needs of your people. As a village representative, write a report on what is happening in the picture.

2. Compare notes with your partner. Did your descriptions differ in any way? If they did not, either you have no problems or you have not played your role. If they did, you will see where problems usually start.

3. Discuss in the class only the differences in perceptions among the pairs. The different pairs may have dealt with different situations and land use changes. What can you say about the differences between the planner's perception and the villager's? Did these differences fit a pattern? How would you describe this pattern?

4. Write an essay in support of the statement: **Land use planning is as much a matter of public education and participation as of land use zoning and regulation.**

The activities so far have helped you link the treasures on land and their preservation to existing land use patterns in India and the world. You have also discussed at length the situations that can arise when a land use needs to be changed — the setting of goals, the planning and the conflict resolution. You can *feel* the quality of land changing around you. How much is getting degraded, and how? You will discuss some of these questions in the next chapter.

Figure 4.1: A village meeting.

Chapter 5

Land degradation

Most of the treasures in the land have taken millions of years to be what they are today — the life forms, energy sources and other non-living matter. You can use it well and enjoy these treasures for centuries. If you are unmindful of its treasures you may lose them before you even become aware of what you have lost.

Consider this story. Four friends F1, F2, F3, and F4, out on an adventure along a deserted, uncharted road, find a large clay urn (pot), ornately designed. They respond in different ways to the sight of the urn.

F1: What a beautiful urn! I must have it.

F2: Let us see what it contains.

The three friends F2, F3 and F4 jostle each other to peer into the wide mouth of the pot, while F1 is still admiring the urn.

F3: This is marvellous! There is life here! A chubby, healthy little baby is gurgling happily. I must get it out and nurture it. Break the urn. Scatter away everything. Let us just take the baby and leave. Nobody will know we were here.

F4: Can you not see and smell all the delicious food inside? It is food that we need to survive our journey. Let us break the urn, remove the baby far from the road, pack up the food and leave.

F2: You two must be blind and stupid too. Those sparkling diamonds inside are all we want. They will make us very rich. And they are easy to carry too. Let us just take the diamonds, crush everything else leaving no trace of our having been here, and get out of here before anyone else comes.

F1: Hey, I will not let you do that. We should throw all its contents far away, take the urn and get on our way.

The four friends bicker about what to take along, and how best to leave no trace. In the fight that ensues, the urn topples over. The food and diamonds scatter to the ground and mix with the dirt. The child chokes on some food and a diamond. The ornate designs of the urn are in a thousand fragments.

Ponder over the story. Discuss what you may have done in the situation. Assume that it may not be possible to carry everything away.

1. This is a simple story, where the folly of the friends is very obvious. Do you think humans may be using their resources in similar, but not so obvious ways?

2. You are sensible enough to advise the friends on how to use their treasures — the urn, baby, food, and the diamonds — wisely. In the first activity in Section 2.4, you have listed all the treasures in land. When reaping the benefits of some of these resources, do people destroy other precious resources of land? Against each resource in your list write down which other resources are normally destroyed while using this item.

3. Discuss in the class how destruction of multiple resources of land can be avoided in each case.

Humans are intelligent enough to observe nature and abstract the laws governing natural processes. Hence, they have the potential to predict changes, and adapt to them. Many changes in landscapes, air and water are accelerated by human activities. It turns out that, when humans interfere, it has often been the case of the four friends and the treasure urn. In the following sections, you will discuss a few instances of natural degradation of land, as well as degradation by human activities.

5.1 Erosion

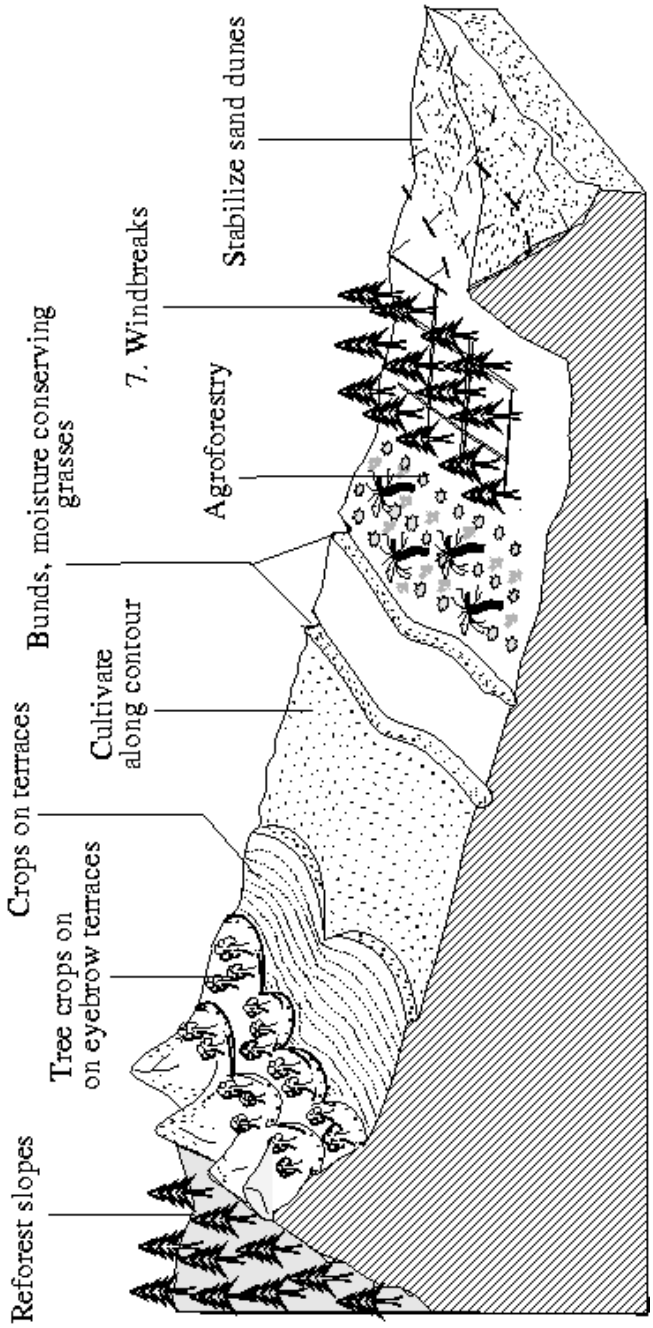
Figure 5.1 shows a slope on which are depicted different ways of preventing desertification. Desertification is the conversion of productive land containing soil nutrients that support vegetation into land that cannot support any vegetation. Of course, this does not mean that the desertified land has no resources. The land may be a source of mineral and other inorganic resources and a home to many life forms. Desertification of land implies that a large set of interdependent resources — plants, animals and nutrients — have been decimated. Study the picture in Figure 5.1, and discuss the issues raised below.

1. Why should desertification of land be prevented? List your reasons individually. Then share your views with the class. List all the reasons given by the class on the blackboard. How many did they add up to? You should get at least 10. If you were able to come up with over 20 different reasons, you are really sensitive to the problems of land!

2. Three million people in India live inside forests. Forests have been designated as protected areas to conserve their flora and fauna. This puts a pressure on the forest resources both by the people living within and from the people outside. Apart from population pressures, there is a threat to protected areas from irresponsible industrial activities, industrial needs, mining, and infrastructure development like roads and dwellings. List the causes of desertification. Write a page on how each "developmental activity" could lead to desertification of productive or forest land.

3. Forests on slopes of mountains are a common sight. However, they may be destroyed by forest fires or excessive cutting for timber, followed by overgrazing. This could lead to the slopes not being able to retain water, thus decreasing the water table in the area and silting the rivers into which the mountain streams drain. In what ways do each of the strategies suggested in Figure 5.1 help prevent desertification? What disadvantages could each one have? Tabulate your ideas, or make a list of the suggested methods, their advantages and disadvantages. Agroforestry in the figure refers to a mixture of farming, growing fodder for cattle, and growing woody plants on the same land.

Figure 5.1: Many ways of preventing desertification.



4. Figure 5.1 also shows some reforestation efforts. You are aware of the afforestation programmes of the Government. Do you think these 'new' forests could ever resemble the forests that existed before in the same place? Justify your stand in about 500 words, describing what a forest means to you, and explaining whether these new forests meet all your expectations of a forest.

5.2 Economic pressures

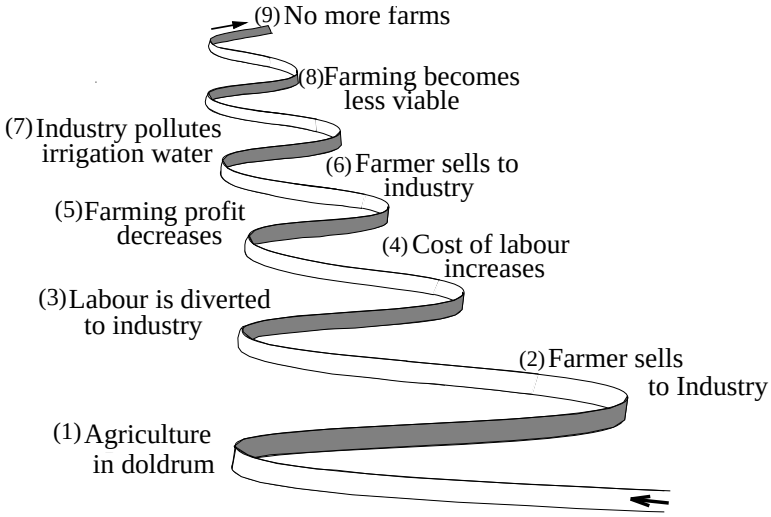
Younger members of farmers' families choose to take up an office job. Offsprings of town people rarely opt for agriculture as a profession. Agriculture in India is still a highly labour intensive activity. The remuneration is dictated by the Government, which fixes the retail price of grains and other essential food crops. On the other hand the wages of labour are decided by the market, that is availability of labour, strength of labour unions, etc. Given all this, the farmer may find it rewarding to sell off the agricultural land to an industry offering a tidy sum, after letting the land lie fallow for a stipulated number of years. A possible scenario is schematically suggested in Figure 5.2. Study the figure and ponder over the issues below.

1. Talk to an elderly person in your locality about the extent of productive land during his or her younger days. What has become of it now? What caused the degradation of land according to them? Do you agree with them? Justify in a paragraph.

2. One scenario that is imagined from the spiral shown in Figure 5.2 is – a farmer fell into hard times. An industry offered to buy up some of his land for a substantial price. The farmer took the opportunity and sold his land. The industry attracted the local labour, making labour scarce for farming. This increased labour cost and made farming less viable. More farmers sold their land, and so on. You can imagine many other possible scenarios to explain the spiral.

   Form groups of 2 to 3 members. Each group should write a story of a village where slowly all the land was converted from agriculture to other uses. Let your imagination free. Give the village, the farmers, and the industry interesting names. Different groups should think of

Figure 5.2: An economic spiral that destroys agricultural land.



different ways in which the land use changed. You may also make a picture composition — a set of picture frames at each turn of the spiral depicting the change. Some of the groups could also write the script for a full play or street play. Make it as realistic as you can.

5.3 Land pollution

Land pollution is the degradation of the Earth's land surface. This could be through misuse of the soil by poor agricultural practices, mineral exploitation, industrial waste dumping, and indiscriminate disposal of urban wastes. Pollution is avoidable to some extent. At times it may require greater economic inputs, which need to be shared by the people of the land. This might become easier to achieve if you knew the worth of land preservation, and if you wanted to leave a habitable earth for future generations.

The activities below should help you discover the links between individual's actions and large scale land degradation.

1. What constitutes solid wastes? List the different human activities that

Table 5.1: Format for listing solid waste reduction possibilities.

Activity producing solid waste	**Waste type**	**Reduction strategies**
Example: 1. Cooking 2. Office maintenance	organic paper, plastics, metal scrap	vermiculture, compost reduction of initial use, separation of waste, recycling

produce solid wastes. Against each activity note down the types of waste produced. Suggest possible strategies/ plans at the individual or societal level to minimise the waste at the generation point. Table 5.1 gives a format for organising your thoughts. A few examples are given to illustrate what you can fill. Expand the list with at least 5 more types of human activities producing solid wastes. Think of all the activities that humans engage in.

2. Compare the lists made by the whole class and discuss the suggestions that each of you can implement yourself.

3. Most industrial countries have adopted the method of sanitary landfill for disposing solid wastes. In our country we still resort to open dumping. Sanitary landfills are large pits lined at their bottom and sides with special materials to avoid seepage of water, and are often covered on the top to avoid dispersal by birds and animals. They also have provisions for channelising the toxic chemicals formed to a safe place. This costs money and takes time to construct. What harm could open dumps cause? Discuss the issue in class and decide the better option for India in the long run. Are open dumps useful in any way? Why do we resort to this in India? Is there a way out?

5.4 Cleaning up *Kachrapuri*

Some information about the solid waste management (SWM) system in a megacity called **Kachrapuri** is given in Table 5.2 [11]. It consists of the formal sector under the municipal corporation and the informal sector. The

informal sector undertakes the critical job of retrieving valuable materials from waste, and also serves to mobilize a market for recyclable materials. Study the information and discuss the issues raised below.

1. Table 5.2 contains a few question marks in the quantity and units columns. Study the table and fill the missing information.

2. The data given in the table corresponds to a real city in India. Collect similar data about your city, town or district. Collect as much information as you can about the solid waste management system that is supposed to be employed in your locality.

3. The data is divided into two parts: the formal sector and the informal sector. Divide the class into 2 groups. One group, the **Formals** should investigate the formal sector and the other group, the **Informals** should look into the operation of the informal sector. As good investigators besides filling up data in a table as in the previous activity, you should also read up about the issues involved in solid waste management. This is the *background research* before the investigation.

4. The *Formals* should elect a group of about 5 members who will visit the office of the local municipality or panchayat and locate the official in charge of solid waste management. Talk to the official about his or her difficulties in managing the locality's wastes as well as the success achieved. Discuss how a little more cooperation from the residents might help in reducing the quantity of solid waste. Report your interactions to others in the *Formals* group.

5. In the mean time the *Informals* should interview the non-government organisations and individuals in the area who help in recycling the solid wastes. If there are none, the group should study the need for such a system. Are resources being dumped wastefully or burnt away destroying the resources and the land? List a plan of action that will make recycling more efficient and less hazardous.

6. The *Formals* chalk out a plan of action for mobilising community involvement in keeping the locality clean and reducing solid wastes using separation of wastes, and adequate and well-designed bins. List the **throw away habits** that need to be changed. Draw up a resolution

Table 5.2: The soild waste management (SWM) system in **Kachrapuri**.

Different inputs to SWM system	**Quantity**	**Units**
Staff of SWM dept. of Municipal Corporation	26,299	persons
Number of points of collection	6000	bins
Population of Kachrapuri	10,000,000	persons
Hence, staff per 1000 residents	?	persons
Garbage collected per year (not debris)	1,800,000	tonnes
Garbage per year per SWM staff	?	tonnes
Amount of garbage generated per person per year	?	?
Amount of debris collected per year	730,000	tonnes
Number of vehicles for collection	1100	vehicles
Distance covered by a garbage truck in a trip	100	kms
Number of trips per day	778	trips
Distance covered by trucks in a day	?	kms
Cost of collection and transport of garbage in 1991-92	135	crores, Rs.
Estimated cost of garbage collection/ disposal per resident per year	?	?
Total land put aside as dumpyards	1.7	sq. kms
Estimated value of this land	150	crores, Rs.
Number of dumpsites	4	sites
Approximate ragpickers in Kachrapuri	100,000	persons
Garbage picked by each ragpicker per day	12	kgs.
Garbage picked by ragpickers per year	?	tonnes
Worth of useful materials injected back into the economy by the ragpickers per day	30	lakhs, Rs.
Worth of recyclable materials per year	?	?
Land area set aflame by garbage collectors at dumpsites	50,000	sq. metres
Garbage burnt per day	100	tonnes

stating what needs to be changed, and how the residents can help in conservation of land. Specifically, list your own plan of action for mobilising community involvement. Changing attitudes of the community is not easy. Discuss all strategies that will help.

7. Organise a meeting of at least the whole class, but preferably inviting all students and teachers of your institution and the local community, to discuss solid waste management in your locality. The *Formals* and *Informals* will report their findings at this meeting. The official could be invited to address the meeting. You could then submit your plan of action.

8. Write an article to the local newspaper describing the garbage scenario in your locality (city, town or village) analysing its strong and weak points.

9. Write a persuasive article to your local newspaper protesting against any land use pattern that you disapprove of. Make your theme: **A community that destroys its land forfeits its future.**

Part II

Resources: Air

Chapter 6

A breath of fresh air

Air is a mixture of gases, and supports life. This naturally makes it a very important resource. However, air is an intangible resource — you cannot see it, or even *feel* the need for it, until you are deprived of it. It is different from other resources like land, water and energy. Since air is an essential resource for life, quality of air directly affects the quality and quantity of life.

Through the activities in this and succeeding chapters you will explore the properties of air that sustain life on earth and discuss issues relating to deteriorating air quality with regard to life.

6.1 Air your thoughts

Air is a fascinating English word: one among the 1000 most frequently used words of the language [8]. It has over 15 distinct usage including noun and verb forms. Most of the meanings have their origin in one of the perceived properties of air. Only one of these refers to air being a gas that supports life. In this section, you will dwell on the richness of *air* and its meanings.

1. Many different words are used in association with air. For instance,
    - Fresh air: If you have been cooped up in class for several hours at

a stretch, you need to go out and get some fresh air.

- Heavy air: The air in a dirty city is heavy and laden with dust.

List such associations and form a sentence or two indicating the context in which you might use this description. Compare your list with other lists in the class. You should be able to describe air in over 20 different ways.

2. Table 6.1 is a list of meanings of air taken from the Longman Contemporary English Dictionary [8]. It also includes a few related words. The table indicates whether the word is used as a noun (**N**), verb (**V**), adjective (**Adj**) or adverb (**Adv**). Write a sentence or two using air in a context that clarifies each meaning.

6.2 Our friendly atmosphere

There is not one among you, I am sure, who has not looked up into the sky and wondered about life in outer space. Those of you who are dreamers probably even conjured up a picture of *people out there*. But few would have imagined that they would look like humans or anything living on Earth. When you do think of humans in outer space, even on the moon, you also clothe them in space suits. Why do you think that way? What is so special about the Earth that we do not have to walk around in space suits? What makes it such a friendly habitat for life of mind-boggling variety? You will answer such questions through the activities in this section.

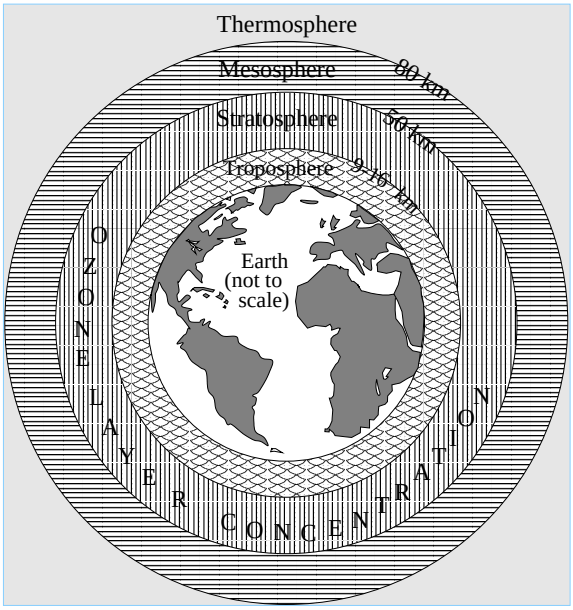
1. The word *atmosphere* meaning a ball of vapour, comes from the Greek *atmos* meaning vapour and *sphaira* meaning ball. Many planets of the solar system have substantial atmospheres, most of which is near the surface of the planet. Though they are close in terms of astronomical distances, the planets show an amazing variation in the constitution of their atmospheres. List the planets of the solar system. Which are the inner planets and which ones are called the outer planets?

2. Form groups of 3 to 5 members and discuss the kind of atmosphere you might expect for the inner and outer planets. Recollect your secondary

Table 6.1: Many meanings of *Air*. (Whether the word is noun (**N**), verb (**V**), adjective (**Adj**) or adverb (**Adv**) is indicated).

Meaning	**N/V**	**Explanation**
1. Gas	N	Mixture of gas we breathe, that surrounds Earth
2. Space	N	The space above the ground or around things
3. Flying	N	By air
	N	Involving or connected with planes and flying
4. Appearance	N	Air of confidence or mystery
5. Up in the air	N	Something has not been decided yet
6. Be on/ off the air	N	Be/ not be broadcasting on the radio or television at present time
7. Airs	N	Behaviour in which some people try to make themselves seem more important than they are
8. In the air	N	A lot of people seem to feel (an emotion) at the same time
9. Music	N	A name given to a piece of music
Air +		
10. + Clothes	V	To put a piece of clothing in a place that is warm or has a lot of air
11. + Room	V	To let fresh air into a room
12. + on TV/ Radio	V	To broadcast a programme
13. + Views	V	To say publicly what you think about something important
14. + Grievances	V	To tell others about things that you think are unfair
Related Word	**Adj/ Adv**	**Explanation**
15. Airily	Adv.	Without being concerned
16. Airy	Adj.	A space that has plenty of fresh air, is large or has lots of windows
		Cheerful and confident even when you should be serious and concerned
17. Airy fairy	Adj.	Not very clear or practical, vague

Figure 6.1: Schematic of the extent of Earth's atmosphere.



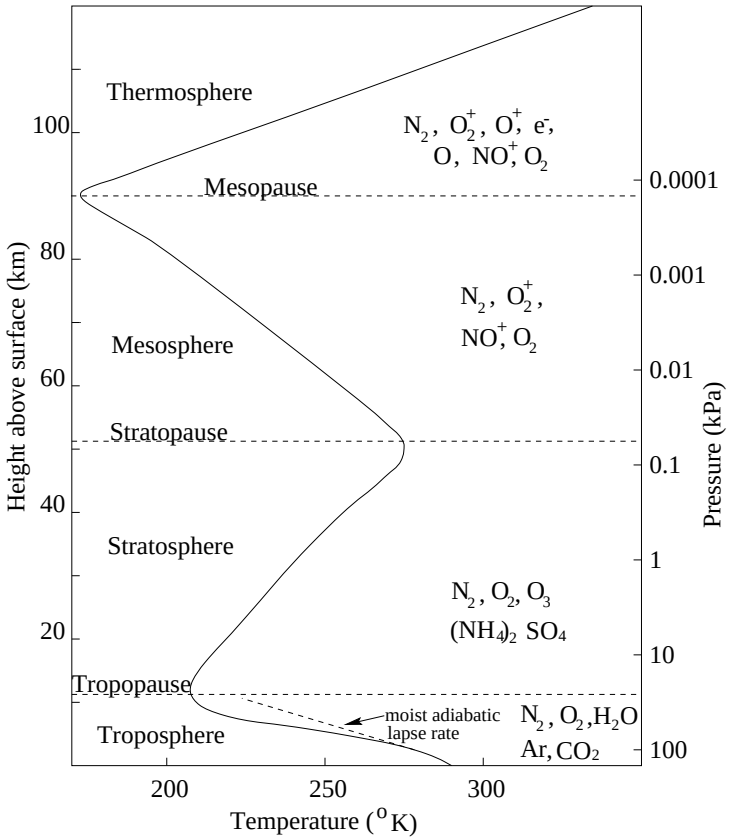
school science, when you learnt about size of planets, their distances from the sun and the gravitational acceleration on them, to make intelligent guesses about their atmospheres. Discuss the results in class. Ask your Physics teacher or the sky-watchers you know.

3. Figure 6.1 is a schematic of the extent of the Earth's atmosphere, from the troposphere close to the surface to the outermost layer called the thermosphere. Guess the gas constituents of these layers, and the nature of variation of its temperature and pressure. Discuss the reasons for your guesses.

4. Figure 6.2 shows the actual variation in the atmospheric temperature and pressure as a function of distance from the Earth's surface. How would you describe the pressure variation? Does it increase or decrease as you go away from the Earth? Why does it do so?

5. The right side of Figure 6.2 shows pressure values corresponding to the altitude given on the left. How does pressure vary as a function of altitude? Is the variation linear, quadratic or exponential? At what

Figure 6.2: Temperature and pressure variation with altitude above the Earth.



levels would you find most of the mass of the atmosphere over the Earth?

6. Anyone who has gone up a mountain knows that the temperature is lower at a high altitude than it is on the ground. The variation of temperature with altitude is characterised by a quantity called the **lapse rate**. Typical units for the lapse rate are degree Celsius per kilometer (^oC per km). If the temperature decreases by 4^oC for each km increase in altitude, the lapse rate is -4^oC per km. The minus sign reminds you that the temperature decreases with increasing altitude. What is the *lapse rate* in the troposphere? What are the average *lapse rates*

Table 6.2: Atmospheric constituents and their mixing ratios on Venus, Earth and Mars (units – mole fractions).

Properties	Venus	Earth	Mars	Patterns in values
Surface Pressure (bars)	90	1	0.006	
Surface Temp. (^{o} K)	732	288	223	
Constituents	**Mixing ratios on**			
	Venus	Earth	Mars	
Hydrogen (H_2)	1×10^{-5}	5.3×10^{-7}	—	
Helium (He)	2×10^{5}	5.2×10^{-6}	—	
Water (H_2O)	2×10^{-5}	0 to 0.04	3×10^{-4}	
Methane (CH_4)	6×10^{-7}	1.7×10^{-6}	—	
Ammonia (NH_3)	—	$< 1 \times 10^{-8}$	—	
Neon (Ne)	1.5×10^{-5}	1.8×10^{5}	2.8×10^{-6}	
Hydrogen sulfide (H_2S)	2×10^{-6}	1×10^{-10}	—	
Carbon dioxide (CO_2)	0.965	3.35×10^{4}	0.953	
Nitrogen (N_2)	0.035	0.781	0.027	
Oxygen (O_2)	2×10^{-5}	0.209	1.3×10^{-3}	
Carbon monoxide (CO)	3×10^{-5}	$4to20 \times 10^{-8}$	7×10^{-4}	
Sulfur dioxide (SO_2)	1.4×10^{-4}	1.1×10^{-10}	—	
Argon (Ar)	7×10^{-5}	9.3×10^{-3}	1.6×10^{-2}	
Nitrous oxide (N_2O)	—	3×10^{-7}	–	

in the stratosphere and mesosphere? What are the *lapse rates* in the tropopause, stratopause and mesopause? Does their name indicate their temperature variation?

7. Do you think the nature of variation in the troposphere ever changes? In what way? What consequences could it have? You will learn more about this in Section 7.3.

8. Table 6.2 lists the constituents of the atmospheres of Earth and 2 of her nearest neighbours: Venus and Mars. The values are called *mixing ratios*, and units used are *mole fractions* [22].

   Study the table and compare the mixing ratio of each constituent on Venus and Mars to that on Earth. One way to judge similarity is to

see if they match in the order of magnitude, that is, they vary by a factor less than 10. On the basis of the above criteria, for which of the constituents are Earth and Venus similar? Are Earth and Mars similar for any constituent? How far are Mars and Venus from Earth?

9. Another way to compare the constituents of air on the three planets would be look for patterns in the value of each constituent. Since Earth lies between Venus and Mars, you might expect its mixing ratios be between Venus and Mars. In the last column, mark the constituents for which Earth does not follow this pattern, that is, its values do not lie between the values for Venus and Mars.

10. In particular, what can you say about the mixing ratios of H_2O, CO_2, N_2, O_2 and CO on the 2 neighbours relative to Earth?

11. Write a paragraph giving plausible explanations for your results in the activities above. What are the processes that may be contributing to making Earth so different from her neighbours?

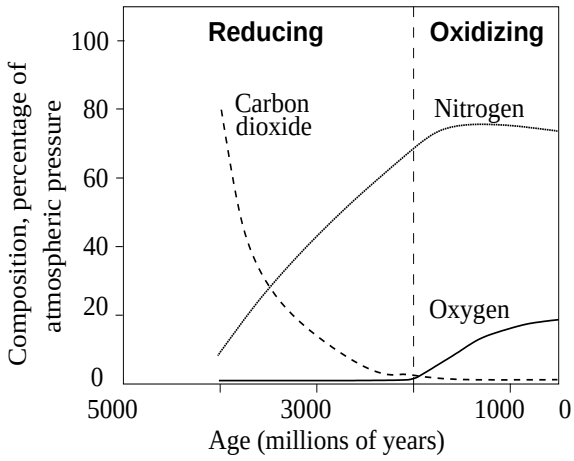
6.2.1 Life on Earth

In the 1920s, the Russian biochemist A. I. Oparin and the British geneticist J. B. S. Haldane independently proposed that synthesis of amino acids, the building blocks of life, could only take place in a mildly reducing atmosphere rich in methane, ammonia, hydrogen and water [14]. Recent experiments confirm this and add that all the precursors needed for the complex organic molecules originate from an atmosphere of carbon dioxide, nitrogen and water. Life could not have begun in an oxidising atmosphere.

1. Figure 6.3 shows a guess of how carbon dioxide, nitrogen and oxygen may have varied over the approximately 4 billion years of Earth's existence. What happened about 2 billion years ago?

2. Given the above information, can you speculate about the possible evolution of life on a planet like Venus or Mars? Each of you could write a page or two setting the scene of evolution and explaining variations in the atmospheric concentration of gases.

Figure 6.3: Speculated variation of carbon dioxide, nitrogen and oxygen in the Earth's atmosphere over 4 billion years.



3. Discuss some of the more interesting writings in the class. Invite a University biology teacher, a person who is knowledgeable about evolution of life on earth, or a geologist, to talk to you about how life must have evolved on Earth, and the clues that help us reconstruct the scene.

4. Was Earth born with a constitution different from Venus and Mars? Justify.

6.2.2 Life supports oxygen

When oxygen first appeared in the earth's atmosphere it was poisonous to most organisms. But as often happens in evolution, adverse conditions create new opportunities. The *respirers* — those organisms that adapted to oxygen by evolving processes to neutralise its poisonous effects — thrived. In fact, oxygen expanded their ability to produce energy. *Fermenters* — microorganisms that do not use oxygen — can get only 2 units of energy (*ATPs*) per glucose molecule. A *respirer* can get 20 units of energy per molecule. With this advantage the *respirers* (many bacteria and virtually all multicellular organisms, including us) have come to dominate the living world.

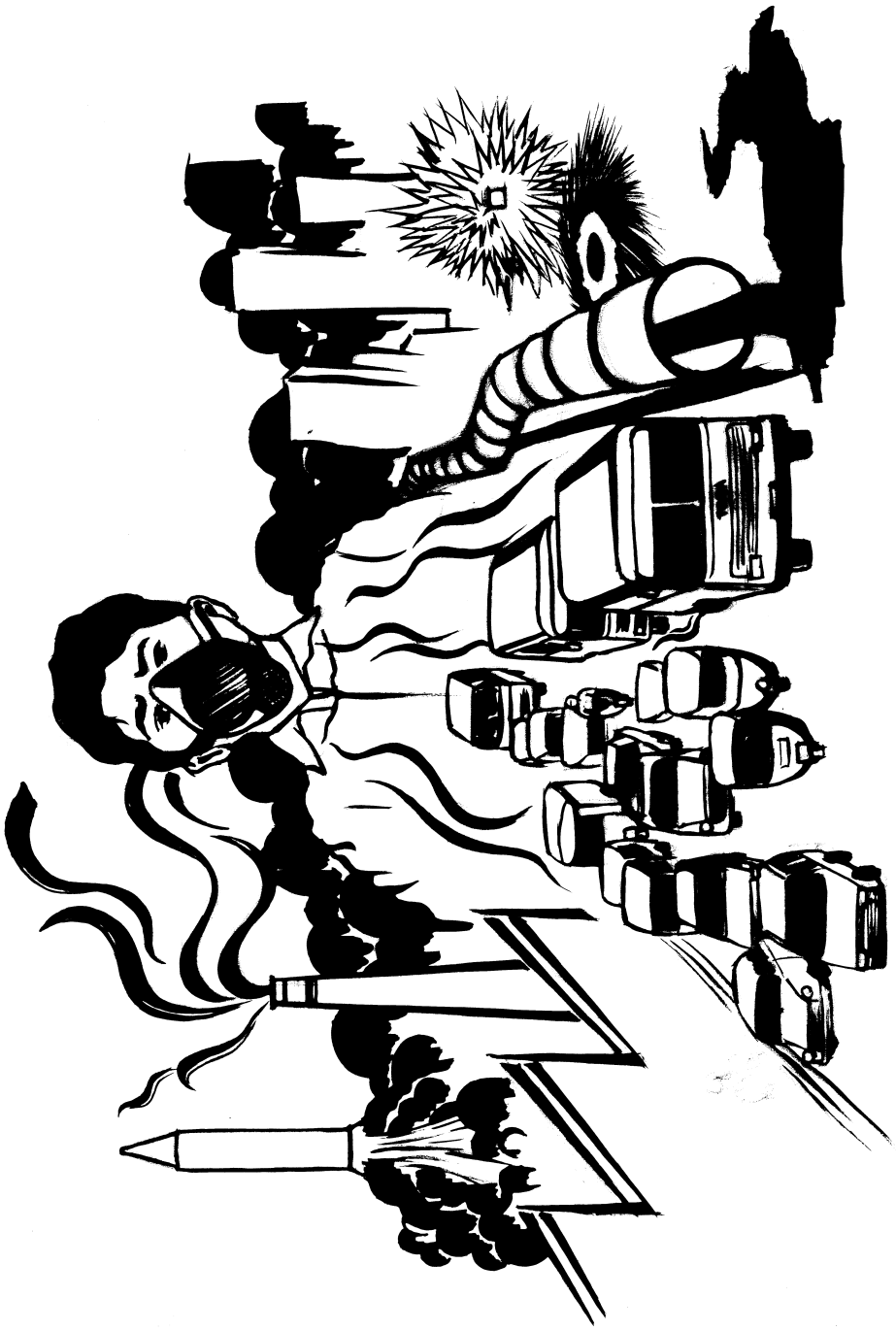
However, there is something odd about oxygen's role in respiration. It is hydrogen that an organism needs to produce energy. Oxygen combines with the hydrogen which has been *spent* in a reaction and converts to water.

1. Based on this argument write a paragraph explaining how the concentration of oxygen in the atmosphere, on which life now depends, is itself maintained by the life on Earth.

2. You have argued that life has evolved to take advantage of the poisonous gas oxygen. Extend your argument to what would happen if the concentrations of present poisons in the air, like carbon monoxide, sulphur dioxide, ammonia and methane, increase with time. Which organisms are more likely to adapt to the new conditions through biological evolution? How will humans respond? Give biological and cultural responses.

You will discuss the oxygen balance and other such balances in nature in the book *Ecology: Balance in Nature*. Oxygen and ozone are also discussed in later books.

Figure 6.4: Poisons in the air.



Chapter 7

Poisons in the air

Air is a free resource. You do not pay for its use. You might argue that a commodity as precious for life as air cannot be priced. That may be so. Yet, if used irresponsibly, poisonous substances would accumulate in the atmosphere. In sufficient concentrations they would endanger human health and life. These poisons may be added to the atmosphere by many processes. The term **air pollution** is restricted to substances added to air by the activity of humans, and in concentrations sufficient to cause harmful effects to health, property and crop yield, or to interfere with the enjoyment of property.

7.1 Causes and origins

1. The six major types of air pollutants are carbon monoxide, hydrocarbons, nitrogen oxides, particulates, sulfur dioxide, and photochemical oxidants. List the human activities which could add one or more of these pollutants to the atmosphere.

2. Table 7.1 gives the proportion of four pollutants — total suspended particles, particles less than one hundredths of a millimetre, sulfur dioxide and nitrogen oxides — emitted by different sources in the city of Mumbai over a year (1992). The values shown are percentage contributions of each source. For instance, suppose the annual load of SO_2 was 7660

Table 7.1: Proportion of different air pollutants from various sources in Mumbai in 1992.

Sources	**TSP**	**PM10**	SO_2	NO_x
Vehicular traffic	54	40	16	52
Power plant	6	10	33	30
Industry	7	10	48	11
Domestic sources	17	14	1	4
Marine docks	2	3	2	3
Refuse burning	14	23	–	–

Note: TSP - total suspended particulates; PM10 - TSP < 0.01 *mm in diameter.*

tonnes. Of this 16%, about 1226 tonnes, was contributed by vehicles. (Refer 1987 values in Table 8.4 of Section 8). Which of the sources in the table are localised sources, which are mobile and which are distributed? Justify.

3. If you lived near a thermal power station, what would your air be polluted with? Which of the polluting sources (industry, homes, vehicles, etc.) in the table is the major problem in your locality? Would this vary from one locality to another? Why and to what extent?

4. If you were in a room or house with a smoker (of cigarette, cigar or bidi), how many air pollutants would you be inhaling? How many of these are carcinogenic (that is, could potentially cause cancer)?

5. Will a source in one place affect people of another locality? How far away will these effects be felt? List the factors that will determine whether the pollution is confined or spread out.

6. List a set of industries that pollute air. Against each industry list the pollutants that they generate. If you are in doubt, ask your chemistry teacher for the processes used and the possible gaseous emissions. You could visit the industry in your neighbourhood and ask the concerned people about the processes used and the gases emitted.

7. List a few living and non-living components of the environment affected by air pollution. In what ways are they affected? Add information about how far they must be located from various sources so that they are not affected.

8. Besides industry, vehicles, agriculture, mining and quarrying are other activities that add to air pollution.

   (a) What are the air pollutants added by vehicles of all types?

   (b) How does agriculture, farming and horticulture increase air pollution?

   (c) What is a quarry? List some of the items in your household that may need materials from a quarry. How does quarrying pollute air?

   (d) You have seen in the Part I (*Land*) that irresponsible mining degrades land resources. How does this activity pollute air?

   Add as many polluting activities to this list as you know.

9. The black smoke rising from a chimney is the most noticeable form of air pollution. Is it also the worst kind of air pollution? Can colour of air help you infer something about the the type of pollutants? Use your secondary school knowledge of the colour of various gases and make some educated guesses.

10. Elements like lead and aluminium are often blown on to surfaces exposed to air. Find out how these metals are detected. Where do you think they originate?

11. You can detect some pollutants in the air by their smell. List as many as you know. Discuss everyone's list in the class. Did your pollutants differ?

12. Smells have a cultural aspect. What seems like fragrance to one culture may be foul odour to another. This may also vary among individuals within a culture. It appears then that smell alone cannot form the basis for deciding pollutants. Yet, smell is an important sensory information for our survival. Associate different smells with various areas in your city, town or locality. Ride in a bus or walk through the locality with a

Table 7.2: I can reduce air pollution in my varied social roles.

Role	**Deed**
I am an individual concerned about my health and economy.	
I am a member of a family. I would like to see it healthy and prosperous.	
I belong to a society. I know that the society's health is linked to mine and my family's.	
I am a resident of a city/ town. I know that residents can force authorities to reduce air pollution in the locality.	
I am a responsible citizen of my country. I realise that our long term prosperity is linked to the health of productive individuals, and is affected by air pollution.	
I am a responsible global citizen. I realise that air pollution does not respect country borders. Economies of all countries are linked in the long term. Citizens of all countries have the duty and power to enforce reduction in global air pollution.	

friend. Close your eyes for a long time as you travel (your friend should ensure that you come to no harm) and identify each area by its smell. How close were you? Share your experiences with all the members of the class.

13. Write a page or two on what determines the quality of air and explain how the air quality degrades as a result of developmental processes.

How can I reduce air pollution?

Table 7.2 lists some of your roles in the world as a thinking social human. In the last column, write what you can do in each role to reduce air pollution.

7.2 Choking on smoke

Smoke billowing from a factory or power plant has become a signature of development, especially in this century. However, since Rachel Carson raised an alarm, [4] this has attracted attention and concern. The density of smoke can be estimated visually by comparing it with a pattern of series of grids [20]. Maximilian Ringelmann suggested this device in 1898. It is formed from squares of black lines on a white background. The black lines cover an area equal to 20%, 40%, 60% or 80% of the total in a series of 4 patterns. A Ringelmann number of 1, 2, 3 and 4 are associated with the respective patterns. The Ringelmann grid is given in Figure 7.4 at the end of this chapter. You may cut out the part carefully and use the grid for estimating smoke density. The steps listed below will help you estimate the density of smoke from a factory, power station or any stationary source.

1. Paste the grid on a cardboard for stiffness, and cut out the central blank rectangle to make a window.

2. Observe the smoke plume through the rectangular window. Hold the chart in front of you and compare the smoke to the grids on the chart. Ensure that the light shining on the chart is the same as that shining on the smoke. For best results, the sun should be behind you.

3. Match the smoke with the pattern corresponding to Ringelmann number 1, 2, 3 or 4. Record your results and the time of your observation.

4. Calculate *observed smoke density* S_1 in percentage for a single observation as,
$$S_1(\%) = Ringelmann\ number \times 20$$

5. Make 10 or more such observations, — preferably asking your friends and relatives to view the smoke.

6. An average percentage smoke density for a number of observations N, S_{av} is calculated as,
$$S_{av} = \frac{Sum\ of\ all\ Ringelmann\ numbers \times 20}{N}$$

7. Repeat these observations for a particular factory in your neighbourhood in the morning and evening, and on different days over a month. Tabulate your results. Plot smoke density (y-axis) as a function of day/date for your morning and evening observations (say, S_{am} and S_{pm}) separately. Do you see a pattern in the variation of smoke density over the day, or over the month?

The poisons in the air do not remain at the location at which they are added. They may rise higher or fall closer to the ground. They may also get blown by winds and air currents. Whether air at a particular altitude is lighter and rising or heavier and falling is governed by the temperature pattern in our troposphere. You will discuss this in the next chapter.

7.3 Spot the foul air

You have seen in Section 6.2 above that the temperature decreases up to an altitude of 9 to 15 kms. You have also realised that this troposphere contains about 80% of the entire mass of the atmosphere. Your *lapse rate* calculations showed that on the average, it was about -7.5^oC per kilometer in the troposphere. What do these conditions imply for movements of air and its pollutants?

7.3.1 Temperature inversion

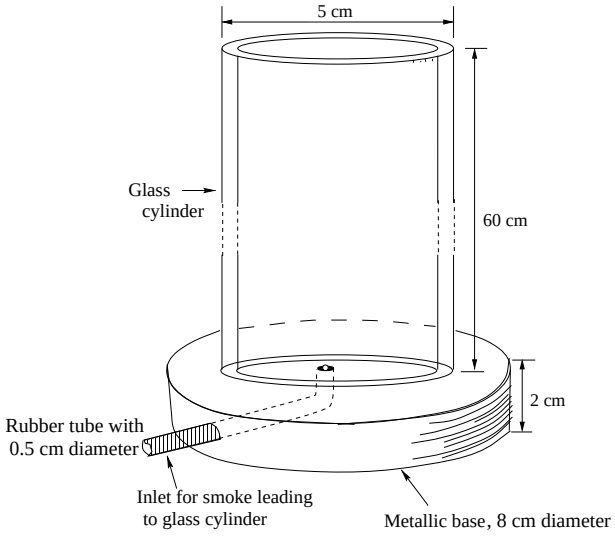
First, you will see for yourself through an experiment, how changes in the nature of temperature variation affect the mobility of air pollutants.

1. You will need the following for the experiment.

   (a) A glass tube, about 5 cms in diameter and 60 cms in length.

   (b) A metal disc, about 8 cms in diameter and 2 cms high. Make a 0.5 cm through hole in the centre, and a corresponding hole at the side to insert a rubber tube about 0.5 cms in diameter. It may help to

Figure 7.1: Experimental set-up to show effect of temperature on settling of smoke particles.



smooth the edges of the glass cylinder so that it sits vertically on the surface of this metal disc.

(c) A source of smoke, say a hurricane lamp.

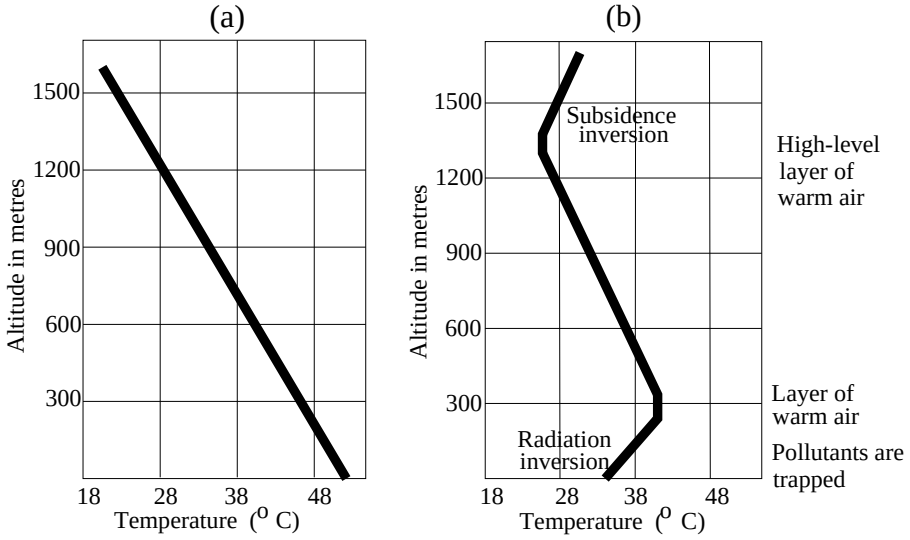
(d) A 0.5 cms diameter rubber tube, about 60 cms or so long to guide some of the smoke from the lamp to the centre of the metal plate.

(e) Ice to cool the metal disc.

2. Arrange the apparatus as shown in Figure 7.1. Do not use the ice yet. Let smoke into the glass cylinder at its bottom, through the rubber tube. Wait for about 15 minutes. Observe the inside wall of the glass tube. Where has the smoke settled?

3. Clean the glass tube thoroughly and place it back on the metallic disc, over the hole. Use ice cubes to cool the metal base disc. Wait for about 5 minutes for the temperatures to stabilise. Let smoke in again as before. What happens this time? How are your observations different from the previous case?

Figure 7.2: Typical temperature variation with altitude close to the ground: (a) on a sunny day, with no temperature inversion; (b) showing both radiation and subsidence temperature inversions.



4. Discuss what must have happened. Discuss its implications for air pollution.

The first observation shows that a condition of decreasing temperature with height causes a mass of warm air and smoke to rise. This is the same as the conditions required for warm air to rise from your room floor. The dispersal of pollutants from a smoke-stack relies on rising warm air to carry the particles into the upper atmosphere.

When the temperature increases with altitude, it is called a **temperature inversion**. The two most common causes for temperature inversion are: *radiation*, which is closer to the surface, and *subsidence*, which is higher up in the troposphere. In the daylight hours of a normal, sunny day, the temperature will decrease with altitude up to a few kilometres as expected in a troposphere. This is shown in Figure 7.2 (a). At night, the ground and the air in the first 300 to 600 metres cool, thereby producing an inversion in the temperature distribution at that altitude. This is indicated in the lower

portion of Figure 7.2 (b). Air pressure, as well as temperature, increases with increasing altitude in this case.

Under certain conditions, cool high level air will sink to a (lower) high pressure level. Once in the high pressure area, the cool air is compressed and it warms. As a result, the air temperature is higher than normal in a local area and a temperature inversion results. Inversions of this type, due to subsidence lowering of air, tend to form at altitudes of about 1 to 3 kilometres.

At the surface of the Earth, we normally notice the effects of radiation temperature inversion. Engage in the following activities and discover what this implies for pollutants near the surface of the Earth.

1. When there is temperature inversion during the night, what happens to the pollutants released? What could happen when the sun comes up in the morning and warms the ground?

2. In which season would you expect the temperature inversion effects to occur more often? What could happen on a cloudy day?

3. In Section 7.2 you have observed the smoke from a nearby factory at various times in the day. Have you noticed effects that you could attribute to temperature inversion?

4. Could there be correlations between temperature inversion and respiratory ailments among people living in polluted areas? Would they increase in certain seasons? How will you find out such correlations?

5. Form groups of students who live in the same locality. Talk to a general practitioner (a *family* doctor) in your neighbourhood. Request the doctor to maintain a log book of the number of patients who are diagnosed to have respiratory ailments every day. You maintain an account of days when you see temperature inversion effects in your locality. Do this for at least 3 months, preferably over the winter months. Tabulate the data as shown in Table 7.3.

   (a) Enter the serial number of your data in the first column (**N**).

   (b) Note down the date on which the data was taken.

Table 7.3: Hypothetical data and format for studying correlation between temperature inversion (TI) and number of patients with respiratory ailments (RA).

N	**Date**	**TI**	**RA**	$TI \times RA$	**Square of RA**
1	10-11-97	1	12	12	144
2	11-11-97	0	8	0	64
3	12-11-97	0	9	0	81
4	13-11-97	1	10	10	100
5	14-11-97	0	11	0	121
6	15-11-97	0	9	0	81
7	16-11-97	1	11	11	121
8	17-11-97	1	8	8	64
9	18-11-97	0	8	0	64
10	19-11-97	1	11	11	121
Total		STI = 5	SRA = 97	STR = 52	SRAS = 961

(c) In the third column note whether temperature inversion was noticed on that day. If it was present, enter the value for **TI** as **1**. If it was absent, enter **0**.

(d) Find out from the doctor's log book the number of patients that the doctor diagnosed to have respiratory problems on corresponding dates. Enter this in the column for **RA**.

(e) For each record date, calculate the product $(TI \times RA)$, and RA^2.

6. You are now ready to calculate the correlation between temperature inversion and respiratory ailments. The **correlation coefficient** is a ratio of numbers and its value always lies between -1 and +1. A positive value of the coefficient indicates a positive correlation. There is perfect correlation when the coefficient equals 1. There is no correlation when the coefficient is zero. The steps below will guide you to calculate the correlation coefficient.

(a) Calculate the following totals and fill the last row, as shown in the example in Table 7.3.

- Sum of **TI** values = STI

- Sum of square of **TI** values = STI (since TI = TI^2)
- Sum of **RA** values = SRA
- Sum of the product of **TI** and **RA** = STR
- Sum of square of **RA** = SRAS

(b) Use the formula for correlation coefficient **r** given below.

$$r = \frac{(N \times STR) - (STI \times SRA)}{\sqrt{[(N \times STI^2) - (STI)^2] \times [N \times SRAS - (SRA)^2]}}$$

For the hypothetical example in Table 7.3 this would work out to

$$r = \frac{(10 \times 52) - (5 \times 97)}{\sqrt{(10 \times 5 - 5^2) \times (10 \times 961 - 97^2)}} = 0.49$$

The data given in the table shows moderate positive correlation. It is far from perfect (= 1).

7. Following the survey, did any of the groups find a positive correlation between the occurrence of temperature inversion and respiratory ailments? In which areas were the coefficients maximum? What can you say about the pollution in these areas relative to other areas?

8. Based on your survey and its findings, discuss in the class what can be done to reduce the problem. Write a letter to the local newspaper giving your results and suggesting remedies.

7.3.2 Local risky air spots

Local air pollution can often spread out to encompass areas of many thousands of square kilometres. Meteorological conditions and types of landscapes can greatly influence air-pollution concentrations at any given place. For example, atmospheric inversion form over cities located in valleys. Such cities are especially likely to suffer from incidences of air pollution. You can be an activist and do something about air pollution in your locality. First, you need to think about historical air pollution disasters and their possible recurrence in the future.

1. List as many cases as you can of local air pollution incidents or disasters which have led to health hazards.
2. Write a page explaining the Union Carbide factory incidence in Bhopal in December 1984. How was it an air pollution disaster?
3. Write a paragraph about any other (other than Bhopal) major or minor air pollution disaster that you know.
4. Discuss the disasters reported by the whole class. How many did the class unearth? Could any of these have been averted or reduced in magnitude if the local people had been aware and vigilant?

7.3.3 Fog and its relatives

Fog, like cloud, is composed of water vapour that has condensed on particles of dust in the atmosphere. Cloud and fog are both caused by air temperature falling below dew point. Fog, however, exists at the surface of the earth. How dense the fog is, depends on the number of water particles it contains. Technically, fog refers to a condition when visibility is reduced to 1 km or less. It is referred to as **mist** when the visibility is 1-2 km. A haze is produced by smoke or dust. There are two types of fog:

- An **advection** fog is formed by the meeting of two currents of air, one cooler than the other, or by warm air flowing over a cold surface.
- A **radiation** fog, on the other hand, forms on clear, calm nights when the land surface loses heat rapidly (by radiation). The air above is cooled to below its dew point and condensation takes place.

Sunlight falling on automobile exhausts can initiate photochemical reactions. One photochemical reaction is the action of sunlight on automobile exhaust fumes, which results in the production of ozone and nitrogen oxides (NO_x). The products of photochemical reactions include ozone, aldehydes, ketones, peroxyacetyl nitrate (PAN), and organic acids and other oxidants. Sulfur dioxide (SO_2), which is always present to some extent, forms sulfuric acid and becomes part of the particulate matter.

Industrial polluted areas have a continual haze of smoke over them, and if there is a temperature inversion, a dense yellow *smog* forms. **Smog** is a fog which contains impurities, mainly nitrogen oxides (NOx) and volatile organic compounds (VOCs) from domestic fires, industrial furnaces, certain power stations, and internal combustion engines (gasoline or diesel). A contraction of the words smoke and fog, smog has been the most harmful kind of air pollution. The infamous London fogs have killed many people. About 4,000 deaths were attributed to the severe fog of 1952.

Armed with the information given above, discuss the effects of fog and its **relatives** in your locality.

1. Photochemical smogs are common in all urban areas, more often in some than in others. Figure 7.3 shows the hourly variation of the constituents of an intense photochemical smog. These are hydrocarbons (HC), aldehydes, NO_x, and ozone [15]. Write a paragraph describing the variation in concentration of different constituents during the day hours. What implications would this have on working people, and those who are outdoors in the day hours?

2. Table 7.4 lists the differences between the Photochemical and London smogs. Did any of the consequences listed in the table figure in your discussions in the above activity?

3. Have you ever observed smoke or fog anywhere in your city, town or locality? List the locality in which you have observed one of these conditions — smoke, fog, mist or smog. Next, specify its possible origin, say around a factory, over a colony of huts, in the vicinity of a certain traffic intersection, and so on. In cases where it is hard to localise the origin, you may specify a famous landmark in the locality.

4. For each case in the above activity, note down the time of the year and day when the incidence was most intense or noticeable.

5. Which of the locations you have listed is most worrisome for you in terms of your health? Call these locations **RASPOTS** — Risky Air SPOTS. Discuss the RASPOTS with the whole class. Are garbage piles air pollutants? Justify. Include in your list of RASPOTS all spots that are related to health risk through foul air.

Figure 7.3: Hourly variation of the constituents of an intense photochemical smog.

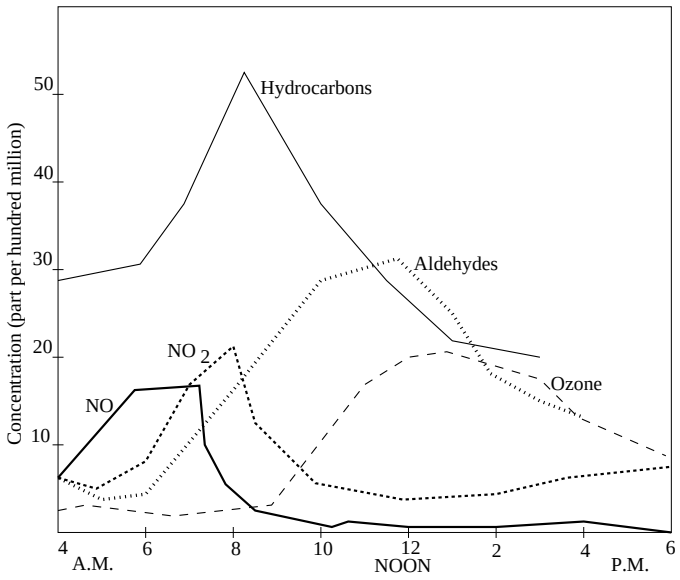


Table 7.4: Characteristics of photochemical and London smogs.

Characteristics	Photochemical	London
Major fuels involved	petroleum	coal and petroleum products
Principal constituents	O_3, NO, NO_2, CO, organic products	particulates, CO, sulfur compounds
Types of reactions	photochemical and thermal	thermal
Time of maximum occurrence	midday	early morning
Principal effects	eye irritation	bronchial irritation, coughing
Visibility	about 0.8 to 1.7 kms	less than 100 metres

6. Form groups of students who live or pass through the same localities. Each group will address the health issues of RASPOTS in their respective localities.

7. Elect a leader in each group to co-ordinate its activities. List the strategies that you could adopt to solve the RASPOT problem in your locality. Corresponding to each strategy, list the possible action plans. This could involve the actions given below.

   (a) Survey the locality for
   - number and types of factories,
   - huts in colonies and types of cook-stoves used in them,
   - number and types of vehicles on the streets and roads,
   - garbage dumps and their burning, and
   - other information relevant to sources of air pollution.

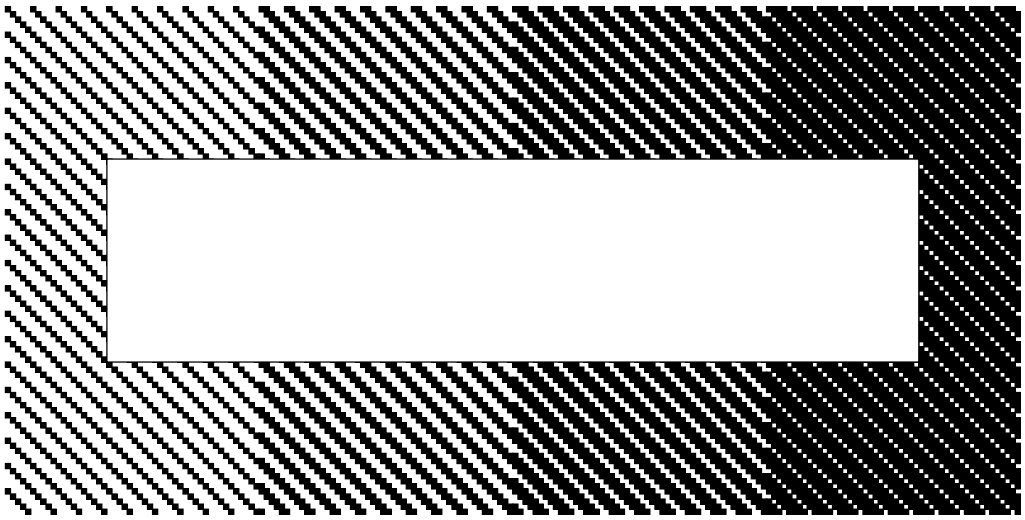
   (b) Contact the Non-Government Organisations (NGO's) in your locality and find out what they are doing about air pollution.

   (c) Visit the polluting factories, and learn about their operations that pollute air, and the feasibility of adopting alternatives.

   (d) Talk to the people in charge of polluting factories about the local citizens' concerns. Persuade them to win local people's good will.

   (e) List possible ways of solving the smoking cook-stove problems. Get information on smokeless chulhas, proper chimneys in houses, and people who manufacture and propagate the use of these fuel efficient cooking devices for the poor. Disseminate this information to the people.

Figure 7.4: Ringelmann grid for smoke density estimation.



(f) List significant dates in each month — dates that have historical, social, cultural or environmental importance. Plan activities by one or more groups on each of these days each month. The activities should attract public attention to the RASPOTS. They could include exhibition, street plays, essay writing, drawing, poetry and elocution competitions. Invite important people who could influence local policies to reduce pollution. Garner the support of your institution and local NGOs.

(g) Write to the local newspaper about your survey on the RASPOTS, and its significant findings.

8. Prioritise the actions from the immediate to long term ones. A subgroup of students could take responsibility for carrying out one or more actions. Arrange a group meeting each month and discuss the actions carried out till then. Report to the whole class.

One RASPOT more common to all groups would be an intersection of streets with vehicular emissions. You will deal with this issue specifically in the next chapter.

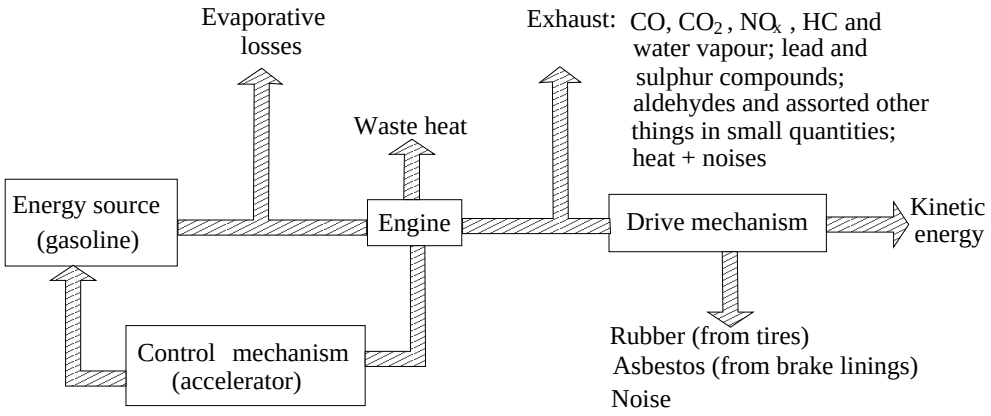
Chapter 8

Driving into foul air

All automobiles need energy to keep them moving. According to the second law of thermodynamics, explained in the book titled titled *Resources: Energy*, a certain loss of energy from the system to the surroundings is inevitable whenever energy is converted to work within a system. Most automobiles run by the energy obtained on combustion of fossil fuels, which is a chemical reaction. As in any chemical reaction, combustion of fuels leads to formation of one or more products. Besides the heat energy, the chemical by-products of combustion are released, treated or otherwise, into the surrounding atmosphere. This is schematically represented in Figure 8.1. The picture shows emissions of heat and chemicals when energy from petrol is converted to the kinetic energy of the vehicle. The vehicle in this picture is not fitted with any emission control systems other than a muffler for noise reduction.

Thus, air is a sort of dumping place (a sink) for heat energy and chemicals produced in vehicles. You can imagine that this must affect the composition of air, other materials, and all living beings in some way. First you will get a feel for the quantity of poisons released into the surroundings by automobiles. You could then discuss in detail about the contribution of motor vehicles to air pollution [19].

Figure 8.1: Basic functions of a motor vehicle power system, showing the emission of material and noise while converting fuel into kinetic energy.



8.1 Vehicles on the road

1. Vehicles on the road are of several types: petrol-driven cars, diesel-driven trucks, buses and automobiles, 3-wheelers and 2-wheelers. The total vehicles of different types registered in India in 1951, 1971, 1991 and 1995 are given in Table 8.1 [1] [19]. Which category of vehicles is increasing in numbers at the fastest rate?

2. India's metropolitan vehicle population has roughly tripled since 1990. Some people point a finger at globalization which began in this decade, and the delicensing of passenger cars in 1993. Do you agree? Justify your answer.

3. List all the possible reasons for increasing vehicle population. Discuss the lists made by all members in the class. List the distinct causes given by the class on the blackboard.

4. For each cause listed, discuss whether it should have been avoided or was a welcome change, indicative of a positive development.

5. Does the increase in the number of vehicles indicate an overall positive trend or an avoidable problem? Count the number of members in the

Table 8.1: Total registered vehicles in India in 1951, 1971, 1991 and 1995 (1995 values are estimated).

	Vehicles, in thousands			
Year	**1951**	**1971**	**1991**	**1995**
All vehicles	306	1865	21374	27229
Two-wheelers	27	576	14200	18166
Cars, Jeeps, Taxis	159,	682	2954	3630
Buses	34	94	331	412
Goods vehicles	82	343	1356	1901
Others (tractors, trailers, 3-wheelers)	4	170	2533	3120

Table 8.2: Projected annual vehicle sales for 1994-95, 1997-98 and 2000-01.

Vehicle type	**Sales in thousands**		
	1994-95	**1997-98**	**2000-01**
Two-wheelers	2400	3165	4213
Three-wheelers	90	118	158
Cars	240	400	850
Jeeps	60	79	105
Carrier vehicles (Light, medium, Heavy)	195	257	342
Total	2985	4019	5668

group who think this is a positive trend. Organise a debate on: **The increasing number of vehicles on our roads is an indication of our developed status.**

6. Table 8.2 gives the projected annual sales of vehicles of different categories in 1994-95, 1997-98 and 2000-01 [19]. Study the table and list the possible repercussions (effects) of this burgeoning vehicular population on air quality as well as mobility on our roads.

7. How would you decide on the capacity of production of various vehicles for 2000-01? Discuss the issues concerned with putting more vehicles

Table 8.3: Percentage contribution by petrol and diesel vehicles and resuspension from roads to the annual emission of 4 pollutants.

Sources	**TSP**	**PM10**	SO_2	NO_x
Petrol vehicle exhaust	5	8	12	18
Diesel vehicle exhaust	9	16	4	34
Resuspension from roads	40	16	–	–

Note: TSP - total suspended particulates; PM10 - $TSP < 0.01mm$ diameter.

on the road. From your experience of roads, pollution and traffic management, make reasonable suggestions. Justify each suggestion. Write out a draft policy.

8. Table 8.3 gives the contribution of exhausts from petrol and diesel-driven vehicles, and from the dust that rises from the roads due to vehicular movement (resuspension) to the annual emission of 4 different pollutants in Mumbai city in 1992. The values are shown as percentage contribution of that source. The explanations are similar to that given for Table 7.1 in Section 7.1. From this table, what can you say about the choice of fuels that must be used for vehicles?

9. What does the high load due to *resuspension* from roads tell about the condition of our roads? What would you suggest to reduce this?

10. Figure 8.2, parts I, II and III are graphs showing how three pollutants, suspended particulate matter (SPM), SO_2, and nitrogen dioxide (NO_2), have varied since 1978 in three of our country's most poisoned cities — Delhi, Calcutta and Mumbai. The data for 1988 and 1989 are missing (the region has slashes over the solid line). Can you guess their values? How correct would your guess be?

11. The WHO guidelines are also shown in the three graphs, as a shaded portion in I and II, and by a dotted line in III. How do the 3 cities compare relative to each other and with regard to the WHO guidelines for each of the pollutants? Do you think the situation should be changed? In what way?

Figure 8.2: Variation of emission loads of SPM, SO_2 and NO_2 in Delhi, Calcutta and Mumbai over the period 1978 - 1993.

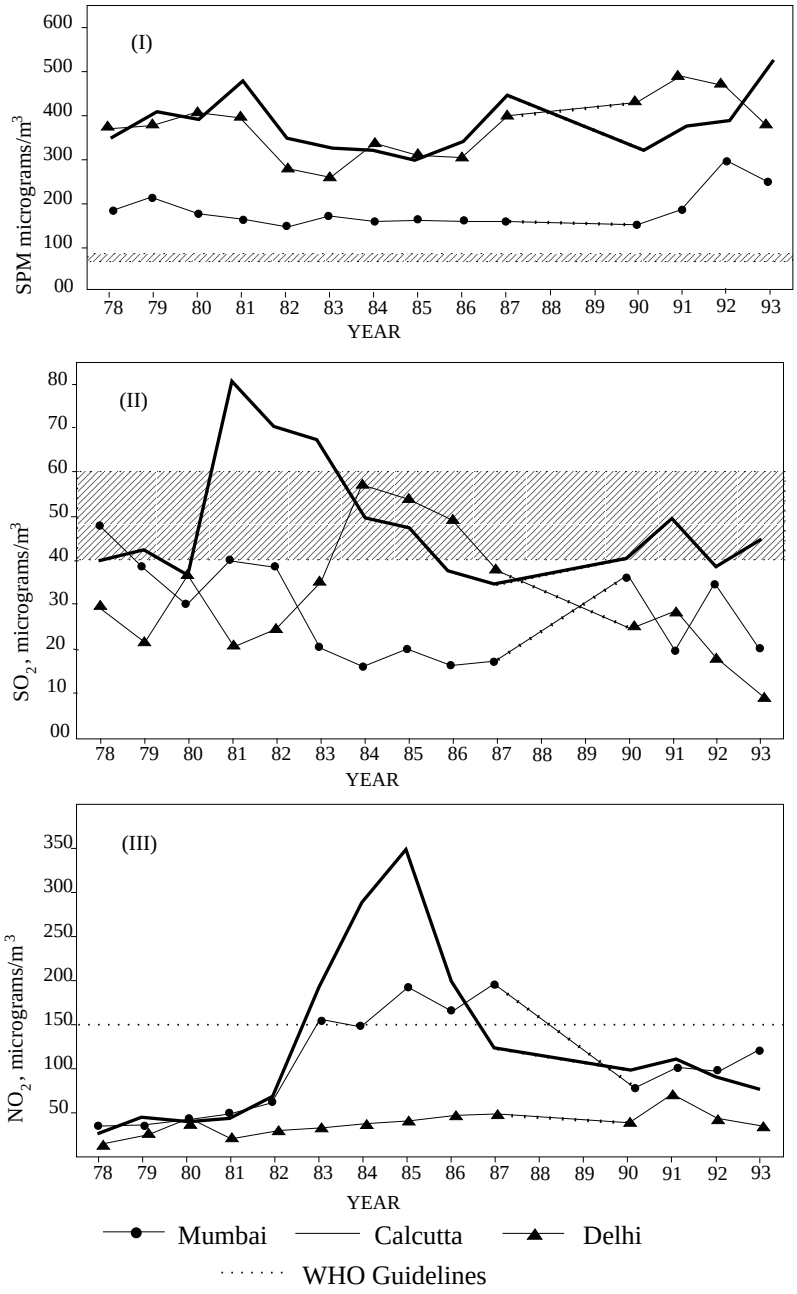


Table 8.4: Estimated vehicular emission load in metropolitan cities in 1987.

	Vehicular pollution load (tonnes per day)					
City	**SPM**	SO_2	NO_x	**HC**	**CO**	**Total**
Delhi	8.58	7.47	105.38	207.98	542.51	872
Mumbai	4.66	3.36	59.02	90.17	391.6	549
Bangalore	2.18	1.47	21.85	65.42	162.80	254
Calcutta	2.71	3.04	45.58	36.57	156.87	245
Ahmedabad	2.46	2.41	33.33	56.46	149.28	244
Pune	1.99	1.07	13.50	61.0	135.2	213
Madras	1.95	1.68	23.51	42.05	119.35	188
Hyderabad	1.62	1.30	14.30	46.94	105.14	169
Jaipur	0.98	1.04	12.74	17.49	42.73	75
Kanpur	0.88	0.90	11.14	18.53	40.35	72
Lucknow	0.95	0.79	8.07	18.75	41.02	70
Nagpur	0.46	0.34	4.24	13.60	29.16	48
Grand Total	29.42	24.87	352.39	674.96	1916.01	2998

Note: Source - CPCB 1989, Assessment of vehicular pollution in metropolitan cities (as on 31st March 1987), 1988-89.

12. Write a paragraph describing the trend of vehicular pollution in the three cities.

13. Table 8.4 gives the estimated vehicular emission load in some of the Indian metropolises in 1987 in the descending order of the total load [11]. The units are tonnes per day. Study the table and discuss the issues raised below.

    (a) Is there a pattern that links the different columns in the table? Discuss what pattern you can discover and how you will go about discovering them.

    (b) Tabulate the ratio of carbon monoxide emission to the total emission for all the cities. What can you say about the values you get? Were you surprised? Justify in either case.

    (c) Form groups of 5 students each. Every group should calculate

the ratios of all constituents to the total emission load. What can you say about the numbers you get? Are some ratios more or less constant? Calculate the mean value of the ratio for each constituent and the maximum deviation from the mean.

(d) Discuss the pattern within the group and guess the reasons for the pattern as well as the deviations. Present your findings to the class. Did any group discover a totally different pattern?

(e) Given the emission load of one of the constituents in the table for a city, say Motornagar, can you estimate the values of others? What assumptions would you be making about the vehicles in the city of Motornagar? List the assumptions and discuss how valid each would be for this Indian city.

(f) How different would your answer in the last activity be if the city had been Autoburg in Germany? Why?

8.2 Solid waste transport

Solid wastes lying by the kerb and near residences is a common sore sight in urban areas. Besides assaulting your visual and olfactory senses, it is a cause of health problems and related loss of productivity in the country. You have discussed Solid Waste Management (**SWM**) and its implications for land degradation in Chapter 5, Section 5.3. In this section, you will discuss the many ways in which solid waste and its mismanagement contributes to air pollution.

1. Refer to the data in Table 5.2 on the transport of solid wastes in Kachrapuri. In case you had not guessed it, the data refers to Mumbai in 1990. Trucks laden with wastes make 778 trips, each truck covering about 100 kms a day. Assume that these old and run-down trucks run at an impressive mileage of 3 kms per litre of diesel (most them are much worse!). Estimate the annual diesel consumption.

2. The second column in Table 8.5 gives an estimate of the total emissions from a vehicle when it has used 100 litres of diesel. This varies over a large range depending on many factors including road conditions and

Table 8.5: (A) Exhaust from 100 litres of diesel, and (B) Annual emission load from a dump site burning an average of 100 tonnes of garbage a day.

	(A) Exhaust from diesel	**(B) Garbage burning**
Pollutant	**kg**	**kg**
Carbon monoxide	2.3	14125
Hydrocarbons	0.9	–
Nitrogen oxides	4.3	657
SPM	0.002	3577
VOC	–	5000
Sulphur dioxide	–	2664

Note : VOC – Volatile organic compounds

vehicle maintenance. However, these values should give you a feel for the magnitude of vehicular pollution due to waste disposal in an urban centre. Using Table 8.5, estimate the annual emission of these pollutants in tonnes (1000 kgs) by the Kachrapuri garbage trucks.

3. Besides the transport of waste, burning at dump sites also contributes to air pollution. Remember, we in India still resort to land dumping instead of land filling, which is now followed in all developed countries. In 1993, 100 tonnes of garbage was burnt on the average per day at a certain dump site (Deonar). The third column in Table 8.5 gives the annual emission of some of the pollutants from the burning wastes at this site. There are other noxious gases, like dioxins, which are emitted in smaller amounts and are more dangerous to health. Do you see this as a major health problem for the local residents? How far from the site do you think their effects will be felt?

4. Do you think local citizens should protest against garbage burning? Discuss in the class. What would you do if you were a resident in the affected locality? What would you do if you were living farther away?

5. What consequences will the pollution load due to burning at dump sites have if there were streets and highways adjoining the site? At certain times of the day, visibility in the vicinity deteriorates to less than 7

metres (20 feet) due to the smoke. What does this imply for traffic and safety? What is the way out of this difficult situation?

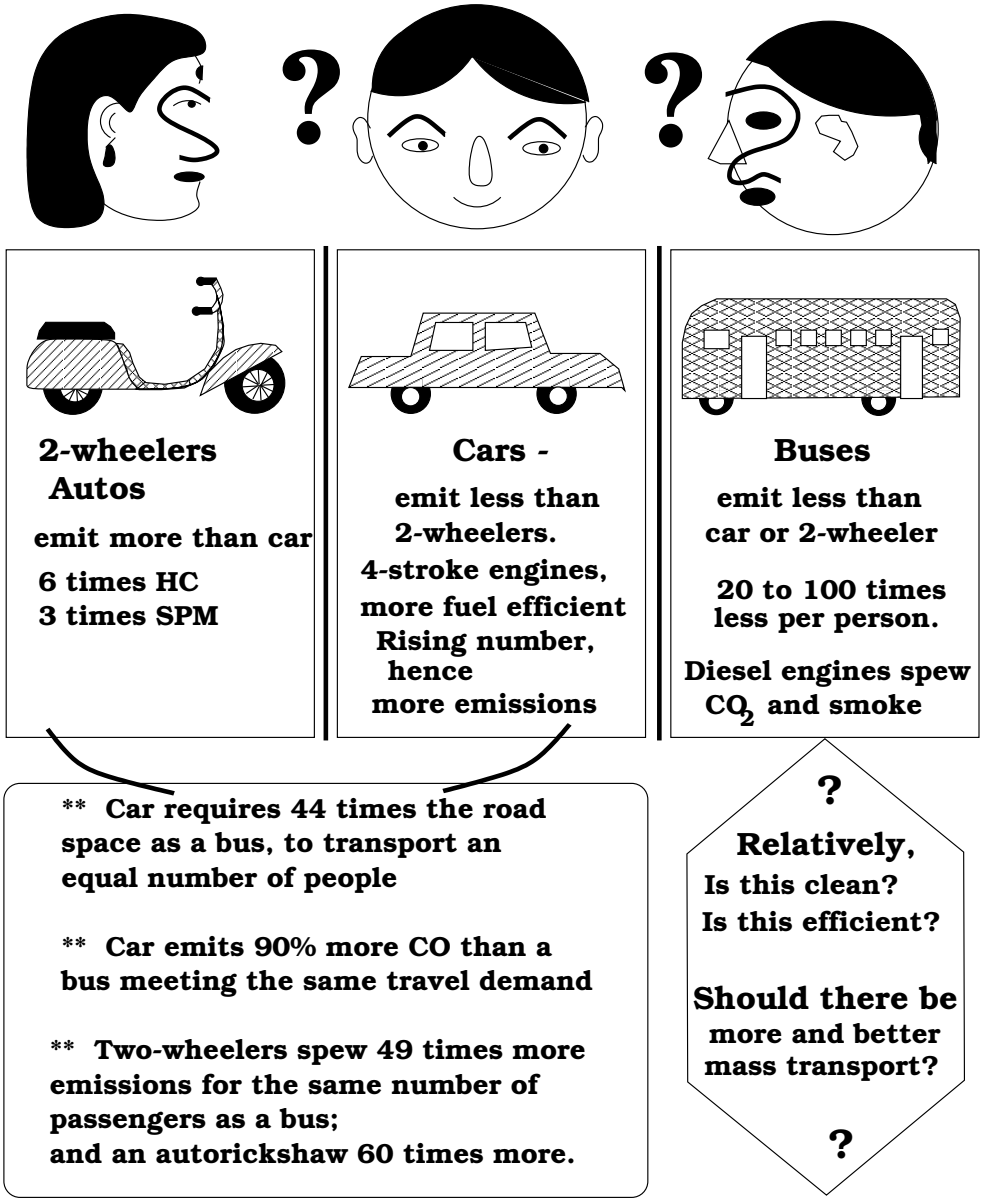
8.3 Which will you ride of these?

1. Study the information in Figure 8.3, and list the steps that must be taken to reduce vehicular pollution in your city/ town.
2. Write a persuasive article to the local newspaper urging that such steps be taken to ensure clean air for the residents of your locality.
3. What role do the following steps play in reducing air pollution? Mark 1, 2 or 3 against each step to indicate how important you feel it is for reducing air pollution. Mark 1 if it is very important, 2 if it affects pollution, or 3 if you think it is unimportant.
   (a) Introduce and strengthen mass transport systems.
   (b) Design urban areas better to avoid congestion, and reduce transport needs.
   (c) Plan better and efficient traffic control.
   (d) Increase energy efficiency of vehicles: mandate the use of 4–stroke engines for two and three wheelers, increase fuel-efficiency of cars and trucks, and require better maintenance of all vehicles.
   (e) Improve means of telecommunication.
   (f) Use electric or battery operated vehicles. Ensure that you do not trade air pollution for chemical pollution and hazardous waste.
4. Which vehicle would you rather use, and advocate others to use? Make separate choices that are appropriate for trips within your town, covering short distances, and long distances. Do not forget the bicycle.

8.4 Health effects of foul air

Air pollution can cause respiratory illness and death, physical damage and loss of vision. Several health effects like chronic lung diseases and lung cancer

Figure 8.3: Which will you ride of these?



in adults, and adverse pregnancy outcomes for women exposed during pregnancy, such as low birth weight and stillbirth are also suspected to be caused by polluted air. Air pollution is not always visible or perceivable by your senses. If you see a puff of fume from the vehicle exhaust, the environmentally sensitive and sensible among you may respond. However, when pollution level builds up steadily over long periods, like a life-time, even a whole generation of people may not recognise it before it has actually wreaked havoc on health.

Take the example of CO. Carbon monoxide is a colourless, odourless and tasteless gas. However, concentrations of only 0.1% (by volume) produce unconsciousness in one hour and death in four hours. This has caused the death of numerous children, when mothers locked their children sleeping in closed cars while they shopped in the malls. You have to be aware about the following **donts**. If you commit these errors, it can be fatal and there will be no alarm signals to warn you.

- Do not run an internal combustion engine (like in a car) in a closed garage.
- Do not tolerate a faulty exhaust system in an automobile.
- Do not burn a charcoal grill in closed rooms or a tent.

Some air pollutants like nitrogen oxides and hydrocarbons may not directly affect plant and animal life adversely. However, the effect of chemical reactions, as in the case of a photochemical smog is of major concern. Nearly every major city in the world is suffering from the effects of one or both of the smog types: photochemical smog and London smog. There may be economic damage, plant and animal impairment, and possible alteration of weather. The effects generally attributed to smog are:

- Characteristic damage to vegetation.
- Eye irritation.
- Respiratory distress and even death.

- Reduction in visibility, causing accidents.
- Objectionable odours.
- Excessive cracking of rubber products and damage to other materials.

Table 8.6 gives a brief summary of the effects of air pollutants on health [15] (Refer *India Today*, December 15, 1996). Study the table and discuss the issues raised below. PAHs stands for **Polycyclic aromatic hydrocarbons**.

1. Which are the 3 kinds of information included in Table 8.6? Are there other effects of air pollution that you would like to add to the table?
2. Have you or your relatives ever suffered from an illness that was attributed (by your physician/ doctor) to polluted air? List the illness and the place or circumstances in which it was contacted. Compare the lists made by everyone in the class. Discuss the health risk due to air pollution in the area where you live, travel and study (work).
3. It is said that "the amount of health damage per unit of emission for pollution released indoors can be more than a 1000 times that from a smoke-stack outside the town." What could be the sources of pollution indoors? List as many as you can. Discuss the lists from all the members of the class.
4. Indian rural population uses substantial quantities of non-commercial fuel like crop residues, animal dung or wood. You will recollect discussing issues related to this in the book *Resources: Energy*. Air pollutants due to biofuels are largely released directly amidst the people, inside or near homes at meal times everyday. Medical help in the rural areas is grossly inadequate. What suggestions would you make to counter these problems? List your own strategies. Then discuss them in class.
5. Table 8.6 also lists the organs of the body affected by pollutants in the air. Using the incomplete schematic of the human body in Figure 8.4 make a chart of the organs affected by different pollutants. You could choose different symbols and colours to represent different pollutants.

Table 8.6: Brief summary of health effects due to air pollutants.

A. Effects of oxidant concentrations in photochemical smog.

Exposure ppm	Duration hrs	Effect, comments
0.05	4	vegetation damge, leaf injury to sensitive species
0.15	—	eye irritation, at maximum hourly average concentration of 0.025 to 0.05 ppm
0.03-0.3	1	Impaired performance on exposure prior to race

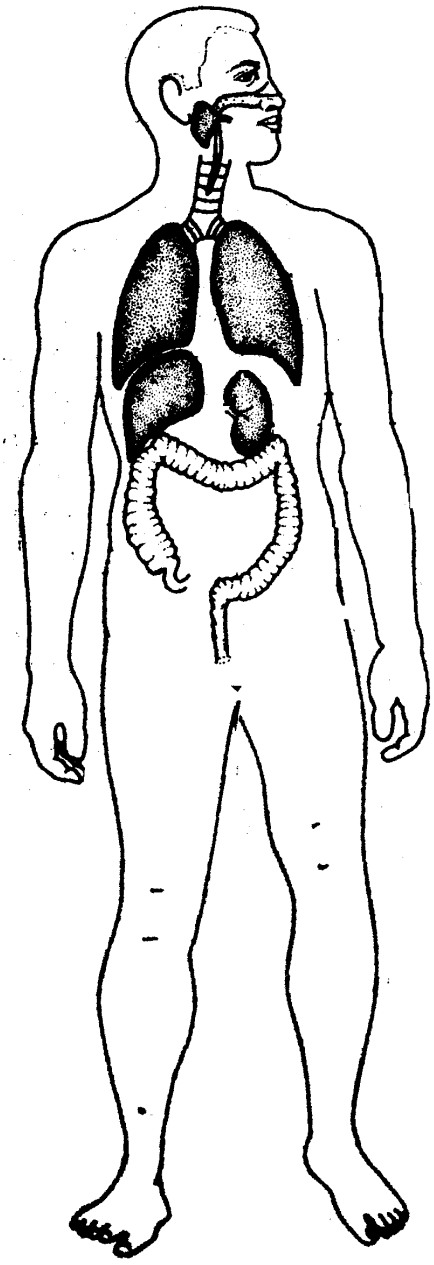
B. Effects of CO (for particular exposure and duration)

30	8+	impairment of visual, mental acuity
200	2-4	tightness across forehead, slight headache
500	2-4	severe headache, weakness, nausea, dimness of vision, possible collapse
1,000	2-3	rapid pulse rate, coma with intermittent convulsions
2,000	1-2	death

C. Effects of other pollutants

Pollutant	Body organs affected	Comment; Source
Lead	kidney, brain, central nervous system	reduced IQ, increased crime, hypertention, children at risk; leaded petrol
SPM	nose, eyes, respiratory tract, lungs	coat lungs, persistent cough, throat irritation, aggravate asthma; factory, vehicle
PAHs	nose, eyes, respiratory tract	drowsiness, suspected carcinogens, no safe limit; diesel engines
SO_2	respiratory tract	bronchial problems, nose blockage, hacking cough; diesel exhaust, factory
Benzene	entire body, lungs, central nervous system	carcinogen – lung cancer, leukaemia, no safe limit; unleaded petrol, catalytic converters
NO_x	respiratory tract	fibrosis (recent spurt in Mumbai); motor vehicles, power stations

Figure 8.4: The human body — template for a pollution chart.



6. Form groups of four. Each group could make a poster on air pollutants showing their effects on the health of people, plants and other materials. Use pictures, and dramatise the effects. You may use collage and other techniques. This activity complements the previous one.

7. Air pollution has reached such alarming proportions in our cities, that entrepreneurs cash in on the need for gas masks. How effective do you think these are in protecting you from pollutants? Contact the Consumer Education Research Centre at Ahmedabad (Gujarat State) and find out the effectiveness of available gas masks.

8. List the ways in which air pollution can slow the development of the country. Be sure to include health effects, loss in productivity and medical costs. Discuss the issue in class.

Numerous, and often ingenious methods have been proposed for removing pollutants from the atmosphere after they have been emitted. All have proved impractical, primarily because of the huge mass of air that must be treated to remove small amounts of poisons. Control of air pollutants at the source is so far the only effective means of decreasing air pollution.

Why do we say control and not elimination? Can air pollution be completely eliminated? Consider the following arguments.

- We have been inventing numerous processes to increase our comforts.
- Most of these result in gaseous end products which are often poisonous.
- Converting these to harmless byproducts or non-gaseous products would involve increased costs in producing the comforts — costs which will have to be borne by us.
- This will put comforts beyond the reach of many people, and increase social disparity. Hence poisons in the air are unavoidable.

Are there loopholes in the argument? Discuss the issues raised and present plausible counter arguments.

At the present juncture, it appears that the only way to ensure that technical and economic compromises do not ignore the quality of human life is to establish proper ambient air pollutant concentration standards and adhere to them. However, efforts like forcing automobiles to be equipped with catalytic converters cannot practically solve the problem. On the other hand, attempts to convince people, "that more personal automobiles is not the best option under the given conditions," have been only partially successful.

In the long run, wisdom of individuals at all levels will dictate the quality of life enjoyed by you. The activities in this book are meant to set you on the path towards a better quality of life: for you, for the communities in which you live, and for generations hereafter. In the race of generations towards a better life, the baton is in your hands now.

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Appendix A

Units

Some commonly used units for expressing length, area and volume are given in Table A.1. The table also gives conversions between units.

Table A.1: Units of length, area and volume

Length		**Area**	
1 cm	= 0.3937 inch	1 sq metre	= 10,000 sq cm
1 metre	= 3.282 feet	1 acre	= 100 sq metre
	= 39.371 inches	1 hectare	= 10^4 sq metre
1 km	= 0.6214 miles	**Volume**	
8 km	= 5 miles (app)	1 m^3	= 10^6 c.c. = 10^3 litre
1 inch	= 2.540 cm	1 gallon	= 4.546 m^3 = 277.4 cubic inch
1 foot	= 30.4799 cm	1 cubic foot	= 6.29 gallons = 28.32 litres
1 yard	= 0.9144 m	1 litre	= 1000 cm^3 (c.c.)
1 mile	= 1.693 km		= 0.22 gallons
			= 0.0353 cubic feet

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