SCIENTIFIC and TECHNOLOGICAL LITERACY for All

Materials from the
UNESCO-ICASE-CSEC
Delhi Workshops

Editors
Jack Holbrook, Amitabha Mukherjee and
Vijaya S. Varma

Drawings and Layout
Karen Haydock

Published by the
Centre for Science Education and Communication, University of Delhi
10 Cavalry Lane, Delhi 110 007
under contract 860.094.8 with UNESCO Delhi
and in association with the
International Council of Associations for Science Education
March 2000

Printed at Sudhir Printers, 151 D. B. Gupta Market, New Delhi 110 005

FOREWORD

As part of its "2000+: Scientific and Technological Literacy for All" Project begun in 1993, UNESCO New Delhi is initiating several activities in collaboration with the International Council of Associations for Science Education (ICASE).

This present document is the result of a series of joint ventures undertaken by the Centre for Science Education and Communication (CSEC) of the University of Delhi, ICASE and UNESCO. It primarily addresses teachers and, through them, students of grades 6-9. It is intended to be used as supplementary teaching material to suit the Indian school, and its aim is to consider science and technology education for the 21^{s1} century in a more holistic way.

The twelve scripts contained in the document will be field-tested and modified as necessary. This initiative is in line with similar initiatives launched in other Asian countries by UNESCO Bangkok and ICASE.

We hope that this work is only the beginning of a sustained process which will culminate in a Supplementary Resource for Science Teachers to be prepared by UNESCO and its partners.

Dr. M. S. Alam
Officer in Charge
UNESCO New Delhi

March 2000

PREFACE

This volume is the outcome of a 15-month long collaboration involving UNESCO New Delhi, the International Council of Associations for Science Education (ICASE) and the Centre for Science Education and Communication (CSEC) of the University of Delhi.

When UNESCO New Delhi decided to hold a Workshop on Scientific and Technological Literacy (STL) for All, as part of the UNESCO-ICASE global initiative Project 2000+, it approached CSEC to help organise it. For CSEC this was a natural extension of its activities in school education. It also provided an opportunity for making STL familiar to teachers in India.

For the Workshop held in Delhi in May 1999, CSEC brought together a variety of Indian participants from both the formal as well as the non-formal streams of education. These participants were expected to imbibe the philosophy of STL, look at some exemplar materials and then go on to produce new materials which were to be in consonance with the requirements of STL and relevant to Indian conditions. These would then be used as models in future regional follow-up workshops intended to train teachers in producing similar scripts on their own for use in their classes.

Preliminary versions of twelve scripts were produced in the May 1999 Workshop, and reviewed by the authors in a follow-up Workshop in January 2000. In the interim there were several rounds of circulation, editorial suggestions, and anxious moments spent by the editors in waiting for the all-too-rare communications from the authors, who are all busy people. We have finally been able to produce this volume, much to the relief of all concerned.

We are very grateful to all our authors who not only took a whole week off their busy schedules in May, but also bore the Delhi heat without too many complaints. Unfortunately some of them could not attend the January 2000 Workshop, and thus missed the opportunity of braving the Delhi cold. The responsibility for any imperfections to be found in their scripts must of course be laid at the doors of the editors.

We wish to place on record our thanks to our resource persons. Sharda Maharjan from Tribhuvan University, Kathmandu, with her quiet ways acted as the ideal peacekeeper when tempers got frayed. Maria Malevri, Education Programme Specialist at UNESCO New Delhi, made it a point to attend the Workshop sessions and we thank her for her support on all the important issues. We would also like to take this opportunity to thank Professor Moegiadi, Director UNESCO New Delhi, for his interest in the programme.

We are grateful to Professor Abhai Mansingh, Director South Campus, University of Delhi, for constantly smoothing administrative procedures. The staff of CSEC - Mr Itrapal Singh, Mr Ashok Babu and Mr Nanda Ballabh Choubey - worked tirelessly for the success of the Workshops.

Finally, we thank Professor P. K. Srivastava, Director CSEC, for his personal interest in the whole endeavour, and for his constant support and understanding.

Jack Holbrook

Amitabha Mukherjee

Vijaya S. Varma

March 2000

CONTENTS

PROJECT 2000+ AND THE DELHI WORKSHOPS

1. Background

The UNESCO-ICASE-DU National Workshops for the Development of Scientific and Technological Literacy Materials (held at the University of Delhi, the first in May 1999 followed by a second in January 2000, and henceforth referred to as the Delhi Workshops), were organised within the framework of 'Project 2000+: Scientific and Technological Literacy For All'. This is a project launched by UNESCO in 1993, in co-operation with, among others, the international Council of Associations for Science Education (ICASE), following a recommendation of the World Conference on Education For All (Jomtien 1990).

The Jomtien Conference recognised that "sound and basic education is fundamental to the strengthening of higher levels of education and of scientific and technological literacy and capacity, and thus to the development of self-reliance." Project 2000+ aims to revitalise and reform science and technology education at all levels. It also recalls the worldwide concern for the environment and for the quality of human life put forward in Agenda 21 of the UN Conference on Environment and Development (Rio Summit, 1992).

Rationale for Project 2000+

Project 2000+ is an initiative of ICASE and UNESCO that sets out to mobilise worldwide support for action in which governmental and non-governmental bodies collaborate at the national level to achieve a greater level of scientific and technological literacy, perceived as necessary for the 21st century. A declaration put out by the participants at an international forum organised by UNESCO highlights the action required by Governments and other bodies.

The World Conference on Education for All (1990) declared that "... every person ... shall be able to benefit from educational opportunities designed to meet basic learning needs. These needs comprise both essential tools (such as literacy) and the basic learning content (knowledge, skills, values, and attitudes) required by human beings to be able to participate fully to improve the quality of their lives, to make informed decisions and to continue learning."

It is clear that today's education needs to prepare citizens who are empowered to lead productive lives and to enjoy the best possible quality of life. To achieve this a variety of societal problems that deal with issues such as population, health, nutrition and environment as well as sustainable development at local, national and international levels, need to be resolved. These societal issues require an increasing degree of scientific and technological literacy on the part of citizens, both for understanding the issues and for the decision-making involved in implementing the required action. Yet, in many countries, science education in schools includes little that will help students achieve such literacy or feel confident either in applying their knowledge or in dealing with societal issues.

Aims of Project 2000+

Project 2000+ recognises the growing need for a scientifically and technologically literate society and seeks to:

(a) identify ways of promoting the development of scientific and technological literacy for all

(b) create educational programmes (both formal and non-formal) in such a way as to empower all to be able to satisfy their basic needs and also be productive in an increasingly technological society

(c) encourage the formation of national task forces involving personnel from Government as well as Non-Governmental Organisations (NGOs) to initiate programmes for greater scientific and technological literacy and to identify and support projects which promote the desired aspects of scientific and technological literacy

(d) support the development of a wide range of projects that aim to improve the quality of life and productivity in society, and that lead to promoting solidarity and cooperation in achieving scientific and technological literacy for all

(e) provide guidelines for the continuous professional development of science and technology educators and leaders

(f) support the evaluation of existing and projected programmes to ensure scientific and technological literacy goals are being met.

The need for supplementary teaching materials

One approach, which can guide science education towards greater relevance for the 21st century, is the use of STL supplementary teaching materials. These materials are not extensions of the textbook, but are additional resources for the teacher. They are intended to be optional and to be used as and when the teacher feels they would be appropriate. If the materials allow students to engage in activities relevant to STL, they enhance the learning situation and hence guide students to achieve the intended educational objectives. The Delhi Workshops were aimed at developing exemplar materials within such a framework..

After the launch of Project 2000+, the first follow-up action for Asia and the Pacific took place in 1994, when a Regional Workshop on "Scientific and Technological Literacy For All" was organised by the National Institute of Educational Research in Tokyo. One of the issues discussed was the need to develop teaching/learning materials in science and technology education that would be relevant in the 21st century. In response ICASE, with the support of UNESCO, organised material development workshops in Estonia for Eastern Europe, Pakistan for South Asia, and Argentina for South America. A subsequent Workshop held in Manila aimed to develop additional teaching/learning materials as well as to evaluate the exemplar materials that were developed during the Pakistan Regional Workshop. A similar Workshop to develop relevant STL materials for Nepal was held in Kathmandu in 1998. In each of these Workshops, participants attempted to develop exemplar materials based on their understanding of the criteria and educational objectives suggested for developing supplementary resource teaching/learning materials for STL.

These materials as well as those produced in the Delhi Workshops have been developed as complementary resources for teachers to guide students to achieve wider STL-related educational goals. All such materials are expected to be field-tested, and modified in the light of feedback from such trials. These Workshops have always been envisaged as only the beginning of a continuous development process, which will pass through a phase in which a Supplementary Resource for Science Teachers will be made available as exemplars for teachers, in print and possibly via the Internet. The idea is that eventually this will culminate

in teachers in schools being able to develop STL materials on their own for use with their students.

2. Objectives of the Delhi Workshops

The Delhi Workshops, like other such Workshops, also aimed to develop additional STL teaching/learning materials, but with an Indian context in mind, in an effort to make them particularly suited to Indian schools. It was expected to do this both by drawing inspiration from, and on the basis of an evaluation of, the exemplar materials that had been developed during the earlier Workshops. Specifically, the Delhi Workshops were organised to:

1. evaluate the supplementary teaching/learning materials that had been prepared during some of the earlier Workshops, reflect on the criteria proposed for the development of STL materials, and develop additional materials that would be suitable for use in Indian schools

2. attempt to develop teacher-based formative and summative assessment as a measure of how well the materials are designed and written to achieve the goals of scientific and technological literacy for all

3. discuss possible piloting procedures for testing the teaching/learning materials as well as collecting feedback from such trials for later modification of these materials, and

4. plan future actions for promoting STL by holding follow-up regional workshops in different states of the country in collaboration with UNESCO.

3. Venue, dates and participation

The first Delhi Workshop, organised by the Centre for Science Education and Communication (CSEC) of the University of Delhi, was held in the main campus of the University of Delhi, from the 17th to the 23rd May 1999. Over 30 science educators from different parts of the country participated. There were five resources persons: one from UNESCO, two from ICASE and two from CSEC. This was followed by a second Workshop in Delhi from the 14th to the 16th January 2000. This was organised to give the participants another opportunity to look at the scripts they had developed earlier and to incorporate in them changes on account of any field-testing they may have done. This publication can be regarded as the consolidated outcome of the two Delhi Workshop.

BACKGROUND PAPERS

Jack Holbrook, Secretary ICASE

1. Creating and implementing STL teaching materials

Introduction

For teachers to begin in create STI teaching materials of their own, it is enıcial that the teachers appreciate the STL philosophy. Without this the materials will not reflect the intentions of STI. teaching and will be just another teaching resource. Carefully conceived STL materials will, it is predicted, guide teachers *to* teach in an STL manner and recognise the objectives of their teaching in this direction.

To begin creating STL teaching materials, the teachers should recognise that they are not writing a textbook and that what they produce will serve as supplementary teaching material. İt may or may not be used with students by other teachers. If it is used it is expected that it will enrich the students' learning experiences and play a positive role in developing the altitudes of students towards science. If it is omitted it is not expected to detract from the gaining of conceptual content by students.

Teachers are thus writing supplementary teaching materials that can be useful in presenting a wider version of science education and enabling students to be directly involved in such teaching experiences, As such the material can follow us own pattern and emphasise aspects considered Appropriate for STL. It can include the strategies put forward in earlier section us being important for STI, teaching and can stress the teaching approaches and classroom atmosphere considered desirable to enhance learning. Below a structure is proposed to enable teaching materials true to the STL philosophy, to be constructed and used effectively in the classroom.

Making a start

It is suggested that teachers sun crating STL material by recognising an issue or concern arising in their students' societal perspective that is worthy of study in a science lesson. This could arise from a student question in class (often a situation at the primary school level), or from a topical concern recognised by students as something that affects, or may affect, them, their family or their community (perhaps something bring expressed in the media - the newspaper, television, radio). Thus issues such as 'how to save energy in the home' can be considered a starting point, rather than statements commonly found in science teaching material such as 'energy in the home', or issues such as "how do we clean clothes?" rather than the more scientific expression 'oxidation by chlorine'.

Who do the workshop participants see as identifying the concern or issue?

The major factor here is that the issue or concern is seen as relevant in the eyes of the student. With this in mind the following sequence of importance is suggested:

1. Best choice - the students.
2. Another choice - (he teacher, taking the idea from J secondary source e.g. newspaper. TV
3. Or the teacher, initiating the title artificially e.g. from the textbook, etc.

Developing a title for the material

Allow participants to suggest a title for their materials. What type of titles do the participants suggest?

It is important that participants see the need to put forward titles that reflect the social scenario. Relevante of the learning material in the eyes of the students is intended as the major factor here. Often there is a tendency to make the topic loo large (e.g. noise pollution, health care, energy for the home). It is more appropriate to gear the title to an area that can be taught in 1 to 2 lessons (e.g. the danger of loud noises in our health, recognising a balanced diet, transporting electricity to our homes). Having done this, it is worth checking that the title does reflect a relevant issue or concern as seen from the students' point of view (Spicy dishes - are they healthy? Was my breakfast good for me? The Transformer - our energy savior). And of course it must reflect science that is pan of lite intended curriculum.

Guiding student learning

From the topic chosen, the skill of the readier is to determine an activity (or activities) that can best help students to appreciate the concern or issues from a science educational perspective. The materials must have educational merit. The materials need to help the students gain the necessary scientific background, as well as provide adequate feedback to show them how far they grasp the concepts and skills being introduced. Finally the materials need so pay attention to communication skills relevant to the teaching situation.

Student motivation

An important component of student learning is motivation. Students need to be aware of the objectives of science education and to recognise these objectives are important to them (relevance). The objectives need lo he explicitly stated in the script.

Student motivation will be enhanced very strongly by the leaching style adopted by the teacher. The teacher needs to

(a) stress what the learning is and its purpose
(b) relaie the learning to students' needs.

Understanding the education components

A major recognition in STL education is that science teaching is about educating students. Teaching facts or even guiding students to acquire isolated scientific concepts is not enough. Science teaching must aspire to helping students gain the total range of educational objectives put forward for schooling at the given age level. Each script should indicate the educational objectives to be achieved by the students in undertaking the activities proposed.
It is recommended that the educational objectives are sub-divided into four categories so as to highlight different areas, but there is no suggestion that these areas can be taught in isolation, or that the descriptors given below are unique and clearly reflect only one attribute. The descriptors merely try to point oui that there are different aspects, which STL teaching materials should recognise and give some direction for tackling the attribute involved.

In creating the STL teaching material, it is proposed objectives arc put forward in each of these four areas. i.e. at least one objective in each of the areas, and given in this sequence:

social values (decision making with justification)

science method	(science skills)
personal skills	(especially communication and co-operative skills)
science concept	(science knowledge with respect to comprehension, application, and the range of higher order cognitive skills e.g. analysis, evaluation, problem solving)

Allow participants to add educational objectives in each of the four areas mentioned that relate to the title of the script chosen. One can of course how more than one educational objective per area if necessary, but for the material to be STL there needs to be at least one objective stated for each of the four areas.

The teaching

Our own feeling is that the

- approach needed is very much from society to die science
- relevance is seen from the point of view of the students and that
- teaching proceeds at a pace that is appropriate few the students.

It is proposed this means each material should encompass

a) A Scenario

The Scenario 'sets the scene' for the learning. This can be, for example, a newspaper cutting, a case study, a hypothetical situation, or an experimental observation. Its purpose is to give context to the learning and stimulate motivation on the part of the student.

b) Student activities

The script must have student activities. It is not recognised STL teaching material without them. The activities however can be very varied and can include, for example, individual writing, drawing, or presenting; group-work for discussing, undertaking experimental work, developing a presentation, formulating a point of view, creating a questionnaire, undertaking a library search; whole class activities e.g. brainstorming, planning class actions-letter to the community leaders, poster for public awareness, participating in a play, a class debate, or a simulation of a decision making process in a village punchnyat.

It is essential that each student activity is a learning situation. The activities are not play time. This means the activities are undertaken for a clearly specified purpose i.e. each activity relates to achieving a specific objective, or objectives. The link between the activities and the objectives must be clear.

Allow participants to create the Students ' Guide component of the script such that it includes:
a) a Scenario
b) activities.
The activities can be usefully headed 'Your Tasks'.

Teaching strategies

The manner in which the learning will proceed must also be made clear. This is best illustrated by suggested teaching strategies that elaborate the progress of the lesson and detail the actions undertaken by the teacher to ensure the student activities run smoothly and achieve their objectives. It is recommended that the teaching strategies need to be given in sequence, starting from the beginning of the lesson and proceeding through the various tasks undertaken

by the students. The role of the teacher, whether watching, listening, talking in small groups or assessing students. needs to be made clear by the detail given when elaborating the teaching strategy. It is recommended that each step in the suggested teaching strategy is numbered and that each number relates to a different strategy adopted by the teacher within the lesson.

Participants can now add the first part of a Teacher's Guide, which is to elaborate the ¡caching strategies, numbering each stage. The participants should elaborate this to the extent that another teacher would be able to follow dearly the strategies proposed.

Linking student tasks and educational objectives

The achievement intended by students is stated in the educational objectives, written on the first page. The manner in which the objectives are to be gained by students is elaborated in the student activities, labeled 'Your Tasks'.

It is recommended that the relationship between the student tasks and the objectives to be achieved should be clearly indicated in a tabular format. This is intended to be part of the Teacher's Guide also.

Participants should he guided to create a table that clearly links educational objectives with the student task. Each objective should relate to one or more tasks.

Determining student achievement

The most important aspect for the teacher is to determine whether the students have achieved the objectives to the level desired. This is the subject of the assessment component.

The assessment component enables the teacher to ascertain whether the students have achieved the various social values, science method, personal skills and science concepts objectives. I he manner in which the teacher is guided to determine these, either by formative or summative assessment procedures, needs to be given clearly.

It is recommended that the assessment criteria be targeted at 3 levels:

Level x	not acceptable, not exhibiting acquisition of the objective being tested
Level √	acceptable, clearly exhibiting the skills being taught
Level √√	more than acceptable, the student is exhibiting skills beyond the level expected or the student being very able, is responding to the extended learning being demanded.

Participants should odd the assessment component to the material, detailing whether it is by formative and/or summative means. Assessment should cover all the educational objective areas whilst not neglecting the science method and science conceptual components.

Finalising the teaching material

The guidelines given above should enable the major components of the teaching material to be completed. Other aspects that can be added which teachers find very useful arc:

List of science concepts covered. This enables teachers to recognise the most appropriate area of the curriculum to which the material relates.

Handouts to the students. The inclusion of these enables the teachers to be clearly aware of material that can be used to guide the students during the teaching process. As the teacher would like to guide the lesson and its direction, the Student Handouts are given as pan of the Teacher's Cuide and not included in the part to be given to the students at the beginning of the lesson.

Background information. Teachers appreciate more information on the science background, especially where this is not easily available from hooks. Many of the more social aspects of science are rarely found in the standard textbooks and teachers often have little confidence in their knowledge in this area.

Allow participants to suggest additional components to their materials that would be useful.

Implementation in the classroom

The teacher, knowing the students in the class and their aptitudes and needs, should select the appropriate teaching material and the point in time when it should lie introduced.

What do the participants suggest is necessary before teaching can begin?

The teacher will need to be conversant with the material and prepared for the teaching by making sure all support materials are available. In particular, students will need a copy of the introducing page and the Students' Guide. Preferably this should be made available for each student as an individual script, but group scripts can also work. (This may be prepared as work-cards if desired.) In a more sophisticated situation, it may be appropriate that students download the instructions by e-mail.

Do participants feel they are permitted to change the proposed teaching strategy?

Teachers need to read carefully the teaching strategy being proposed. This has been carefully developed to enable the student activities to be linked to the educational objectives being promised. However teaching materials cannot be expected to take over from the expertise of the teacher. The teaching strategy in the materials must remain a suggestion and teachers must have the freedom to modify it in the light of circumstances.

Where teachers do modify the strategy, they should be careful to ensure that the educational objectives remain the sole purpose of the lesson. The usual reason for modification is that there is insufficient time to complete all the activities. This tends to mean student activities are cut. teachers will need to be vigilant during the assessment component in ensure that learning is actually taking place.

Evaluation

Clearly teaching materials of this nature arr of little worth if they do not fulfil their expectations. If they are not interesting to the students, then they are not likely to be motivational and a majur educational stimulus is not available. If the objectives cannot lie achieved by the activities stipulated then there is basically no learning and the students are wasting their time. And if the assessment by the teacher shows that the students are not gaining from the experiences, then it is important that the teachcr takes approprite remedial action.

All of the above points to the necessity of piloting teaching materials. If this is undertaken by a number of teaehers then the results of their experiences can be utilised to modify the material with the view to making it a better teaching resource.

A problem with this approach is that teachers are often very poor at helping other teachers. Once they have perceived how to handle a situation themselves, they assume other teachers will also appreciate the manner in which the situation should bit handled. Of course this is a fallacy. But it does mean that teachers do not find it easy to explain what is wrong with the material or how the material could best be modified. To help to overcome this situation, an evaluation form is presented on the following pages.

2. Evaluation Form for piloting STL supplementary teaching materials

(To be completed by teachers using the STL materials in their classrooms.)

THANK YOU FOR TRYING OUT THE MATERIAL PLEASE CAN WE INVITE YOU TO COMPLETE THE FOLLOWING QUESTIONNAIRE?

This questionnaire is designed to determine how teachers utilisc any of the STL materials in their classrooms and how far the STL materials meet the criteria specified.

In the questionnaire the term

TOPIC refers to the subject being taught as per the curriculum

SCRIPT refers to one specific STL material as supplied.

Part A General Information (please complete)

NAME OF SCHOOL

NAME Of TEACHER

TITLE OF SCRIPT

Dale of piloting

Type of school

Students involved (Grade level)

Age range of students

Student ability (if streamed) above average/average/below average

or (if not streamed) mixed ability

Number of students in the class

Total number of lessons involved

Part B Teacher Comments (Circle the best choice and complete any blanks. Please add additional comments at the end if appropriate.)

For each lesson in which all or pan of an STL script was used, please answer the following:

1. Which script did you use for this lesson?

Title

Part(s)

[If you used the whole until write ALL. If only part of a unit was used, please indicate with reference to numbers from Your Tasks in the Students' Guide, or sub-headings].

2. Into what teaching topic from your syllabus were the materials introduced? (Use the topic heading as per the curriculum guide.)

3. Was the script used for

A. one complete lesson Number of minutes

B. less than one whole lesson Number of minutes

C. more than one lesson Total number of minutes

If your answer to 3 is (B), please further indicate whether the script was used

A. at the beginning of the lesson

B. In the middle of I he lesson

C. at the end of the lesson

D. some other combination (please specify)

If your answer to 3 is (C), please further indicate which parts (based on the Your Tasks in the Students' Guide) were used in each lesson

Lesson 1 parts included

Lesson 2 parts included

Lesson 3 parts included

4. List key scientific concepts that you think were particularly well covered in the materials you used in your lesson

5. List any scientific concept introduced in the script which student found difficult.

6. For which of the following were the Teachers' Guide and/or Additional Notes not sufficient;

A. giving background scientific knowledge?
B. providing answers to be expected to question in the students' sheet?
C. putting forward ways of organizing and managing the activities?
D. the teaching strategy recommended?
E. illustrating assessment procedures ?

7. What societal situation/concern is illustrated in the script?

8. Did you consider the societal situation that was referred to in question 7 was:

A. very appropriate for the learning need of student
B. only adequately useful for developing learning opportunities
C. poor at providing a learning situation
D. I omitted the social learning activity (please explain)

9. In using the material in your lesson, did you

A. encourage extensive student participation (more than 70% of the teaching time)
B. manage only partial student participation (30-70% of the teaching time)
C. include very low student participation (0-30% of the teaching time)

if your answer to question 9 was (C) , please continue to question 11,

10. If your response lo question 9 was A or B, please indicate how well the students became actively involved in (answer for all parts that are applicable):

ACTIVITY	Very well	Well	Poorly	Very-poorly
Solving numerical problems				
Discussing issues				
Planning procedures				
Doing practical work				
Making decisions				
Communicating orally				
Communicating in written form				
Working co-operatively				
Handling data				
Scanehing for data				
Interpreting data				

11. Did you consider the language level of the unit

A. very suitable?

B. suitable?

C. unsuitable?

12. Did you consider the language, diagrams, photographs, font size

A. very suitable?

B. suitable?

C. unsuitable?

13. How well did you consider the STL script met the educational objectives specified ?

A. very well students generally acquired the learning skills

B. provided good practice and review of existing skills

C. lacked adequate attention to one or more objetctive

14. Did you consider the script enhanced the development of scientific and technological literacy (see the main text for more information on a possible interpretation of STL)

A. Yes, because...

B. No

15. Based on feedback from student responses, please indicate whether the script was

A. interesting and motivational

B. interesting

C. not considered enjoyable

16. Did you, as a teacher, enjoy using this script in your teaching?

A. Yes

B. No. Why was this?

17. Would you use the material again?

A. Yes

B. No. Why is this?

If yes, would you use it

A. unchanged

B. With modifications (please give me indication of the type of modifications you have on mind)

18. Further comments (please complete as appropriate)

[e.g. other modifications; new teaching aids, etc.]

Part C Comments by students

(Please give reactions by students to the tasks suggested in this script on a separate sheet)

Do participants consider this evaluation form easy to understand and valise in the classroom? Do they feel the evaluation from will gather useful information concerning the teaching material?

INTRODUCTION TO THE MATERIALS

1. Exemplar STL scripts and creation of materials

The STL materials ("scripts") in this volume have been prepared by people who have long experience of innovative interventions in the Indian school system. These scripts are meant to serve as exemplars. It is expected that STL materials actually used in schools will be essentially created by the teachers of those schools themselves. It is important that STL materials he appropriate to - indeed, arise from - the specifics of local conditions- The reader will notice that several scripts in this collection arc strongly locale-specific. The process of creation and testing of STL materials is discussed in detail in Jack Hollbrook's article "Creating and implementing S'IL leaching materials", reprinted in this volume as a background paper. Anybody seeking to produce STL materials for her/his classroom should be able to suitably adapt the procedure described there. It is hoped that the present scripts will serve as useful models in the process.
All the scripts presented here are intended to actualise the STL philosophy in the classroom. Thus they are based on certain common premises about science, education and society. These are elaborated on in the following section.

2. Common educational objectives

The key assumption of the STL philosophy is that science education is effective and meaningful when it stems from societal concerns. Thus it is expected that all STL materials will share certain common objectives. Jack Holbrook, in his background paper, has classified the possible educational objectives under four heads, as having to do with (a) social values, (h) science method, (c) personal skills, and (d) science concept acquisition. These will serve as useful points of reference. The elaboration below, however, is based on the collective understanding of the authors of these scripts.

There are two "personal skills" goals which inform all the materials in this collection: cooperation and communication. Every one of the scripts seeks to encourage students to cooperate as members of a group. This is not a prominent goal of conventional approaches to science education, which emphasise individual achievement and competition. The same is true of communication skills. An objective of all these scripts is that students should learn to communicate effectively with peers as well as with the community at large.

Of course, for the materials to qualify as "science", science process skills have to form an important component of their makeup. Thus the usual tools of science - experimentation, observation, analysis, the drawing of inferences - have 10 lie developed. In addition, a number of scripts in the present collection involve surveys and questionnaires. These specific skill-related objectives are subsumed within the general objective that students should be able to make use of science in arriving at real-life decisions on issues at the science-society interface.

On goals relating to science concept acquisition, there is need for caution. Concept-building is a slow tortuous process and no child will acquire a concept merely by doing the activities in one script. Nevertheless, for every script one should always ask, "What is the science content we are trying 10 get at?" The answers will necessarily he very diverse, bin it is perhaps reasonable to expect that for every script there will be at least one science concept towards whose development the activities will contribute.

At the two Delhi Workshops, there was considerable discussion on the reliability of goals relating to social values. Certain social values, such as awareness of one's surroundings, the need to preserve the environment, and the sharing of responsibilty for maintaining community hygiene, can be said to be common objectives of all 01 most of the scripts. Other social values may he more controvcisi.il ;ind some participants were not sure how they should be handled in a science class. Others were ofihc opinion that although they may require finesse ,-md maturity on the part of the teacher. Never the less the opportunity should not In; lost to address such issues rationally and objectively. See the following section for more on sonul values goals and '.heir relevance lo the structure of these scripts.

3. Comments on the structure of the scripts

All the scripts presented here have a certain common structure. By and large, this is the same as that described in the background paper, with one or two systematic differences. Each component of the scripts is brielly described below.

The first page ol each script has an Introduction, which introduces the material in general terms. The science concepts involved are listed. These should be read with the caveat above, and not interpreted in the narrow sense of acquisitional objectives. The intended grade level of the material and the previous knowledge assumed are also stated on this page. Finally, the teaching/learning materials required are listed Educational objectives arc not listed - the reasons ¡ire explained below.

The introductory page is followed by the Students' Guide, consisting of a Scenario and a summary nf activities entitled Your Tasks. The Scenario is, in most eases, a narrative - a story or a real-life happening. It is hoped that field trials will throw up similar narratives even in the remaining eases. The description of tasks in Your Tasks has been kept brief, Kxccpt in one or two cases, all details of activities have been moved to Student Handouts.

The next section in each script is the Teacher's Guide. The first part of this contains the suggested teaching strategy, which is in most eases very detailed, but not necessarily in one to-one correspondence with the Tasks. There are certain teaching strategies which arc common to many or most of the scripts. These are summarised in Section -I of this Introduction. Note that Student Handouts form part of the Teacher's Guide. The idea is that the teacher decides when a particular Handout needs to he used. In many of the scripts, there is.-i section called Additional Infunnalion/Notes for the Teacher, which is exactly what it savs.

At the Delhi Workshops, then: was a lot of discussion, sometimes healed, on whether the educational objectives should be explicitly stated at the beginning of each script. One view was that, without ¿1 detailing of objectives, there was a danger that the activities would become aimless. The opposing view was Dial such detailing is undesirable as it circumscribes the freedom of the teacher. Finally it was decided that anyone who intends to use these should he free :o decide fur herself what the objectives were and how they were 10 be achieved It was agreed that at the end of every script there would be a page entitled "About the script". Any statement about objectives could be included in it.

I he following section contains suggestions on how the scripts could be used.

4. How to user these scripts

Although these scripts arc mean to the exemplars, they aie so written that someone who wishes to use them can do su with appropriate modifications and adaptations. Given below are some suggestions on the mode of use of diese scripts. They a« addmssed 10 the teacher: who inlends m use the materials in ¡1 fuimal school. These suggestions arc made specifically In.- the pi osent collection: however, ihcy may also apply to the use 01 other STL iiou-rials.

Preliminary

[lefoie leaching any unit, read Ihc entire script and get an overall perspective. Check that the setting of the scrip! is sufficiently similai to that or your school so that you can adapt ii to your needs Assess your students' knowledge and see thai it matches the previous knowledge assumed by the authors of the script.

Fdncatlonal objectives

Noic down what, according to you, are the educational objectives of the script. A scheme for classifying the possible educational objectives is given 111 Jack Holbrook's background paper, but feel fiec 10 devise your own. Also note down which of the objectives you expect to be able m address in your actual classroom situation. mid how.

Planning and preparado»

Please note that it is not possible to complete the whole of a script in one leaching period. Use your discretion to divide ihc script suitably.

You are free to make appropriate modifications in any 01 all of these activities in order to make them suitable to youi situation.

Plan activities in advance, particularly those requiring materials noi normally available in ihc classroom. In the ea.se of experiments, ny them out before asking children to do them I ins should give you a feel for how Ihcy are done, the time required, and ihc arrangements that must be made beforehand. Arranging field irips and interaction wilh people in the community also requires prior preparation.

Prepare a sufficient number of copies of the Student 1 landouls one for each group. You carı modify litem to make them mum relevant to your situation.

Teaching Strategies

When using these materials, the focus should be on socicial issues and concerns and the way in which science 1 elates to them. Students will appreciate the importance of science better when the science emerges from a mal problem of relevance to them.

1. 'Learning by doing' is the recommended teaching approach. Learning by memorising is to be discouraged, as this will not promote the right attitudes or positive actions. It is important to develop and examine attitudes and behavioural changes.

2. Most of the activities should be student-driven, wilh children always being active participants. The tcacher's rule should he that of a catalyst, facilitator and organise, of various activities. One of the techniques iceommended for whole class sessions is brainstorming The teacher seeds the discussion by raising a question or putting forward a keyword to which students react. All student icspnnscs arc written un the hoard, and naturally feed into the discussion that follows.

3. Student activities will include discussion in groups and in the whole class, working cooperatively in small groups, engaging in design and decision making, estimation, calculation, measurement, experimentation, recording of results, summarising, etc. Students are expected to record their findings, draw inferences and share these with others. Arrangements should be made for the display/exhibition of student's work both inside the class and in the community.

4. The teacher should point out various sources of information. Help in the form of making the facilities available for the activities and guiding the students in drawing inferences and conclusions should be forthcoming, as should help in creating tests, collecting information and writing reports.

5. Some of the experiments may be hazardous and may need teacher supervision. Assessment strategies The importance of assessment has been pointed out in the background paper. Once you have worked out your educational objectives, you can move in the direction of creating your own assessment criteria. Two of the scripts in this collection have the assessment component as appendices. They may be of use to you.

CAN WE GET RII) OF MALARIA?

RAJAN PATIL

Grade Icvcl: Class IX

Introduction

Malaria is an infectious disease which has iroubled human beings since ancicnt times. It can dciinitcly be controllecl hy taking appropriate preventive measures. These include, on the one hanci, personal protection and, on the other hand, bringing down the mosquito population by various methods, illustrating thc well-known proverb "Prevention is better than cure". In keeping with rising environment awareness, the thrust of educating childrcn should be to control malaria through bio-environmental methods.

Science concepts

1. The life eyele of the malaria parasite
2. The lite eyele of the *Anopheles* mosquito
3. Uio-environmental control strategies
4. Physical characteristics of mosquitocs

Previous knowledge

1. Malaria is transmitted by mosquito hites.
2. Mosquitocs breed in stagnant water.

Teaching/learning materials

Uowl with handle, rope, bucket, tray (white), guppy fish, and pipette to collect larvae.

Students' Guide

Senario

Mangalore city in particular, and South Cañara district of Karnataka in general, is one of the most literate, well-informed and resourceful regions of India. The prosperity of the region is closely linked with the health of the population. Unless people continue to enjoy good health, this prosperity cannot be maintained. Over the last 7-8 years, malaria has made major inroads in the region. Numerous reasons are attributed to this, e.g. construction work, migrant labour, etc. The city will face serious problems in the future if malaria is not brought under control immediately. Perhaps students can play a significant role in the process.

Your Tasks

1. Suggest ways to tackle the malaria problem.
2. Recognise mosquito larvae and identify potential breeding sources.
3. Describe the life cycle of the mosquito and its characteristics.
4. Describe the life cycle of the malaria parasite.
5. Find out what can stop mosquito larvae from developing into adult mosquitoes.
6. Devise an action strategy to control or prevent mosquito breeding for each kind of breeding source.
7. Suggest who should share the responsibility for control of mosquito breeding, and express this by writing letters to the relevant authorities.
8. Prepare a map of water bodies in your locality and identify possible breeding places of mosquitoes.

Teacher's Guide

Suggested teaching strategy

1. Conduct a brainstorming session on the symptoms and problems of someone having malaria. The teacher writes the word "Malaria" in a box in the middle of the blackboard and then writes all student suggestions 011 symptoms and problems, as they are given, around the box. It is important for the teacher to include all suggestions at this stage, even if they seem to be very similar to each other or irrelevant.

2. As a whole class exercise, students select the main points from the brainstorming session. In doing this it is expected students will make comments on

(a) how malaria is spread

(b) what we can do to avoid getting malaria.

Encourage such comments and at the end of this part of teaching gel students 10 record responses to these two questions. It is not expected that their answers will be complete at this stage. The object of the exercise is to determine how far their knowledge of malaria and the mosquito extends.

If necessary the teacher introduces 5 possible ways to get rid of malaria - kill mosquitoes, kill parasite, stop mosquitoes breeding, stop mosquitoes biting us, become immune 10 the parasite.

3. Introduce group work through the use of student handouts. Student Handout 1 covers 'can wc kill mosquitoes?', 'can we kill the parasite?', 'can we stop mosquitoes giving us malaria?' and 'can wc become immune to the parasite?' It will involve students in library work, if this is possible, and seeking answers from a variety of sources, li will involve students learning about the life cycle of the mosquito and the parasite and other characteristics of mosquitoes relevant to the problem.

4. From a whole class discussion following the group work of Student Handout I, il is expected the teacher can establish that the best approach is probably to try 10 stop mosquitoes from breeding. Kot only is ii the most feasible, it is also not too expensive.

5. The last item in Student Handout 1 seeks students' ideas on how we can stop mosquitoes from breeding. It is expected that students will come up with a number of ideas. These arc then shared between different groups 10 build up an extensive list. At the end of the session the teacher (by going around the groups, etc.) needs to ensure the following are at least represented:

(a) no stagnant fresh water is allowed to collect

(b) if stagnant water cannot be removed, then

i) cover the surface with soil, expanded polystyrene (EPS) beads, etc.

ii) introduce ways of destroying or killing mosquito larvae by various methods like bio-larvicide, introducing guppy fish, pouring kerosene, etc.

6. If possible, the activities in Student Handout 2 should be carried out. These show, firstly, that mosquitoes come from larvae, and, secondly, that larvae can be prevented from developing into adult mosquitoes by several methods.

Try oui the activities in advance. The likely outcomes are listed below.

Activity I (letting a covered beaker with larvae stand for 3-4 days): The larvae disappear from the water and mosquitoes are seen trapped inside the beaker. This shows that mosquitoes emerge from larvae.

Activity 2 (effect of kerosene): The larvae are found dead.

Activity 3 (covering the water surface with LPS beads): The larvae ate found dead.

Activity 4 (introduction of guppy fish): The fish gobble up the larvae.

Mosquito larvae can be found in any stagnant water body which has remained standing for at least 7 days. Contact the local malaria worker or PIIC doctor for information on how to identify larvae and for a supply of guppy fish. The local zoology teacher may also be able to help. Ask the PIIC doctor how EPS beads can be obtained.

7. Student groups are now ready to check their neighbourhoods for places where mosquitoes could breed and to pul forward remedies to stop such breeding. Each group draws up a list of places to check. The idea is that they will check whether mosquito larvae are present, and put forward simple and feasible ways to stop breeding.

8. After discussion and exchange of ideas between groups, the students collectively create a chart of places where to look, whether larvae arc present, anil recommended action, with a final column for action by whom.

9. Students in groups conduct the field work. They probably need to do this during their free time. If each group sub-divides into 2-3 persons, the group can cover a number of potential breeding sites.

10. F.ach group reports its finding and suggested remedies.

11. The teacher then leads a whole class discussion on the pros and cons of other mosquito control strategies of the kind listed below (bearing in mind feasibility, economics, environmental hazards, etc.):

    (a) pouring kerosene over water

    (b) spraying DD I' (discuss the environmental and health hazards)

    (c) EPS beads (discuss economic factors).

12. As part of the discussions, students can consider who should have the responsibility for reducing the breeding sites for mosquitoes and the action they themselves can take in this regard. The teacher encourages the students to become involved and to put forward plans for actions such as:

    (a) breed guppy fish and introduce them into pools of stagnant water

    (b) write to the owners of sites where there is stagnant water

    (c) write to the town council about the need to take action against stagnant water

    (d) contact the local member of parliament with suggestions for action that should lie considered, e.g. a poster campaign to educate the public.

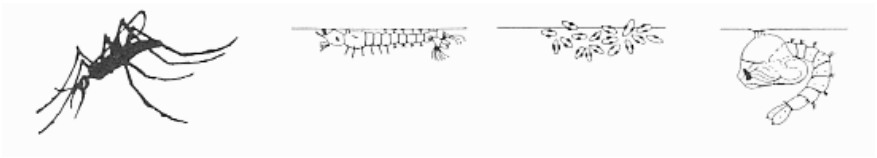
Student Handout 1: Possible ways to control malaria

To assist in answering the main questions listed below in bold letters, consider also the related questions given with them. In this task you must seek information from libraries, clinics, hospitals and other sources.

(a) Can we kill mosquitoes?

What are mosquitoes?
What do mosquitoes live on? Is there a difference between male and female mosquitoes?
Describe their life cycle.
Shown below are pictures of each stage in the life cycle of the mosquito. Put them in order and describe the life cycle.

Adult Larva Eggs Pupa

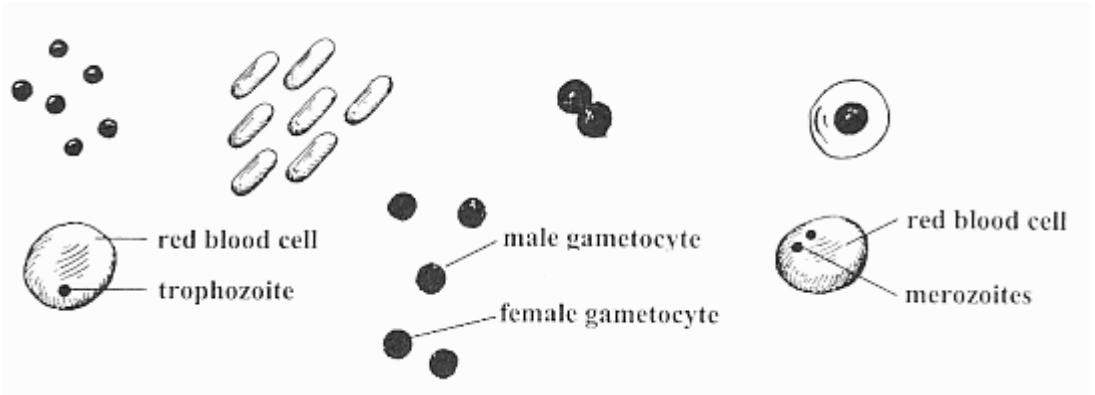


What can kill them?
Do you consider it feasible to eliminate mosquitoes by trying to kill them?

(b) Can we kill the parasites in mosquitoes?

What are the parasites?
How did they get in the mosquito?
What is their life cycle?
Given below are stages in the life cycle of the malaria parasite *(Plasmodium).* The pictures are not in order. Find out the order and make a chart showing the life cycle. Also show where each stage of the parasite lives and develops (in a mosquito's stomach, in its blood, in human liver, in human blood plasma, in human red blood cells, etc.)

Merozoites **Sporozoties** **Male andfemale Gametoeyte fusing** **Fertilized Eggs**



What can kili them?
Do yon consider ii feasible lo kili the parasites?

(c) **Can w e stop niosquiloes from giving us malaria?**
How do mosquitoes give us malaria? VVhy do they bilc us?
Can we protcct ourselves against iheir biles?

(d) **Can wc bccomc imniiinc lo the parasiles?**
How docs the parasite make a person ill?
Can medicines be used lo kill the parasite in Ihe human body?
Can wc become immunc to lhe parasite?

(e) **How can we prevent niosquiloes l'rom breeding?**
Where do mosquitoes breed?
Why is stagnant water essential l'or mosquito breeding and for how long musí the water be stagnant for breeding to take place?
Is it feasible to remove stagnant water? If so, how?

Student Handout 2

A. lake t lirce big beakers half-filled with water and introduce a few mosquito larvae in cach. Apply the following strategics to the beakers:

I Cover the mouth of the first beaker with a piece of mosquito neiting. l.et it stand for 3 to -I days. Observe and repon what happens.

2. Pour some kerosene into the second beaker. I.et it stand lor a few hours. Observe what happens.
3. Introduce EPS beads in the last beaker until the water surfacc is fully covcrcd with a layer of beads about lem tliick. Observe what happens after a few hours.

B. Take a jar about three-quarters tull of water, with about 3-4 guppy fish. Now slowly introduce a few larvae in this jar with the help of a pipette. Observe what happens.

Can you suggest explanations for what you observe?

Additional Notes tor the teacher

Possible breeding sources and action strategies

S. No.	Possible Breeding source	Presence of larvae (Yes/No)	Possible Action Strategy	Action taken by
1	Wells		Release guppy fish	
2	Overhead Tanks		Change water once a week	
3	Garden Tanks		Change water once a week or introduce fish	
4	Roadside ditches/puddles		I- ill with stone and mud	
5	Drains		| Introduce fish	
6	Construction sites		Change water once week	
7	Base plates of indoor plants		limply plates alter watering	
8	Coolers		Drain water once a week	
9	Window shades		Drain water. Keep dry	
10	Discarded tyres		Remove water by puncturing or with the help of a cloth	
11	Discarded pots, tins, bottles		Destroy and dispose	
12	Coconut shells		Destroy and dispose	
13	Unused wells		Introduce F.PS beads	

Community Action

Letters could be written to the Town Council or appropriate individuals to:

- sort out the problem
- suggest action
- make offers of help by students
- request permission to take action and/or monitor progress.

After sending the letter(s). students could take a number of steps such as

- seek a reply to the letter
- recheck the situation regarding the stagnant water
- take actions insofar as they are possible.

Goa experience

In 1980 there was high incidence of malaria in Goa. The Junior Red Cross (JRC) took up the issue. A campaign was formulated with students acting as the main disseminators of knowledge. Malaria control and prevention was incorporated in the regular syllabus and accepted by the Goa Board of Secondary and Higher Secondary education. Students divided themselves into teams, surveyed the area around the school and talked to residents to create awareness.

The syllabus was introduced in 100 high schools all around Goa.

The role of construction work and migrant labour in spreading malaria

The role construction work and migrant labour in spreading malaria
Studies by the Malaria Research Centre as well as other independent studies, have proved
Beyond doubt that construction work plays a role in the spread of the disease, so during the construction sites allow stagnation of water for long periods, This is specially so during the curing process, in which water has to be retained for at least 21 days, Secondly, consruction
Work usually employs migrant labour. If the workers come from a malarious region
To seek employment, they become the source of the parasite and thus contribute to the spread
Of the disaese,

Malaria in a wider context

Tacking malaria in a rural set-up different from an urban one because the subspecies of the
Anopheles mosquito responsible for transmission of malaria in villages and different,
They have very different breeding places;hence the control strategies will different.The rural
Species of mosquito for malaria(Anopheles culicifacies)prefers to breed in paddy fields or in
Deep footprints left behind by cattle in which water has collected, The urban malaria mosquito (Anopheles stephenes)docs not breed in such collections of water,

Besides malaria there are a host of other mosquito-borne diseases e.g, dengue by *aedes aegypti* flariasis by Culex, Japanese encephalitis by Culex, etc, Each of these mosquitoes has
Very different dynamics of breeding and disease transmission,The control strategy for tacking
Each one is therefore different,
In localities where two or three mosquito-born disease arc present, the approach has to be
Integrated vector control is one of the may control strategies, Some other strategies are (to
Mention just a few) mosquito repellents like coils, creams, oil of *neem* etc, mosquito nets,
Wire meshing of windows, etc,

Madras city experience

A seven-point action plan was prepared for malaria control. An action committee was constituted. Students made house-to-house visits and interacted with residents. One of the main misconceptions that was addressed was that overhead tanks should not be closed as that would make the water stale, i.e. they should be only partially covered so that air could enter and keep the water fresh. A student action group was formed. The students were drawn from different schools and colleges. They also monitored the status of the fish in overhead tanks after they were released. All the schools in the city with grades 6^{th} to $I2^{th}$ were targeted.

The handouts consisted of:

1. procedures for schools
2. posters
3. fact sheets for teachers
4. handouts for the students
5. pamphlets for the community.

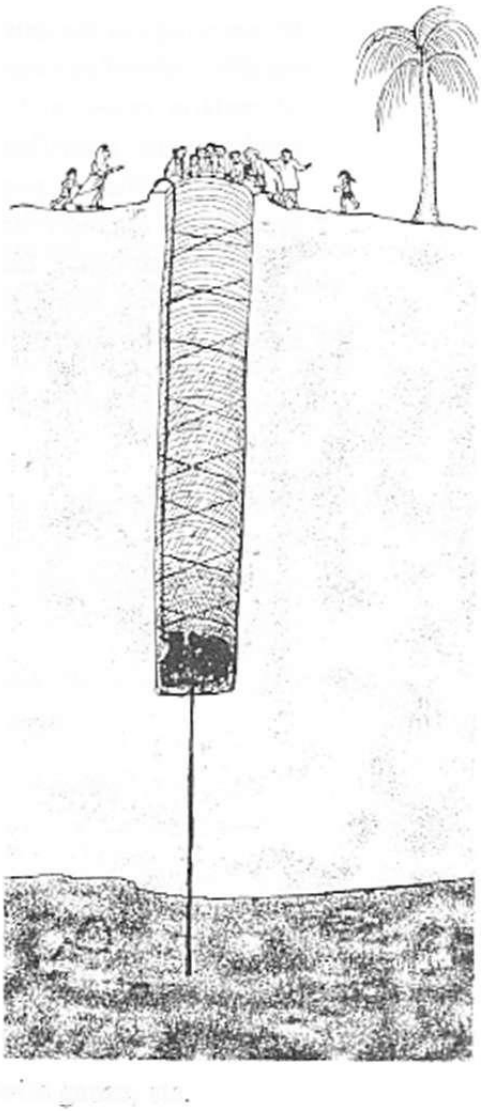
School principals were informed about the campaign through letters. One or two teachers in each school were oriented; they, in turn, oriented the students.

About the script

This script arose out of a very real concern in the context of Mangalore city. It may thus seem very urban-oriented, but the problem of malaria is a larger one that affects the whole country. Solutions are likely to be locale-specific: thus the present script is expected to be useful mainly in an urban setting. By carrying out the activities described here, it is expected that students will become aware of the life cycle of the mosquito They should understand the importance of the prompt treatment of malaria cases, and the ecological balance in the triad of People, Mosquitoes and the Environment. Specifically, they are expected to appreciate that bio-enviromental methods, which are aimed at preventing mosquito larvae from reaching maturity, arc likely to play a crucial role in controlling malaria. On the basis of this, they should be able to devise an action plan for controlling the spread of malaria. The author also hopes that they will be able to indicate, using sound arguments, the societal responsibility of every individual in controlling mosquitoes through participation in community action.

Introduction

Gases can build up ai the bottom of a deep well. These may contain a high percentage of methane which seeps out of the ground inside such wells and which can cause suffocation. In villages of West Bengal, during the summer, wells often dry up and farmers bore a hole down to the water table and set up a pump inside a dry well to lift water for irrigation. Often these pumps are powered by diesel engines which produce deadly exhaust gases such as $C0_2$, SO* and CO. The result is that people often die on entering such wells. This script has been written to make students aware of such dangers so that they can prevent a deep well from becoming a death well.



Scientific concepts

1. Gases such as CO2, SO2, CO, CH_2 can accumulate at the bottom of a deep well and can cause death by suffocation or poisoning.

2. Different gases have different properties which can be used to identify them.

Teaching/learning materials

Bottles, polythene bags, rubber tubes, various chemicals, candles, wire gauze, etc.

Students' Guide

Scenario

A very sad incident look place in Baghadari village in the district of Midnapur, West Bengal. In the summer the water table drops until even deep wells dry up. Some farmers then bore a hole at the bottom of the well and place a diesel pump there to lift ground water for irrigating their fields. Such wells may be 7-10 metres deep and quite narrow, so that it is often too dark to see from the top what is happening inside. One morning, several members of a family died inside such a well. It happened in the following way. First one person went inside the well to switch off the pump and clean the water that had collected at the bottom during the night. As he seemed to be taking a long time, his brother followed him, then his father and his uncle. An alert villager realised what was happening and went inside the well after taking suitable precautions and found them all dead inside. It was a terrible tragedy. Can we do anything to prevent disasters like this? Can science help in any way?

Your Tasks

I- Suggest reasons why the men died. What precautions should people have taken before going inside the well?

2. Collect the following gases - $C0_2$, $S0_2$, CO, CH_4 (only $C0_2$ and SO2 should be prepared) and study the properties of each by:

   (a) determining the effect of the gas 011 a burning candle or match

   (b) determining the acidic or alkaline nature of the gas with a moist pl-l paper strip or litmus paper (pH strips would indicate the actual pH of the gas)

   (c) determining whether the gas has colour, smell or other distinct properties (avoid smelling CO because it is highly toxic)

   (d) determining whether it is combustible or not (if it burns observe the colour of the flame).

3. Perform confirmatory chemical tests on the individual gases. On this basis, suggest which of these gases could have been responsible for the accident described in the Scenario.

4. Discuss with your teacher how to collect a sample of gas from a deep well. Collect such a sample and test it to see if any of the four gases mentioned above are present in it. Ask your teacher to help you identify $C0_2$ and $S0_2$ separately from a mixture of the two.

5. Test gases inside a well directly by lowering a burning candle enclosed in a wire gauze cage (i.e. a Davy safety lamp) to various depths inside the well. Observe whether the candle burns more brightly or is extinguished. Does the gas inside the wire gauze start burning? Explain the need for the wire gauze cage around the candle. It may help you to understand its function if you see what happens when a piece of wire gauze is placed over a candle flame.

6. Discuss whether it would be ethical to lower a living rat into a well to test if any toxic gases arc present before someone goes down the well.

7. Prepare for a public meeting where you may be called upon to talk about the gases which may be present in a deep well and discuss preliminary tests that should be performed and the precautions to be taken before going down such a well.

Teacher's Guide

Suggested teaching strategy

1. After discussing the Scenario, the teacher should hold a brainstorming session to find out the possible gases that might be present in a deep well in which a diesel pump has been running.

2. Another brainstorming session should be held to find out the different precautions one should take before going down such a well.

3. Students, in groups, should be asked to:

(a) find out how to prepare $C0_2$, $S0_2$, CO and Cll_4 - the gases under investigation, by surveying the literature

(b) prepare samples of $C0_2$ and $S0_2$ in the laboratory. CO and CU_4 should not be prepared but only collected

(c) undertake tests on the gases as indicated in the Student Handout.

4. The teacher goes around the groups checking on progress and asking questions to see if students understand the preparation and testing of the gases. Students record their findings individually (the teacher must check the records).

5. In a whole class discussion, students determine how they would go about testing a well safely and suggest any apparatus they would need. The teacher demonstrates the use of any apparatus to determine whether it would be appropriate. If possible, students and the teacher should perform the necessary tests at the chosen well.

6. The students hold a debate on the question whether it is ethical to use live animals in tests which could lead to their death even if this can prevent the death of a human being.

7. Each group prepares for a meeting with villagers to explain the problem of deep wells and the precautions that need to be taken before going down such wells.

8. Arrange a meeting with villagers to increase public awareness of the problems associated with deep wells.

1. **Tests for $C0_2$**

(a) Place a burning strip of magnesium in a bottle containing the gas and observe.

(b) See the effect of the gas on lime water.

2. **Tests for $S0_2$**

(a) Place a burning strip of magnesium in a bottle containing the gas.

(b) Sec the effect of the gas on lime water.

(c) Add a small quantity of acidified potassium permanganate solution to a bottle containing the gas and shake. Sec if the solution loses its colour.

(d) Sec the effect of the gas on acidified potassium dichromate solution to sec if the colour changes from orange-yellow to green.

(Tests (c) and (d) may also be performed with CO2 to try and distinguish between CO2 and $S0_2$.)

3. Tests for CO

(a) See if the gas burns with a blue flame.

(b) Pass the gas through either ammoniacal or hydrochloric acid solution of cuprous chloride. It is absorbed due to the formation of a new compound.

4. Tests for CH_4

Test the gas to sec if it bums.

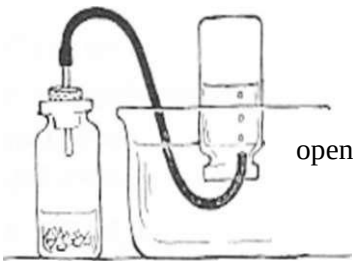
Additional Information for the teacher

1. Carbon dioxide (CO2)

Preparation: $C0_2$ is usually prepared by the action of acids on carbonates. The gas is obtained in the laboratory by the action of hydrochloric acid upon marble chips:

$$CaC0_3 + 2HCI \rightarrow CaCI_2 + H_20 + C0_2$$

The gas can be prepared using used injection bottles. It is collected over water (though it is somewhat soluble), or by the upward displacement of air as it is 1.5 times heavier than air.



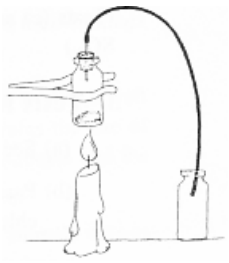
Collection: The gas can be collected from a soda water or a fizzy drink bottle. To do this put a plastic bag over the neck of the bottle. Carefully the cap of the bottle and after collecting sufficient gas (you may need '.0 shake or warm the bottle a little) remove the plastic bag and seal it.

Properties: The gas is not poisonous but docs not support respiration; animals die in it from suffocation for want of oxygen.

Too high a concentration in air (10-20%) causes unconsciousness, failure of the respiratory muscles and a change in the pll of the blood.

Confirmatory tests:

(a) An ignited magnesium strip burns in the gas with separation of carbon.



(b) Carbon dioxide turns lime water milky due to the formation of insoluble calcium carbonate. The milkincss disappears on continued exposure to the gas owing to the formation of soluble calcium bicarbonate.

2. Sulphur dioxide (SO2)

Preparation: In the laboratory sulphur dioxide is prepared by reducing hot concentrated sulphuric acid with copper turnings. The gas is collected by the upward displacement of air and can be prepared in an injection bottle.

It is also possible to make sulphur dioxide by burning sulphur in the bottom of an injection bottle and collecting the gas in another injection bottle by the upward displacement of air.

Collection: A simple way to get a sample of this gas is to take a purifying tablet and make it react with a little acid (vinegar) in an injection bottle in the same manner as described for CO}- Substitutes for the purifying tablet arc sodium sulphite, sodium hydrogen sulphite, etc. The gas is readily obtained without heating by adding concentrated sulphuric acid to a solution of sodium hydrogen sulphite or sodium sulphite.

Properties: It is a colourless gas heavier than air with a choking smell of burnt sulphur. It is incombustible and does not support combustion. It turns lime water milky which disappears in excess of the gas. Moist coloured flowers are bleached colourless by the gas. The gas does not support respiration.

Confirmatory tests:

(a) It decolourises an acidic solution of potassium permanganate.

(b) It reduces acidified potassium dichromate, the colour of the solution changing from orange-yellow to green.

Both CO2 and SO2 turn lime water milky. To detect them individually when they are mixed, the mixture is passed through a tube containing acidified potassium dichromate (or potassium permanganate) which turns green (potassium permanganate turns colourless) and the SO2 is removed at the same time. The residual gas which is CO2 can be tested with lime water.

3. Carbon monoxide (CO)

(Student should not prepare this gas but only collect it as described below.)

Collection: It may be collected from a car exhaust by placing the mouth of a plastic bag around the exhaust pipe. To maximise the concentration of CO it is best to collect the exhaust gas when an engine is started from cold, as it is then known to work at low efficiency.

Properties: It is a colourless, odourless and highly poisonous gas. As little as 9 parts of the gas in 10,000 parts of air will cause nausea and headache while a concentration of about 1% breathed continuously causes death.

Its poisoning effect is due to the fact that it combines with haemoglobin, the oxygen carrier of the blood, forming a relatively stable compound - carboxyhaemoglobin. This prevents the blood from absorbing oxygen and fulfilling its normal function in respiration. This explains why it is dangerous to sleep in a room with an open fire.

In the event of CO poisoning, the patient should be kept warm and administered oxygen containing 5% $C0_2$. Mice and canaries arc very susceptible to poisoning by CO and are often used to detect the gas in mines. The gas is a treacherous poison because of its odourless character and insidious action. In high concentrations, people collapse without warning.

The gas is slightly lighter than air, and is sparingly soluble in water, about *3%* by volume. It does not support combustion, but burns in air or oxygen with a pale blue flame, yielding $C0_2$.

$$2\ CO + 0_2 \rightarrow 2\ C0_2$$

Confirmatory tests:

(a) It burns in air with a pale blue flame (avoid smelling the gas).

(b) When CO is passed through either ammoniacal or hydrochloric acid solution of cuprous chloride which is absorbent of the gas, CuCI.CO.2H2O is formed.

4. Methane (CH_4)

(Student should not prepare this gas but only collect it as described below.)

Collection: Methane may be collected from a biogas plant used to turn excrement into a source of fuel. The village may well have one of these or a small one can be built in the school.

Properties: Methane is a colourless, odourless and inflammable gas also known as firedamp. It is the end product of anaerobic decay (without air) of plants underwater. It is the major constituent (up to 95%) of natural gas. It can be seen bubbling to the surface in swamps (hence its other name: marsh gas). It is lighter than air and does not support respiration.

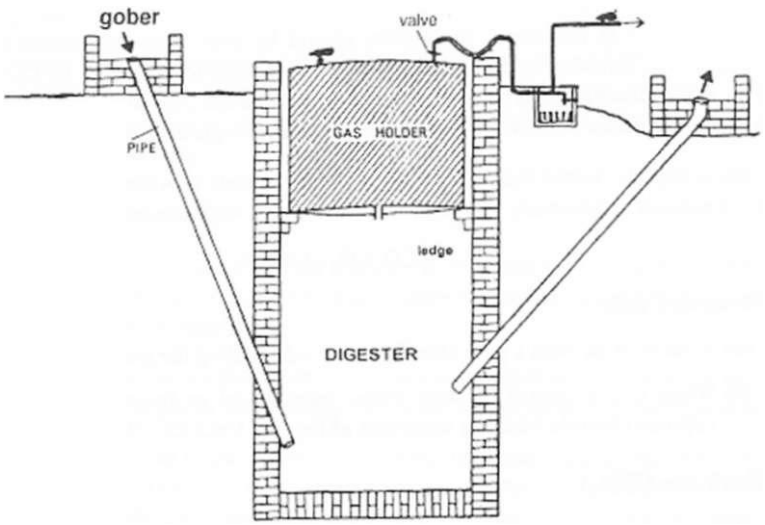
Confirmatory test: The gas is combustible and burns with a normal coloured flame.

A preliminari test before descending into a well should be performed using a Davy safety lamp. Sir Humphry Davy devised the lamp for use \u the presence of inflammable gases. That is how the lamp gets its name. It works on the principle that a flame will not pass through a wire gauze (the gauze dissipates the heat) and hence a combustible gas can burn inside the lamp but the lamp will not sec fire to the gas outside. The gas entering the lamp gives the flame a characteristic appearance which can be used to detect its presence. The presence of methane in a well can therefore be detected in this way. Students can easily make such a lamp.

To understand the role of the wire gauze, place it over a burning candle or a Bunsen flame. The flame will burn beneath the gauze but not above it. Now extinguish the flame, place the gauze over the Bunsen (candle) and quickly try to light it above the gauze. With a Bunsen flame this is easy to do, but not so easy with a candle flame.

To construct a safety lamp, make a cylindrical cage from wire gauze with the bottom missing. The size of the cylinder depends on the size of the candle and the base on which the candle is placed. Fix the cylindrical gauze to the bottom of Che base so that it is airtight once the candle has been lit (a liquid wax seal will be fine if the candle is kept upright).

6. A Biogas Plant



Principle: A biogas plant works on the principle that complex organic matter can be anacrobically broken down to simpler forms by bacterial action within days to yield CH_4. Biogas, popularly called gobar gas (since the plant works mostly on dairy animal excreta), is simply methane. A biogas plant can therefore be a very good source of methane, which can be collected from it and used in the laboratory.

The plant consists mainly of two parts - a digester and a gasholder. Here we describe a design developed by the Khadi and Village Industries Commission (KV1C), which is commonly used.

The digester is the most important part of a biogas plant. For a daily yield of 3 cubic metre of gas the dimensions of the well of the digester arc: depth 4.8 m and diameter 1.5 m. The well is dug and cemented. It takes about 40 days after charging for the first yield of gas after which the unit remains working for years. Frequent stirring should be done for better gas yield.

The gasholder is of the floating type, inverted over the mouth of the digester. The storage capacity of a gasholder for the yield mentioned is 2.1 cubic meter. This is so that the gas collected overnight can be used in the school during the day over a period of 7-8 hours. A PVC tank may be used as a gasholder.

A central pipe is fitted in the gasholder for collection of gas from the digester. A ledge is built into the digester at a depth equal to that of the gasholder. It arrests the gasholder from going down when no gas is left in it, thus preventing the slurry from entering the gas outlet pipe. It also guides air bubbles from the digester into the gasholder.

About the script

This script arose from a real-life incident. Without any investigations on the spot, the authors could not identify the gas or gases responsible for the tragedy. The activities suggested here could possibly help do that.

It is expected that, after carrying out the activities given here, students will be able to put forward reasonable guesses for the identity of the gases that might have been present in the well in the Scenario. They should be able to refer to the literature for the properties of the gases. They should be able to prepare CO2 and SO2, and to collect CH_4 and CO, and to identify them by carrying out confirmatory tests. With a bit of luck, they may even be able to collect a sample of the gases from a deep well and test it. However, others who have read the script feel that this may pose logistic problems which could be hard to solve.

Students should be able to understand the reactions involved in the preparation and testing of the gases and the precautions needed when undertaking the experimental work. It may also be possible to enter into a discussion on why the pump needs to be placed inside the well and discussions on atmospheric pressure may be relevant here.

The authors hope that students will engage in a debate, putting forward rational arguments, on whether it is ethical for villagers themselves to go down such wells or to put a living animal into a suspected poisoned well.

Finally, this is only one of two scripts in which an attempt has been made to develop a set of criteria for assessment. This has been included as an appendix to the script.

Appendix: Assessment

Formative Assessment

The teacher observes how groups proceed from guessing to determining the gases present in a suspected poisoned well, gives hints wherever required, provides supportive knowledge and involves students in discussions.

A Student cannot guess the identity of the gas even after being given hints. Teacher indicates the possible gas that could be present. Student refers to the literature and yet cannot proceed with the preparation, collection and testing of the gas nor suggest ways of collecting a sample.

B Student cannot guess the identity of the gas even after being given hints. Teacher indicates the possible gas that could be present. Student refers to the literature and proceeds with the preparation, collection and testing of the gas, but cannot suggest ways of collecting a sample.

C Student guesses the identity of the gas after being given hints. Student refers to the literature to confirm guess and for method of preparation, collection and testing. Student proceeds with the preparation, collection and testing of the gas, but cannot suggest how to collect a sample.

D Student guesses the identity of the gas after being given hints. Student refers to the literature to confirm guess and for method of preparation, collection and testing. Student proceeds with the preparation, collection and testing of the gas but fails to determine the gas causing death in the deep well due to improper recording.

£ Student guesses the identity of the gas. Refers to the literature, proceeds with the preparation, collection and testing of gas. Suggests methods for collecting sample of the gas and testing it. Records all the above systematically. Identifies correctly the gas causing death in the deep well.

2. The teacher observes students during experimentation, group discussions and the public presentation.

A Student tends to let others in the groups do the thinking and carry out of the experiments or organise the meeting; may record results but usually copies them; is passive during discussions and cannot make presentation in public.

B Student participates in the process of thinking and carries out the experiments diligently and carefully; records results systematically; works well in the group, communicates orally but cannot make public presentations alone.

C Student acts as a group leader, does the thinking and experimentation diligently and guides others in the group as well; records results, draws inferences, communicates orally and guides the group for public presentation. Can make a public presentation on his or her own.

3. The teacher asks questions on the nature of the chemical reactions involved, the preparatory steps and the procedures for testing the gases. The teacher may discuss the validity of the method of sampling and note how students determine the gases that are present in a well.

A Student cannot determine the nature of the chemical reactions. Performance of experiments is poor, the recording is inconsistent and fails to draw the correct inference.

B Student cannot determine the nature of the chemical reactions. Performance of experiments is good, the recording systematic, yet fails to draw the correct inference.

C Student can determine the nature of the chemical reaction by careful observation. The performance of experiments is good, the recording systematic and student is able to draw the correct inference.

4. The teacher listens to discussions within the groups and between the groups.

A Student unable to pose arguments during the debate.

B Student suggests reasons why villagers should not go down a suspected poisoned well on their own without adequate preparation.

C Student suggests reasons for villagers not going down a suspected poisoned well on their own and also suggests which animal would be most appropriate to send down the well if such a step was necessary. Is also able to debate on ethical grounds the desirability of using animals for such tests.

ARE YOU BEING CHEATED IN THE MARKET?

KAMAL MAHENDROO Grade level - Class VIII

Introduction

Balances are commonplace in markets. They are used to weigh groceries, fruits and vegetables from as little as 100 g to more than S kg. There are also balances that can weigh more than a quintal of grain, coal or other goods. How accurate are they? Are they being used honestly by the sellers?

There is a common notion that if the beam of a balance rests horizontally when both pans are empty then the balance is true. Further, if the beam tilts to one side, then it is assumed that, by adding a compensatory weight to the pan on the other side, the balance can be corrected. How many people realise that the balance may still be faulty even after this initial adjustment? Investigating this can lead to a lively discussion in the classroom and give rise to a number of activities.

Science concepts

The principle of moments

Teaching/learning **materials**

A metre or half-metre scale, a set of weights, assorted bags, string, etc.

Students' Guide

Scenario

Rajesh was sent by his mother to buy 2 kg of sugar from Rambabu's grocery store. As he was handing the packet of sugar to his mother she asked suspiciously, "Were you watching carefully while he was weighing? The sugar seems to be less than it should be." On checking they found that the sugar was indeed short in weight. Rajesh was sure he had been watching carefully while Rambabu was weighing the sugar.

What could have gone wrong?

"Are you sure he put a 2 kg weight in the weighing pan?", his mother asked.

"I did notice that he put a 1 kg weight and two other smaller weights," Rajesh recalled.

Can you guess what those smaller weights should have been for weighing the required amount of sugar?

"Did you check if the balance was weighing correctly?" she asked again. Rajesh did not know how to answer this.

Can you help him? Do you know how to check whether a balance being used is true?

To check whether a balance is true or not, we first see that it is balanced with empty pans, i.e. its beam comes to rest freely in a horizontal position. Then we put equal weights say, 500 g, in each pan and see if it still remains balanced. Only then can we be sure that the balance is correct.

Your Tasks

1. Get a balance and a set of weights and examine them closely. Make a simple balance and weights of your own and test them.
2. Make a balance with a half-metre scale and find out how it balances with equal weights on both sides. Do the same with unequal weights. Discuss your results and come to an understanding of the Principle of Moments on which a balance works.
3. Make drawings of the balances being used at different places (like the grocery store, the goldsmith's shop, the grain market*/mandi,* the coal depot, the post office, the railway station, the health centre, etc.). Can you explain how these work? What are the differences between them? Which are easy to use and which are more' accurate?
4. Make a balance that uses only one pan.
5. Comparing the two balances you have made, which do you consider easier to use and which to be more accurate? Which is more appropriate for use in the market ?
6. To check the weights used in the market it is necessary to use a standard. Find out about standard weights in India.

Teacher's Guide

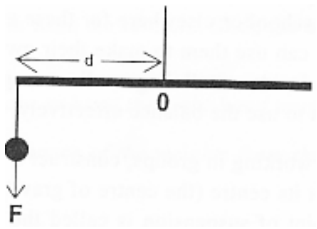
This activity material is designed for students to use largely by themselves and should need only occasional guidance from the teacher. The initial motivation of students will play a crucial role in ensuring the success of this activity.

The experiments arc intended to lead to the Principle of Moments and hence an understanding of the way different balances work. But this information is of little value if we cannot put it to use while discussing the accuracy or misuse of balances.

Moment of a Force and the Principle of Moments

Suppose you want to use a spanner to loosen a nut, like the nut on the axle of a cycle or a scooter. Two things will make this easy - firstly if the force is applied at right angles to the handle of the spanner, and secondly if a spanner with as long a handle as possible is used. The longer the handle the more leverage you will be able to exert. The technical word for this leverage is moment. The moment of a force is its turning effect.

Suppose a force of magnitude *F* acts on a line at right angles to it at a distance *d* from a point O on the line. The moment of the force about O is (F x *d).* If the force is applied by a suspended weight then the magnitude of the force is the weight in units of gramme weight.



Any turning effect or moment will be either clockwise or anti-clockwise. We generally take anti-clockwise moments to be positive and clockwise moments to be negative. If there are a number of forces acting on a body, the total moment on a point is the sum of all the moments exerted by the individual forces on that point.

If a body does not turn under the action of these forces, the total moment on the body must be zero. This is the Principle of Moments.

In the case of a balance we usually consider moments about the point of suspension or the fulcrum. For the beam to remain horizontal, the moments of the forces due to the weights suspended on either side must be equal. Thus if the weights are different the beam can still be balanced by placing them at different distances from the fulcrum such that the product of the weight and its distance from the fulcrum is the same on both sides.

Suggested teaching strategy

1. You may begin with a balance in which one arm is shorter than the other and the pans are fixed at the ends of each arm. Use it to pose the following puzzle:

   "It seems the balance is not correct. I low do we correct it?"
   Expected Answer: "By a compensatory weight."

   The teacher proceeds to correct the balance in this way.

   "Now if we put a 100 g weight in each of the pans should the scales balance?"
   Expected Answer: "Yes, it should."

   The teacher demonstrates that this does not happen.

   The observation is intended to be puzzling enough to motivate students to do the rest of the activities and experiments. This can also lead to discussion on the use of balances in the marketplace and elsewhere.

2. Students, working in groups of four, should be guided to make their own balances using locally available materials. Begin by showing them a balance and demonstrating its construction and working. Then they can make a hand-held two-pan balance. The balance may be held or suspended from a hook or nail using a short length of string. The teacher should arrange, if possible, for a box of weights for every group of 4 students, from the neighbouring high school or elsewhere for these experiments. If only one set of weights is available, students can use them to make their own weights using marbles, stones, plastic, sand, etc. placed inside small bags. Encourage them to explore and suggest better materials and learn to use the balance effectively.

3. Help the students, working in groups, construct a balance using a metre or half-meter stick by lying a string at its centre (the centre of gravity) so that it is balanced when held up by the string. The point of suspension is called the fulcrum. Loops of string arc tied to the weights so that they can be slipped over the stick and suspended at different distances from the fulcrum. Students should use their balances to carry out the experiments in the Student Handout. They should record the observations in the table given in the Handout.

4. Explaining that (weight x distance) is called the moment of a force, get students to express their conclusions in terms of moments on the left hand side versus the moments on the right hand side. To ensure understanding, students should be encouraged to formulate their conclusions in their own words. You can provide additional activity for students who don't understand the concept even after they have done the experiments. This should be checked by asking them how one can find out whether a given balance is true.

5. Ask students to investigate different types of balances in use. Encourage them to discuss in groups how these balances work and how accurate they arc. Get them to make one-pan balances of their own, based on the examples they see in a post office or in a railway station. They should also realise that accuracy of weighing depends, among other things, on the accuracy of the weights. This should lead to the question of what is the standard of weight in India. Students should be assigned a project to find out.

Student Handout (Translated and adapted from "Bal Vaigyanik" - Class VIII)

Experiment 1

Take a half meter scale. The a thick string around its middle to form a loop. When fitted with this loop scale should remain horizontal. The point at which the loop of string is tied to the scale is called the fulcrum. Note the position of the fulcrum and make sure the string does not slip from this position throughout the experiment.

Take out regular 20, 30, 40 and 50 g weights or the equivalent weights you have made yourself. Tie a loop of thread around each as shown in the figure. You will use these loops to hang the weights from your scale.

Hang a 20 g weight on the scale exactly 10 cm to the left of the fulcrum. The loop of thread should hang straight over the mark on the scale as shown in the figure.

Hang another 20 g weight on the right hand side of the scale at such a distance that the scale is balanced when you lift it by the central loop.

How far from the fulcrum did you have to hang the second weight? (!)

Now hang the left-hand weight 15 cm from the fulcrum. Slide the other weight till the scale is balanced again.

How far from the fulcrum did you have to hang the right-hand weight this time? (2)

What can you conclude about the distance of the weights from the fulcrum if the scale is to remain balanced? (3)

Repeat the experiment with pairs of 30, 40 and 50 g weights at different distances from the fulcrum and check if your conclusion remains correct. (4)

A puzzle

The pans of a pair of scales are the same weight and so are the weights placed in each of them. The scales still don't balance.

Based on the observations of the previous experiment, what can be the reason? (5) ***Experiment 2***

In the previous experiment you used equal weights. Now we shall repeat the experiment with different weights on either side of the scale.

Balance your scale by sliding the loop of thread to the position of the fulcrum you had noted in the last experiment. Hang a 20 g weight 16 cm from the fulcrum on the left of the scale. Hang a 40 g weight on the right side and adjust its position so that the scale becomes balanced.

How far from the fulcrum did you have to place the 40 g weight?

Now hang the 20 g weight at a distance of 24 cm from the fulcrum.

How far from the fulcrum mum the 40 g weight he hung now for balance? (7)

If the 40 g weight is hung 7 cm away from the fulcrum on the right, at what distance from the fulcrum on the left must the 20 g weight be hung for balance? (8)

Check your answer by actually carrying out the experiment.

If you hang the 40 g weight / / cm from the fulcrum on the left, where will you have to hang the 20 g weight to balance it? (9)

Repeat this experiment using a 30 g weight on one side and a 60 g weight on the other. Record your new observations. (10)

Experiment 3 - The principle of the balance

First copy the table given below in your notebook and fill in it all the data you gathered in the two previous experiments. (II)

Left Hand Side of Fulcrum			Right Hand Side of Fulcrum		
Weight attached (g wt)	Distance from fulcrum (cm)	Weight × Distance (g wt × cm)	Weight needed to balance (g wt)	Distance from fulcrum (cm)	Weight × Distance (g wt × cm)
20	10	200	20		
20	15	300	20		
20	16	320	40		
20	24	480	40		
40	7	280	20		
40	11	440	20		
30			60		

After entering all the observations you have taken so far, complété the table by calculating the necessary products. Compare the products on the left of the table with those on the right.

What do you find in each case? (12)

Is there any genera conclusion that you can draw from the experiments you have done? Discuss this with your teacher and write it down in the form of an équation. (13)

If you find it difficult to come (o a definite conclusion, you can take some more observations with different weights hung on either side of the fulcrum.

Noling that the product (weight x distance from the fulcrum) is called the moment, express your conclusion from the table in terms of the moments on the left side versus the moment on the right side. (14)

About the script

This script is different in its approach as compared to the others in as much as it attempts to be student driven with a minimum of intervention by the teacher. The Scenario tries to warn against the likelihood that balances being used in the market place may not be true even though they might appear to be so. It attempts to make students understand the conditions that must exist before a weighing can be reliable. Students investigate this problem experimentally. They are encouraged to make their own set of weights, if these are not available in sufficient quantity, and construct different types of balances using locally available materials and tools. In the process they are expected to arrive empirically at an understanding of the principle of moments on which the functioning of a balance depends.

The Student Handout in this script is an adaptation of a Unit from *Hal Vaigyanik* which is a Workbook of the Hoshangabad Science Teaching Programme. This programme of activity based science teaching was initiated in 1973 and currently runs in nearly 500 middle schools in the State of Madhya Pradesh.

WHY DOES KALULAL HAVE TO CO FAR TO GRAZE HIS CATTLE?

H. K. DEWAN, AMITABHA MUKHERJEE and PRIYANKA SINGH

Grade level: Classes V1II-X

Introduction

With the reducing availability of pastures, cattle need to be taken further and further afield to find new land for grazing. Gradually more and more land gets degraded, so that it is no longer suitable for grazing, and the problem continues to grow. There is a need to stop this process and recover pastures that have already been destroyed. In order to appreciate this problem better, one must collect data about such changes and analyse them to see the possible underlying patterns.

Science concepts

1. The relation between food availability and population
2. Growth and regeneration of plants
3. Degradation of grasslands

Previous knowledge

Grasses are plants, with their own growth cycle.

Teaching/learning materials

Flowerpots, soil, scissors and magnifying glass.

Students* Guide

Scenario

Kalulal is a 12-year-old Gamcti boy, living in Rava village of Udaipur district in Rajasthan. His village is surrounded by many hillocks and his house is also on a hillock. Kalulal lives with his parents and two younger brothers. His elder sister Mala was married three years ago and now lives in a village 15 km away. Kalu's parents work the small patch of agricultural land they own. Apart from this, his mother also works in the house and has lo walk almost a kilometre everyday to fetch water. His sister Mala used to help their mother in the house before her marriage and also took the domestic animals for grazing. They own one cow and three goats. When Mala got married, Kalu had to stop going to school and take the animals for grazing. Mala used to spend around 2 hours everyday grazing the animals. When Kalu started, he would take around the same time, but now he spends almost 4 hours because he has to take the animals to different sites for grazing as there is never enough grass at one place. Mala used lo have time to play with her friends while the animals grazed but now Kalu has to herd them continuously. His friends also narrate similar experiences.

Your Tasks

1. In small groups, brainstorm why Kalulal has to go farther for grazing. The reasons generated should be shared with the whole class.

2. Carry out a survey of your village to find out the status of land, livestock population, grazing area and grazing pattern, and how these have changed over the last 25-30 years.

3. Compile the results of the survey, analyse the data and build a picture of the entire village.

4. Discuss in the class, using the findings of the survey, the possible reasons why the pastures available to Kalulal may have got reduced or degraded in quality.

5. Observe how different animals (cows, goals, etc.) graze, to see if there is any difference in their grazing behaviour and whether this difference can affect the regeneration of grass.

6. Do an experiment to find out how grass grows back after being grazed by animals.

7. As a whole class, examine the findings of the survey, your observations oT the grazing behaviour and the results of the grass-growing experiment to understand the reasons for the degradation of pasturelands.

8. Suggest possible actions that can be taken by the village community lo stop further degradation of pastures and help regenerate them.

Teacher's Guide

Suggested teaching strategy

1. Students in groups of 4-5 suggest reasons for Kalulal needing to travel so far to graze his animals. Some of these could be:
   - there is no grass near Kalulal's house for his animals
   - the number of animals in the village has increased
   - the grazing space has gone down in the village
   - there are fewer trees in and around the village
   - there is less forest available
   - there is less water available for grass and other plants to grow.
2. The students can check the reasons suggested by talking to the elders of either their own or of a neighboring village. They can try to think of a set of questions which they can ask. A sample questionnaire for the purpose of this survey has been designed and is enclosed as Student Handout 1.

   Note that the sample questionnaire is designed to find out how things have changed over a period of 30-40 years. The Handout contains some suggestions on how to elicit information, but it may still be difficult to get answers to all the questions. Moreover» the volume of data involved is very considerable. You should help students design their own questionnaire, using your knowledge of local conditions.

   The students work in groups and each group tries to cover 3 or 4 households depending on the size of the village.
3. Once the students have completed the survey, you should help them to compile the data. This may require finding out the range of values of each parameter and its average value. The compilation and analysis should enable students to get a picture of the land and livestock status of the village as a whole.
4. The teacher leads a whole class discussion to explore the relationship between grazing and the degradation of land. The teacher will have to help children connect their findings on livestock census, land status, grazing pattern, etc. to make any statements about the reasons for the degradation.
5. The discussion may bring out that the animals are being taken to different grazing sites periodically. If so, the teacher can ask students to explore the reasons for this. An observation sheet is provided in Student Handout 2 for students to record their findings.
6. Students observe the way different animals, such as cows and goats, graze grass. Do they graze only the top, do they graze it close to the ground or do they even pull out the grass completely? (Student Handout 3 gives a possible format for recording the observations.) The idea is that if they graze without uprooting the grass, the grass has a chance to grow back. If however, the grass is uprooted, it probably needs to be replanted. Students also observe what other plants are eaten by the animals, which parts are eaten and to what extent.
7. The experiment in Student Handout 4 is aimed at finding out how grass regenerates after being grazed. Before undertaking the experiment, students study the parts of a grass plant and draw what they see. Roots, stem and leaves arc easy to identify. Depending on the season and the species of grass, seeds may or may not be visible. Students may also be able to identify runners.

The experiment itself consists of two parts: to measure the growth of a single grass plant, and to determine the time needed for a patch of grass to regenerate. Care will have to be taken that the pots containing the planted grass remain safe for the duration of the experiment. The time scales suggested for growth and regeneration are fairly typical. However, there is a lot of variation among different species of grass. The rate of growth also depends on the temperature, humidity and the quality of the soil.

8. The whole class discusses the probable reasons for the degradation of pastures in view of their observations of the feeding behaviour of animals and the regeneration of grass, and tries to come up with plausible reasons for Kalulal having to travel further for grazing his animals.
9. Students in groups propose possible courses of action that can be taken by the community to prevent further degradation of pastures. These are compiled after being discussed in the class.

Student Handout 1: Sample questionnaire

While administering the questionnaire you may not get direct answers to some of the questions. For example, for the question on area of land, the answers might not come in hectares, acres or any other familiar unit of area. But it may be possible to get a sense of the area of land available for grazing earlier (as far as the memory of your respondent goes) and now. You may often also have to mix questions to get responses in a way that you can record. You can also draw pictures for both the questions and the answers, to help the respondent to work out the answer. You may need to go back and forth to different sections within Handout I, and even between Handout I and Handout 2, for eliciting responses.

Name(s) of the student(s)

Village of study

Name of respondent (person being interviewed)

Section I: Land Status

	Then (30-40 years ago)	Now
What was/is the area of land (approximately) available for grazing?		
How much grass was/is available from the land?		
How many animals could/can graze on that patch of land and for how many days?		
Was/is the grazing land used for any other purpose?		
Who owned/owns the land?		

Section II: Fodder Status

	Then	Now
Was/is there something else available that could/can be used as feed?		
Did/do you cut and store grass?		
Did/do you grow anything especially as fodder?		
Was/is grass sold?		
Was/is fodder sold?		
Did/do you buy or sell grass or fodder?		
If yes, what was/is its value in Rupees?		

Is there any change in the amount of grass cut and stored compared to the total requirement of grass now as compared to then?

Section III: Livestock Census

How many animals did/does your family own?

	Then	Now
Cows		
Buffaloes		
Bullocks		
Goats		
Sheep		

Section IV: Grazing practices

Where did/do you take your animals for grazing (tick the appropriate entry)

	Then	Now
Village pasture land (*Charagah, Charnot)*		
Private wasteland (*Beed)*		
Other village		
Forest		
Any other place		

B

What distance did/do you have to travel to take animals for grazing? What was/is the proportion of fodder (including grass) from different sources?

Open grazing	
Private Wasteland	
Purchased fodder	
Any other	

Student Handout 2

Get answers to the following quest ions from someone who lakes animals for grazing on a regular basis. The person could be your respondent for Student Handout I, but this is not necessary.

Do you take your animals to graze repeatedly to the same
place? If yes, why? If no, why not?

In the last month, have many spots have you changed and how frequently (e.g. once every four days)?
In the last 15 days, how many spots have you changed and how frequently?

If you do not get any answers, request the respondent to observe the grazing pattern for the next month, and repeat the questions after that.

Student Handout 3: Grazing behaviour of different animals

Go to a place where there are many animals grazing. Observe the grazing behaviours of different animals and record them by licking the appropriate box or boxes as the case may be. If you find something new arid interesting that does not fit into the table below, extend it by adding more rows.

	Cows	Goats	Buffalos	Sheep	Any other
Graze only the tips of crass					
Close-crop the grass					
Uproot the grass while grazing					
Graze on leaves and shrubs					
Graze on whatever is available at any height					
Lat only the leaves, leaving the stem intact					

Student Handout 4: Watching the grass grow

How docs a plant (including grass) regenerate or grow back alter animals have eaten a portion of it? Which of the following do you think actually happens?

1. Fresh leaves take the place of new ones.
2. New branches come out.
3. New shoots grow from the stein or root.
4. Something else happens.

Is there any difference between the way grass and larger plants regenerate?
How long does this process take for grass or other plants eaten by animals?
Here is an experiment which may help you get answers to some of these questions.

Experiment: Parts of a grass plant and its growth

1. Pull out a grass plant and look at it carefully. Make a drawing of what you see. Can you identify parts like leaf, stem and roots?

2. Does grass have seeds? If you can't get the answer by direct observation, try asking someone who is involved in the planting and care of grass.

3. Which part of the grass plant do you think actually grows? To find out. you will need to plant some grass in a pot, or in a patch of land in or near the school, which can be protected from animals and people. Put some soil in the pot and carefully transplant some grass into it. This means that you should remove the grass from where it is growing without damaging the roots. Choose a small plant and make a mark with ink in the middle of the green part. Measure the height of the tip of the blade as well as the height of the mark from the ground. Let the grass grow. Make sure that it gets some sunshine for a few- hours every day. If the weather is very dry, you will also need to water it. Look at it after 3, 6 and 9 days. Measure the two lengths each time. What does this tell you about which part grows?

•I. To find out how grass grows back after being grazed by animals, you will need grass planted in two similar pots. Crop the grass in pot 1. That is, break off the leaves about 2-3 cm above the ground. Pot 2 serves as a control it is kept iii the same conditions as pot 1, but the leaves are not damaged in any way. Look at the two pots every day, and keep a record of your observations. Note especially whether the broken leaves continue to grow, or whether something else happens. We can say that the grass has grown back or regenerated when the two pots present the same appearance once again. How much time does this take?

5. What do you think will happen if the grass is repeatedly cropped without giving it time to grow back?

About the script

This script has its origins in the problem of degradation of grasslands that plagues Udaipur district, where two of the authors work. Many parts of the country face similar problems.

In carrying out the activities in this script, children are expected to design questionnaires and conduct simple surveys. They have to record, organise and analyse data of two kinds. One kind is characteristic of social sciences, e.g., interviewing villagers and extracting organised information from such an interaction. The other kind involves processes traditionally associated with science, e.g., measuring the growth of grass, maintaining a control, observing the feeding behaviour of different animals, etc. It is expected that students will come to appreciate that grasses, like other plants, require a certain minimum time to grow and regenerate, and that the pressure of population leads to overgrazing. The deep underlying concept is that of the carrying capacity of an ecosystem, though of course ii is not expected that it will be addressed directly. The authors also hope that children will begin to get a glimpse of the complex interaction of human society with natural resources; in particular, to appreciate the need to attempt a more sustainable management of land.

After the first version of the script was written, one of the authors carried out a preliminary study in Udaipur district. She came to the conclusion that overgrazing is only one of the reasons that Kalulal has to go far. The causes of degradation of pastures are manifold cutting/felling of trees, privatisation of common grazing land, acquisition of forest land by the state, etc.

PLANTS: DO WE CARE?

G. P. PANDE, SATHEESH H. L., NAL1NI GITE and SAROJ GHOSE

Grade level: Classes V-VI

Introduction

This script looks at plants and the role they play in sustaining life on Earth. The activities aim at raising an awareness of and a concern for plant life. In so doing, the script also tries to develop skills related to scientific investigations. Its major goals are that pupils will know more about plants, come to appreciate the importance of plants and assume the responsibility expected of citizens in preserving and promoting the flora around them.

Scientific concepts

1. Plant are living beings and they have all the characteristics of life (e.g. they need light, food and water, they grow and decay, they respond to stimuli and they reproduce).

2. There is interdependence among organisms.

Teaching/learning materials

Containers like coconut shells, earthen pots, ice cream cups, tin cans, tumblers, etc. Various types of commonly available seeds (beans, Bengal gram, peas and the like), scale, activity sheets, chart paper, sketch pens, gum/sellotape, potted plants.

Students'* Guide

Scenario

One day in March 1973, a contractor came to Mandal, a village near Gopeswar in UP. He wanted to cut some ash trees for making sports equipment. The villagers politely told him not to do so. When the contractor insisted on cutting the trees, they decided they must prevent it. They hugged the trees meant for felling. Later in 1974, women of village Reni lead by Gouri Devi barred the path through their village to the forest to prevent the felling of trees by contractors. Undaunted by the number of men or their axes, the women of the village stood in their way, sang songs and declared "This forest is our mother's home, we will protect it with all our strength". These events lead to the birth of a movement for saving trees known as 'the Chipko Movement'. The success of the movement sparked off similar movements in other parts of the country as well.

Your Tasks

Part 1

1. Go out and observe plants in your surroundings. Make sketches of the plants you see of their leaves, seeds, fruits and flowers. Try and identify the names of some of the commonly found plants in your area. To do this, you can take the help of your friends, teachers and elders. In what way are the plants alike and how arc they different from each other? Record your observations and comments. Discuss and share your observations with your classmates.

2. Visit an orchard, park or farm and observe the plants there. Compare their similarities and differences with plants in your surroundings. Report your observations to the class.

3. Suggest a way to classify the plants that you have seen in Tasks I and 2. Reach a consensus on classification within your group. Put the plants you have seen in the different categories you have chosen. Compare your classification with those of others.

4. Collect a few samples of leaves, fruits and seeds of different plants that have fallen on the ground. Mount the collected specimens. Observe their features. Write the names of the

specimen.(If you know them), the date and place of" their collection. Use this collection to create a table listing similarities and differences among leaves and among seeds.

5. Find a touch-me-not plant. Touch its leaves. Observe, record and report your findings. Try- to explain your observations. Discuss within your group whether all plants behave in the same way and record the reasons for your point of view.

If a touch-me-not plant is not found in your locality, you may observe any other plant which reacts to light, touch or any other change in its surroundings. For example, you could observe the reaction of a sunflower or of the night queen plant to darkness.

Part 2

6. Take a few seeds of pea, Bengal gram, green gram or wheat. Sow them in small containers and grow their seedlings. Different groups of students may grow different kinds of seeds. Observe the changes each day and keep a careful record. Make drawings of the changes if possible. Compare your findings with those of other groups.

When the sapling emerges from the seed, measure the height of the sapling on alternate days. Record your measurements and draw a graph (o show the changes.

7. What do plants need to grow? Try to find out through experiments if they need (a) light, (b) soil, (c) water. You will need to design suitable experiments after discussion in your group. Take the help of your teacher if necessary. Discuss why plants need light, soil or water. What happens if these are not available to plants?

8. Find out the different ways in which we use plants and plant products. Group the plants on the basis of their use. Indicate the plant or the part of it that is used.

9. Make a list of the animals you are familiar with. Some animals eat plants to survive while others eat other animals. Write in your list who eats what.

10. Make a list of human activities in your area that are contributing to the loss of plant life. Discuss ways of using plants judiciously.

Part 3

11. Find out about persons or organisations in your area working for the protection of plants. Find out what they do. Discuss in your group what they do and list the kind of questions you would like to ask them. Meet them and find out about their work and why they do it.

12. Participate in a role-playing exercise. One person plays the role of a tree. Others take on different roles of insects, birds, cows, farmers, city dwellers, timber merchants, travellers, sick persons, doctors, carpenters, shepherds, etc. Let each character ask the "tree" the question "Tree, tell me how are you helpful to me?". Let the "tree" respond appropriately to each one. At the end, the tree should ask each one 'How are you helpful to me?'

13. Is there a small space available around your school or home? Try to grow some plants there. Take care of them. You may get the sapling from a plant nursery near your home.

14. Develop a set of slogans/messages/posters/paintings on the importance of plants and their care, for display.

Teacher's Guide

Suggested teaching strategy

1. Start with the story of the Chipko movement described in the Scenario. J f there are similar movements in your own area, you may talk about them instead. For example, if you are in North Karnataka, you may start with the 'Appiko movement[1]. If you arc in Rajasthan, you may begin with the story of the Vishnoi community of Khetri. Ask students their opinion on why such movements arc initiated by people. It is useful for the teacher to collect information, newspaper reports and pictures relating to people's movements for environmental concerns.

2. The object of Student Task I is to help the students explore, observe, identify and collect information about plants in their environment. To make this activity effective, the teacher should tell the students about the activity and the tasks expected at least a day in advance. Take the children around the school for a guided exploration of plant life. Enable the children to observe keenly the variety in plant life. Also help them to observe and record the features of different varieties of plants. Lin cou rage them to draw sketches. Let the

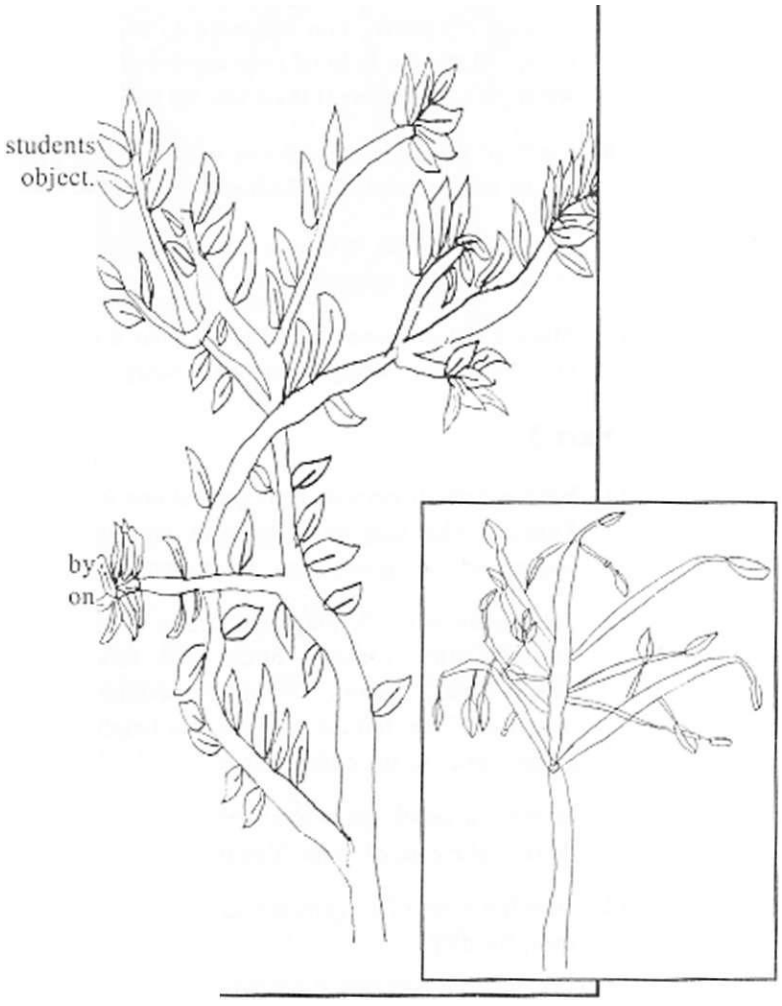
Drawing Pictures

Drawing pictures serves two purposes in science. It provides a way of recording observations, and it also helps students learn to observe more closely. Since every person observes differently and has a different point of view, no two will draw the same picture of the same Thus you should avoid telling students what their drawings should look like, and avoid asking them to copy a picture.

Take the students outside to find real plants to draw. Give the following instructions:

Before starting to draw, look carefully at the plant. Then draw what you see. As you draw, keep looking at the plant to check if you are drawing the way the plant looks. Look at all the details, and draw them.

Assure the students that they can draw themselves. Refuse to 'help' them by drawing their sheets. Help them by asking them (and repeatedly reminding them) to look and draw what they see. Give them plenty of praise and you will find there is not a single student who cannot draw. Don't expect their pictures to conform to your preconceived notions. Accept each drawing for what it is: a student's individual work of self- expression. Appreciate the child-like visions and qualities. Shown alongside are two examples by Class III students who were asked to draw plants in this manner.



students identify the plants by name wherever possible. Encourage them to identify as many plants as possible. They may ask elders for help.

After the exploration, arrange for a discussion of the experiences. This may be done with the entire class as a whole or in small groups. The object of this session is to provide for sharing of experiences. While sharing experiences, children may use the sketches they have made. Arrange for a proper display of the children's drawings.

3. Classification is a very important skill that we need to develop in children. Allow children to group the observed plants in categories of their own choice. This is best done with children working in small groups. Afterwards, arrange for a discussion to compare and examine the various criteria used for classification by different groups.

4. Ask students to collect samples of leaves, seeds, flowers, etc. Ensure that they do not damage or kill the plants while collecting samples. Guide them on how to bring back the collected samples carefully. Old newspapers or a bag arc useful in carrying the collected samples. Help children mount the samples in the manner indicated below:

(a) collect fresh leaves, flowers or seeds
(b) dry the samples by placing them between sheets of newspaper
(c) change the newspaper sheets periodically to ensure proper drying
(d) mount the specimens on a sheet of paper or card
(e) label the specimens.

5. The intention of Task 5 is to enable students to appreciate that plants respond to stimuli like other living organisms. Teachers may carry out any other appropriate activity for this purpose. They should arrange a whole class discussion on the student's observations. Draw attention to the fact that animals, including human beings, also respond to stimuli.

6. Task 6 is meant to develop in children the skills of observation, experimentation and measurement. It also seeks to develop the ability to represent data by graphs and sketches.

7. The objective of Task 7 is to enable children design and conduct simple investigations. Teachers may discuss in the class the ideas of children in this regard and reflect upon them. It is better to take one idea at a time (e.g. what happens if plants are starved of water?). When the method is finalised, the teacher should explain the procedure, step by step, along with illustrations, if necessary. Instruct children to record their observations regularly and systematically. They may do so either in writing or through diagrams or both. During the discussions, the teacher may point out that, like other living beings, there are different varieties of plants. They need light, water and soil in varying quantities and qualities. The observations of children may be discussed periodically during the science classes until the entire experiment is completed. At the end. arrange for a sharing of experiences. After the experiment on one theme, another theme may be taken up.

S. Brainstorming could be used to carry out Task 8. At the end of this session, consolidate the responses of children. You will probably wish to group these into areas such as source of food, aesthetics (beauty), protection against wind erosion of soil, uses such as firewood, timber, etc.

9. Task 9 is to enable students to understand the dependence of all animals (directly or indirectly) on plants.

10. Task 10 intends to bring awarenes in childreıı abouıt various human activities that are threateniıg planı life. Use brainstorming and focus on indiscriminate ıise of plants. Encourage childrcn to comc out with suggestion tor rational use of plant resources.

11. For Task 11 hokl a ınccıing with students and discıiss the purpose of ıhc activity. Ask them to üst the information ıhcy desire to seek. Let thcm üst thc cpıestions. Thcy should obtain the information outside school hours by talking ıo pcrsons in ıhc rcgion involved with thc handlitıg of plants in horticulturc centrcs, forcstry centres, farms, ete. Altcrnatively» pcople m ay be invited to school and an interaction eould be arranged.

12. İn Task 12, childrcn play roles as suggested. Allovv childrcn to innovate and preseni tlıcir ideas through their dialogue with the 'tree'. Lncourage childrcn to makc a resolve that thcy w i 11 be friendlv with trees. The activity can be modified for other themes \vhcrc different pcople ask the tree "Why arc yon angry wiıh ine?" The teacher coııld at îlıe end emphasise the carcful use and sustainability of resources.

13. Task 13 aims at giving practical expericnce in the carc of plants. Teaclıcrs may encourage children to undertake activities like developing a school garden, planting of irecs, ete.

14. Task 14 aims at dcsigning publicity materials. I hese can be in the foı m of posters. slogans, paintings, exhibitions, songs, short plays and skits that focus on the imporlance of plants and how w e should lake carc of thcm. F.vcn compctitions eould be arranged as a part of 'World Hnvironınent Day\ ' World Ilabitat Day', 'World Population Day' or 'VVorld Iiartlı Day[1] cclebrations.

15. Use Student Handout 5 to assess aıiitıidinal or value changes. ifany, among the students.

Notcs for the Teacher

Plants play a very crucial role in maintaining life on our planet. Thcy help to sustain life in nıany ways. İt is important lor the teacher to have kno\vledge and understanding of these. This w i 11 help thc teacher in guiding the students during the discussions. Please ıiote that (his list is meant for teachers and should not be thrust on students.

1. Phocosynthesis (conversion of thc sun's energy inio food)
2. Maintaining the watcr eyele
3. Maintaining thc quality of soil by:

(a) rcduciıig erosion
(b) soil fonnation
(c) inereasing soil fertility
(d) maintaining thc watcr table

fc) maintaining ıhc vvater content of ıhe soil
(0 fixing nitrogen in the soil.

4. Maintaining the Oxygen and thc Carbon eyele (Grcenhouse effect)
5. Rcducing sound pollulion
6. Providing habitaıs for many organisms
7. Forming the basc of thc trophic level
8. F.nhancing the beauty of our surroundings

Student Handout 1 (Studcıt Task 3)

By now you must have become q ıı i t e faıniliar \vith thc plants in yoıır surroundings. Makc a lisi ofthe plants that a re used tor various purposcs in thc space »iven below:

a) Plants used lor making furniturc or building maicrtals:

b) Plants used for medicinal pıırposes:

c) Planls used as vegetables:

d) Plants used as graiıı or food:

e) Plants used for supplying edible frıiits:

f) Plants that are omamental:

Student Handout 2 (Student Task 4)

Observe thc conımonly fourıd plants in your surroıındings. Collect samples of thc plant, prepare sketches and mount specimens on cards. Label eaclı mount with the name of the plant, the datc and place vvhere thc sample \vas collectcd atıd thc usc to which the plant is put. Take the help of your teachers, if ıiccessarv. Prepare as rnaııy mounts as possiblc.

Studcnt Handout 5 (Student Task 10)

Obseı ve the various things in your home that are ınade of wood. Make a 1 ist of (hem. Suggest alternatc materials for replacing wood in each case.

List of'ilems made ofvvood	Possible alternativc materials

Studcnt Handout 6

Ciıven belovv are some statenıents that are incomplctc. Copy ıhem in your notcbook aııd complete each of theııı by puding do\vıı your vievvs. Write the tlrst thought that coıncs to your mind. Do not spend too ıiıuch time on any one iteni. Remember that there are no riglıt or \vrong answers:

Plants are ...

We should take care of plants because

If I vvcre a tree, I vvould have

Trees shoııld not be

To savc trees I vvill

About thc script

This script is intended (o dcvclop in studcnts a concern for preserving and protccling plants,

İt attcmpts to do this by making childreıı faıniliar with thc plants around them by going on ficld trips in thcir ncighboıırhood and collccting samplcs of plants they see therc. İn thc process it is hopcd that they will devclop a practical classification system for thc plants thcy see and collect. This schcınc will nıost likcly bc based on thc characteristics of planls that thcy actually observe.

Thc script should make students awarc of thc basic characteristics of living things and rcalisc that plants arc also living creattıres. Thc activiiics and discussions should expose studcnts to the variety of different ways in wlıich plants arc uscful to us and it is hoped that thcy will come to rcalise the interdcpcndcncc of different living organisms. At the end of thc day thcy should bc able to put forward a point of vicw based on sound arguments on thc nccd for conscrving plant life.

A possible extension of the script is to makc students aware of thc many different ways in which we usc wood in our daily lives and get them to estimate thc total volunıc of wood used in items in thcir homes. By pooling together thc information from ali the studcnts in thc elass one could try and estimate thc total volume of wood that is in use in a typical city and how many trees must have been cut down to provide ali this wood.

WHAT DO WE DO WITH GARBAGE?

BHOLESHWAR DUBEY, PRAKASH BURTE, KISHORE PANVAR
and H. K. DEVVAN

Grade level: Upper primary

Introduction

Everybody wants to keep his or her surroundings clean and free from disease. People clean their houses, collect the garbage and throw it out, since no one wants to keep garbage in the house. As a result, garbage collects at various public places. Shops and other commercial houses also produce large amounts of waste, which is disposed of without care.

What happens to all this garbage?

Science concepts

1. The relationship between unattended waste and human health
2. Classification of waste materials
3. Usefulness of degraded material in agriculture
4. Recycling of waste
5. The process of biodegradation

Previous knowledge

1. Students know the identification of materials on the basis of their visual properties.
2. Students know what is compost.

Teaching/learning materials

Magnet, aluminium pieces, beakers/glasses, lemon juice, lime water, large bowl/bucket, mesh supported by a wooden frame, soft (eloth covered) board.

Students' Guide

Senario

Surat, an industrial and business city of Gujarat, encountered a severe community health problem with the spread of a plague epidemic a few years ago. Many people died and the rest of the population fled the city. A massive city cleanliness campaign was launched. As a result the situation returned to normal. From this experience, the local administration and citizens launched a special effort to maintain the cleanliness of their city. Today Surat is regarded as one of the clean cities of India, due to its proper garbage disposal management. The Surat episode can be repeated wherever a proper garbage disposal system is licking and people's awareness towards the sanitation of their local surroundings is low.

Nowadays all villages and cities are facing garbage management and disposal problems. This is a side effect of economic growth and carelessness towards natural resources. If we fail to tackle this problem, "civilized" habitats will not only be unaesthetic, but will also pose health and environmental problems at enormous social cost.

Therefore, it is desirable to find ecologically friendly ways for garbage disposal. Can it be degraded or recycled? Let us find out.

Yo ur Tasks

1. Identify the ways of garbage disposal being practised in your village town.
2. Identify the materials commonly discarded as garbage and categorise them.
3. Suggest how to make garbage disposal easier by sub-dividing the way in which garbage is collected.
4. Organise the collection of garbage in the school or in the area where you live, based on these different sub-divisions.
5. Perform lests to identify different kinds of garbage. Relate the results to the natural degradation as well as the treatment of garbage.
6. Understand the meaning of recycling by making recycled paper. Find out what other garbage items are recycled.
7. Undertake a project to make compost for the disposal of wet garbage. Explain what you leave learnt about biodegradability from your project.

S. Suggest a garbage disposal system for your village or town. Preset this to the village/town council. Explain how it works on a small scale in your school.

Teacher's Guide

Suggested teaching strategy

1. Conduct n brainstorming session on the problems of garbage disposal in your village/town is this a big problem, if so why, and what can we do about it? It is suggested that the teacher write "garbage problem" in a box in the Centre of the blackboard with ideas suggested by students being written around it. All student ideas should be included.

2. It is expected that the questions "What is garbage? How do we dispose of it at present?" will come up. Students work in groups of 4-5 to find out how garbage is disposed of, e.g.,

- allowed to remain wherever it is thrown
- sorted
- carried away
- treated.

For this they can visit common dumping grounds and interview people in the neighborhood. Student Handout l contains a suggested set of questions to which answers are sought.

3. Students then discuss what can be done to improve garbage disposal. It is expected that they will suggest separating the garbage so that different kinds of waste materials can be handled separately. If this idea does not arise, the teacher will need to guide the discussion in this direction.

A. As group work, students suggest how the garbage can be sub-divided. Members of the groups üst the different categories and put forward ideas how this can be done.

5. In a whole class meeting, each group puts forward its list. From this the class decides on the categories into which the garbage can be sub-divided. Here the intention is that in future the different categories will be collected separately and hence they need to be simple. The categories could be:

wet garbage (things that rot) - organic matter, and
dry garbage (things that don't rot)

(a) plastics
(b) paper
(c) glass
(d) metals
(e) other.

6. Once the categories have been set up. the students arrange for separate collection bags/bins for the different categories. These are then placed around the school for the collection of garbage. All students are guided to make use of these containers. To assist users, it is probably helpful to colour code the different garbage collectors, e.g. red for wet garbage, yellow for plastics, green for glass, black for metals and blue for paper.

Students can also try to do the same in their neighborhoods. For this the class will have to be divided into groups of 4-5 students who live close to each other.

7. For this system to work it will be important to check the containers every day. It will be necessary to make sure that everybody remembers to put things in the
proper bin. For.

example, the Principal should address the whole school if the system is abused. Only by diligently enforcing the system front the beginning is it likely to prove feasible to collect separated garbage.

8. Student groups now decide how the collected garbage should be handled. To help them, groups undertake a series of experiments to find out more about garbage and the ways it can be handled, by following the relevant Student Handouts.
9. Student Handout 2 involves testing
   (a) plastics
   (b) glass
   (c) aluminum and iron
   (d) paper.

   The purpose of these experiments is to find out how these materials can be treated.

   Plastics can be separated into two categories by the fact that some rnelt and burn and others (e.g. Bakelite - used for electric sockets, switches) do not. Make sure that students do not inhale the fumes emitted by burning plastics. By comparing the results of the melting test with the information obtained from rag pickers, one may perhaps be able to conclude that plastics that melt can be recycled.
   Glass is harder and smoother than most plastics. A domestic coal fire (angHhi, kangrî) will give a sufficiently high temperature that glass can be softened. İt shows that glass does not have a definite melting point (plastics share this property). Take care that students use small pieces of glass only (these can be obtained by wrapping the glass object in a thick towel and hitting it with a hammer). Do not attempt to that any glass object that is sealed (e.g. electric light bulbs) because there is a great danger that they will explode when heated**. If these precautions are difficult to enforce**, the test should be omitted.
   Iron can be detected using a magnet. İf a magnet is not available, it is possible to make your own electromagnet using plastic-coated wire wrapped in a coil around a nail and connected to a battery. This electromagnet has to be used with care. İt will get hot if Icfl connected for any length of time and of course this \vtll quickly rtın the battery Hat.
   Iron also reacts with acids and hence lemon juice will give the outside of iron objects a clean appearance as it reacts with the outer surface. If the acid is strong enough, it may be possible to detect bubbles of gas being given off. Aluminum is amphoteric and reacts with both acids (lemon juice) and bases (lime water).
10. Paper can be recycled and tlıe experiment here is to do just that. For the success of this experiment, oııe should shred the paper as small as possible and use a fine mesh which is tightly stretched aeross a \vooden l'rame (Student Handout 3).
11. Organic (wet) garbage is biodegradable. To introduce this idea, students are asked to observe dutııped garbage over a period of time (Student Handout 4).
12. After the activities in Student Handouts 2-4 have been carried out, the teacher çatı lead a discussion on what is likely to be involved in the treatment of garbage.
13. The project work involves making a compost heap. Students should be able to suggest how to carry out the project for themselves. Composting can be done in small pits, earlier

pots or even in a plastic bucket by dumping Household garbage and covering it with soil in layers, followed by regular moistening for 30 to 45 days.

14. Students meet their neighbors and the elderly persons of the locality. They discuss the problem of garbage and talk about the possible health hazards of unattended vaste. They seek community support in managing garbage disposal of the town so as to keep their surroundings clean. They explain the system of garbage collection set up in the school and suggest that a similar system be operated in the village or town. Its success depends on a good community spirit with citizens willing to lıclp the system succeed by carefully separating their garbage. Furthermore, since the burning or recycling of plastics leads to air pollution, impress on people that it is better to minimize the use of plastics as they can cause a variety of environmental problems.

Student Handout 1

Visit a common area where garbage is dumped in your locality. Try to find out answers to as many of the following as you can. You may also need to interview people who live in the neighborhood.

1. What kinds of items/materials are dumped as garbage? This may require handling the garbage. Do so with care, looking out for sharp or pointed objects. Remember to wash your hands with soap and water after handling garbage. Make a list of different things found in the dump.

2. Who puts garbage in the dump?

3. Does anyone handle the garbage after it is thrown on the dump? Is it sorted? If there are rag pickers in the locality, try to talk to them to find out what items they look for and what they do with them.

Student Handout 2: Testing garbage materials

This worksheet involves testing (a) plastics, (b) glass, (c) aluminum and iron and (d) paper.

(a) **Testing for plastics**

(i) Inspect the material. This is likely to give some idea as to whether it is plastic.

(ii) Is it pliable or is it very hard and rigid? If pliable it is likely to be plastic.

(iii) Heat a piece of the suspected plastic. Docs it melt? Does it burn? **(Avoid inhaling any fumes (hat may be emitted from burning plastics.)** A pliable material that also gives a positive melting or burning test suggests a plastic material. [Unfortunately, if it is brown, is not pliable and does not melt or burn it can still be plastic **(in this case, Bakelite**)!.

(iv) It is possible to separate plastics based on density **(float on kerosene, float on water but not on kerosene, float on lubricating oil but not on water**).

(b) **Testing for glass**

(i) Inspect the material. This will give a good indicator whether it is glass. (Normally, glass is smooth and transparent, and can't be scratched with a fingernail.)

(ii) Heat a piece of glass on a coal fire. (Do this very carefully!) Does it melt slowly? This indicates glass (glass does not have a definite melting point but softens slowly on heating).

(e) Testing for aluminum and iron

Equipment Needed

6 container, water, lemon, lime water* and a magnifying glass.

Consumables

3 pieces of iron and 3 pieces of aluminum.

Experimental Procedure

1. Test the waste material with a magnet and collect 3 pieces of iron or steel. For the aluminum use pieces of foil from cigarettes, medicines, or food wrapping.
2. Put the pieces of iron into separate containers (plastic, glass or ceramic). Label the containers A, R and C. Similarly, put the pieces of aluminum into containers labeled X, Y and Z.
3. Add some water to containers A and X.
4. Pour saturated lime water in containers B and Y.
5. Squeeze one lemon each into containers C and Z.
6. Cover all the containers with lids or Petri dishes.
7. Put all the containers in a safe place for one week. It is helpful to stir from time to time and to add more water should the original amount become substantially less.

Observations

1. Note changes in each of the containers. Particularly look to see if the metal has reacted with the lime water and/or the lemon (acid).

2. Observe all items with a magnifying glass. Record any apparent reaction of the iron or the aluminum.

3. If a reaction is suspected, test the solution by slowly adding lemon juice or lime water (the opposite to the reactant used in the original test) and look for the formation of turbidity. The cause of turbidity will be an insoluble hydroxide (iron hydroxide or aluminum hydroxide).

Caution: These hydroxides are soluble in acids, so an excess of lemon juice can make the turbidity disappear.

* Lime water can be made by adding water to lime paste (*chuna*) which is readily available at any *paan* shop. The lime water should be saturated, i.e. there should be an excess of solid at the bottom of the container. This is because hydrated lime (calcium hydroxide) is not very soluble in water. Other alkalis can be substituted e.g. washing soda, sodium hydrogen carbonate (bicarbonate of soda), and milk of magnesia.

(d) Testing for paper

Paper is usually pretty easy to recognize. A good test is that it bums.

Student Handout 3: Making recycled paper

Equipment required
Large bowl/bucket, mesh supported by a wooden frame, soft (cloth covered) board.
Experimental procedure
1. Tear up the paper into small pieces and put in water.
2. Allow the paper to soak tor 4-5 hours.
3. Stir and break up the pieces so that a uniform water/paper mixture is formed. The pieces of paper should now be very fine and all about the same size.

4. Place a mesh frame* horizontally into the mixture with the mesh-side up and slowly pull upwards (see figure). Allow the water to drain, leaving paper particles on the mesh.

5. Carefully invert the mesh and press the frame gently onto a cloth board. This should transfer the paper from the mesh to the board. If this is a problem, check that the board is not too hard and that the frame can be settled comfortably on it. Repeat these steps if thicker paper is required.

6. Aİİ0W the paper to dry.

7. The thickness of the paper depends upon the amount of paper in the paper water mixture and whether one or more layers of paper are deposited on the board.

* Making the mesh frame

The frame needs to fit horizontally inside the paper Avatar mixture container. Therefore do not make the frame too large. Using wooden strips (1 cm x 1 cm is fine but other sizes are also appropriate) make a frame. The corners can be cut at 45" or can be left at 90°. Fix the frame using nails or reserves. Stretch a mesh over the frame. Mosquito netting can be used as the mesh, but a metal mesh can be stretched better. Secure to the other side of the wooden frame using pins or nails. Make the mesh as tight as possible.

Student Handout 4: Biodegradability

1. Mark out a small patch of land. Dump garbage in it for a week. Allow the garbage to remain for a month. Take care that garbage is not blown away. I.ook at the garbage again after a month. Which parts of the garbage remain as they were and can still be identified?

2. Take two banana skins. Keep one in the open on a dry surface where it is exposed to the sun. Keep the other on damp earth and moisten it every day. Look at both of them after a week and see if there is any difference.

Biodegradability: a Note

Solid materials left in the open undergo a process of degradation due to the action of air and water. This involves physical changes (weathering) and chemical changes due to reactions of materials with water, dissolved substances, oxygen and other gases present in air. For example, iron rusts. copper develops a green coating, etc.

For organic substances, another kind of degradation plays an important role. This is biological degradation or biodegradation. Our environment - air, water and soil is full of microorganisms. These have enzymes to break down many complex organic molecules into simpler substances, which arc used as food by the organisms. In the process some of the simpler substances are emitted in the form of gases. Many of the emitted gases such as hydrogen supplied and phosphine have unpleasant smells. This process is what we call rotting or decomposition. Rotting plays a very important role in Nature. as it prevents the piling up of solid waste. Most naturally occurring organic materials arc biodegradable and hence do not present a long-term problem of disposal although they can be health hazards if not disposed off properly. However, artificially produced materials such as polythene and PVC are generally not biodegradable. They tend to pile up in the environment and thus pose a serious disposal problem

About tlıe script

This unit is a product of the concern about the problems of garbage disposal and the threat to public health from inappropriate modes of garbage disposal. The concern arises primarily in urban and semi-urban areas, although even rural children may find themselves being faced with similar problems. It is assumed that students know the identification of materials on the basis of their visual properties.

It is expected that students will be able to suggest a possible classification of different types of garbage. They should also be able to perform simple experiments for the identification of waste materials. It is best not to propose any rigid classification scheme for the types of garbage because its composition may be quite local specific. In an earlier version of the script it was suggested in the 'Teaching Strategy' that aluminium could be one of the categories. However, a preliminary enquiry by one of the authors in a semi-urban area revealed that hardly any aluminium was to be found in garbage. In fact, in rural areas a family will never thro\v out any metal waste.

The scientific concepts involved are those relating to tests for the identification of waste materials, degradation, biodegradability and the possibility of the recycling of waste material.

The authors hope that, after the unit has been done in class, students would be appreciative of the need for better garbage disposal systems, and willing to participate in building public awareness to this end.

One possible direction in which the present script could be extended is to try and establish a connection between proper waste disposal and public health as has been pointed out in the Scenario. It might also be worth having a look at the script called The Loo Story.

IS EXAMINING TEETH A GOOD WAY TO SELECT DOMESTIC ANIMALS?

KAMAL MAHENDROO, KALURAM SHARMA, VIJAY DUA and U. S. POSTE

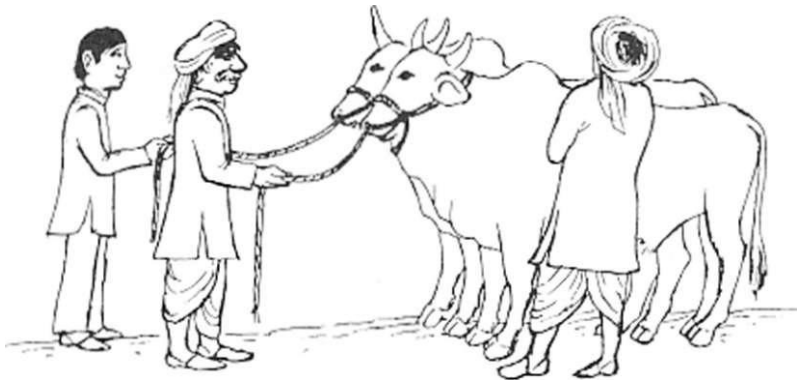
Grade level: Classes VII-VI1I

Introduction

Villagers do a number of interesting things at the time of purchasing an ox. They cautiously regard the strength of its shoulder. They observe the lower part of the neck and the symmetry of its horns. A glazed skin is preferred. What it eats is carefully considered. Sometimes they pull and twist its tail. The tongue is observed. The age of the animal is estimated on the basis of the number of teeth, their wear and their shine. Different aspects are considered while purchasing different kinds of animals. When a cow is bought, factors like the quality of the teats may be considered to be important, for a goat the factors to be seen may be different. One of the things that is almost certain to be examined is the teeth of the animal.

Scicnce concepts

Function of different types of teeth



Students' Guide

Scenario

Rajaram's grandfather bought a pair of bullocks from the animal fair. When others in the village saw the bullocks, they were full of praise. One of the village elders came and looked at (he bullocks. He rubbed their backs, twisted their tails, looked at their teeth and exclaimed, "Wow! What a pair of bullocks!"

When the villagers had left, Rajaram asked his grandfather, "What are the things one should look for when buying bullocks?"
"Identifying good bullocks is not something everyone can do. Some people are experts and they can tell a lot about the animal just by looking at it carefully. But even you can tell the age of a cow, bullock, buffalo or horse by looking at its teeth", said Grandfather.

"I! How can I tell the age of an animal from its teeth?" asked Rajaram in surprise.
Grandfather said, "Firstly, by counting the teeth, secondly, by their shine and thirdly, by looking at how they sit in the mouth".

Your Tasks

1. Find out which animals are commonly bought and sold around your area. What arc the aspects of the animals that people look at when they buy different animals?

2. Create a questionnaire so that you can interview farmers in your locality to learn

(a) how they can tell the age of an animal by looking at its teeth

(b) how they can tell whether the animal is healthy by examining its teeth.

3. Look at the teeth and lower jaw of animals that cat grass, leaves or any other kind of fodder, e.g. cow/bull, buffalo, goat, rabbit, etc. What kind of teeth do they have?

4. Find out, by discussing with the teacher or from a book, about the teeth and the jaws of a cat, a dog or other such animals. How are they different from the teeth of grass-eating animals?

5. Study your own teeth. Find out how many different types of teeth you have, and how many of each type. Are your teeth different from those of a grass-eating animal? How do they compare with those of a dog?

6. Think about the purpose of the different types of teeth and put forward suggestions why you think (he different teeth arc arranged in the manner you have observed. Find out if other animals also have different types of teeth. What is the advantage of the particular combination of teeth they have?

7. Have a discussion in the class on "What would life be like without teeth?"

8. Make a list of ways you and others in your group keep your teeth healthy.

Teacher's Guide

Suggested teaching strategy

1. Students talk about the animals that they think are usually bought and sold in their areas. They can visit the local markets (hoots) to find out which animals are sold.

2. During the visit to the market, they talk to people selling or buying animals and ask them what they look for while selling or buying an animal. The data should be carefully recorded and organised. One way of organising it is to record observations about different body portions separately. A format for this is provided in Student Handout 1.

3. Assist children in compiling the data for the entire class and put it on the blackboard. One way could be putting down the data in a tabular form as in Student Handout I, but you are free to devise your own system with the students.

4. One aspect that is looked at by people buying animals is the teeth of the animal. Have children think about the features of teeth that arc examined and how they help the buyer decide which animal he/she would buy.

5. Students, in groups, devise a questionnaire so that they can interview a farmer to find out

(a) how they can tell the age of an animal by looking at its teeth

(b) how they can tell whether the animal is healthy by examining its teeth.

This questionnaire should be shown to the teacher before being used to interview farmers. A sample questionnaire is given in Student Handout 2. Students interview fanners and record their responses to the questions. Subsequently, they analyse the results of the questionnaire.

6. Students in groups examine the teeth of grass-eating animals like a calf, a cow, a buffalo, a rabbit, etc. They record for each animal the different kinds of teeth, the number of each type of teeth, its age, and the nature of its lower jaw (Student Handout 3). By consulting books in the library or elsewhere, students try to find out the arrangement of teeth in carnivorous animals like cats and dogs. If they find any differences in the teeth arrangements of different animals, they attempt an explanation.

7. Students in groups undertake an activity to count the number of teeth they have and try to determine the different types of teeth and how many of each type there are. A worksheet (Student Handout 4) guides students to record their observations and to suggest the purpose of the different types of teeth. Students can put forward suggestions why they think the different kinds of teeth are arranged in the manner they are.

8. At this point, you could ask the class to consider what life would be like without teeth. Through brainstorming the teacher can create a list of foods that could not be easily eaten without teeth.

9. This activity leads obviously to the need to take care of teeth. Students in groups can be asked to make a list of the ways that they take care of their teeth. This will include points such as brushing their teeth at particular times and being careful about what foodstuffs they eat. Ideas from each group can be shared with the whole class, by each group making a presentation.

Student Handout 1

Kallu wanted to buy a pair of bullocks and a couple of buffaloes. He took Rehman *kaka* along with him to the Umretha fair, where a large number of cattle had been brought to be sold. Kallu found two bullocks that looked very healthy and were good to look at. Rehman *kaka* looked at them and examined their teeth carefully. He was very happy with them until he counted the teeth of both the animals. He said, "They don't have the same number of teeth and won't make a good pair." Kallu then pointed at another well-built bullock and said "That's a good animal too." *Kaka* said, "Yes, but it has a big *jhalar* (fold of skin) below the ncck." Kallu said, "But my *Mama* in Sohagpur bought a bullock like that." *Kaka* said, "Yes, a big *jhalar* in bullocks is preferred in the Sohagpur region, but not here." The buffaloes also came in for close examination, with Rehman *kaka* looking carefully at their teats and feeling the region between the nostrils.

When you go to the market, see what animals are being sold. Find out from the buyers how they select an animal for purchase. Ask them all the things they observe and the reasons for observing them. Record the information separately for each animal, under specific body parts. You can use the table below, adding more columns as needed.

Serial number and name of animals Body parts		Animal 1 : Bullock	Animal 2
HEAD	Horns - colour, rings		
	Forehead		
	Jaws		
	Mufal		
	Ears		
BODY	Skin and hair - colour, glow, flexibility, ctc.		
	Proportion		
	Muscles		
TAIL	Length		
	Hair at end		
OTHERS	Teats		
	Excreta		
BEHAVIOUR	Herding		
	Quiet or not		
	How it stands up		

The table shows some of the things people observe while looking at animals. Your questions may lead to entirely different observations. Record them too. For example, some people believe that the horns should be neither too hot nor too cold, the *mufal* (space between the nostrils) should be cold and wet, a buffalo's ears should not be too big, the faeces should be soft and not hard, the urine should not be thick, etc. You may also find that there are many other characteristics that arc observed. Feel free to add more rows to the table if necessary.

After you come back, take your teacher's help in compiling the data gathered by all the groups into a large table. Check if you all get a consistent set of things to look for while examining different animals. Can you sec the logic behind the different choices? Are there any contradictions in what the different features arc thought to reveal about the animal being examined?

Student Handout 2

Create a list of questions you would like to ask farmers to find out how and why they examine the teeth when they are considering purchase of domestic animals.

Questions might be

1. When you purchase an animal do you look at its teeth?
2. What do you look for when examining the teeth?

(a) the colour?

(b) to see if they are worn?

(c) to see if any are missing?

(d) their size?

(e) the number?

(0 the sharpness of their edges?

(g) gaps between them?

(h) their pattern in the lower and upper jaw?

(i) the symmetry of their arrangement?

3. Is it possible to say something about the health of the animal by looking at its teeth? How can this be done?

4. Is it bad if there arc gaps between the teeth? Why?

5. Can you tell the age of an animal by observing its teeth?

If so, how is this possible?

What do you look for?

Student Handout 3

Be careful when you go to look at the teeth of any animal. Keep in mind that the animal may be upset if you trouble it. There are four types of teeth that you may find. These teeth have different functions. You have to ask your teacher how to recognise them before you start. Count the number of teeth of each animal carefully and record the pattern of their arrangement. Also see if any of these teeth are fused together. You may find that the jaw and the arrangement of the teeth of grass-eating animals look something like what is shown in the figure.

Notice the plate-like structure. Of what advantage is this plate to the animal? Also observe how the plate moves.

From your teacher, a library book or some other source, try to find out how the teeth of a meat-eating animal, such as a cat or a dog, are arranged.

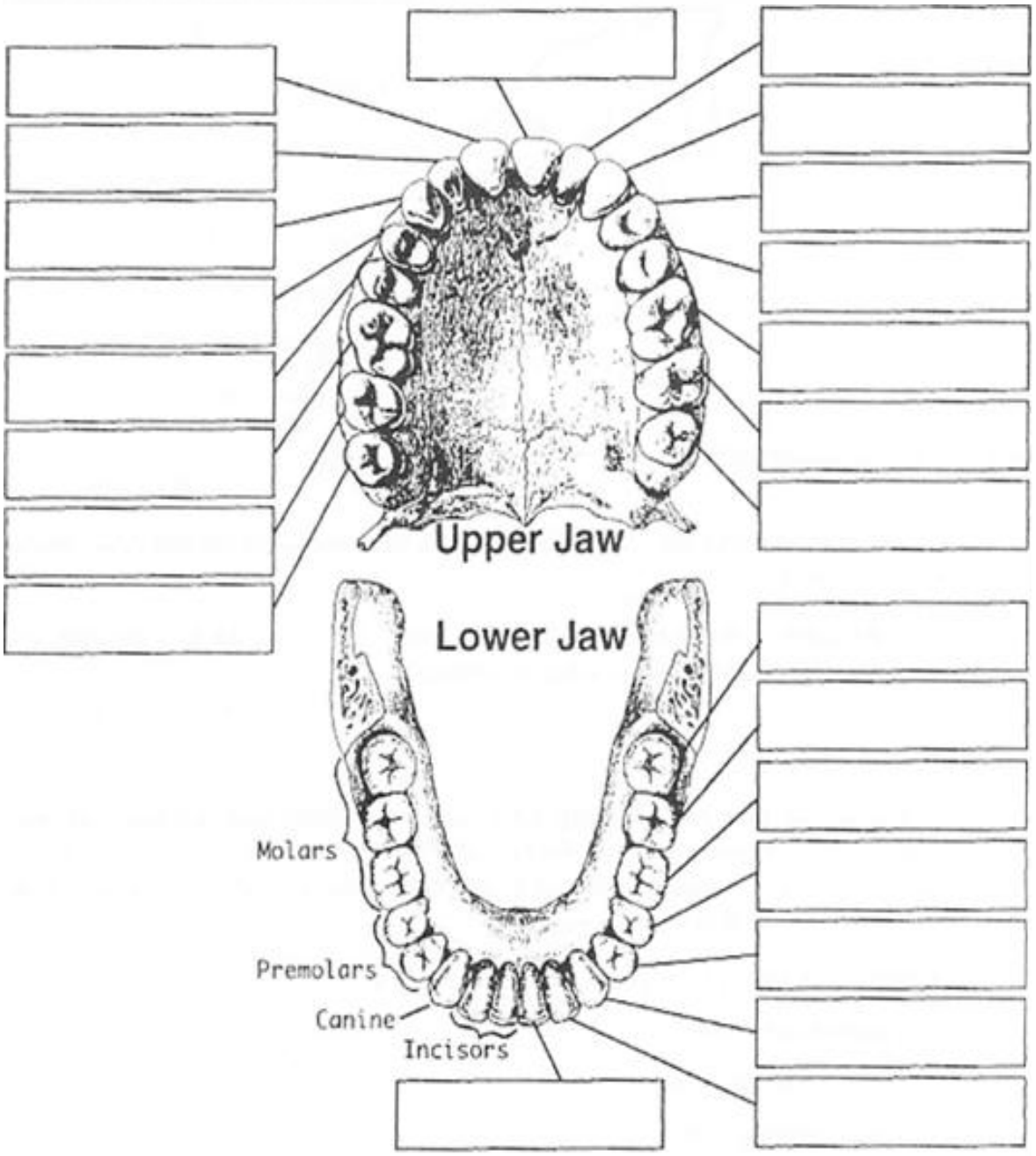
Student Handout 4

1. You clean your teeth every morning, but have you ever really examined them carefully? Look inside your own mouth with the help of a mirror. How many types of teeth do you have? How many of each type do you have? Record the information. Do you have the same number of teeth as others in your group?

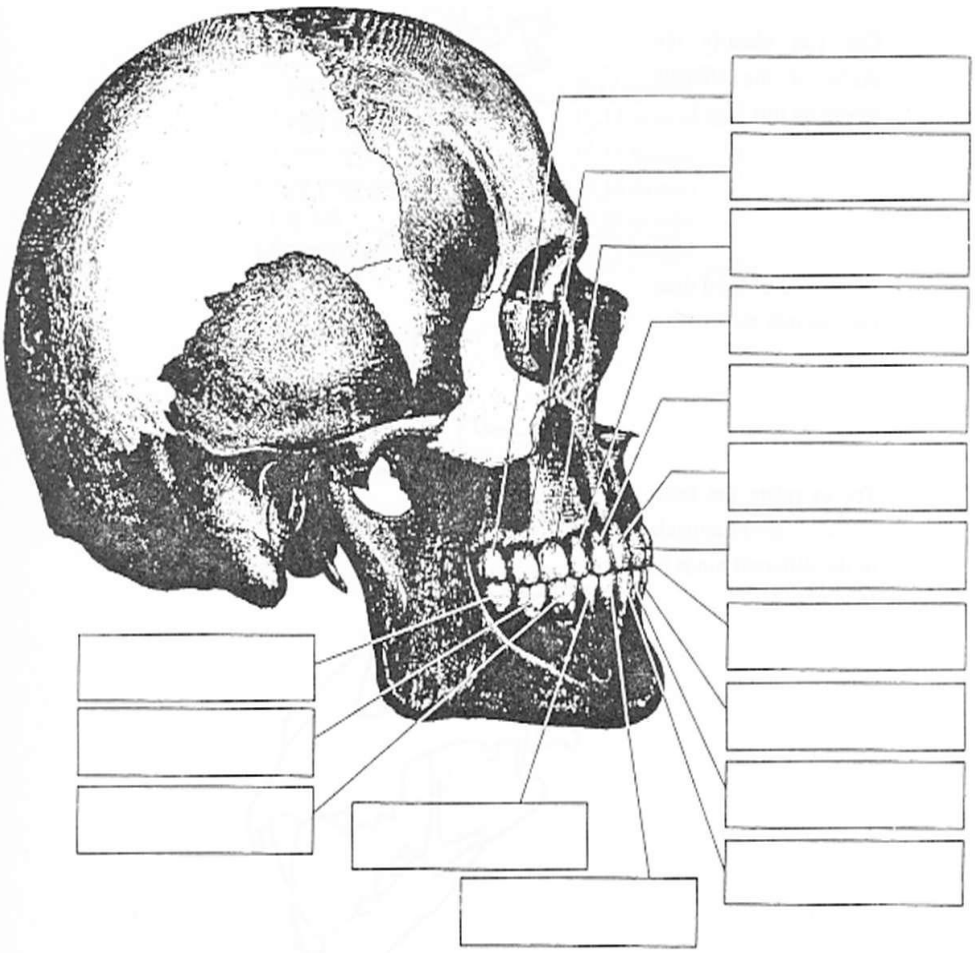
2. Examine each type of tooth and determine whether it is
   (a) pointed and strong
   (b) has a broad top surface
   (c) has a sharpened end.

   Suggest in each case whether the tooth is good for
   (a) cutting
   (b) tearing
   (c) grinding.

3. Different types of teeth have different names. Some of the teeth in the following picture *have been labelled. Use what you have found in (2) to label the remaining teeth.*



4. Now label the teeth in this side view of the human skull.



Student Handout 5: A puzzle with animal skulls

Can you identify the skulls of the animals shown on this page?

What kind of food does each animal eat?

Try to relate the teeth of the different animals to the different kinds of food they eat.

Information for the Teacher

1. There are 32 teeth in a human adult: 8 incisors, 4 canines, 8 premolars and 12 molars.
2. All the teeth of frogs, geckos and fishes are of the same kind, whereas cows, goats, horses, dogs and elephants have teeth of different kinds.
3. The teeth on the sides of the jaws are used for chewing food. If these molars were in the front of the jaws, what kinds of problems would arise?
4. It is possible to tell the age of an ox by looking at its teeth.
5. Ask a farmer or a person in your village or town who is a professional buyer or seller of cattle what one looks for when buying an ox.
6. The table below gives information on which teeth appear when in a human child.

Upper central incisors	9-12 months
Upper lateral incisors	12-14 months
Lower lateral incisors	14-1S months
First premolars	15-16 months
Canines	20-24 months
Second premolars	30-32 months

About the script

In rural and semi-rural areas, there are a large number of folk practices associated with the buying of domestic animals. This script arose out of the question of the scientific basis of such practices.
After carrying out the activities in this script, students are expected to be able to identify different kinds of teeth. They should be able to explain the functions of the different kinds of teeth in mammals, and to appreciate that there is a connection between diet and dentition. It is hoped that this will also lead them to understand the problems associated with the care of teeth, and to take better care of their own teeth.
Studies by the authors at animal fairs have failed to throw much light on the initial question, namely, do the traditional activities performed at the time of buying cattle have a scientific basis? However, it is hoped that students will be able to at least engage in the question, giving plausible reasons for their statements.
At the follow-up Workshop in Delhi, a participant commented that this script highlights the fact that, in real-life situations, it is often impossible to control all variables to carry out a systematic study.

4

CAN YOU HELP FARMERS CONTROL THE WEATHER?

J. K. MOHAPATRA and A. K. DAS
Grade level: Classes VI - VII

Introduction

This script is based on (he desire to help farmers cope with the vagaries of weather. It suggests that science could provide solutions to recurring community problems.

A farmer who watches helplessly as his crop is destroyed by drought can only blame his fate. Another, who finds that his crop has been laid low during a storm in the night, interprets it as the curse of the 'Wind God'. It is possible that such superstitions would become less widespread if human action could be seen to reduce the effects of such calamities.

People believe that the weather cannot be controlled. It is certainly difficult to control the weather on a large scale. People have tried many experiments (do you know of any?) to cause rain during a drought, but almost all such experiments have failed. However, it may be possible to control the effects of weather on a limited scale. For the farmer, controlling the effects of weather amounts to controlling the weather.

Science concepts

1. Wind is the movement of air.
2. Air exerts pressure.
3. Difference in air pressure controls wind speed.

Teaching/learning materials

Thermometer, coloured paper, calendar, funnels, cans or containers, ping-pong balls, string, drinking straws, etc.

4

Students' Guide

Scenario

This is a story about a village located in the district of Dhenkanal in Orissa. The village is in a valley surrounded by hills. It is a compact unit. The villagers have their houses, their agricultural land, a school, a public health centre, a small weekly market and a small community place where people assemble to discuss common problems and seek solutions.

The village is surrounded by hills. The only access to the village is from the north-east, where there is a natural passage because the hills do not meet on that side. One natural calamity the villagers have to face is that almost every year in December a strong north-easterly wind damages their crops, sometimes blowing away the temporary roofs of the shops in the marketplace and even damaging the more permanent roofs of their thatched houses.

When this happens, the villagers meet as a community and contribute liberally to help those afTcctcd. But is this the only solution? Can you help them 'control' the wind?

Your Tasks

1. Describe weather and list the factors which affect it. Which of these can you measure?
2. Measure daily the temperature and the rain that has fallen in the previous 24 hours near your school. Record these measurements on a chart.
3. Discuss different weather patterns and the problems that can arise from the vagaries of the weather. List the different kinds of damage that can be caused by excessive wind.
4. Make simple instruments to measure the direction and speed of wind.
5. Do experiments to understand what air pressure is, and the relation between differences of air pressure and the movement of air.
6. Discuss with your friends how one can reduce the effect of wind on crops, roofs, etc. Test your ideas in open fields, orchards and the wind-shadow of a wall. Can the planting of trees in strategic locations help in any way?
7. Prepare a three-dimensional model of the area around your school or village showing the plantation of trees, their location and their shape.
8. Write a report for the local community on how to reduce the effects of excessive wind.

Teacher's Guide

Suggested teaching strategy

1. The teacher introduces the lesson with a brainstorming session in which students are asked to describe different kinds of weather. Typically they may come up with suggestions like sunny, rainy, windy, cloudy, cold, hot, etc.
   The teacher should then ask for factors which affect the weather. They will probably come up with factors like location, time of year, presence of hills, oceans, lakes, rivers, etc. All suggestions should be listed on the blackboard.
2. Students, in groups, should be asked to come up with suggestions for a weather chart. The teacher should then guide the different groups to adopt a common colour code for each weather condition, such as 'sunny' - yellow. Students should cut out squares from coloured paper and stick the square matching the weather of the day on the calendar. The colour-coded pages of the calendar should be displayed in class. This activity should be carried out for a whole year. Students should be encouraged to interpret the data displayed on the calendar.
3. Students, in groups, should be asked to make a rain gauge (Student Handout 1). This should be used to keep a daily record of the rain that fell in the previous 24 hours. A thermometer should be used to measure the temperature at a given time cach morning. Students should be encouraged to carry out this activity throughout the year if possible.
4. The teacher can introduce wind through another brainstorming session so as to understand pupils' experience-based constructs about such issues as:
   (a) What is wind?
   (b) What damage can be caused by strong wind or storms?
   Possible responses that may emerge arc that strong winds
   - affect vegetation and crops
   - damage houses and structures
   - blow away roofs of thatched houses
   - cause soil erosion.

   It is possible that one may get responses such as: wind affects the flight of birds or aircraft, but in the framework of our Scenario such responses may be eliminated through negotiations.

5. Students make their own wind vanes to find out the direction of wind (Student Handout 2). They also devise simple ways to measure wind speed. One possible way is using the familiar *charkhis* (paper spinners), which they make for themselves. A measure of the wind speed could be the number of rotations the *charkhi* makes per minute when held against the wind. Another kind of wind speed indicator can be made following Student Handout 3.
6. During a whole class discussion, the teacher explores the understanding of students on:
   (a) the use of a thermometer to measure temperature

(b) 4wind being the movement of air
(c) the pressure exerted by the atmosphere (students can be shown how to use a barometer if one is available in school or in the neighbouring high school)
(d) movement of air being from regions of high pressure to regions of low pressure (c) movement of air causing a fall in pressure.

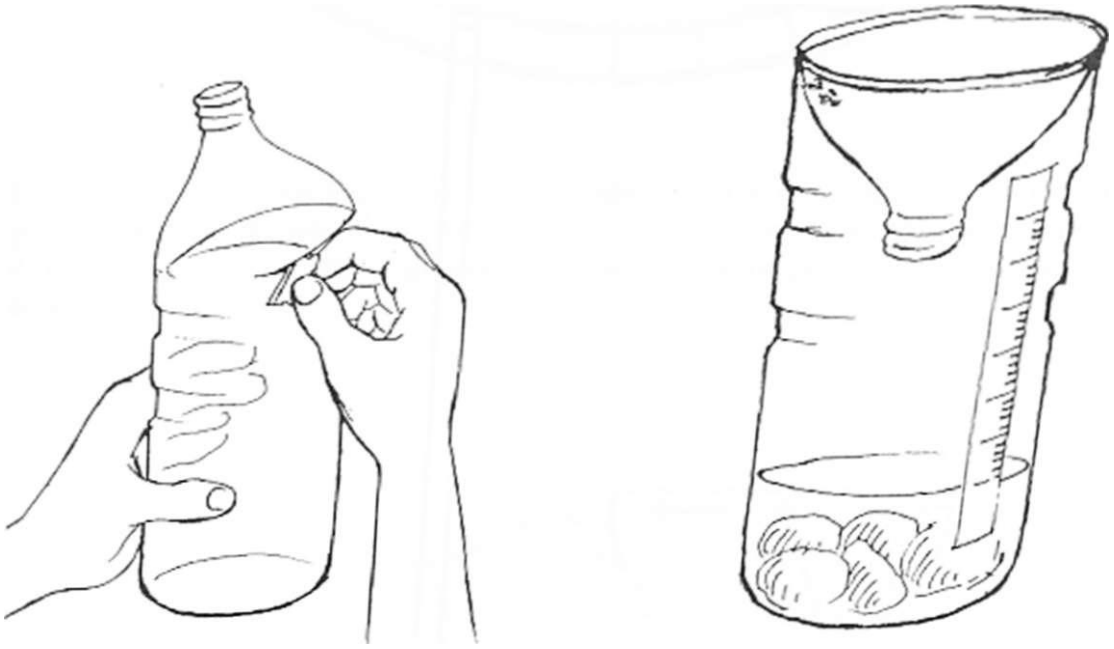
7. Students, in small groups, perform experiments to clarify these concepts as necessary (Student Handout 4). The teacher should go round the groups asking questions to determine students ability to interpret the experiments.
8. Students can be taken outside on a windy day for field study. They carry their wind vanes, *charkhis* and wind speed indicators with them, and measure the speed and direction of the wind at various locations. Here, instead of accuracy, what is important is that students learn how to improvise, design and carry out an experiment. Observations may be taken
   (a) in an open field
   (b) in an orchard or bamboo grove
   (c) standing in the wind-shadow of a wall.
9. The teacher may initiate a group discussion on where the speed of the wind is less and help the students to conclude that:
   (a) planting of trees reduces the speed of the wind and hence its power to cause damage
   (b) suitably built walls can also work as wind-breakers.
10. The teacher can assist students in making a 3-dimensional model of the village described in the Scenario, and elicit suggestions from them regarding
   (a) places for the plantation of the trees
   (b) types of trees to be planted
   (c) the pattern in which the trees could be planted.
11. The teacher can ask students to write down other benefits of planting trees. Some of the ideas that students could come up with arc that the planting of trees:
   (a) protects against soil erosion
   (b) keeps the surroundings cool or controls the temperature
   (c) provides clean air by using up CO2 and releasing O2
   (d) provides flowers and fruits.
12. Students in groups are asked to explain how wind is generated, explain the possible causes of damage to crops and the lifting of roofs by strong winds. They are asked how to minimise the effects of high winds on crops and houses. These explanations are then presented to the rest of the class and a common report is prepared on what actions should be taken to combat strong winds.

Student Handout 1: A rain gauge

A simple rain gauge can be made using a plastic water bottle. Cut off the fop, invert it, and use it as a funnel.

A strip of centimetre graph paper about 2 cm wide should be pasted on its outside and labelled 0, 1, 2, 3 ... along the centimetre markings. It is essential that the zero mark should lie some distance above the bottom of the bottle. Put some small stones in the bottom to prevent the bottle from blowing over.

The rain gauge should be set up every day by filing it up to the zero mark with water, placing the funnel over the mouth of the bottle and leaving it out in the open. Al the same time the next day, the level of water in the bottle should be checked to see if there is any increase. Any increase would indicate the number of centimetres of rain that fell in the previous 24 hours.

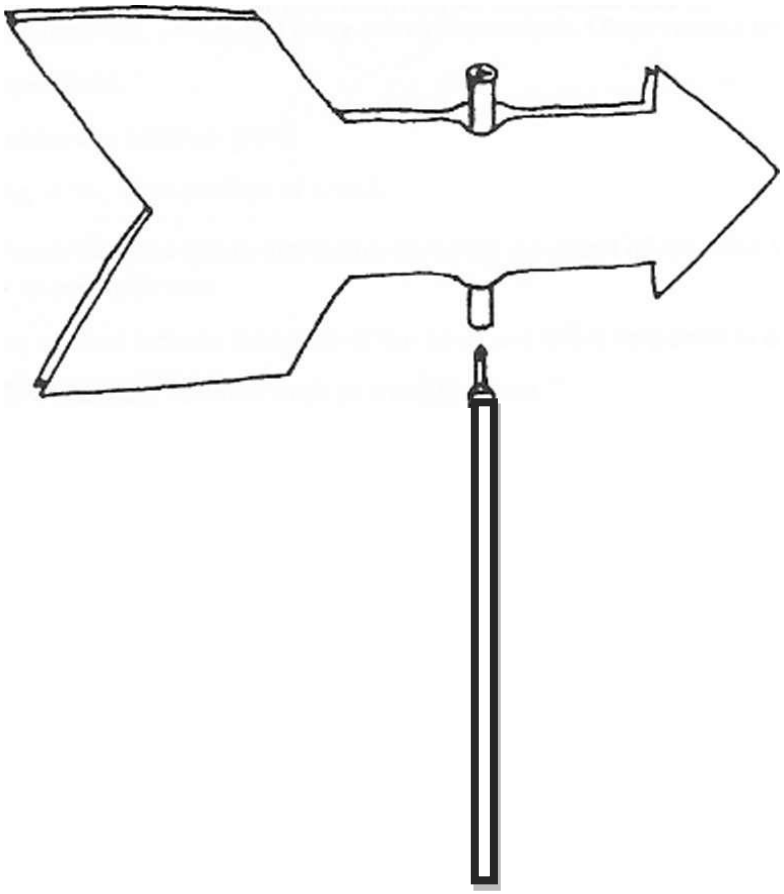


4

Student Handout 2: A wind vane

Work out your own way of making a wind vane, or try this suggestion:

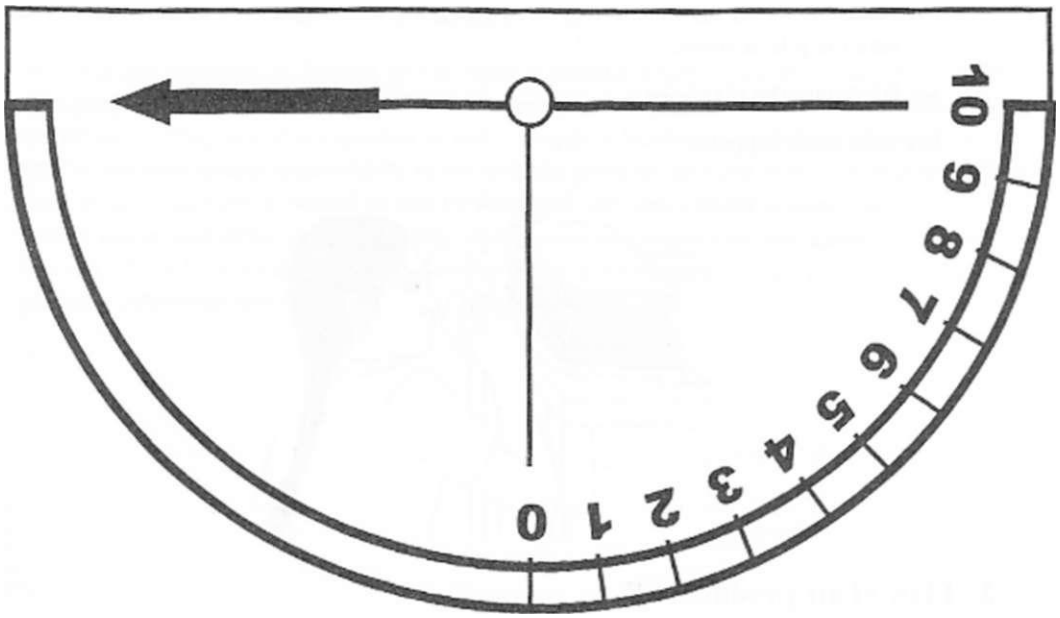
Cut a piece of a used ball-pen refill as shown. Glue an arrow cut from a card sheet to this piece. Stick the arrow on top.



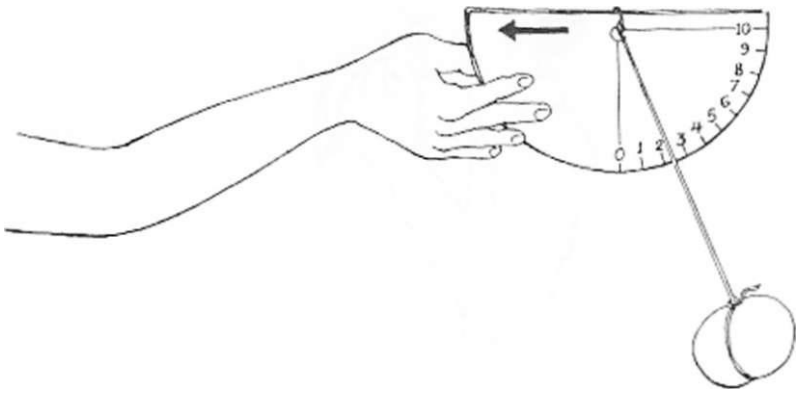
4

Student Handout 3: A wind speed indicator

Cut out the protractor shape shown below and paste it to a thick card sheet. Cut the card sheet in the same shape and make a hole as indicated. Tie one end of a string to the hole and attach a light object to the other end. The object could be a ping-pong ball, a wad of paper, or something else.



Hold the protractor vertically, the arrow pointing into the wind, and see how far the object gets blown. Note the maximum gust strength using the scale of I to 10. You may need to try different objects as weights to get one that is best for the range of winds to be found in your area.



4

Student Handout 4

1. Use air to lift weights

(a) Place a plastic bag flat on a table, but gather the open end together so that it is possible to blow air into the bag.
(b) Place books on the plastic bag. You can place as many books as you like but make sure the pile is stable.
(c) Blow into the plastic bag.
(d) Note what happens.

2. Flow of air produces lift

(a) Take a strip of paper (5cm wide and 10-15 cm long).
(b) Hold the strip over your index finger.
(c) Bring the finger to your lips (the end not held will droop).
(d) Blow hard over the top of the strip. Observe what happens.

4 About the script

This script is still in a preliminary stage and we expect that it will undergo major modifications when it is tried out in the field. It arose from an attempt to relate activity in the science classroom to a problem that actually affects a community, even though such a problem may not be very widespread. It should therefore be viewed as an attempt to develop teaching units that are locale specific as an antidote to the strongly centralised curriculum development which is the norm in our country.

Students are expected to discuss and develop a weather chart. They are expected to make a rain gauge and use it along with a thermometer to keep a record of the daily rainfall and the temperature. They are also expected to make simple indicators for wind speed and direction, and to perform simple experiments to do with air pressure and the effect on pressure of the flow of air. They are expected to put forward and test ideas about minimising the effect of strong winds and write a report on this topic based on discussions and experimentation. By the end of the Unit students should develop some understanding of the relationship between pressure difference and air speed.

4

WHY IS THE SUPPLY OF ELECTRICITY SO ERRATIC?

RAKESH MOHAN HALLEN and R. JOSHI

Grade level: Classes VII-VIII

Introduction

This unit draws on the common experience of the erratic supply of electricity in India particularly during summers. Students are encouraged to investigate the possible causes of frequent power failures in their neighbourhood and to think about how they can help to make them less frequent by avoiding wasteful consumption.

Scientific concepts

1. Electrical circuits
2. Series and parallel circuits

Teaching/learning materials

One set of the following items will be required for each group of 4 to 5 students: two bulbs or LEDs, dry batteries (two 1.5 Volt cells in series for LEDs), connecting wires, rubber bands, aluminium foil, etc

Students' Guide

Scenario

Have you ever faced a situation when you could not complete your homework or read a story or watch your favourite programme on TV because there was no electric supply? You might have wondered what goes wrong with the electric supply or why it is so erratic. This unit may help you to find answers to such questions.

Your Tasks

1. Find out the main source of electric supply to your locality. Find out how it reaches your home or your school from the powerhouse. Present this information in the form of a diagram.

   Discuss and prepare a list of the possible reasons why the power supply is erratic.

2. How will you connect a torch bulb or a light emitting diode (LED) and a battery so that the bulb or the LED will light up? Draw the diagram of such an arrangement. Compare your diagram with those drawn by your friends.

   Get a bulb (LED) and a battery (two dry cells in series for an LED) from your teacher and connect them together as shown in your diagram so that the bulb (LED) lights up.

3. Draw diagrams of the different ways in which a battery and two bulbs (LEDs) can be connected so that both bulbs (LEDs) can be made to light up. Show these diagrams to your teacher and ask his help in identifying them as either series or parallel circuits.

   Set up the series and parallel circuits in turn and see whether individual bulbs (LEDs) can be separately switched on or off(you will need to combine with another group to do this with the LEDs so that you can use two batteries in series). How must the batteries be connected to each other to do this? Which type of circuit, series or parallel, do you think is used for supplying power to homes or schools?

4. Understand the working of a fuse by making a simple fuse and blowing it up. When does a fuse blow in your home? Could the blowing of a fuse be one of the reasons for an erratic power supply?
5. Make a list of the electrical devices found in your home noting down the power rating of each in watts or kilowatts. Understand the relationship between the power rating of a device and the electrical energy it consumes in one hour of operation. Estimate the total number of units of electrical energy consumed in a month in your household assuming reasonable figures for the amount of usage of each device. Does this estimate match the consumption recorded in your monthly electricity bill?

   Estimate the total power required to run all the appliances that are normally switched on in the evening in your home. Collect this information from each of the members of your group. As a class activity, estimate the total power requirement in kilowatts at peak usage time for the whole of your locality. Include in this estimate the different types of consumers in your locality - shops, factories, street lamps, etc. Compare your estimate with the total power sanctioned/available to your locality.

6. Discuss in the class, possible consequences of the power supplied being less than the demand for electricity. Could this be one reason for the erratic power supply in your

locality? Discuss in the class and make suggestions as to how to you can deal with such a situation.

7. Estimate the amount of electrical energy that could be saved if every household in your locality switches off one lamp of 60 watt for one hour. Discuss in the class other ways of saving electricity and the need for its judicious use.
8. Discuss various possible causes of disruption in the supply of electricity and understand the importance of the use of reliable equipment and the role of proper maintenance in ensuring an uninterrupted supply.
9. Discuss in groups what actions can be taken (by the Electricity Board or by yourselves) to remove or reduce the problem of an erratic electricity supply. After presenting your ideas to the other students in the class, create a combined list of all suggestions and use this to devise a questionnaire to administer to the local Electricity Board to seek their views on your ideas.

Teacher's Guide

Suggested teaching strategy

The best time to use this module is when there are frequent power breakdowns in the school or at the homes of students.
A breakdown of power supply in a particular locality can be due to:

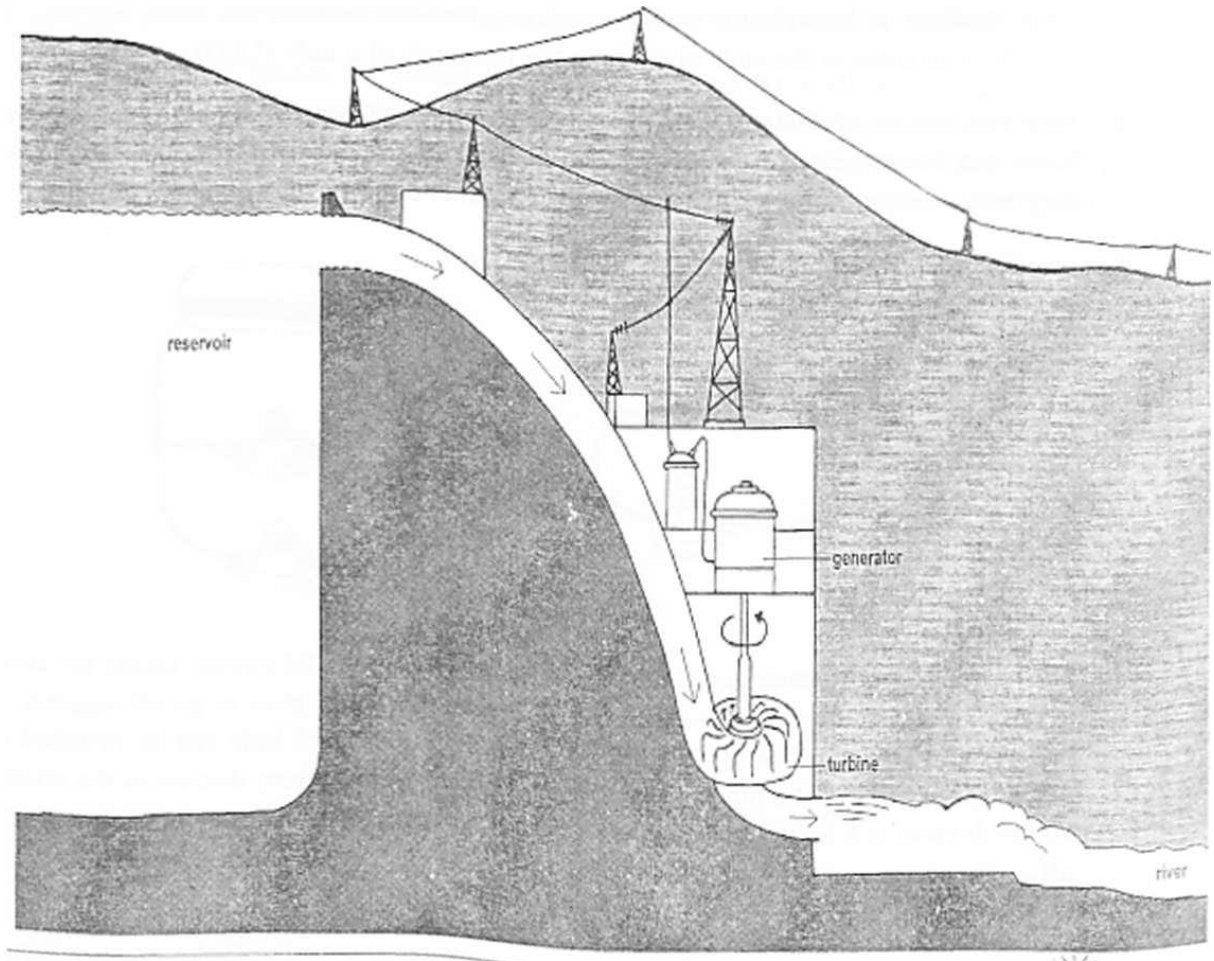
- improper maintenance or poor quality of the equipment installed
- overloading of transmission lines
- deliberate load shedding by the local power distribution agency
- natural calamities.

A particular household may not have power because of:

(a) overloading of the circuit causing a fuse to blow or a circuit breaker to trip

(b) short circuit due to defective equipment.

I. As a whole class activity, arrange a group discussion to find out the prime source of electric supply for the village or city or town in which your school is located. Try and draw a map of ihe path taken by the supply from the powerhouse to the school with the help of inputs received from the students during such a discussion. The adjoining figure may help you in visualising such a diagram. You will need to know which thermal or hydroelectric powerhouse supplies electricity to your village, town or city. You will also need to know its generation capacity or the total power available to your locality.



4. You may also ask students to list the different situations in which an electrical devicc like an electric lamp or a fan stops working. The answers will probably fall under the following categories:

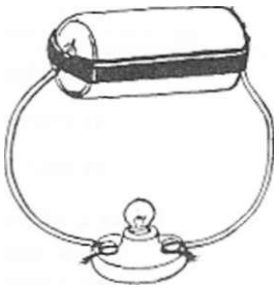
(a) switching off or disconnecting the device from the power source

(b) blowing of a fuse

(c) defects in the device or the circuit

(d) disruptions of the power supply.

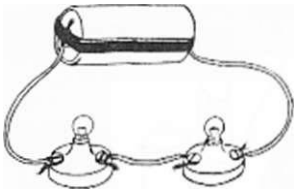
2. You should now introduce the concept of a simple electric circuit (comprising a source, an electric device and connecting wires) as illustrated in the figure. Get students to work in small groups of 4 or 5. Provide each group with one set of materials listed in the Introduction. Ask each group to set up a circuit by connecting the bu.lb and the battery, disconnecting a wire to act as a switch. Ask them if the bulb would light if its filament were broken. The idea is to get them to note that a device stops working if the supply of current from the source is stopped due to a break in the circuit or due to a defect in the device.

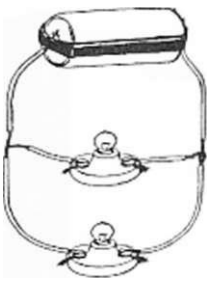


Students are expected to make the circuits without having to use a cell holder. They should improvise a cell holder from a thick rubber band cut from an old inner tube of a bicycle. The rubber band should be stretched over the length of the cell so that the bared ends of two wires can be lodged between the cell and the rubber band at the two ends of the cell. The teacher should test out an arrangement of this kind before asking children to do it in class.

Help students to identify the positive and negative terminals of dry cells and also show them how to connect the ends of wires to the terminals of a bulb (LED).

3. Now ask groups of students to draw circuit diagrams of the different ways in which two bulbs can be connected to a battery. Check the circuits drawn by each group to sec that they each contain examples of a series and a parallel circuit.





Provide materials to each group to set up a series and a parallel circuit. Guide the students to observe that in the case of a series circuit both bulbs either glow or go off together when the circuit is switched on or off while in a parallel circuit each bulb can be switched on or off independently of the other. On the basis of these observations discuss in the class why all the devices in a house or factory do not stop working as soon as one of them is switched off

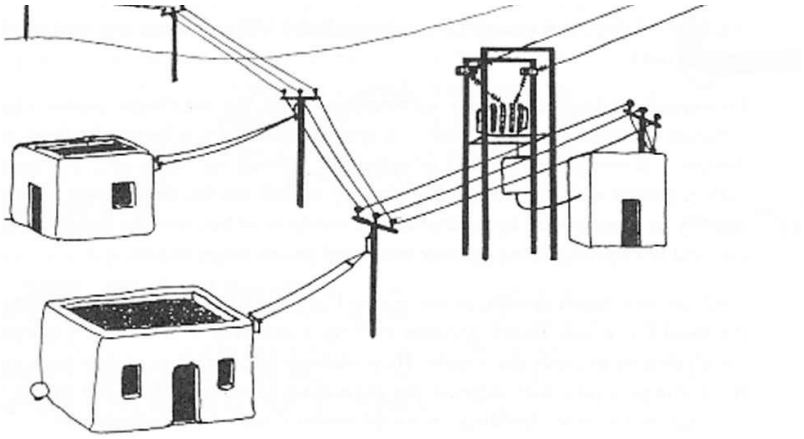
Student Handout 1:

Electric supply

On a separate sheet of paper:

4. Draw a picture showing how electricity reaches your school.
5. Write down the main source of electricity to your village/town/city.
6. List the possible causes of an erratic Electric supply.

Student Handout 2: Electric circuits



Before you set up your circuit by connecting different components, read the following instructions carefully:

- Get your circuit diagram checked by your teacher before setting it up.
  » Identify the positive and negative terminals of the dry cells given to you to set up the circuit.
- Check that once the circuit is complete, the bulb (or LED) lights up. If ibis does not happen, check your connections. If still nothing happens, ask your teacher for help.
- As soon as your bulb or LED is lit, disconnect one wire in your circuit. This is to save your battery. Do this after each observation.

On a separate sheet of paper draw pictures of:

1. the way you would connect a bulb (LED) and a battery to make the bulb light
2. two possible ways in which you would connect two bulbs and a battery to make both bulbs light.

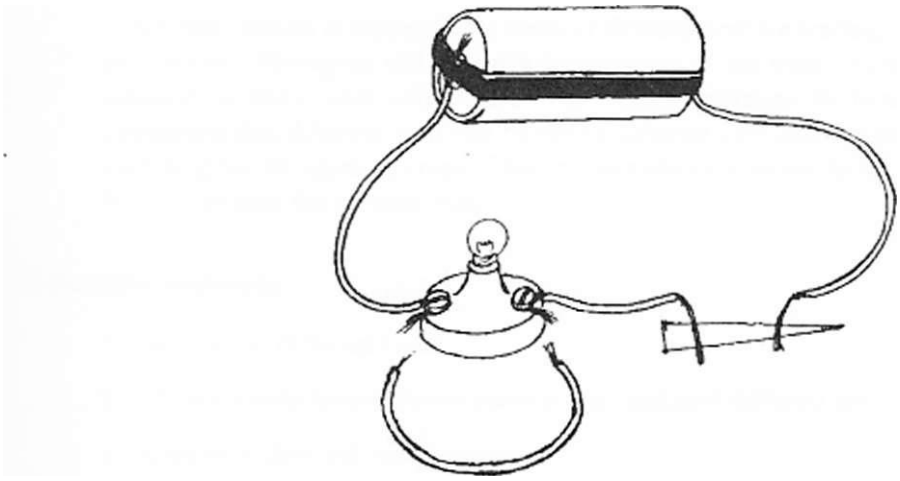
Set up these circuits in turn and see if they work.

4

Students' Handout 3:

Fuses

Cut a strip of thin aluminium foil from an old cigarette packet in the form of a narrow, Iong triangle (base I cm and height 3 to 4 cm). Now make the circuit shown with the help of a bulb, a battery and the aluminium strip. Hold the two wires in contact with the aluminium strip, one near the base of the triangle and the other near the tip. Does the bulb glow? Now ask your friend to short the bulb by joining the two terminals of the bulb with a piece of wire. If the tip of the aluminium foil is really narrow, it should gel very hot and burn out. Does the bulb still glow? Does an electric current still flow through the circuit? Based on this experiment, can you describe in your own words how a fuse works?



About the script

This module has been designed to help students realise the problems related to the availability of an uninterrupted supply of electricity. It is intended to help them understand the basic concepts of an electrical circuit; in particular, when a circuit can be said to be complete. It is also meant to enable them to distinguish between series and parallel circuits and to represent them by appropriate circuit diagrams.

Frequent power breakdowns have become so much a part of our life that we often accept it as routine without ever giving a thought whether wE as individuals can help in eliminating this inconvenience. This script is meant to draw the attention of students to social attitudes which pay no attention to the wasteful use of resources. Although power failures are sometimes due to the breakdown of old equipment (which points to the need for better maintenance), the script should enable students to realise that the frequency of such failures can be reduced if we are careful in avoiding unnecessary consumption of electricity.

4 **BASHIR AHMAD DAR**

Grade level: Classes VI-VII

Introduction

Agriculture and farming are among the earliest human activities. Ancient civilisations usually flourished on the banks of rivers that had fertile land around them. Agriculture remains one of the major activities in India with 60-70% of its population engaged in it.

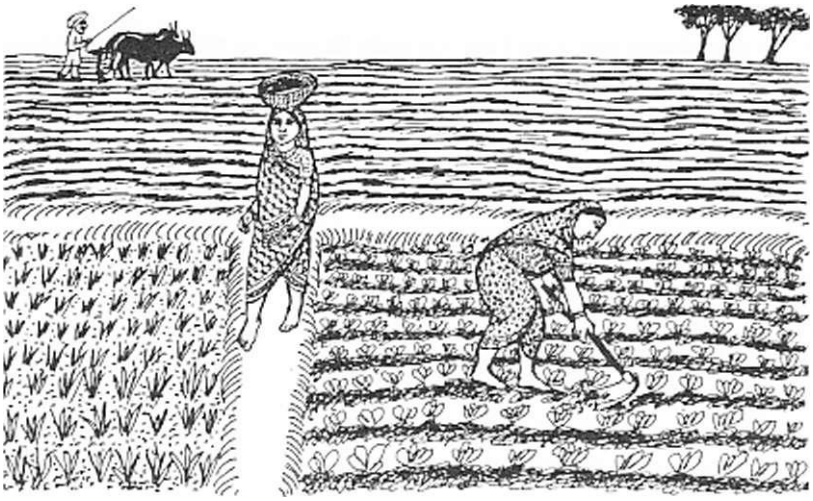
It is becoming increasingly necessary to produce more food for our growing population. To increase food production we need to maintain the fertility of our soil. Deforestation and other undesirable human activities in the name of development are leading to loss of fertility and to soil erosion. Managing soil properly is necessary if we wish to conserve it. For this it is essential to know what soil is and what factors determine its fertility. It is necessary to understand that different soils can be put to different uses and that one single soil cannot be used to grow all types of crops. This unit introduces students to the different types of soils that can be used for growing food.

Scientific concepts

1. Soils are of different types.
2. Different soils have different particle size, and hold different amounts of water and air.
3. Soils have different compositions.

Teaching/learning materials

Polythene bags, funnel, filter paper or blotting paper, sieves of different mesh sizes, a magnifying glass or a thick lens from an old pair of reading glasses, a measuring jar, a pair of scales or a common balance.



4

Students' Guide

Scenario

If you look around a village, the majority of the people are engaged in agriculture. If you live in a village you may have noticed thai it is possible to have two households farming nearly equal areas of land and yet one can be prosperous while the other barely grows enough to feed itself. Why is this so? What determines how fertile the soil is in a plot of land? How can the fertility of the soil be improved?

Your Tasks

1. Suggest ways to produce more food.
2. Determine the properties of clay, *sandy soil and humus.
3. Compare the properties of different soils and relate this to their composition.
4. Discuss the constituents of soil and why each is important.
5. Put forward arguments to support your suggestion of what should he the constituents of fertile soil.

6. Develop and administer a questionnaire to find out what farmers think is fertile soil.
7. Prepare a report on fertile soil, carefully supporting any claims made with suitable evidence.

Teacher's Guide

Suggested teaching strategy

1. Begin with a brainstorming session on how to produce more food. The ideas will vary enormously and the teacher will need to follow up by zeroing in on soil so that students see a relation between production of food and the quality of soil.
2. The whole class then considers questions like:

What is soil?
What is soil made up of?
Are all soils similar?

3. Assuming the students are not able to give full answers to these questions, the teacher guides students to carry out investigations in groups of four or five using Student Handout I. These activities should involve the students in:

(a) determining the properties of clay, sandy soil and humus using the handout provided
(b) Determining the proportion of clay, sand and humus in the soil samples.

4. To consolidate understanding of the role of each constituent of the soil, every group is asked to suggest how they would try to overcome the following problems:

(a) the soil is lumpy
(b) the soil is powdery and dry
(c) the soil is very wet
(d) plants in the soil are easily uprooted. No unique answer is expected.

5. Each group summarises its findings and decides what is a fertile soil. Each group presents its conclusion to the class. A whole class debate then attempts to arrive at a consensus on what is meant by fertile soil.
6. Each group devises a questionnaire to ask farmers their views on what constitutes fertile soil. After the groups discuss these with each other and arrive at a consensus, they administer the questionnaire to farmers in the region.
7. A group discussion takes place on why all soils are not fertile and whether fertile soils will remain fertile in the future. If not. what responsibility do people have today to make sure thai fertile soils remain fertile tomorrow? Outcomes are presented to the rest of the class.
8. Each student writes a report on fertile soil '.o be submitted to the teacher.

4

Student Handout 1:

What is soil?

Working in groups, carry out the tests given below on (a) clay, (b) sandy soil and (c) humus (used for plants in pots).

Work on small samples from each type of soil at the same time, with different members of the group testing different soils. One member of the group should record all the findings and these should be shared among all members at the end.

7. Look at the sample using a magnifying glass.
   Record the colour and texture of the sample (does it stay in one piece and how difficult is it to separate its constituents).
   Rub the soil between your fingers. Is it sticky?
8. Feel the sample. Which of the following can be used to describe how the soil feels? (you can choose more than one if appropriate)
   1. silky
   2. smooth
   3. damp
   4. sticky (e) sharp

   (f) gritty , or

   (g) describe in one or two words of your own how it feels).

9. Size of particles in the soil:
   Collect 4 sieves of differing mesh sizes. Using dry samples, separate the different sizes of soil particles with these sieves, starting with the one with the largest size mesh (coarsest). Weigh and record the amount of soil left in the sieve after each sieving.

First Sieving	Second Sieving	Third Sieving	**Fourth** Sieving

Describe in a few words the kind of particles and their sizes after each sieving. Are there any stones in the soil?

4. Soil may contain a number of things. It may have animals (small insects) or bits of plants. To find out, take a sample and look at it carefully using a magnifying glass. Make a list of things you find in the table given below:

Living	Non-living

5. Does the soil hold water?

Take a sample and weigh it. Place it in a dish, crumbling any lumps. Leave it to dry in a warm place fur a few hours. Reweigh.

Weight of soil sample before drying = g
Weight of soil sample after drying = g
Difference = g

Explain any difference that you find.

How will you know if you left the soil to dry for long enough?

10. Drop a small ball of soil into a jar of water and observe what happens.
(If the soil is too powdery to make a ball, wrap and lie it up in paper tissue.) Describe what you see.

1. Count the number of bubbles rising in, say, 5 minutes.
2. Now compare the number of bubbles from a smaller and a larger ball of soil.
3. Compare the number of bubbles from a wet and a dry ball of the same size. What are these bubbles of? Explain your answer.

11. How well does the soil drain?

1. Place a bit of cotton wool in a funnel.
2. Take a known quantity of soil and place it in the funnel (it should half fill the funnel).
3. Pour water over it and using a measuring container- find the volume of water collected in 5 minutes.

Measure this amount for all the other soils and compare.

4

Student Handout 2:

Composition of soils

Using the experiments given in the previous Handout, investigate the composition of:

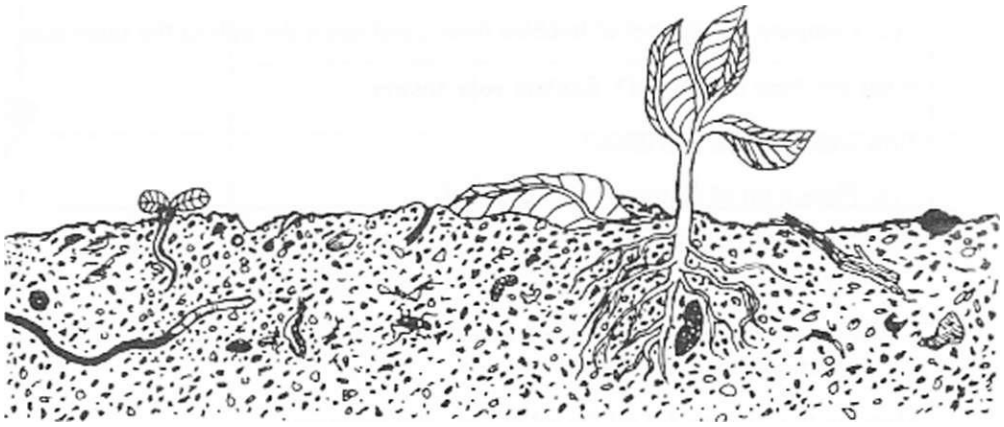
(a) soil samples from different places
(b) a soil sample from the surface and one from a depth of 30 cm
(c) soil from the same place but collected on a wet and on a dry day.

Record your findings. Study them and suggest the likely composition of the soil (do not forget to mention if air and water are present in the soil).

Student Handout 3

With the help of the activities you have done so far, you should have found out that soils are likely to contain clay, sand and humus. You have discussed the likely proportions of each for fertile soil. This questionnaire is to determine whether farmers have a consistent view of what is fertile soil and whether their ideas agree with yours.
You need to develop a set of questions that can enable you to obtain the views of the farmers. Be careful that the questions are not too vague e.g. 'what is fertile soil?'. The farmer is unlikely to answer such questions in terms that you will find useful.
Do ask questions such as:

1. Is the presence of worms in the soil a good sign? Why?
2. Can you describe soils in which many worms are to be found?
3. Would you describe such a soil as a fertile soil?
4. Can there be other types of fertile soils? Can you describe them?
5. How much clay, sand and loam would you suggest is needed in a fertile soil?



4

About the script

This script was developed to make students familiar with some of the properties of soils and the factors on which their fertility can depend. They are expected to develop suitable procedures to test samples of soils and become familiar with their composition. Students are expected to learn about the fertility of soil by doing experiments and talking to farmers about what is a good soil. They du this by recording and interpreting their observations and by collectively devising a questionnaire and administering it to determine the views of farmers. It is hoped that by the end of this Unit they will begin to see that it is a common social responsibility to look after the fertility of the soil for future generations. The author has tried out this script in a few select middle schools and reports that the response was good.

4 Students' Guide

Scenario

li is almost as if plasties have become an iniegral part of our lives. Put to every possible and conceivable use from house doors to car parts, from clothes to various types of containers and bags, they have slowly replaced materials like metals, glass, wood, ETC. This is especially true of packaging of materials used in our daily life, in which various types of plastics are used extensively.

But what happens to all the plastic materials once they have outlived their usefulness? I low do we dispose of them in the home or in the school? What happens to plastics after they are thrown on rubbish dumps along with household garbage, or simply thrown out on the streets by people who don't care? Why are people talking about the threat to the environment and human life posed by the excessive use of plastics and the way in which they are disposed of.[1]

Let us explore some of the questions posed above. By performing experiments, collecting information, going to places and meeting people, perhaps we can find out some possible answers.

Your Tasks

12. Look around your home and school and note down the variety of uses of plastics. Discuss them with your classmates and prepare a detailed list of uses plastics are put to.

13. Prepare a list of all plastic materials discarded from your home in a week. Divide the list into categories such as plastic bags, containers, wrappers, clothing, etc. Estimate the percentage of plastics in the total waste. Hence estimate the waste being generated by 100 households, and how much of it would be plastics.

14. Classify the collected (discarded) plastic materials based on any criteria you can think of.

4 Undertake tests to distinguish between different plastics. Find out more about them based on their strength, behaviour when heated, solubility, etc. Reclassify the collected plastic materials based on the results of the tests.

1. From an encyclopaedia or any other source, try to find out the reasons why different plastics have different properties.

2. Set up an experiment for finding out about the biodegradability of plastics.

3. Visit a plastic processing unit and find out the common name, chemical name and structure of the plastics being processed. Try to find out what additives (colours, plasticiser, etc.) arc being used and why, and also the complete chain in the recycling of plastics.

4. Find out, from any available source, whether the additives being used are carcinogenic (i.e., cancer causing).

5. Write a brief report based on your visit detailing the processing of plastics. Also write a brief note about how the plastic recycling chain functions.

   Note: In case you are unable to visit a processing unit, collect the above information from various sources like petrochemical companies, reference books, etc.

Suggested teaching strategy

15. Begin with a whole class discussion on how plastics have invaded our lives and how they are slowly replacing traditional materials like glass, porcelain, wood, paper, etc. in day-today use. The discussion should lead to an assignment for students to observe and note the variety of uses plastics are put to, and to prepare a detailed list. Student Handout 1 could be used for the purpose.
16. After students have come back with their individual lists, there can be a further discussion guided by the teacher about the possible uses of plastics, ending up with an exhaustive list of plastic usage. The teacher may ask the students to prepare collectively an exhaustive list of plastic usage and display it in the class. This could be done by pooling together lists prepared individually by each student as well as by small groups.
17. Ask students to collect discarded waste plastic materials from home for one week, or some other suitable period of time. Help them to make categories based on usage, such as plastic bags, wrappers, etc. See Student Handout 2.

■4. Guide students in estimating the percentage of plastic waste vis-a-vis the total waste generated by a household. Show how different techniques can be used to estimate waste generation. For example:

1. Multiply the waste generated by one household by one hundred to get an estimate about 100 households. It may be better, however, to get an average based on the data provided by the whole class and multiply it by 100.
2. For estimating the waste generation by a city, the number of households can be calculated by dividing the total population by the average number of members in a household (4-5 for example). Then total waste generation can be calculated based on the above data.

The result should be recorded in Student Handout 2. Emphasis may be laid on the enormity of disposal of such a huge quantity of waste.

2. Students should be encouraged to create equivalent samples of various types of plastic waste and design tests for finding out:
   2. pliability/strength (e.g. how much weight a sample can take without stretching)
   2. effect of heating (small samples in a test tube could be taken)
   2. effect of water, cooking oil, methylated spirits, petrol, eic. on plastics.

   flic presence of the teacher is necessary when students conduct these experiments. The teacher must see to it that students do not inhale fumes created by heating/burning of plasties.
3. The teacher could make suggestions regarding reclassification based on the results of the experiments. Also if felt necessary the teacher may encourage students to find out
   3. common names of various types of plastics
   3. chemical names and formulas of the above

(c) reasons for varied properties of the plastics.

In case students are unable to get the above information, the teacher may have to demonstrate to them how to use various sources like encyclopedias, the Internet, etc.

7. Facilities for conducting the experiment on biodegradability should be planned in advance so as to avoid last-minute confusion. Advance planning may include:

(a) demarcation of sites for pits

(b) tools for digging
(c) availability of varied waste materials including plastic waste
(d) availability of common salt
(e) dating of the pits.

The question of the use of common salt to aid decomposition could be discussed and reasons could be inferred. The effort should be to let students discover for themselves that plastics are not biodegradable. Also a discussion could be held on how non- biodegradability is threatening the environment and human life.

8. When visiting the plastics processing or recycling plant, the emphasis should be on:

(a) collecting information regarding additives like colours, plasticisers, resins and their carcinogenic nature
(b) the plastic recycling process - the various links in the chain - rag-pickers, *kabadiwalas* and plastic granule makers; and also the fact that only a fraction of the total plastic waste being generated is recycled
(c) drawing diagrams of plastic processing and how different kinds of plastics are processed differently.

9. After the students have done their report writing and drawn the conclusions, small groups could be formed to focus on a particular aspect of the problem and come up with some

solutions. This may help in a focussed brainstorming and debate on the issue of social responsibility for the excessive usage of plastics and their disposal. The points that are thrown up by the debate could be summarised by the teacher and then attached to each student's report as a recommendation of the group.

4

Student Handout 1:

Usage of plastics

Observe and note the usage of plastic in day to day life, at home and in the school Record your observations in a list like this:

Usage (as basic material, layer, wrapper, bag)	Purpose of use (e.g. to carry vegetables)

Student Handout 2: Information on waste generation by a household

For one week or some other agreed time period, prepare a detailed list of the items and the quantity of plastics materials that are discarded from your home. List them in categories such as plastic bags, containers, wrappers, clothing, etc. Weigh the quantity of plastics in each category. Estimate the percentage of the total waste being disposed of by your home. If possible, collect together all the plastic waste for one week and create a pile. Take a photograph of the pile.

It is suggested that two separate containers may be kept in the house, out of which one could be exclusively for plastic waste. This will help you not to soil the plastic waste.

Day/date	Estimated weight of non plastic waste generated	Estimated weight of plastic waste generated	Kind of plastic waste Bottle/wrapper/toy etc
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			

Use another sheet if necessary. In case plastic waste generated in one day is too little to weigh, the weighing should be done after a week. Your teacher will conduct a class discussion on how to calculate average waste generation. Complete the following after the discussion.

Weight of plastic waste generated in one week .....
Weight of plastic waste generated by 100 households .....
Weight of plastic waste generated in your city .....
Is photographic evidence attached? Yes/No

4

Student Handout 3: Experiment worksheet

Aim: To examine and distinguish between characteristics of différent kinds of plastics.

1. Preparation of samples for tests
   Number of samples prepared ----------
2. Physical examination

	Sample 1	Sample 2	Sample 3	Sample 4
1. Colour				
2. Transparency				
3. Hardness				

3. Elastic properties

(a) Test for pliability/strength

	Bends easily	Bends with some force (mention weight applied)	Does not bend at all
Sample 1			
Sample 2			
Sample 3			

(b) Stretching under weight

	Stretches under kg wt/g wt
Sample 1	
Sample 2	
Sample 3	

4. Effect of Heat

	When heated	When burnt
Sample 1		
Sample 2		
Sample 3		

5. Effect of various solvents

Sample	Kerosene	Water	Petrol	Methylated sprit	Any other
Sample 1					
Sample 2					
Sample 3					

Any other experiment:

4

Student Handout 4: Experiment on biodegradability of plastics

I. Depth and other dimensions of the pit dug

2. Physical examination

a) The waste to be put

b) Percentage of plastic in it

3. Amount of common salt sprinkled

4. Pit covered for ……...days

5. Physical examination of the waste after 3 weeks

6. Physical examination of the plastic waste

7. Inference drawn by you

Student Handout 5: Field trip to plasties processing unit

1. Common name of the plastics being processed
2. Chemical name/formula of the plasties
3. Physical properties
   (a) Structure: Granular/powder/liquid
   (b) Colour
   (c) Melting temperature
4. Additives being used:

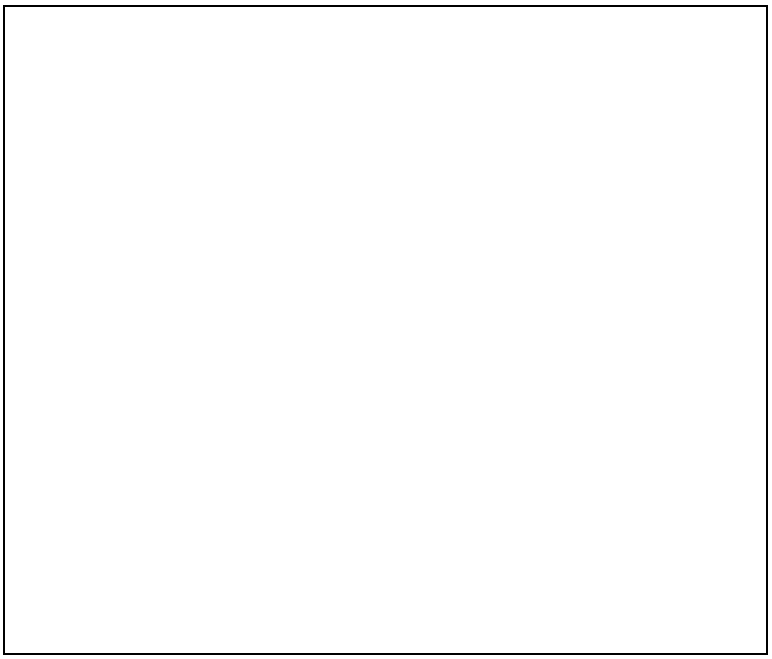
   (a) Colour
   Common Name: Chemical Name: Formula:

   (b) Plasticiser
   Common Name: Chemical Name: Formula:
   Reason for using it:

   (c) Anything else being used?

5. Plastic recycling chain
   - Who collects waste plastic?
   - For what value is it sold?
   - Who buys it?
   - What is done to the waste plastic?
   - 1 low much plastic waste is being recycled?
   - I low did you arrive at this estimate?

   Diagram of the plastic-processing unit
   (1 nil is space is not enough, draw it on a separate sheet)



Arc the additives carcinogenic? Yes/No

If yes, give reasons Reference information from

4 About the script

It is envisaged that, through the activities in this script, students will be sensitised to the enormity of plastic waste generated by society and the threat to the environment and to human life that this poses. Students will also be able to estimate how much plastic waste an average family generates in a month and how it is being disposed of. Through observation and experimentation, they will be able to distinguish and categorise plastic waste material. Exploration regarding biodegradarion of various substances including plastics will help them discover the fact that plastics arc not biodegradable. Ending out more about plastic processing and recycling should lead them to learn more about chemicals like colours, resins, etc. which are added to improve the quality of plastics. This in turn should lead to the discovery of the fact that some of these additives arc carcinogenic in nature and could cause cancer in human beings by their excessive use. During this exploration, they will probably get familiar with and understand more about polymers, thermoplastic and thermosetting plastics, and moulding processes used in shaping plastics.

The activities should hopefully lead students to come to some understanding (based on arguments and observations, field trips, experimentation, etc.) 0.1 whether society or the public has a social responsibility to use and discard plastics more wisely, and whether even the use of certain plastics should be banned.

Teachers should also look at the script "What do we do with garbage?" which has some related activities.

4 THE LOO STORY

KAREN HAYDOCK, VANDANA MAHAJAN, ANITA RAMPAL and VIJAYA S. VARMA

Grade level: Classes VIII - IX

Introduction

People are able to make use of technology to collect and dispose of human excreta. They can also dispose of such waste products as other animals do, letting it rot in fields, etc. What is the best way to dispose of human waste?

Science concepts

1. Production and disposal of human excreta
2. Aerobic/anaerobic decay of waste
3. Microbial contamination and transmission

Previous knowledge

The students should have some knowledge of:

1. the scientific method (asking questions, hypothesising, testing, recording results, modifying tests, drawing conclusions, etc.)
2. the digestive system
3. germs and micro-organisms
4. decay and decomposition.

Teaching/learning materials

Scales or balances, graduated cylinders or measuring containers.

4

Students' Guide

Scenario: Baisakhu's Dream

(Adapted from the Oriya folktale, "A Scavenger's Dream", as told by A. K. Ramanujan)

Once upon a time there was a girl named Bisania who lived with her brother Baisakhu and worked in the palace. She went to the palace every day to remove the nightsoil from the princess' toilet.
One day Bisania fell ill, so there was a problem. Who would clean the toilet? Since the princess' staff could find no one else, they finally asked Baisakhu. When he went to the palace, Baisakhu was admitted through the back door so that he could remove the basket of nightsoil from under the latrine hole.
As he was leaving he caught a glimpse of the princess' foot. Just one glimpse and Baisakhu was infatuated with the princess, lie began to imagine how beautiful the rest of her must be. Even while he trudged home, his mind was with that small part of the princess' foot. He was so taken with her he could neither eat nor sleep. Bisania kept asking him what was wrong and why he was mooning around all the lime. He finally confessed his infatuation.
"He Bhagwan! How can you get the princess? How can you, a scavenger, ever dare to dream of the princess? If you had wanted any other woman, we might have had a chance, but the princess herself - forget it. Ordinary people can't even get a glimpse of her," said Bisania.
But Bisania couldn't distract him from his obsession. Baisakhu's thoughts went round and round and he was all wound up in them. He began to act crazy, didn't change his clothes, didn't eat or sleep. He sat all day under a banyan tree, thinking of nothing else but the princess and how beautiful she must be. Everyone told him he was mad, he couldn't possibly think of the princess. She was so far above him. But he began to think, "Why is she so different? Everyone breathes, cats, sleeps and defecates. Basically we are all the same in the end, aren't we? I have seen the waste of rich and poor - it's all the same. In the end it all rots and goes back into the soil. Why is the princess any better than me?"
Finally Baisakhu came to the conclusion that he would die if he could not see the princess. He stole into her chamber and presented himself before her. Me asked her to marry him.

"What?? You? You are just a toilet cleaner, and I am a Princess," she laughed.

Hearing this, Baisakhu grew angry. He was so upset that his entire body trembled with rage. And the earth trembled with him. "*Achchha*. so you think you're so good, do you? You probably even think your waste is better than mine! I'll show you! Let your waste and the waste of your entire family not rot like it does for the rest of us - let it remain forever as a memorial to your greatness!" lie cursed her.
And that is exactly what happened. From that day on, the excreta of the princess and the entire royal family did not rot. It piled up. It stank.
None of the scavengers would take it away because they did not know what to do with waste that would not rot. So it accumulated in the palace day after day, week after week, year after year. Finally, the royal family was buried in its own waste.

4 Yours Tasks

1. Read the story out loud (use expression and action).
2. In small groups, discuss and collectively write answers to the questions in Student Handout 1.
3. Have a class discussion in which each small group shares its answers with the class for further discussion.
4. Work in pairs to discuss whether it is possible to be buried in human waste, and if so, how long it would take.
5. Working in small groups, find out how faecal waste decomposes.
6. Analyse and compare different methods of faecal waste disposal.
7. Analyse and compare the different designs for toilets.

Teacher's Guide

Suggested teaching strategy

1. Ask students to read the story out loud, with expression und action.

Divide the class into small groups (4-6 students) to discuss the questions in Student Handout I. Ask each group to prepare a written summary of their answers.

The entire class should then have a discussion on these questions. Lach small group should report what it has concluded and other students should then give their comments.

2. The questions listed below could also be raised if the teacher desires. Raising these issues would serve to highlight the connection between science and important social questions that otherwise may not be examined in the classroom.

   (a) How did Baisakhu feel upon hearing the princess' reply to his marriage proposal? Why? Was Baisakhu right or wrong to ask the princess to marry him? Explain why or why not.

   (b) Was the princess right or wrong in her reaction to Baisakhu?

   (c) Was the princess really beautiful? On what basis do you decide? Do different students in your class have different ideas about what is beautiful? How and whv? Give examples.

   (d) Do people in different communities, societies, or countries have different ideas about what is beautiful? How and why? Give examples.

3. Divide the class into pairs of students and ask each pair to work together to answer the questions in Student Handout 2. Scales, balances, and graduated cylinders or measuring containers of some sort should be available to the students in case they need them.

Estimates from various sources of the average amount of faecal waste an adult produces vary from 75 to 300 g/day.

After collecting and assessing the students' work, the teacher should discuss the answers with the whole class.

4. Divide the class into small groups (4-6 students). Each group should devise its own experimental procedure to find oui what conditions influence decay of *gobar.* Some factors which could be relevant are: sun or shade, temperature, dry or wet conditions, open or closed surroundings. Each group should first submit a written account of what they plan to do and what results they expect. The teacher should assess the plans, adding comments and questions to encourage improvements.

The students should be provided with adequate equipment and time to carry out their experiments in class, with minimal assistance from the teacher.

5. As homework, each student should be asked to find out how the family's faecal waste is disposed of at home. The class can then discuss whatever methods were found. They can be shown the diagrams in Student Handout 3 that illustrate different methods of waste disposal, and these can be explained to or discussed with them.

6. The students should brainstorm as to what factors arc important to consider when trying to determine what is the best method of faecal waste disposal, l he teacher should record all possibilities on the board for future consideration. Students will probably come up with

4 such (actors as effectiveness, benefits (fertiliser, methane, etc.), cost, labour, sanitation (health risks), use of water (quantity), suitability under different conditions, social, cultural and gender factors, etc. Some of these can be explored in more detail (see the Student Handouts).

7. Working in small groups, students should analyse the advantages and disadvantages of the various methods of waste disposal (using the factors on the board as well as whatever other I actors they think of), and decide what are the best methods of faecal waste disposal under different conditions.

After collection and assessment, the class should discuss the results.

4

Student Handout 1

Discuss the answers to the following questions in small groups, and collectively write answers, which you will later share with the class:

1. Was ii right or wrong for the princess to rely on Bisania and Baisakhu to take care of her waste?
2. Should some members of society be allowed to produce waste while other people art-responsible for taking care of the waste? (Should some places produce waste while other places dispose of it?) How should we decide who docs what?
3. In the story it is suggested that a curse could stop human excreta from rotting. Write an explanation for the meaning of 'rot'
4. Decide whether it is possible to slop any material associated with living things from rotting. (If it can be stopped, will it still smell? Is smell a part of the rotting process?) From a scientific point of view, do you think it would really be possible to stop waste from rolling, as was done in the story?

Student Handout 2

Work out the answers to the following questions in pairs:

1. Calculation of how much waste is produced

Is it possible to be buried in human waste? How long would it take?

(a) Answer this by determining the average amount of excreta a person produces each day. Here is a suggestion how you could make such an estimate. Use mud instead of real human waste (to avoid contact with germs) to make a model of one day's waste. Measure its volume (e.g. by using containers like jars or tetrapacks whose volume you know). Or you could look in books to find estimates of how much excrement a person produces on average.

(b) Calculate how long it would take 1 person to fill a room of a certain size (say 3m x 3m x 3m) with solid waste.

(c) Calculate how many people it would take to fill a room of this size in one day.

2. Experiment on *gobar* decay

Under what conditions does waste decompose?

Devise an experiment to find out what happens to faecal waste under different conditions. What factors influence decay? Use *gobar* to carry out your experiments, and carefully record your method and results as you work. Also write down your conclusions.

First write down a plan of exactly what you will do. Also write down what results you expect to get and why. After your teacher returns your plan, discuss whatever comments your teacher may have written and carry out your experiment.

Record and communicate your observations and results in tabular and/or graphic form. Analyse, modify and repeat your experiments as needed. Complete a clearly written report of your work.

4 **Student Handout 3**

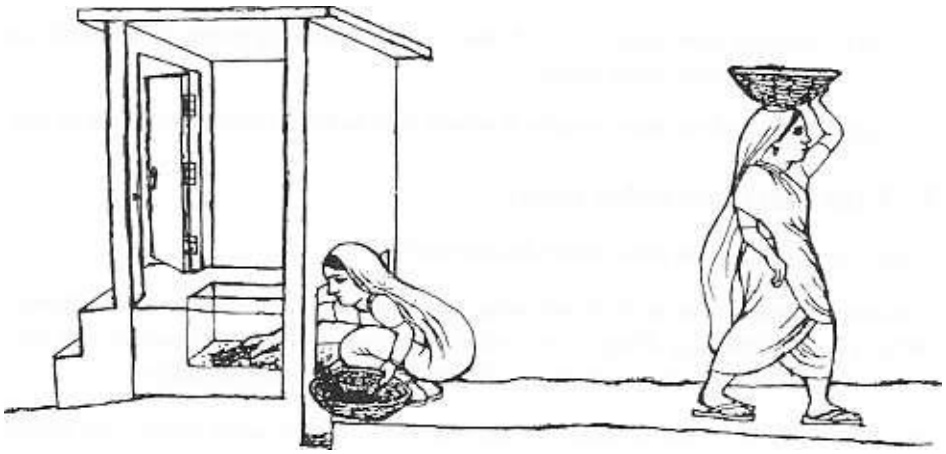
Waste disposal methods

1. Analyse and compare different methods of faecal waste disposal.
2. For homework find out how your own waste is disposed of. Find out as many different ways as you can, including the ones listed below, of faecal waste disposal.
3. Discuss what factors are important to consider when trying to determine which is the best method of faecal waste disposal.
4. Working in small groups, analyse the advantages and disadvantages of the various methods of waste disposal (using all the factors you think arc important). Decide what are the best methods in some of the following situations (feel free to design or modify methods):
    - a house in a small town in Himachal Pradesh
    - a village in a desert region of Rajasthan
    - a hotel in Delhi
    - a slum in Delhi
    - a flat in Delhi
    - a house in a small town in Meghalaya
    - a village near the Bay of Bengal in Orissa
    - your own home.

1)Excretion directly into the environment

In this case people relieve themselves in fields, jungles, or other areas, usually in the most private or remote places that are reasonably accessible to them.

2) Service Latrine



Solid human waste is collected manually, carried away, and dumped in a site in a field, jungle, etc. In some cases the faecal matter may be used for fertiliser, perhaps after a certain amount of (regulated or unregulated) composting (decaying).

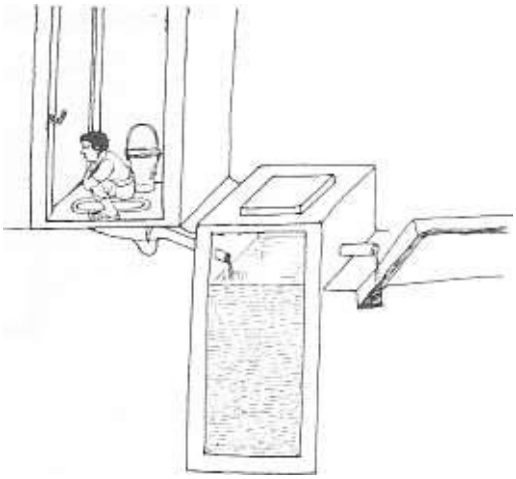
3. Pit Latrine (or dry pit latrine, or composting latrine)

The solid and liquid human wastes are deposited in a pit that has been dug in the ground. In some cases the pit may be lined with bricks. The liquid is allowed to seep into the surrounding soil, while the solids accumulate and decompose, with the help of micro-organisms naturally occurring in the faecal material. Alternatively, liquid waste and water my be allowed to run off into a separate disposal system, while only solid waste is collected in the pit. Sometimes other solid wastes from plants may also be combined with the faecal material for better composting.

Eventually the pit has to be cleaned oui or covered over with earth and a new pit is dug. Under favourable conditions, and allowing adequate time, the solids may decompose well enough to be fairly safely used as fertiliser.

Sometimes a double pit system is used so that the material in one pit can be left to decompose while the other pit is being used. By the time the second pit is full, the material in the first pit will have decomposed and the pit will be ready to be cleaned out and used again.

4.Septic tank system



In this case the solid and liquid wastes are collected in a tank where the solids settle to the bottom, forming a sludge that undergoes anaerobic decomposition (in the absence of air). The excess liquid runs out of a pipe at the top of the tank and usually gets discharged into a *nulla* that eventually empties into a river or lake. Or the liquid discharge could be collected in a soak pit (a pit with holes in it) where it slowly soaks into the earth. It could even go into long pipes with holes in them that are buried underground so that it slowly leaks oui into the surrounding earth.

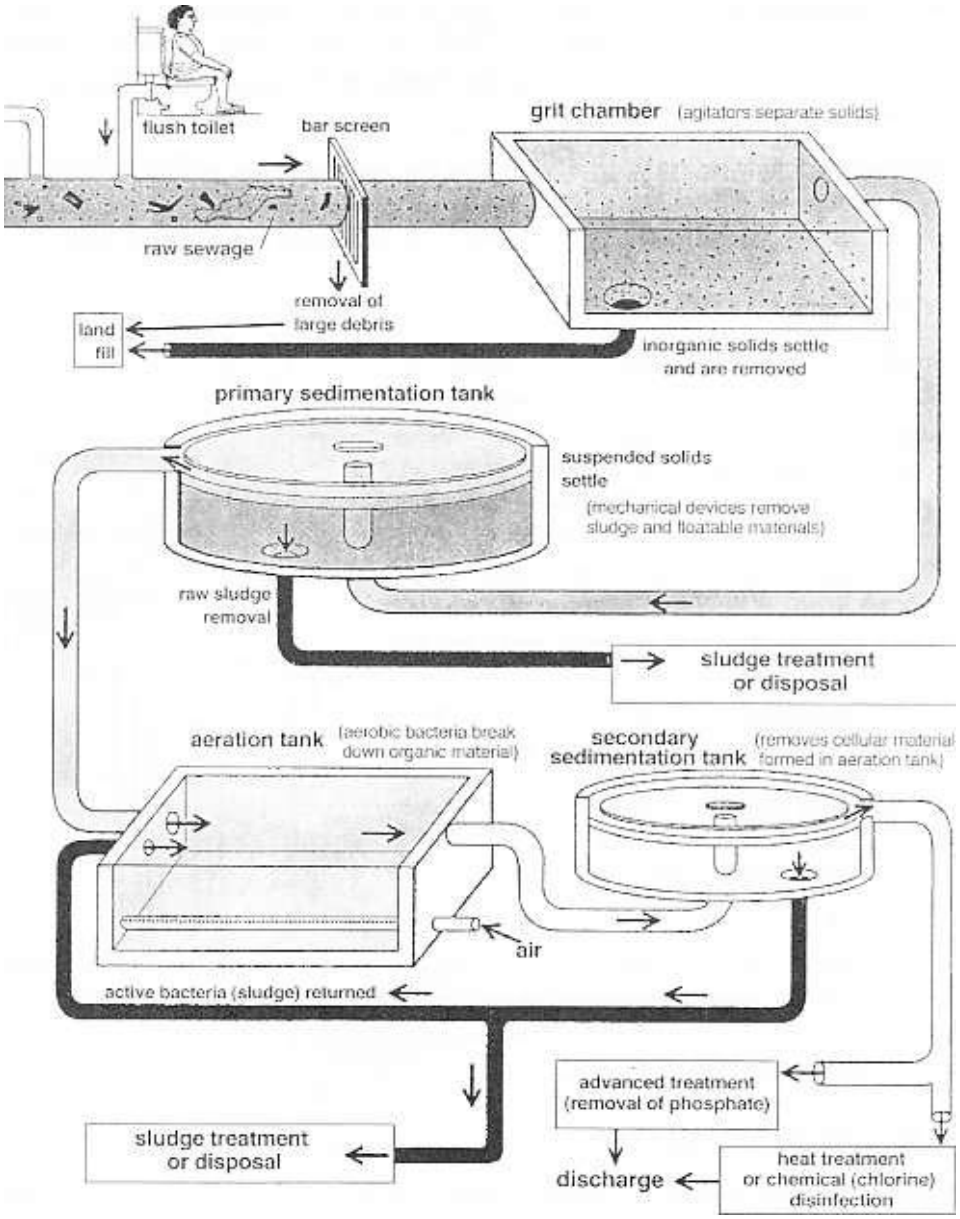
Eventually the septic tank gets full of sludge and has to be emptied. The sludge can be used for fertiliser, sometimes after further treatment to disinfect it.

In some septic tanks, there may be holes or pipes in the bottom and lower sides through which water seeps out. In this case the tank will not need to be cleaned out as often, and some aerobic decomposition may also occur since the material in the tank will be drier, and its surface may be exposed to air.

5.Sewage treatment system

Some large cities have large sewage treatment systems like the one shown schematically in the diagram. Waste produced by thousands of residents can be treated in one large plant containing many tanks of the types shown.

4
In this system, each house has a flush toilet in which the faecal waste is washed out of the toilet with water. This waste, together with waste water from bathing, washing clothes, food preparation, washing utensils, etc. is taken out of each house through underground pipes that flow into larger and larger pipes collecting waste water (sewage) from the whole city. These underground pipes are called sewers. If the sewers do not run downhill the sewage must be pumped. The sewers finally carry all the sewage to a sewage treatment plant.
The first step in sewage treatment is to remove large objects like sticks, cloth, plastic bags and other kinds of large debris by passing the sewage through a bar screen. Then it passes into a grit chamber, where sand and other granular inorganic solids settle and are removed. The grit may be washed and used for construction (e.g. of roads), or it may be disposed with other garbage in landfills and covered with earth.



The sewage passes on to a primary sedimentation tank where as much solid matter (sludge) as possible is removed. The sludge may be disposed of directly or first treated in sludge digestion tanks to disinfect it. Here the sludge is kept in an oxygen-free environment at a moderate temperature (between 35"-60° C) where anaerobic micro-organisms break it down, producing methane gas. This gas can be burnt as fuel (often it is used to run engines in the sewage plant or for street lighting). The remaining sludge can then be used as fertiliser, burnt as fuel, or disposed of.
The liquid discharge (effluent) from the primary sedimentation tank passes into an aeration tank where aerobic micro-organisms digest and break down the organic waste material, converting it into minerals and gases, in the presence of air. Then, the effluent goes into a secondary sedimentation tank where the sludge (containing the micro-organisms that grew in the aeration tank) settles and is removed. Some of this sludge is returned to the aeration tank to replenish its supply of aerobic micro-organisms. The remainder is disposed of or treated as described above.

The effluent from the secondary sedimentation tank is then discharged (usually into a river). It may be heated or chemically treated (e.g. with chlorine) before being discharged in order to kill the remaining micro-organisms. In the most advanced systems the effluent may be additionally chemically treated lo remove toxic chemicals, nutrients, phosphates and nitrogen.

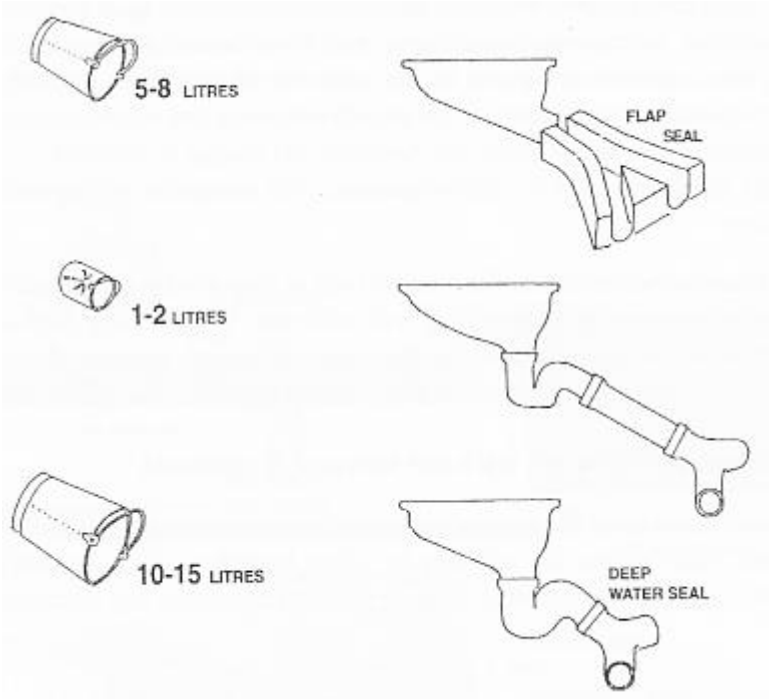
6. Flush toilets and sewers without sewage treatment

Some towns and cities have a system of pipes and/or *millas* to collect liquid and faecal wastes (sewage) from flush toilets (in addition to other household liquid waste). These sewers eventually empty directly into rivers, lakes, or the ocean, without any treatment.

Student Handout 4: Water Usage for Toilets

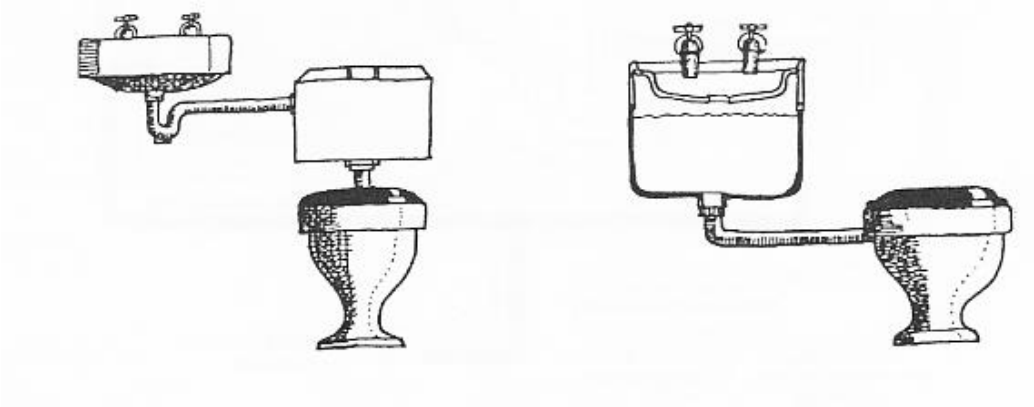
(a) Look at the three different toilet designs shown and draw lines to match the toilet to the amount of water it takes to flush it.

Match the toilet to how much water it takes to flush



(b) What is a water seal in a toilet and why do some toilets have one? What alternatives are there to a water seal? What are the advantages and disadvantages of water seal systems and of alternative systems?

(c) The diagram below shows two designs for systems to save water. These designs make use of the observation that water use in washbasins about equals that for toilets. Explain how these systems work. Discuss their advantages and disadvantages



(d) Design a new way to save water in toilet usage. Describe it in words and pictures. Discuss its advantages and disadvantages.

4

Supplemental Student Handout: 'Service Latrines'

Patasi Bai's work is indispensable lo the people she works for. Bui they take special care to avoid any sort of contact with her. They would not dream of eating with her. They give her one *roti a day* and once a month some of them give her a few rupees.

Patasi Bai (Sikar, Rajasthan, 1999)

"Yes, 1 carry human excrement ('nighlsoil'). The payment is one *roti* a household daily and maybe ten rupees a house each month. 1 clean the dry latrines in about 25 homes every day. We have to carry the excrement in baskets on our heads to the dumping place. Some households give no money. The basic payment is one *roti* a house. If we had trolleys or wheelbarrows it would be better. We keep asking for them. The *Parishad* says yes, but never gives us any."

The girls cleaning human excrement in Sikar arc often young. Shakuntala (16). Lachchi and Reena (both 14) are just three among many. They said, "Some months ago we had something like a strike. For two months we abandoned this work. Nothing happened. No one came to our aid. We were given no other options. So we resumed work, though we hate it. Only women do this job here."

In 1993, the Central Government passed the Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, to abolish the practice of having people clean dry latrines because it is an inhuman and unhygienic method of disposal. But since it is a subject for local governments to handle, it is up to each Slate to enforce laws against such practices.

The workers want to do away with this "*gandagi''* which they see as destroying their dignity. But they also want to be compensated for the loss of earnings a real ban would entail — they would like to be trained and hired for some other kind of work.

What are the problems with 'service latrines' which require people to carry away human excrement?

Discuss what is the best solution to the problem of service latrines from the point of view of the people with service latrines in their homes.

Discuss what is the best solution to the problem from the point of view of the people who clean service latrines.

Discuss what is the best solution to the problem from your point of view.

4 About the script

This script grew out of a desire to make school students aware of the enormous problems related to the proper disposal of human waste in our country. The script attempts to do this by making students engage in discussion, experimentation and analysis. It starts off with a Scenario based on an adaptation of an old Oriya folktale. After an initial discussion on the Scenario, students are expected 10 estimate how much (faecal) waste people produce and then to design and carry out an experiment to find out what factors influence the decay of waste *(gobar).* They arc also expected to explore and analyse different methods of (faecal) waste disposal and decide which of these methods are appropriate in different circumstances. It is hoped that by the end of the exercise students will be able to decide, based on sound argument, which methods of waste disposal are scientifically, socially, environmentally, and economically acceptable. They should also become aware of the need for personal and collective responsibility for their own waste.

The script threw up a whole set of complex issues and led to a lively discussion during the two workshops. No clear consensus emerged on all issues or. to put it another way, the discussion indicated the possibility of the existence of many views on the issues that could be addressed by the script. In the form the script has been presented here, the option of whether or not to raise the social problems associated with human waste disposal for discussion in the class is left to the teacher. Some participants were of the view that even though such issues don't normally fall within the ambit of a science class, they should nevertheless be addressed. Others held the view that such sensitive social issues are best not raised in school, particularly during science lessons. It is possible, of course, that students may raise such questions on their own. Ultimately we thought it best to leave it to the teachers to decide whether or not to make the lesson more cross-curricular by including discussions on such social questions.

One of the authors of the script has already tried out the adapted folktale with students in a co-educational public school with Class IX students. The discussion was enthusiastic and interesting, and extended to questions of caste, untouchability, love, morality and judgement of beauty.

Finally, this is only one of two scripts in which an attempt has been made to develop a set of criteria for assessment. This has been included as an appendix to this script.

4

Appendix: Assessment

1. Science method grade

Task 2

A Does not use scientific thinking in analysing the meaning of rotting.
B Attempts to analyse the nature of rotting from a scientific point of view.
C Understands what rotting is, and understands that we smell things when small particles of those things are dispersed in the air.

Task 3

A Does not use scientific thinking in analysing the question, and does not come up with a reasonable estimate.
B Attempts to estimate waste production from a scientific point of view, but makes some logical or calculation errors.

C Uses initiative to devise a sensible way of estimating waste production, and extrapolates to give a reasonable estimate.

Task 4

A Does not use a scientific method in designing the experiment.

B Attempts to use a scientific method, but does not lake enough care to avoid Haws in the design (e.g. in keeping controls or in separating variables).

C Uses a scientific method, and takes care to avoid flaws in the design (e.g. by keeping controls, separating variables, and redesigning and modifying procedures as needed).

Task 5

A Does not use scientific thinking in analysing and comparing methods of sewage disposal.

B Attempts to analyse and compare the methods from a scientific point of view, but does not consider enough factors.
C Uses scientific thinking in analysing and comparing methods of sewage disposal, shows initiative in investigating methods in local use. and considers many factors in evaluating advantages and disadvantages.

2. Personal skills grade

Task 4

A Does not appear to have the skills needed to estimate and calculate.

B Makes some logical or calculation errors.

C Skilled in estimation and calculation and in communicating results.

4**Task 4**

A Appears to be careless and/or unobservant, and does not record experiment clearly.

B Attempts to use a scientific method, but with less skill than desired.

C Is observant and careful in carrying out the experiment, and records and communicates the results effectively (irrespective of results).

Tasks 3, 4, 5 and 6

A Does not co-operate with other students when working in pairs and groups.
B Co-operates somewhat with other students when working in pairs and groups.
C Co-operates well with other students when working in pairs and groups.

3. Science concept grade

Task 4

A Does not understand the causes and characteristics of decay or the shortcomings of the experiment.
B Has less than desirable understanding of the causes and characteristics of decay and the possible shortcomings of the experiment, and does not suggest appropriate further experiments and related questions.

C Has a good understanding of the causes and characteristics of decay and the possible shortcomings of the experiment, and suggests appropriate further experiments and related questions.

Task 5

A Does not understand the different methods of waste disposal.

B Has less than desirable understanding of the different methods of waste disposal and their advantages and disadvantages, and does not always make sensible evaluations.

C Has a good understanding of the different methods of waste disposal and their advantages and disadvantages, and makes sensible and creative evaluations.

Tasks 6 and 7

A Does not understand the role of a water seal or the relationship between the design of a toilet and the amount of water required for flushing it.

B Has less than desirable understanding of the different designs of toilets and their advantages and disadvantages, and does not always make sensible suggestions for saving water.

C Has a good understanding of the relation between the design of a toilet and the amount of water required to flush it, appreciates the advantage of the suggested design for saving water in a toilet. I he student also makes sensible and creative suggestions for a design for saving water in flushing toilets.

4 THE INTERNATIONAL COUNCIL OF ASSOCIATIONS FOR SCIENCE EDUC ATION: A NOTE

The International Council of Associations for Science Education (1CASE) is an NGO (non-Governmental organisation) created in 1973 with the help of UNESCO and 1CSU (International Council of Science Unions). Its goal is to form an umbrella linking regional, national and sub- national professional STAs (science teacher associations/groups) plus other groups interested in promoting science education at the primary and secondary levels. It undertakes this by means of regional symposia, a quarterly journal, a primary science newsletter and by specialised events and publications planned in conjunction with its member organisations.

ICASE is a voluntary organisation run by an Executive Committee elected by its member associations. The Executive Committee comprises regional representatives (Africa, Asia, Australasia, Europe, North America and Latin America/the Caribbean), chairpersons of standing committees (currently - finance, journal, pre-secondary, publications and Project 2000+) plus the President, President-elect, Secretary and Treasurer.

ICASE aids its member organisations by linking with other international organisations, e.g. UNESCO, in developing projects and publications. A major development is Project 2000+ that attempts to promote a more appropriate science and technology education for all at the formal, informal and non-formal levels. The project is guided by a steering committee comprising UNESCO and a group of international NGOs (ICASE, IOSTE, GASAT, WOCATE and ICSU). 1CASE for its part is trying to help its member organisations promote scientific and technological literacy in the classroom by developing teaching materials that are seen to he relevant and interesting to the students. A major feature is to guide teachers themselves to create the materials and thereby gain ownership of the STL (scientific and technological literacy) philosophy for the teaching of science for all. These materials arc based on local issues and try to relate the learning of scientific concepts to societal concerns and, in so doing, promote problem-solving and decisionmaking skills.

4

THE CENTRE FOR SCIENCE EDUCATION AND COMMUNICATION: A NOTE

The Centre For Science Education and Communication (CSEC) at the University of Delhi was established m 1989 in response to the changing relationship between society at large and the University, viewed as a centre for the pursuit and teaching of science. It is an autonomous institution within the University of Delhi. It is meant to serve as an institution in which studies can be earned out by teachers and students of the University, and other interested individuals, for the generation of ideas and materials for the improvement of science education at all levels and for the promotion of a wider interest in science and scientific issues.

The establishment of CSEC was based on the premise that, while the traditional activities in science in the form of teaching and research should continue to be the principal contribution of the university to society, there is need for attempting a wider and, in some ways, more direct role If tins premise be accepted, it is evident that there should be two major foci of activity of the Centre:

- within the formal streams of science teaching and education - encouraging and managing innovations the teaching and learning of science both at the School and the University levels

- outside formal education - aimed at popularising science, increasing public awareness of issues relating to science and technology, particularly as they affect our daily lives the environment and matters of public policy.

The interaction of .he Centre with schools began in a small way with the Centre organising workshops in electronics for schoolteachers from the Delhi Administration schools These were followed by summer workshops on selected topics in Chemistry. The participants were school and college teachers.

A longer-term initiative was undertaken by a group comprising teachers from the faculties of science and education as well as schoolteachers in addressing the problems of primary school mathematics I he School Mathematics 1'rojcct started formally in 1992-93. The focus from the stand was on the removal of .he fear of mathematics in children, as well as on improving their poor performance m Mathematics at the secondary level. Some key features of the group's approach

- taking cognisance of the child's "initial mathematics"
- emphasis on work with concrete materials, and
- a postponement of written work in the early years of school.

The development of the curriculum has been driven primarily by class teachers, with a plurality of approaches to solving a problem being actively encouraged. The programme has emphasized he role of concrete manipulations prior to the introduction of abstraction, has placed a premium on peer interaction between learners, and encouraged children to articulate verbally the methods they use to solve problems.

Most recently, CSEC has joined Homerton College of the University of Cambridge, in setting up an elementary education Teachers' Research Network with its own website and with nodal partners located in different parts of the country, with a view to promoting reflective teaching practices in elementary schools.

LIST OF ALTHORS

Prakash Burle is Eklavya Fellow, D-84/852 MIG Colony, Bandra (East), Mumbai 400051

Bashir Ahmad Dar is Director Academics and Head, Curriculum Development and Research Wing, Jammu and Kashmir State Board of School Education, which lias offices at Lal Mandi, Srinagar 190008 and at Rehari Colony, Jammu Tawi 180005

A. K. Das is Research Associate, Eklavya, Kothi Bazaar. Hoshangabad, Madhya Pradesh 461001
H. K. Dewan is Educational Advisor, Vidya Bhawan Society, Fatehpura, Udaipur 313001
Vîjay Dua is a Professor and lives at Bandh Mohalla, Parasia, Madhya Pradesh 480441

Bholcshwar Dubey is Assistant Professor, Government S. K. P. Collège, Dewas, Madhya Pradesh

Saroj Ghose is Director Calcutta Muséum (Retd.) and lives at Surya Deep Apartment 4A, 112G Salimpore Road, Calcutta 700031

Nalini Gîte teaches at the Rishi Valley School, Rishi Valley, Taluka Madanapalley, Chittoor District, Andhra Pradesh 517352

Rakesh Mohan Hallen is Scientist Fellow, The National institute of Science Communication, Dr. K. S. Krishnan Marg, New Delhi 110012

Karen Haydock is mostly self employed and lives at T. F. 10, Panjab University Campus, Sector 14, Chandigarh 160014

R. Joshi is Senior Lecturer, Department of Science and Mathematics,
National Council of Educational Research and Training, Sri Aurobindo Marg, New Delhi 110016

Vandana Mahajan is Project Holder, Alarippu, 28B/4 Jia Sarai, New Delhi 110016

Kamal Mahendroo is Fellow, Eklavya, Sandia Road, Pipariya, District Hoshangabad, Madhya Pradesh 461775

J. K. Mohapatra is Professor of Science Education, The Régional Institule of Education, Shyamla Hills, Bhopal 462013

Amitabha Mukhcrjee is Reader, Department of Physics and Astrophysics, Univcrsity of Delhi, Delhi 110007

G. P. Pande is at the Ultarakhand Paryavaran Shiksha Rendra, Jakhan Devi, Mail Road. Almora, Uttar Pradesh 263601

Dharam Parkash is Reader, The Central Institute of Educational Technology, Chacha Nehru Bhawan, NCERT Campus, Sri Aurobindo Marg, New Delhi 110016

Rajan Patil is Research Assistant, Comnmnity Health Cell, 367 Sreenivas Nilaya. Jakkasandra, lst Main, 1st Block. Koramangala, Bangalore 560034

Kishore Pawar is Assistant Professor of Botany, Government P. G. College, Sendhwa, Madhya Pradesh 451666

U. S. Poste is an Upper Division Teacher and lives near Mines Rescue Stations, Jamai Road, Parasia, Madhya Pradesh 480441

Anita Rampal is in charge of the National Literacy Resource Centre, Lai Bahadur Shastri National Academy of Administration, Mussoorie 248179

Satheesh H. L. is TGT Science, Demonstration School, The Regional Institute of Education, Mysore 570006
Kaluram Sharma is Research Associate, Eklavya, A-24/13 MIC i Mats, Vednagar, Nanakheda, Ujjain 456010

Priyanka Singh is Development Professional, Education Unit, Sewa Mandir, Old Fatehpura, Udaipur 313001

Vijaya S. Varma is Professor, Department of Physics and Astrophysics, University of Delhi, Delhi 110007