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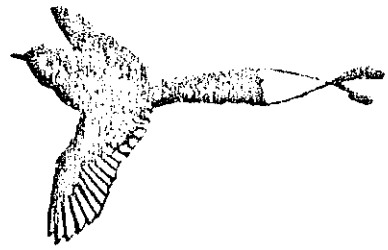

WORKSHOP ON ENVIRONMENTAL EDUCATION HELD AT YADAHALLI, SIRSI TALUK, UTTARA KANNADA DISTRICT FROM 13-18 OCTOBER, 1986

Compiled by : MADHAV GADGIL AND VENKATA RAO

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REPORT OF THE WORKSHOP ON ENVIRONMENTAL EDUCATION FOR SCIENCE TEACHERS HELD AT YADAHALLI, SIRSI TALUK, UTTARA KANNADA DISTRICT FROM 13TH-18TH OCTOBER 1986

INTRODUCTION

This workshop was organised by the Centre for Ecological Sciences, Indian Institute of Science with the collaboration of Karnataka Rajya Vignana Parishad and Sahyadri Parisara Vardhini, Yadahalli. Venue of the workshop was Vidyodaya Junior college, Yadahalli which is 4 Km away from Sirsi town on Sirsi-Siddapur road. All the participants were provided with lodging and boarding facilities by the college management.

About 30 science teachers working in various schools and junior colleges in the state were selected for this workshop(list of the participants is enclosed). The main purpose of the workshop was to educate and to make the teachers acquainted with the nature. This in turn helps the teachers in creating environmental awareness in the students. During the workshop lectures were given about the important aspects of environment. (List of the faculty members involved is enclosed). Laboratory demonstrations were made and the participants were taken to field to expose them to local biota. Chitrakeertana, yakshagana and a slide show were shown which were designed to illustrate the environmental conditions.

WORKSHOP ON ENVIRONMENTAL EDUCATION FOR SCIENCE TEACHERS AT YADAHALLI 13TH TO 18TH OCTOBER 1986

13.10.86

10.00 to 11.00 AM — Registration

11.00 to 11.30 — Tea Break

11.30 to 12.30 — Science as a voyage of discovery

by Prof Madhav Gadgil

Prof Madhav Gadgil in his introductory lecture to the participants expressed his desire to share the excitement of doing science with the participants, the excitement that lies in perceiving new patterns in nature around. He called the teachers of science to communicate the discovery of new patterns, interpriting the causes underlying them. He gave many examples ranging from plants around, the cattle that feed on them and the chulas on which we cook.

12.30 to 2.00 P.M. — Lunch Break

2.00 to 3.15 P.M. — Monsoon Wind

Prof. (Mrs) Sulochana Gadgil

Lecture began with how the clouds are originated, their movement and finally how this leads to rainfall. Climatic change is a global effect, vegetation is the effect of rainfall but the latter one is not yet

proved. Deforestation leads to increase of CO_2 which will increase the climatic temperature and hence there will be decrease in the rainfall.

3.15 to 3.30PM — Tea Break

3.30 to 4.45PM — Environmental Education

Prof. L.T. Sharma

In this lecture, Prof. Lingesh Sharma called for the integrated approach. He suggested that many problems such as floods, draught, population, employment, deforestation and soil erosion etc, can be studied systematically in the light of the environmental education and can be overcome.

14.10.86

6.30AM to 8.00AM — Field Visit - Bird Watching by Ranjit Daniels

12-15 birds were identified

8.00AM to 9.00AM — Breakfast

9.00AM to 11.00AM and 11.15 to 12.45PM — Lecture-Bird Watching as a Science

By Ranjit Daniels

An attempt was made to use birds as a tool in understanding the principles of Ecology, Physics and Biology.

12.45 to 2.00PM — Lunch break

2.00PM to 3.30PM — Chitrakeerthana-Shri. R.S. Hegde, Bhairumbe

An attempt was made through Chitrakeerthana

in the conventional "Harikeerthana" style to praise the forests by quoting the verses of eminent poets. An illustration of this was made through the slide-show. Thus the importance of understanding nature was made clear, so that even the common man can think and act to protect and conserve the nature.

3.30PM to 3.45PM — Tea break

3.45 to 5.00PM — "Parisara Parichaya"-Slide show by Fr. Saldanha

In an impressive way slides were shown and the explanation was given in such a way that the whole environmental aspect is kept in the minds of the spectators.

15.10.86

7.00 to 8.30AM — Bird Watching - Demonstration

By Prof. Madhav Gadgil and shri. Ranjit Daniels. 20-22 birds were identified and their ecological significance was explained. How the primary morphological features such as shape, size and colours are useful to succeed in the environment was explained. Finally, bird call, it's significance in life was also described.

9.00 to 11.00AM and 11.15 to 01.00PM — Economic Uses of Plants - By Shri. D.M.Bhat

Several plants exist around us and we have

to depend on them for almost all our daily needs. Plants or their parts are useful in many ways. They are used as food, fuel, fodder, timber, paper, fibre, etc. In addition dyes, drugs and resin can be obtained. Apart from economic use they have the aesthetic values. Plants have soil binding capacity, they supply oxygen. They are ecologically important as they support wildlife, indicate the richness of the minerals of the soil and fitness of the land for cultivation etc.

11.00 to 11.15AM — Tea break

1.00 to 2.00PM — Lunch break

2.00 to 5.30PM — School Nursery Organization- by Shri. Hemant Hegde and Shri. R.K. Joshi

The Theoretical and practical aspects regarding the organization of a school nursery involving students was delt in detail. The facilities available through government agencies, the expenditure involved in setting up a nursery and the benifit of a school nursery as a tool in learning science was explained.

16.10.86

9.00 to 11.00AM — School and Village Forestry - by Shri. Praveenchandra Pande, DCF, Sirsi

The scope of forestry, the aid that will be given by the forest department, its benifit to the public were explained.

11.00 to 11.15AM — Tea break

11.15 to 12.30PM — School Nursery as a teaching aid to Science-by Shri. Hemant Hegde

An attempt was made in this lecture to use school nursery as an aid to understand the process of propagation of plants through seeds including the process of germination and dormancy. The factors affecting dormancy and the methods to overcome dormancy were explained. Also the use of nursery plants for various laboratory and field experiments were highlighted.

12.30 to 2.30PM — Lunch break

2.30 to 5.30PM — Principles of Physics and Chemistry involved in ASTRA OLE -Lecture cum demonstration by Dr. M.S. Hegde and Shri. C.M.Shastri

In the first lecture- the amount of heat generated by various fuels - the hydrocarbons was explained. Fuel-wood because of its high carbon, hydrogen ratio is of low calorific value. Pyrolysis of

	wood and the product of it was given. Principles of controlled combustion and the measurement of temperature were described.
17.10.86	
9.00 to 11.00AM	Principles of Physics and Chemistry involved in ASTRA OLE In the second lecture, Dr. Hegde showed how the generated heat is transferred to get the useful energy conduction, convection and radiation methods were explained. With some simple experiments above aspects were demonstrated.
11.00 to 11.15AM	Tea break
11.15 to 12.30PM	Open Discussion - Prof. Madhav Gadgil The participants were given the opportunity to discuss about various aspects related to the workshop. At the end, questioneries were distributed to know the response of the participants.
12.30 to 2.30PM	Lunch break
2.30 to 5.30PM	Principles of Physics and Chemistry involved in ASTRA OLE Finally, how the above mentioned principles have been adopted in the ASTRA OLE - its efficiency measurements, and its impact on environment was discribed.
6.00 to 8.00PM	'Nisarga Sandhana'-Yakshagana by Hosthota Manjunath Bhagwat and others

18.10.86

9.00 to 10.00AM

In this 'Yakshagana' Shri Bhagwat described the nature and how it is useful to human beings. Then, the effect of over exploitation of nature is narrated with all the features of the conventional "Yakshagana". Finally, the Yakshagana story ended with the reestablishment of the nature in an appealing way.

Effect of Cattle on Environment -Shri. P.R. Bhat and Dr. G.V. Hegde, IMIF

Cattle, their importance in meeting our requirements was described. Their dependence on plants and the present practise of grazing, rearing etc were dealt with. The impact of these aspects on ecosystem and the solution was suggested to overcome the problems.

10.00AM to 5.00PM

Issue of certificates, to the participants. All the participants were given the certificates by Prof. C.J. Saldanha and "Karnataka Parisara Parichaya" was distributed.

NAMES AND ADDRESSES OF THE FACULTY MEMBERS WHO HAVE INVOLVED IN THE WORKSHOP

1. Prof. Madhav Gadgil,
   Convener, Centre for Ecological Sciences,
   Indian Institute of Science,
   Bangalore 560 012

2. Prof. Sulochana Gadgil,
   Centre for Ecological Sciences,
   Indian Institute of Science,
   Bangalore 560 012

3. Prof. C.J. Saldanha,
   Centre for Ecological Sciences,
   Indian Institute of Science,
   Bangalore 560 012

4. Dr. M.S. Hegde,
   SSCU,IISc,Bangalore 12

5. Prof. L.T. Sharma,
   Gandhinagar.
   Kumta (N.K.)

6. Shri. R.S. Hegde,
   Bhairumbe High School,
   Bhairumbe

7. Mr. R.K. Joshi.
   Vidyodaya Composite Jr. College,
   Yadahalli Sirsi (N.K.)

8. Dr. G.V. Hegde,
   BAIF Sirsi (N.K.)

9. Shri. Praveenchandra Pande,IFS,
   Sirsi Division Sirsi (N.K.)

10. Shri. ~~Hosthota~~ Manjunath Bhagvat,

11. Mr. D.M. Bhat, CES,IISc,Bangalore

12. Mr. H.G. Hegde, CES,IISc,Bangalore

13. Mr. P.R. Bhat,CES, IISc,Sirsi Field Station,Sirsi 581402

14. Mr. C.M. Shastri, CES IISc,Field Station,Sirsi(N.K.)581402

15. Mr. Ranjit Daniels, CES, IISc,Bangalore12

LIST OF PARTICIPANTS

1. Dr. K. Jagadish, Lecturer,
   Department of Zoology, Vijaya College,
   Mulki(D.K.) 574 154

2. Sri. Adimurthy, convener, KRVP Unit-87,
   Shree Siddartha Residential High School,
   Madhugiri,
   Tumkur

3. Sri. C.D. Patil, Lecturer in Botany,
   LVD College,
   Raichur

4. Sri. N Gopalakrishna Udupa, Asst.Master,
   Govt. Girls' High School,
   Tirthahalli 577432,Dist. Shimoga

5. Sri. K.S. Sateeshkumar, Asst. Master,
   S.J. College,Kodigenahalli,
   Madhugiri,Dist. Shimoga

6. Sri. K.N. Krishnamurthy Rao,Asst. Teacher
   Rastrothana High School,
   Hagari Bommanahalli,
   Dist. Bellari 583212

7. Sri. Nagabhushana, Lecturer,
   Siddaganga College,
   Tumkur

8. Sri. S. Siddaiah, Secretary,
   Science club.
   Shri. Jaya Bharati Junior college,
   Mathigatta 573 119, Dist. Tumkur

9. Sri. M.V. Padmanabhaiah, teacher
   Sabarmathi High School,
   Sugatur, Dist. Kolar

10. Sri. S.T. Shivaram, Head Master,
    Sri Mahadeshwar Rural High School,
    Shravandanahalli. Madhugiri,
    Tumkur

11. Sri. R.C. Chikmath, Asst. Master,
    Treasure, KRVP,
    Hykkeri Matha, Shibasaveshwara High School,
    Haveri 581 110, Dharwar

12.Sri. S.F. Jadhav, Convener, KRVP Tiptur Unit,
Reader in Chemistry,
Kalpataru Science College,
Tiptur 572 202, Dist. Tumkur

13.Shri. H.C. Hanumanthiah, Asst. Master,
Shri. Shambhulingeshwar Swamy Rural High School,
Pura, Turuvekere,
Dist. Tumkur

14.Smt. D.G. Mathad, Principal,
H.R. Sarojamma Composite Pre-University College for girls,
Gangavati, Raichur

15.Sri. K.G. Vasudev Murthy,
Lecturer in Geography,
Govt. Junior College, Kikkeri,
K.R.Pet, Mandya

16.Sri. Manjunath Gopalkrishna bhat,
Asst. Master,
Shri. Babrulingeshwar Vidyalaya,
Lukkeri-Masur,Kumta(Uttara Kannada)

17.Sri. M.R. Sheshgiri,
Shri. Kalikabhavani Secondary School,
Kansur, Siddapur(Uttara Kannada)

18.Sri. Ganapathi Ramachandra Bhat, Asst. Master,
Sri. Jagadamba High School,
Sarkuli, Sirsi (U.K.)

19.Sri. P.V. Hegde,
M.E.S. Sahyadri High School,
Sirsi (U.K.) 581402

20.Sri. Ganapathi V. Hegde,
Shri. Mahaganapati High School,
Kibballi,Siddapur (U.K.)

21.Sri. Timmayya Ramachandra Hegde,
Suryanarayan High School,
Bisalkoppa, Sirsi (U.K.)

22.Sri. Gurunath Gajanan Hegde,
Pragati Vidyalaya,
Bharatanahalli,
Yellapur (U.K.)

23.Sri. Venkatraman Parameshwar Hegde,
Assistant Master,
Shri. Gajanan Secondary School,
Hegadekatta, Sirsi (U.K.)

24.Sri. Ganapati. N. Hegde, Asst. Master,
Vidyodaya Higher Secondary School,
Yadahalli, sirsi(U.K.) 581340

25.Sri. Ramachandra V. Hegde, Bhagwat,
Lecturer in Geography,
Vidyodaya Junior college,
Yadahalli, sirsi (U.K.) 581 340

26.Sri. R. shivsingh,
Rotary Kannada School,
Dandeli (U.K.)

27.Sri. Ramchandra Subray Hegde, Asst. Master,
Hindu High School,
Karwar 581301

28.Smt. Mahadevi Nagendra Markande,
Asst. Teacher,
Shri. sharadamba High School,
Bhairumbe, Sirsi (U.K.)

29.Sri. R.M. Hegde, Asst. Teacher,
Janata Vidyalaya,
Baroor, Sirsi (U.K.)

SUMMARY OF REACTIONS OF PARTICIPANTS ABOUT THE WORKSHOP

Totally twenty one participants have responded out of twenty nine.

1. COVERAGE OF VARIOUS TOPICS

The coverage of topics duringworkshop is quite satisfactory is the general expression.

Identification of areas, minerals and different types of soils, etc., could have been included (topics on soil and geology).

It would have better if the topics on Astronomy be included.

Health and higiene topics could have been arranged.

Marine biology demonstration and others could be included.

2. LECTURES

In general lectures were good, "Environmental Education" lecture was more emotional than informative.

Some other lectures could have arranged in case a lecturer is not present in time.

45% of the participants were nonbiologist. So topics on Nature, Ecosystem, food chain, with examples and explanation would have been appreciated.

3. FIELD TRIPS

Ranjit's field trips, for watching birds were very good. Few more field trips could have arranged. Ex. Forest, Fields.

4. EXPERIMENTS AND DEMONSTRATIONS

These were satisfactory. Actual involvement of the participants were better (eg. construction of ASTRA OLE).

5. HAND OUTS AND NOTES

The distribution of these in time, is quite useful extensive and can be used for reference. There is no notes on the subject like forestry.

6. SLIDE SHOWS

Slides were good. But a better projector is needed. Fr. Saldanha's slide-show was very good.)

7. CHITRAKEERTANA

No doubt a good attempt to convey the ideas to a common man. Certain improvement is desired. Explanations and songs should go hand in hand with the slide show. It would have better if the sound recorded in cassettes. Or else in order to retain the original style of Chitrakeerthana presentation is to be improved.

YAKSHAGANA

Excellent in its context and performance, to convey the idea to the common man. The entire songs of the plot may be published. Cassettes and video records may be produced and sold to the public. This can be circulated to all the KRVP Units.

It is better to introduce in other districts, (except N.K. and S.K.) the story and the stars before actual begining of the play.

8. LIVING ACCOMMODATION

Quite satisfactory.

9. FOOD - Variety is expected otherwise everything fine.

10. Any other pertinent matter : Nonformal methods should be introduced. Such as, camp classes in the field itself. Actual involvement of the participants preparing nursery, beds - fabrication of ASTRA OLE.

RELATED

Books may be arranged to the participants during the camp period.

Evening time film-shows on pupular scientific topics, cultural activities may be arranged.

WORKSHOP ON ENVIRONMENTAL EDUCATION

The primary aim of this workshop is teaching of a major component of life sciences as well as aspects of physical, chemical and mathematical organisms, under their natural setting and under laboratory Culture in High Schools.

Children must observe at first hand around 200 different species of organisms including plants like some green algae, bread mould, a moss, paddy or rice, bajra, bamboo, banana, colocasia, Parthenium, Tulsi, Onion, some lily, loranthus, Banyan, Peepal, Mango, neem, Prosopis juliflora, Eucalyptus, Amaranthus, Bombax (silk cotton), Impomoea, Cuscuta, Anogeissus, Terminalia, invertibrate organisms such as earthworm, Millipedes, Rice moth (corcyra), Ants, Drosophila, Tribolium (Flour beetle), Praying mantis, Butter flies, Orb web spiders, snails, fishes viz., Guppy, Gambusia, reptiles viz., Gecko (house lizard), Garden lizard (Calotes), Rat snake, birds viz., House crow, jungle crow, Koel, sparrow, common myna, Roseringed Parakeet, Pariah kite, Blue rock pigeon, spotted dove, coppersmith, Tailor bird, purple rumped sunbird, Redwattled lapwing, Shikra, House swift, common swallow, White wagtail, Green bee eater, Grey drongo, Crow pheasant, spotted owlet, Rosy pastor, Redvented bulbul, White backed vulture and Mammals like Rhesus/bonnet/Assam Macaque Hanuman langur, pipestrelles, flying fox, palm squirrel, Mongoose, cat, dog, donkey, baffalo, Goat, sheep and cattle.

They must develop lab or garden cultures of bread mould, green gram, Amaranthus, Drosophila, Tribolium, Ants, Corcyra, Guppy, Gambusia, etc.

Using these they should be systematically taught the following.

1) functional Morphology (including aspects of physics, chemistry) - communication, locomotion, defense Mechanisms, Mimicry or Camouflage, etc.

2) decimation of diversity as an environmental issue - changes in ...2..

levels of diversity ovdr their immediate surroundings.

Example: Herb diversity on the school campus after or before rains, after and before some major operation like cleaning the playgrounds for the sports day, etc., or bird diversity in the heart of crowded cities, their suburbs, cultivated areas etc.

3) Physiological ecology - plants, insects.

4) Population ecology - sustainable harvest of renewable resources.

5) Community ecology - Pollination
Seed dispersal
Parasitism
Predation

6) Productivity - Agricultural ecosytems.

7) Soil and Water Conservation - soil erosion.

8) Urban ecosytems - fuel and energy requirement.

9) Environmental Toxicology - DDT residues
- Water pollution

10) Behavionral studies (Ethology) - Biological rhythums
(-daily and seasonal)
- foraging behaviour
- reproductive behaviour
- social behaviour
- communication

11) Biogeography - plants and animals.

Yadahalli.
16-10-1996.
SG.

SCIENCE AS A VOYAGE OF DISCOVERY

MADHAV GADGIL

I am delighted to be here with you fellow teachers of science to share our ideas and experiences, especially in the field of environmental education. But more than anything else, we want to share with you the excitement of doing science; the excitement that lies in perceiving new patterns in nature around us. For, science is emphatically not a collection of dull and dead facts, a static experience. It is, on the other hand, the process of discovering new facts, or better still new patterns and the processes that create these patterns. As teachers of science I firmly believe that we should be concerned above all in communicating the excitement of discovering these patterns and causes underlying them, rather than merely cataloguing a series of facts to be learnt by rote.

Our attempt in this workshop will therefore be to expose you to a series of phenomena in the environment around us such that you yourself get to discover the interesting patterns and learn to interpret them. The phenomena that we will talk about will be varied but will all be part of our everyday experience. They will range from plants around us and the cattle that feed on them

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Introductory lecture to the Workshop on Environmental Education for Science Teachers, Yadahalli, Taluk Sirsi, Uttara Kannada, 13th October 1986

and milk that they produce to the chulas on which we cook the grains in our kitchens. It is our contention that we can discover a rich range of patterns by observing these commonplaces, and that all of us, even in a simple village school can do it, even in the absence of any sophisticated apparatus.

Consider the plant life around us. Production of organic matter by these plants has been the basis of all other life, including that of man for eons. Now this organic matter is produced in a whole variety of forms. In fact, it is estimated that even one lowly plant manufactures in its life time a greater range of chemical molecules than the entire pharmaceutical industries of the world. This also means a tremendous variety of plant life, each sharing with others the production of a number of common molecules - starches, sugars, cellulose as well as a variety of special molecules - e.g. alkaloids and tannins that give pepper and arecanut their unique flavour. even amongst the common molecules, e.g. cellulose and starch there is much variation in terms of detailed structure and disposition. this is why, for instance, Indian cotton cannot produce as fine a cloth as Egyptian cotton; and Kayga the brackish water rice takes longer to cook than the Gowri rice grown in nearby freshwater fields.

Plants also differ from each other in their architecture - gross as well as fine. Thus a forest tree has much greater proportion of its tissues in form of stem than the grasses do. Or the traditional tall varieties of jowar than the modern hybrid ones. Furthermore, coconut palm, which is a tree, also has a very different architecture from another common tree, mango.

All such differences have a multitude of implications that we would urge you to discover. Let me point to just a few patterns here:

a) Spice plants - pepper, cardamom, cinnamon, muragalu are all inhabitants of evergreen rain forest.

b) Most thorny plants -babul, ber and many others are inhabitants of semi-arid regions. But there are also some spiny plants such as Sikekai from the rain forest.

c) Fibre yielding plants used in basketry are often monocots - bamboos, canes, palms, agaves, although there are dicots that yield fibres - sunhemp.

d) The proportion of tissue making up reproductive structures is much greater in herbs than in trees.

What causes underlie such patterns? Broadly we believe that all such patterns are functional - thus, for some reason "spicy" molecules are much more useful to evergreen rain forest trees than others; and successful herbs need to produce much more of seed tissue than the successful trees. If so, we must ponder on such functions. What for instance is the function of spicy molecules - alkaloids, tanins and so on for the trees that produce them?. Perhaps it is to discourage growth of fungi, insects and so on that might attack them. If that is our hypothesis, we would be

able to devise a simple experiment in the laboratory to test it. Can we design such an experiment?

Or go on to our kitchens. We eat some food raw - for instance, a ripe mango; others, such as, rice we must cook. Let us ponder why this is so. It may be related to the fact that in nature mango pulp serves the function of attracting birds and bats to disperse the seeds unharmed, while grass seeds such as rice are destroyed by being fed upon and dispersed with the help of structures such as spines. Then we may expect grass seeds not to be easily digestible and require special treatment such as cooking. Again we may devise other experiments on digestibility of seeds and fruits in relation to their natural dispersal to enquire into such an hypothesis.

And that brings us to fuel and cooking. What, for instance, determines the amount of fuelwood needed to cook a kilogram of food? How is this related to the nature of food, the nature of fuel, and the design of the chula? There are clearly a whole lot of physical and chemical phenomena that can be explored by making cooking the starting point. And what can be closer to our everyday experience than the process of cooking food on our hearth?

We shall explore these and many other questions over the next six days. I hope that they will serve to communicate to you the pleasure of discovering patterns in nature all around us - a pleasure that all of us could easily communicate to the active young minds we are in contact with. I hope you will enjoy the experience.

FORESTS AND RAINFALL

JAYASHANA GADGIL C R PRASAD

A FEW years ago there was widespread drought in Kerala. Thousands of coconut trees were affected and the price of coconuts soared. Some attributed the drought to the extensive deforestation carried out in the preceding years. The very next year, however, the rains were good. Immediately, a proponent of the Kerala timber lobby concluded that since continued deforestation had led to such a good rainy season, deforestation had no adverse effect on rainfall.

This illustrates the kind of debate that has been going on in India over the nature of the impact of forests on rainfall. The major flaw in both these arguments is in ascribing year-to-year changes of the rainfall to changing land surface conditions. In fact, we believe that these fluctuations of the monsoon on the interannual scale would occur even if the tree cover was **maintained absolutely constant. The** question is whether the land surface conditions change the mean climate around which these fluctuations occur.

It is well known that the nature of vegetation depends on rainfall. But is the converse true? Does a change in plant cover lead to a variation in rainfall?

From the 19th century onwards, there has been a massive depletion of tree cover in India. Yet, over this period, the variation of rainfall over the country as a whole has not been large. The standard deviation is only about 10 per cent of the mean and the worst drought had a deficit of only 25 per cent. The variation is dominated by large changes from year to year, representing oscillations between droughts and good monsoon years. Furthermore, the average rainfall appears to have increased in the early part of the century and decreased from the mid-sixties onwards. Thus there seems to be little ground for the widespread fear that deforestation will result in a substantial decrease of rainfall over the country as a whole over periods shorter than a century.

However, in the past decade, we have become increasingly aware of the fact that the nature of the land surface plays an important role in moulding the climate of certain parts of the tropics. These are the semi-arid regions surrounding the deserts. (It was the worldwide drought of 1972, followed by a major failure of the rains in the early 1970s, which led to this awareness.) In a pioneering study of this problem, J Charney et al (1977) first pointed out the presence of a biogeophysical feedback in which a decrease in the plant cover leads to a change in the climate — specifically a decrease in the rainfall — which in turn leads to a further depletion of plant cover, or desertification, over these marginal regions. We therefore expect large-scale deforestation of certain sensitive regions to lead to progressive desertification.

Why should deforestation affect rainfall?

Rainfall is associated with the ascent of moist air and the major rain-belt in the tropics is located over the radiative heat source (see box). It is easy to understand how plant cover can influence rainfall when we note that with a decrease in plant cover, the albedo or reflectivity of the land surface and the dust content of the atmosphere increase. Both these factors imply a decrease in the solar radiation received at the surface. Thus we expect the strength of the radiative **source to decrease with a decrease of** plant cover. Also the moisture in the air is likely to be greater in a forested area. Particularly in the semi-arid regions around the periphery of the rain-giving system, namely the ITCZ (see box), the balance is rather delicate and could be easily affected adversely if the radiative source strength decreases due to large-scale deforestation. Since the plant cover itself depends on the rainfall, this will lead to a further decrease in plant cover. In the presence of this biogeophysical feedback between the land surface conditions and the rain-giving system, an initial decrease of plant cover will trigger a process of desertification.

Such arguments can only suggest the nature of impact of a change in plant cover. What actually happens in the complex dynamical system whose

end-product is rainfall depends on a number of other factors. They influence the chain of events in the hogeophysical feedbacks such as the local evapotranspiration, soil moisture and other feedbacks operating in the system, for example, cloud-radiation feedback. Recent observational experiments in the Amazon region indicate that as much as 15 per cent of the moisture content of the air above this region comes from local evapotranspiration. Such factors are thus bound to play an important role in determining the circulation and rainfall patterns.

Model studies

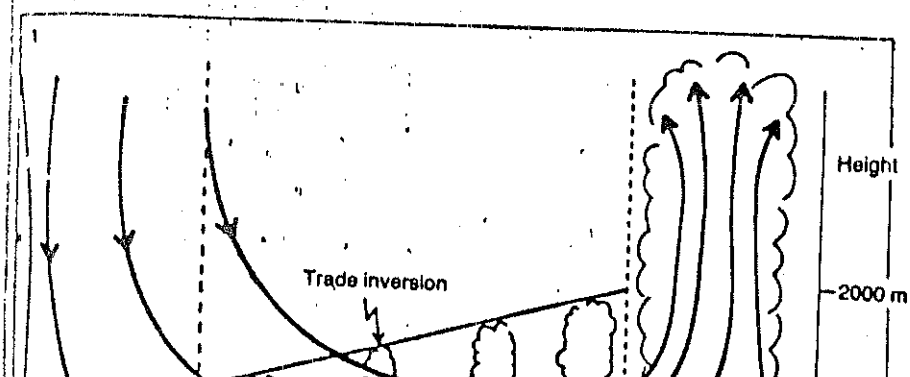
In the last few years, quite a few realistic models capable of simulating the mean tropical circulation and rainfall patterns have been developed. The different effects of deforestation are simulated by a change in the albedo and/or soil moisture etc and the results of the model run are compared with the control run (in which there is no deforestation so to speak) theoretical studies provide an ideal tool for testing the impact of deforestation on tropical rainfall.

The first such study was by Chat and co-workers. In the control exp ment, the albedo of the deserts taken to be 35 per cent and of the of the ice/snow free continents t 14 per cent. The albedo of three ions adjacent to the deserts, inclu Sahel and Rajasthan, was changed f 14 per cent to 35 per cent to simu loss of plant cover. It was found the rainfall over Rajasthan decre by about 50 per cent. This gen trend of a decrease in rainfall resul from an increase in albedo has b confirmed by later studies. A decr (increase) in the evapotranspiratic

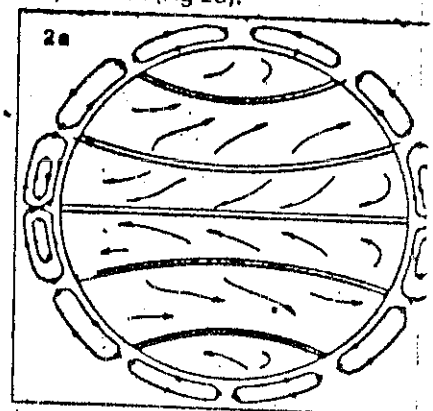
Global circulation, rainfall and climate

RAINFALL IS the end-product of complex dynamical processes occurring in the atmosphere. The energy source for atmospheric circulation is the radiation from the Sun. However, since the atmosphere is almost transparent to this incoming radiation, most of it reaches the surface of Earth where it gets absorbed by the land and ocean, thus warming them up preferentially. Atmospheric circulation is a response to this heating at the lower boundary. Hence it is easy to see that the conditions prevalent (which control their albedo) at the surface of land and ocean are important factors in controlling the circulation. Rainfall naturally depends on the presence of clouds. Clouds are formed when moist air ascends in the atmosphere causing it to cool, resulting in the condensation of moisture. Over the global tropics the ascent occurs in response to the radiative heat source at the lower boundary.

In an annual average, maximum solar radiation is received in the equatorial regions. As a low pressure belt is created over this radiative heat source, air at low levels from both the hemispheres converges to this equatorial trough zone (which is therefore also called the intertropical convergence zone — ITCZ) and rises. On rising, the air cools, water vapour condenses and intense towering clouds are formed over this region of ascent. Most of the rainfall in the tropics occurs in the ITCZ and the cloud band marking the ITCZ is always a prominent feature of the satellite imagery of the tropics. The circulation is completed by the air flowing outward from the ITCZ at the high level and descending in the subtropical high pressure belts around 30° latitude (Fig 1). The downward movement of air in the high-pressure belts prevents cloud formation. All the major deserts are located in these belts. It is important to note that whereas the rainy belt with rising air is located over the radiation source, the sinking occurs over the deserts which are radiative sinks. There are two more cells poleward of the tropical cell (Fig 2a).



Cross section in a meridional plane showing the nature of circulation. The strong heat source over the equatorial region causes ascending motion of moist air over the Equator giving rise to intense clouding which is the chief characteristic of the inter tropical convergence zone (ITCZ). Surface flow of air occurs from higher latitudes on both sides of the Equator



Structure of the general circulation pattern sho ing the mean vertical circulation cells. The stre heating of the surface over the equatorial reg gives rise to strong ascending motion of the over the tropics. This cell also known as the H ley cell is completed by the descent of the air n 30°N latitudes where the sub-tropical highs located. Two more cells, one with ascent over sub-polar lows at 60°N latitudes (known as F rel cell) and the other a weaker polar cell w descent over the poles, completes the general c culation pattern. The prevailing surface wi directions are also shown

Because of the tilt of the Earth's axis there is a seasonal variation of th declination of the Sun. This implies seasonal migration of the latitude o maximum heating and, consequently the location of the ITCZ also exhibits variation with season. The amplitude o this seasonal oscillation is rather larg over the monsoonal regions of th world.

During our summer, the rainbe associated with the ITCZ moves on t our subcontinent in response to th

...veral studies. In a simula... ...periment involving massive ...on of large areas in Africa by ...the maximum rainfall over ...f Africa was found to increase ...per cent.

...hese experiments show that ...mulated climates are sensi... ...land surface boundary condi... ...When soil moisture availability ...ce albedo are changed region... ...mulate the effects of defores... ...changes occur in the tempera... ...d motion field of the atmos... ...ver the region which generally changes are above the levels of the natural variability of the model-simulated climates.

Thus the results of these simulations by and large support the concept of biogeophysical feedbacks which would lead to rapid desertification after an initial deforestation, particularly in marginal areas around the deserts. However, the changes in albedo and soil moisture assumed to represent deforestation in these studies have been generally rather large when compared with what they really are. Thus satellite observations ...Sahel during a drought are only from 20 to 28 per cent whereas in the model studies desertification was taken to be a change in albedo from 14 to 35 per cent. But since other studies with less dramatic changes in albedo have confirmed the nature of the change induced in the rainfall, these observations imply only a reduction in the amplitude of the impact.

Also, the actual conditions do not always deteriorate monotonically. For example, it was found that during a period of several years in which drought conditions prevailed over

...e sources created there. We ...monsoons to this annual visit of ...CZ. The rainfall received is by no ...niform over the entire country. It ...e over the Indo-Gangetic plain ...s the seat of this rain-giving sys... ...the peak monsoon months of July ...August and decreases westwards ...s the Thar desert. It is also large ...the west coast and in the hilly ...n the north-east due to the ...ol air forced by the terrain.

...der next the implications of this ...on for the climate of the tropics. ...mportant climatic elements, ...temperature, pressure and rain... ...hibit a marked variation with ...e. Hence, we consider first the ...r regimes on an idealised Earth ...ich there is no variation in the ...st direction (Fig 2b). The mean ...r temperature is maximum in the ...rol regions and decreases pole... ...n this annual average picture, ...simum rainfall occurs in the ...rial regions which are under the sway of the ITCZ almost throughout the year. Flanking the wet equatorial region on the side would be the wet and dry tropics which are as warm, but not as wet. These monsoonal regions get rainfall mainly in the summer. Poleward of the wet and dry tropics will be found the semi-arid regions with still less rainfall and then the deserts with hardly any rainfall. Poleward of the deserts are the semi-arid regions of the mid-latitudes and then the humid mid-latitudinal regions and, finally, the polar and subpolar regions. The climatic regimes of the real world are not too different from this idealised picture (Fig 3).

Note that relative to the rest of the tropics we in India are particularly fortunate in getting the monsoon rains up to rather high latitudes. We owe this special privilege to the presence of the massive Tibetan plateau which acts as an elevated heat source and pulls the ITCZ over our country.

The location and extent of these different zones exhibit considerable variability. Over long time-scales we know that the polar-subpolar regions expand and contract as we experience the oscillation between ice ages and warm interglacial periods. Over shorter time-scales, such as a century, the global mean temperature changes and deserts spread and shrink. Once in every three to seven years major events occur such as the El Nino over the Pacific which appear to be also linked to the fluctuations of the monsoon. There are also major variations from year to year in regional as well as global climate.

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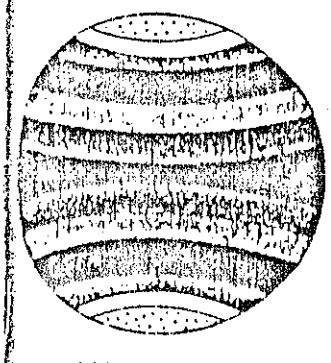
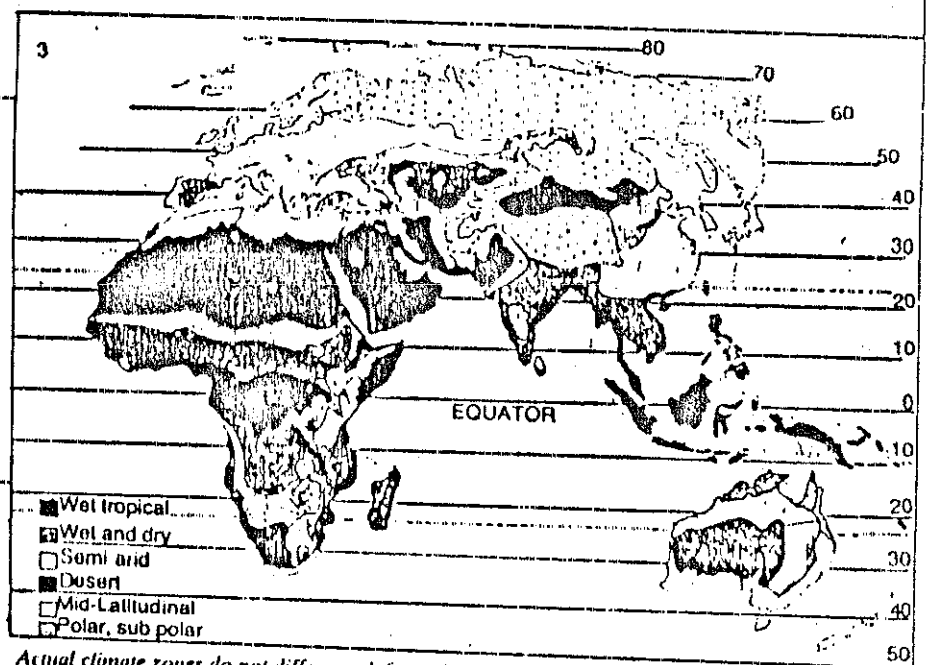


...al climate zones based on the gen... ...ulation pattern shown over the globe ...e east-west variation is ignored. Corres... ...the ascending limbs of the vertical cir... ...cells are regions enjoying high rainfall, ...regions where the dry air descends the ...ert regions are located. In between are ...id regions. The tropical region is ...ed the wet tropics and the wet and dry ...s the latter, rainfall occurs primarily in ...



Actual climate zones do not differ much from the ideal picture shown in fig 2b. The effects of ocean and other orographic features modify the climates somewhat. In the African continent is seen almost a perfect demarcation of zones. The fortunate situation enjoyed by India can be appreciated by noting the other regions with the same latitudes falling into the semi-arid zone

Sahel, the albedo over certain parts of Sahel in fact decreased after an initial increase. This suggests the presence of other negative feedbacks in the system which would temper the effect of the positive feedbacks in real life. We thus expect perceptible changes in rainfall to occur not within a few years but only over long time-scales of several decades or longer.

Empirical basis

There are practical difficulties in detecting any effect of variation of plant cover on variation of rainfall in real life. The reason for this is that there is a tremendous variation in rainfall both in time and space, which exists regardless of any variation of plant cover. Thus, while allowing for this inherent variation, discerning the variation induced by a man-made change in plant cover presents considerable statistical difficulties. Serious attempts have nevertheless been made to investigate the nature of the influence of forest cover on rainfall on the basis of observations over smaller regions within India.

The first such attempt was the classic work of H F Blanford over a century ago. In the early days of British rule, the government had stopped the practice of "shifting cultivation" over a large tribal belt in Central India. The forest cover over this region had therefore made a recovery around 1875-1885, while the vegetation cover in some other neighbouring regions had remained unaffected. Blanford compared the rainfall series over these two regions to determine whether the recovery of the forest cover had led to an increased rainfall in the region where shifting cultivation had been halted. His conclusion was that there was indeed evidence for an increase in rainfall with the recovery of forest cover.

A second study of the same problem by Meher Homji looks at the other side of the coin. He compares the rainfall over time for a number of stations on the Western Ghats which have suffered varying levels of deforestation. He concludes that the level of reduction in rainfall is correlated with the extent of deforestation. However, results of a subsequent in-depth analysis of the time series does not support this conclusion since no clear trend is discernible.

These results are merely suggestive; they support the expectations based on the effect of the changes in the albedos and the soil moisture. But they are by no means conclusive. This is because these studies could not overcome the inherent statistical hurdles. That is not to say that the statistical problems are insurmountable. We can hope for a definitive answer on this critical question in the years to come.

So the situation, as far as we understand it now, is as follows:
Loss of forest is in theory likely to lead to a decrease in rainfall, although the facts are as yet unclear as to the exact quantitative relation between the two and the time-scales over which they occur. However, loss of forest does decidedly decrease the availability of this water for plant and human. The vast destruction wrought by r forest removal to the long-t economic base of the country inc ing the priceless biological heri should be a greater deterrent to fo removal than what we now know al possible climatic change. It has l said that forests precede civilisat and deserts follow them. Let us h that our present civilisation with much greater scientific awarenes the consequences of its actions wil an exception to this rule.

Forests and water balance

HOW DO forests affect the rain once it falls? The forest canopy firstly breaks the fall of the rain as it comes down, then ensures its more gentle penetration in the ground, reduces soil erosion and runoff and improves the underground water table. This regulatory effect of the forest on the water cycle is vital in preventing flash floods and maintaining a continual flow of water into streams and rivers. In the absence of this regulation, our rivers flood in the monsoon and go dry in the summer. Since the water supply in the summer is critical for us, this has the same consequence as a decline in the rainfall. Furthermore, this implies that once vegetation cover is reduced, it becomes more and more difficult to re-establish it, and landing us in a vicious cycle.

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Interannual variations of the monsoon

ONE OF the most challenging unsolved problems in monsoon meteorology is to understand and predictits variations from year to year. It is believed that these interannual variations arise primarily because the response of the coupled ocean atmosphere system to the solar forcing is rather complex and although the incoming radiation is the same on the same date irrespective of the year, the actual conditions at the surface of the tropical oceans are by no means the same on the same date of each year. Because of the slow response of the oceans, the history of the previous seasons leaves its footprints on these waters, as it were, and gives a slightly different character to every year. Regic variations of the monsoon on interannual scale can also arise f interaction of the ITCZ over our re and that over the Pacific. During th Nino, surface temperatures over so ern and central Pacific become ab mally high, and the ITCZ over the e ern Pacific moved southwards fron usual location. This results in drou over some regions, floods over ot and a sudden drop in the fish catcl the coast of Peru. Apparently tl events are linked to (and prob triggered by) abnormal behaviou the ITCZ over the Indian region. \ the advent of satellites the prospec our understanding the interannual v ations and their teleconnections h become very bright and the future h considerable promise for their pre tion.

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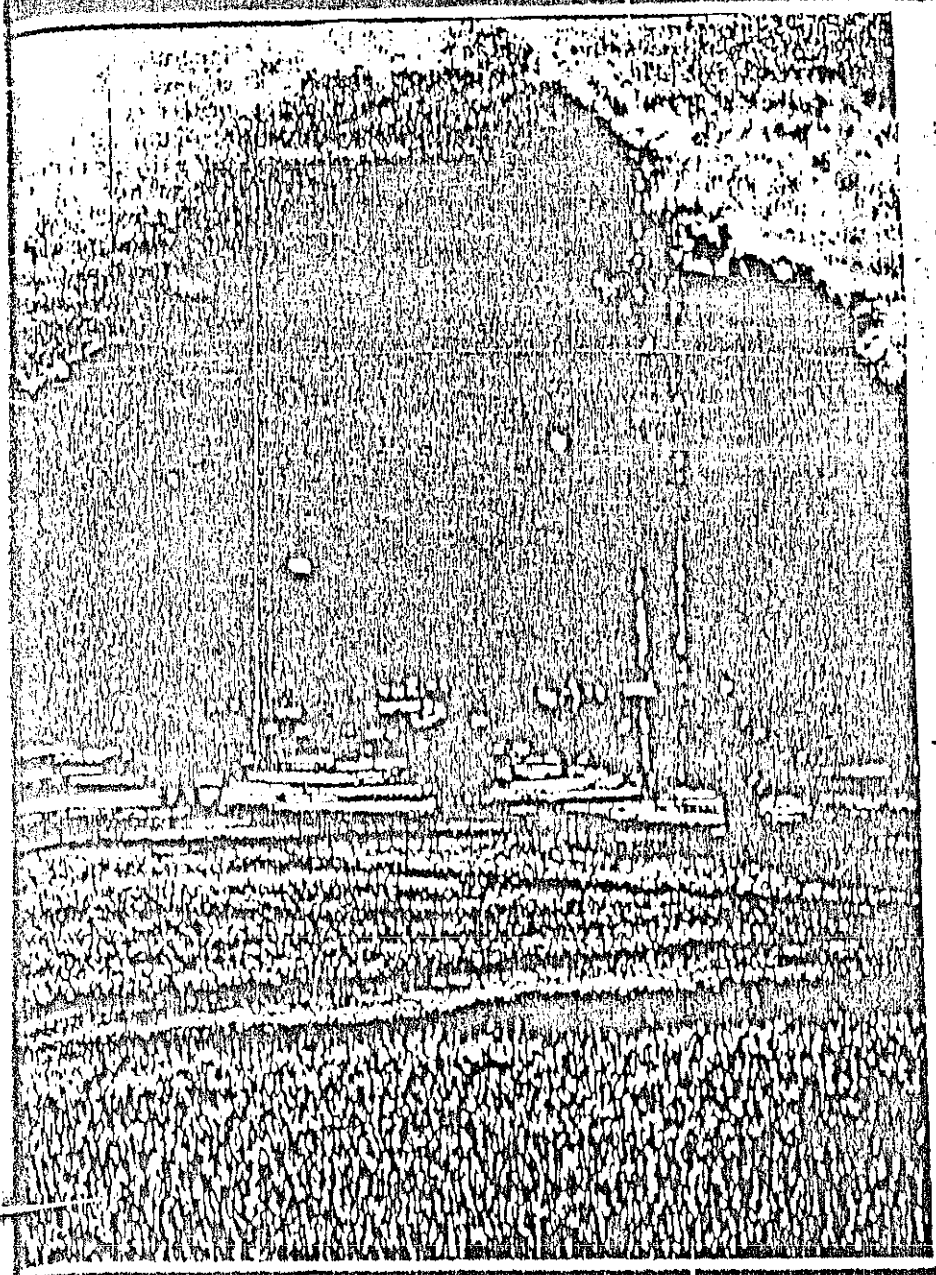
Dr Prasad is a mechanical engineer, who did his undergraduate studies in Bangalore, then MS at Brown University, and PhD at State University of New York, Stony Brook, USA. Presently he is an associate professor at the Indian Institute of Science, Bangalore, affiliated to the Mechar Engineering Department and also the Centre Atmospheric Sciences. His main interests atmospheric radiation, lasers and their app tions and renewable energy.



CLIMATIC CHANGE—A GLOBAL PERSPECTIVE

C R PRASAD SULOCHANA GADGIL

We know what the temperatures were thousands of years ago but not what they'll be tomorrow

WE ARE all aware of t variability of climate fro region to region and fro year to year. A few ye of droughts and a few of floods are part and parcel of the monsoon s tem. This fact is also reflected in our historical writings. Until abo 1960, meteorologists believed th there exists a mean climatic st about which fluctuations occur a that the statistics of these fluctuatio are constant for at least several ce turies. For example, it was expect that the frequency of droughts in In during any three decades would about the same as the frequency any other thirty-year period.

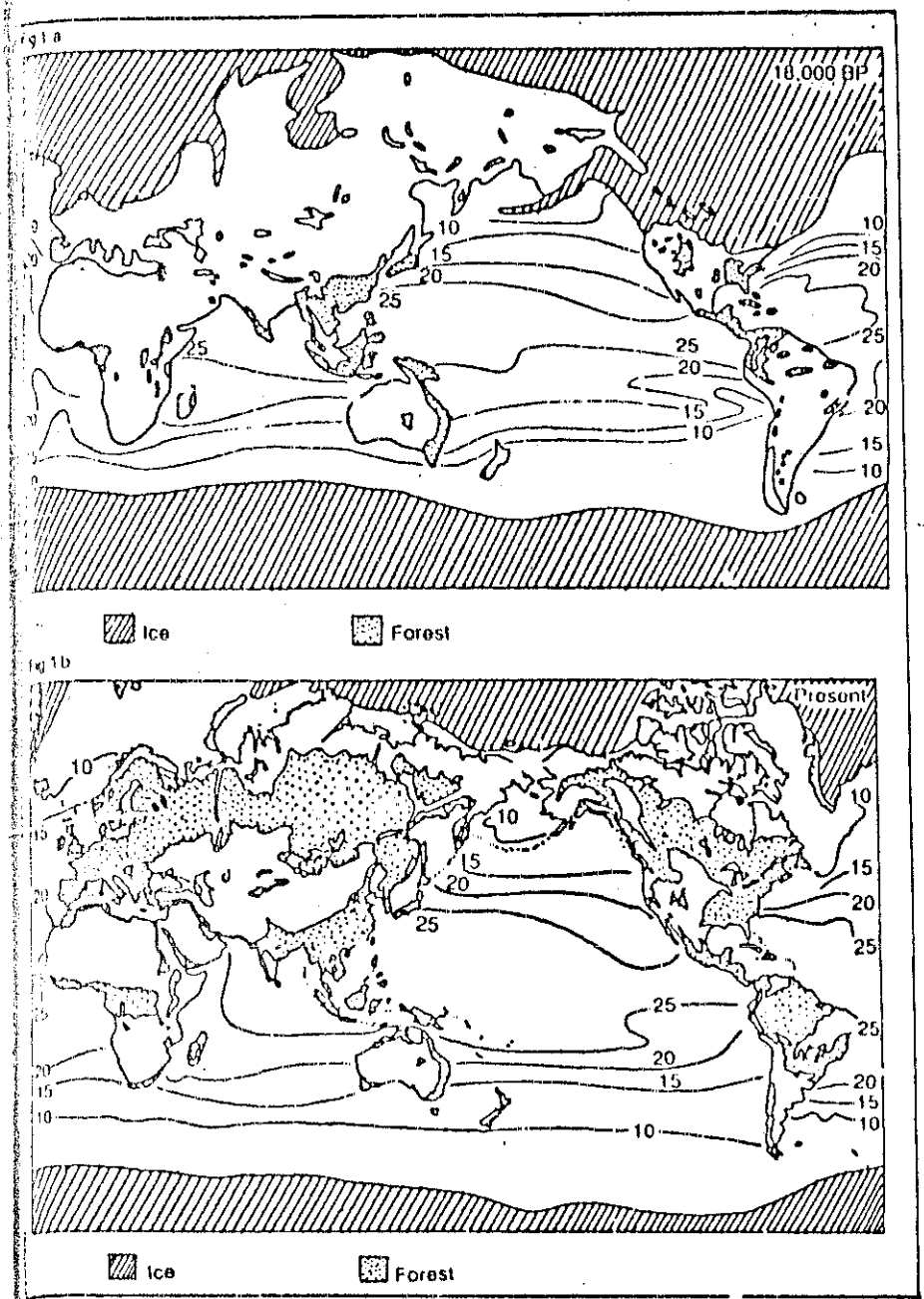
Recent evidence clearly shows th there are significant variations in c mate over time-scales ranging fro the order of a few months to hundre of thousands of years. The oscillatio between ice-ages and interglaci are examples of climatic change ov long time-scales. Even in the l thousand years, a major fluctuati occurred in the climate of Europe a other regions at high latitudes caus a little ice-age between the 15th a 17th centuries.

As our perception of clima change has improved, so has our c cern about the possibility of clim changes induced by human activi — particularly large-scale defore tion and combustion of fossil fu Here we discuss what is known ab climatic change, its causes and c sider the manner in which man-m changes could influence the climat

Accurate climatic data based instrumental meteorological obse tions is available only for the past c tury. Data on past climatic condit (over several thousand years) ca gleaned from descriptions and ob vations recorded in various histo sources. Climatic data of more re periods extending over hundred millions of years are deduced f palaeogeographical studies base ocean-bed cores, fossil records,

...etc. It has been established that ...e isotopic composition of organic ...oduces provides an excellent mea...re of palaeo-temperature.

The history of our global climate, as ...ered from the empirical studies ...d on these sources, shows that ...matic conditions that prevailed over ...last few hundred million years dif...d markedly from those of the pre..., with higher overall temperatures ...also fewer differences in tempera...es in the lower and high latitudes. ...ese higher latitudes began to cool sharply about ... million years ago leading to polar glaciation about a million years ago. The glaciation in the northern hemisphere has fluctuated considerably since then and the most dramatic climatic changes have been the ice-ages which have occurred approximately every 100,000 years. During these ice-ages, ice up to a thickness of three km is formed over the land in the polar regions. The weight of ice caused it to flow outward and southward; ice covered much of North America and Europe (Fig 1 a).



The conditions on the Earth's surface at the peak of the glacial era approximately 18 000 years ago (a) compared with the present (below). The glaciers withdrew about 11,000 years ago, causing a rise in sea levels due to the melting of ice and flooding the continental margins that were earlier exposed. The extent of forests shown in the lower map is the "potential" forest area in the absence of human intervention.

...average Earth temperature is reduced by about 3°C.

After the ice sheets receded following the termination of one ice-age, the levels of oceans rose (by as much as 100 metres) and vegetation patterns changed as seen in Fig 1 b.

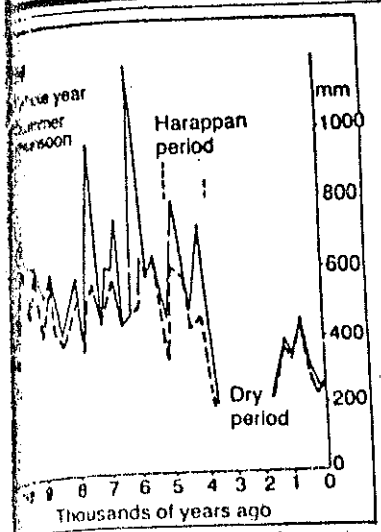
All of the warm period in which human civilisations developed and flourished represents a short epoch which began 10,000 years ago. Within the present interglacial too, thermal conditions have continued to change. It is believed that the monsoons were much stronger in the early part of this interglacial. As a case in point, around 4500-3700 BP (before present), the rainfall in the Indus valley was probably much more than double the amount received now (Fig 2) and agriculture flourished. The drought conditions that followed could have led to the end of the great Harappan civilization. The little ice-age of the 15th to 17th century was also a prominent feature of the variation in the last 10,000 years.

Climatic fluctuations have continued in this century also — with a warming trend having occurred during the 1920's and 30's, followed by a cooling trend which continues to date. Analysis of the fluctuations of monsoon rainfall over India in the last century (Fig 3) indicates that the droughts in the warm epoch of 1930-1960 were considerably less frequent when compared to the previous or succeeding three decades. This suggests that the long-time variations of the monsoon may be linked to those of the global climate. On a shorter time scale, changes in the Earth's temperature following large volcanic explosions lead to a cooling that lasts from a few months to a year or more.

What are the mechanisms underlying these climatic changes over a myriad of time scale? We need to know this in order to predict what the future holds and to what extent we can (or have) modify (modified) it.

Radiation and circulation

The Sun's radiation is the main energy input for the circulation of our atmosphere and the global climate. Because the Sun is very hot the solar radiation reaching Earth is concentrated in the short-wave region. Part of this energy is reflected back to space by the atmosphere (Fig 4). The reflectivity (or albedo) of the Earth's surface determines how much of this radiation can be absorbed at the surface. In turn the Earth-atmosphere system radiates energy back to space. This terrestrial radiation, however, is concentrated over the long wavelengths



...ion of rainfall over the Rajasthan region ... past 10,000 years, estimated from lake ... botanical evidence based on pollen ... The cities of Harappa and Mohenjodaro in the Indus Valley flourished in what are now, during 2500 and 1700 BP when the rainfall was between 500 and 800 mm per

...the Earth is much cooler than ... The atmosphere absorbs the ... radiation, and reradiates it ... to space and partly back to ... (Fig 4) Due to the curvature of ... Earth, the tilt of its axis, and also ... it is spherical, there is a ...sonal and consequently seasonal ...tion of solar radiation input over ...anet; the maximum input is over ... equatorial region and the ...imum over the poles.

...h the exception of ozone, the ... constituents of the atmos... are by and large transparent to ...coming solar radiation. Ozone in ...screens the Earth from the harm... ultraviolet rays of the Sun's radia... When it comes to the outgoing ...mal long-wave radiation the ...sphere behaves quite differently. ...on lies the great advantage that ... Earth derives from its atmos... Two gaseous components — ...on dioxide and water vapour — ...ch present in small quantities effi...y block the bulk of the outgoing ...tion from the Earth. Had the ...sphere not behaved thus, the ...'s surface temperature would ...been much lower (about −18°C, ...h below the freezing temperature ...ater). The two infra-red opaque ...s make the atmosphere act as a ...ket for heat, while permitting ...radiation to come through. This ...omenon is called the ...enhouse" effect. Obviously, an ...ase in the concentration of these ... will enhance the greenhouse ...t and hence lead to a warming of ...Earth-atmosphere system.

...than average over long time scales and over the entire globe the Earth-atmosphere system receives just as much energy as it emits. The mean temperature of the globe is almost constant, but this balance is not maintained for any part of the system. The excess of energy from the tropics is transported poleward by the atmospheric and oceanic circulation. But most climate models ignore the details of the latitudinal variations of temperature and the global circulation, and concentrate mainly on the effects of changes in different climatic factors by using simple models of the world characterised by a single effective temperature. (These energy balance models are sufficient to identify the principal driving forces and the mechanisms by which climatic changes occur).

Mechanisms of climatic change

If the mean reflectivity or albedo of this system is denoted by a_p, the energy gain is a fraction $(1 - a_p)$ of the solar radiation received at the top of the atmosphere (F_{Sun}). The radiation emitted by the Earth-atmosphere system (F_{e-a}) is related to the effective mean temperature (T_e) of the Earth-atmosphere system by the Stephan-Boltzmann law. Hence the energy balance can be written as:

$$(1 - a_p)F_{Sun} = F_{e-a} = BT^4_e \quad \ldots\ldots (1)$$

where B is the Stephan-Boltzmann constant. Substituting the average values of a_p and F_{Sun} (0.285 and 340 W/m^2) in equation (1) we obtain for T_e a value of 255°K which indeed is the value of the effective temperature

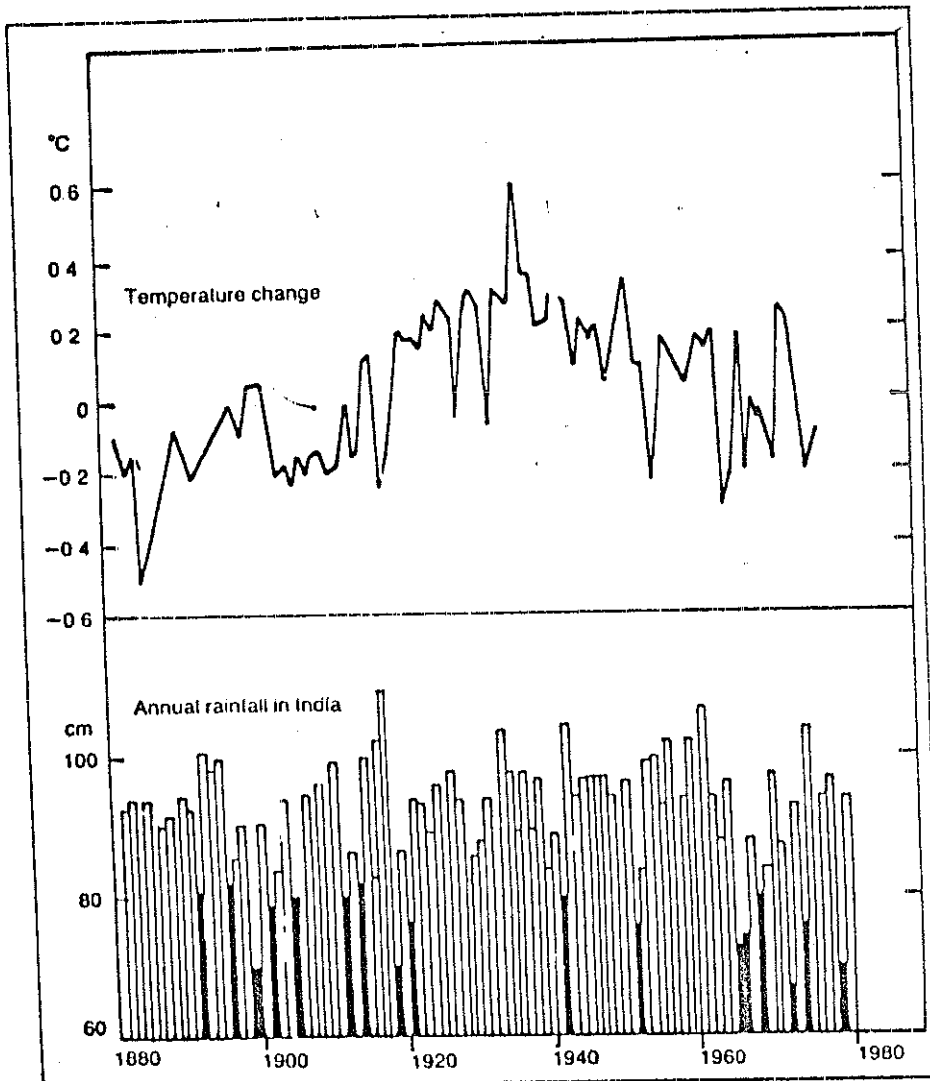


Fig 3 The mean temperature of the Earth has been above normal for a large part of this century. The upper figure shows the departure of temperature (°C) from the normal (long-term average). It is seen that the period from about 1920 to about 1960 has been warmer. In the lower figure is shown the average annual rainfall over India for the same period. Years classified as drought years (when rainfall is 25 per cent or more lesser than normal) are shown as solid lines. One obvious feature is the relative absence of drought years (solid lines) in the warm period indicating the relation between global climate and our monsoons.

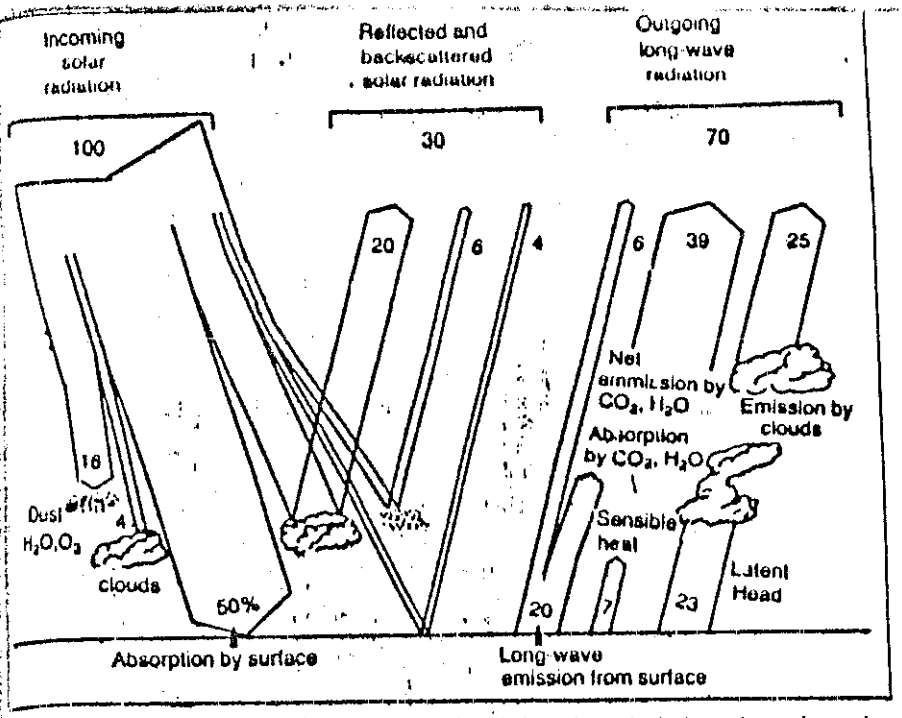


Fig 4 The mean temperature of Earth is determined by a balance between the incoming and outgoing energy streams. Shown here are the various parts into which the radiation stream is divided into. The effective radiating temperature of the Earth as seen by an observer in space (corresponding to the brightness temperature of the total outgoing long wave radiation) is about −18°C, while the effective mean surface temperature is about 15°C for maintaining radiative equilibrium.

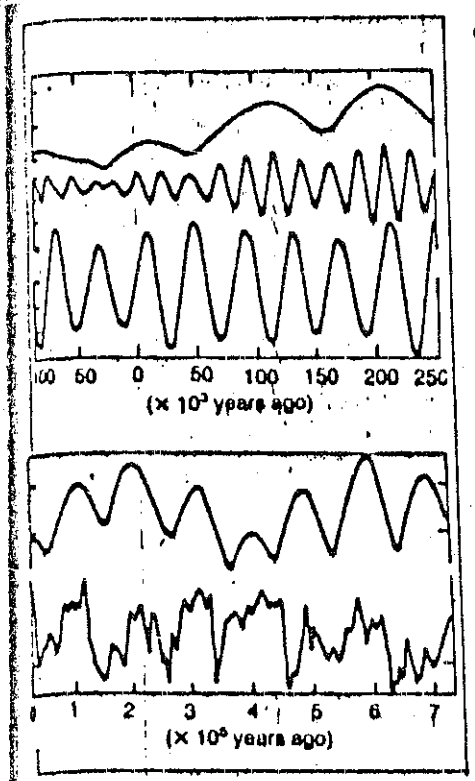


Fig 5 The Earth's orbital characteristics and its climate are well correlated. The upper three curves show variations of eccentricity, tilt (obliquity) and precession of the equinoxes. The lower two curves compare the eccentricity with climate (represented by ice volume) of the last 300 000 years showing the occurrence of ice ages within a period of approximately 100,000 years.

of the Earth as seen from space.

What determines the atmospheric circulation is the energy balance at the surface of the Earth. Here again the gain in energy through the absorbed solar radiation $(1 - a)F_s$ (a is the albedo of the surface and F_s the solar radiation reaching the surface) and the gain through thermal radiation (F_a) from the atmosphere is equated to the loss through radiation to space (F_e) (which depends on the surface temperature T and the emissivity E of the surface) and losses of energy spent in evaporation L and in heating up the atmosphere H (Fig 4). Thus:

$(1 - a) F + F_a = F_e + H + L = E_a T^4 + H + L$ .....(2).

It is obvious that a change in the mean surface temperature (which determines the circulation and climate) can be brought about by changes in either the intensity of the radiation received at the top of the atmosphere or the reflectivity (albedo) of the atmosphere and the Earth's surface or the intensity of the thermal radiation which depends upon the concentration of those constituents of the atmosphere such as carbon dioxide, dust, water vapour etc, which absorb infrared radiation.

Climatic changes on different time scales have been attributed to combinations of these different factors. However, the response of the atmosphere to variations of these factors is backs operating in the complex dynamical system which determines our climate. Consider, for example, what happens when the intensity of the solar radiation reaching the top of the atmosphere decreases by about one per cent. Equations (1) and (2) show that this leads to a decrease in the overall temperature of the Earth by 0.66°C and the surface temperature by about 1.2°C. Hence an increase in the extent of the ice-cover should occur. Since the albedo of ice-covered surfaces is very large, an increased ice-cover results in a higher mean reflectivity and hence a further decrease in the solar radiation received by the Earth-atmosphere system. Some climatic models suggest that in the presence of such a positive feedback even a two per cent decrease of the solar insolation factor can trigger a new ice-age. There are other feedbacks in the system such as the bio-geophysical feedback between desertification and the rain-giving system in the tropics.

Long-term variations in climate

Understanding the dramatic changes on the long time scales, that is, the oscillation between the ice-ages and interglacials, is one the success stories of this field. In 1930 Milankovitch formulated the astronomical theory of climate wherein he showed that the dominant periodicities of the oscillations between ice-ages and interglacials were extremely well correlated with the periodicities of changes in the three parameters describing the orbit of Earth around the Sun. It is now believed that climatic changes occur in response to the variations in the incoming solar radiation and its distribution with latitude resulting from the changes in the orbital parameters (Fig 5).

Eccentricity of orbit, the tilt of the Earth's axis and longitude of the perihelion (or the deviation of the precession of the equinoxes from the mean Sun-Earth distance) are the three parameters governing the Earth's orbit, and hence the amount of solar insolation at any given latitude and seasons. From astronomical analysis it is found that the periodicities are 100,000 years for eccentricity, 40,000 years for tilt and 23,000 years for the precession index. The changes in these quantities are: the eccentricity varies from 0.001 to 0.054 (current value = 0.017), the tilt from about 22.0 to 24.5° (current value = 23.4°) whereas the precession index varies from −6.9 to +3.7 per cent, the index being defined as zero fo

/eather, climate nd predictability

HERE IS what appears at first sight an apparent contradiction regarding the predictability of weather and climate. Weather comprises the effects of meteorological parameters like temperature, pressure, rainfall and winds pertaining to the region at that instant of time. It changes from day to day or over such shorter time-scales such as when a thundershower passes overhead. Further, weather can be widely different at the same instant of time for two different regions. On the other hand, climate is the average or typical weather of a region averaged over a month or season or a year or an epoch. While weather can be predicted (with a degree of accuracy, at all) only for about seven to ten days in advance, the climate of the Earth has been analysed with a great degree of confidence for periods as long as several hundreds of thousands of years. Climate on the other hand deals with the aspects of equilibria. This comes about because here we deal with only the mean conditions and the fluctuations on small spatial and temporal scales are averaged out on the climatic scales. Also, in the study of climatic change, we evaluate the effect of changes in boundary conditions such as oceans, ice, surface, atmosphere and insolation on the system. Since these boundary conditions change over long time-scales they force order into the system as opposed to the chaotic manner in which individual trajectories evolve from an initial condition when the governing system of equations is solved, in the study of weather. This explains how we are able to understand the fundamental causes of the succession of Pleistocene ice-ages that have occurred over the past 700,000 years or so, giving rise to glaciation and interglacial periods on Earth. Since not all climatic changes are caused by natural causes, it is quite likely that human interventions on Earth are also altering the climate.

A large variety of phenomena interacts in a very complex fashion to structure the weather and climate. The delicate balances are easily upset because of the feed-backs that amplify or suppress the disturbances. This aspect is likely to make predictions of climate somewhat speculative at pre-

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AD. The magnitude of the ting changes in intensity is not large, it ranges from a few per at the equator to a maximum of 8 per cent attained around the latitudes. However, in the pre-e of positive feedbacks such as the albedo feedback, a decrease by two per cent can trigger a catas-phic change to an ice-covered th. It is thus likely that the varia-s in the incoming radiation due to orbital variations are indeed the ers of ice-ages.

ecently, the temperature of the h over the past has been deduced m measurements of oxygen isotope s in ocean bed cores. We can see remarkable correlation between deduced temperature and the tal parameters (Fig 6). Using this elation, we can safely say that the t ice-age will come 60,000 years n now. It is unlikely that man-e changes in climate such as the ming due to increased atmos-eric carbon dioxide can delay or ent its appearance. It is difficult predict in detail the manner in h the transition to an ice-age will ur because these transitions are termined by interactions between erent components of the system h as the ice-albedo feedback. The urrence of the little ice age in the 15th-17th century has also been attributed to variation in the solar radiation received at the top of the atmosphere.

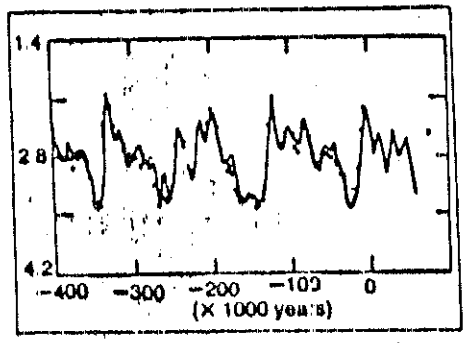


Fig 6 A comparison of the Earth's orbital variations (solid line) with climatic changes inferred from measurements of ratios of oxygen isotopes, in deep ocean bed cores (dots) showing excellent agreement between the two. Based on this analysis, barring any major intervention on climate by man, the next glacial epoch is expected to occur 3000 to 7000 years from now. Currently the Earth has started cooling and will continue to cool except for a few partial recoveries until the glacial maximum (ice age) occurs about 60,000 years hence. Only after this is a full recovery of the warm temperatures encountered earlier in this century expected.

Climatic changes over shorter time scales of a century or so are attributed to variations in the albedo and the concentrations of the important constituents of the atmosphere. Obviously, the albedo of a desert is much higher than that of a thick tropical forest and that of ice and snow is even higher. In other words, the amount of radiation absorbed at the surface decreases with desertification or increase of snow or ice-cover because of enhanced albedo. Changes in land surface conditions naturally have a significant impact on the radiative balance and consequently on the atmospheric circulation and rainfall.

Reflection of solar radiation by the atmosphere depends upon its dust (aerosol) content and clouds (Fig 4). When these increase, more solar radiation is reflected away. Result: cooling of the Earth. The relief afforded by the afternoon clouds from the scorching summer heat is a common experience of this phenomenon. Volcanic eruptions inject massive amounts of particulate matter and condensable gases that can form aerosols into the atmosphere. While the bulk of this rapidly settles out of the atmosphere, very fine particles and aerosols (like sulphuric acid) may stay for several years in large quantities in the upper atmosphere. The dominant impact of the presence of these aerosols and particles in the upper atmosphere is also one of cooling. When large-scale volcanic eruptions have occurred in quick succession, strong correlations between these events and significant falls in temperature have been noted. Recent observations following the eruption of the El Chichon volcano in 1982 have indicated that a cooling by almost 1°C occurred within days of the eruption. A large-scale nuclear war is expected to inject million of tonnes of particulate matter into the atmosphere and thus have a similar effect on climate.

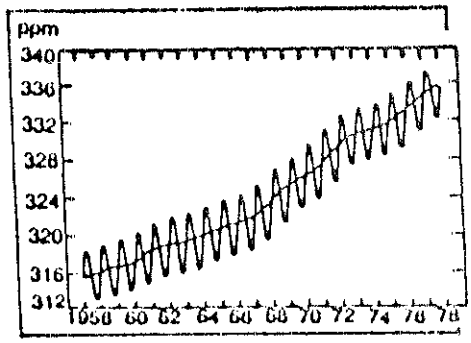


Fig 7 The carbon dioxide concentration measurements as made near Mauna Loa in Hawaii. Seasonal fluctuations due to the large uptake of carbon dioxide in summer by plants in the northern hemisphere and oxidation of plant tissues in winter are seen superimposed on steady increase. There are fewer fluctuations in the tropics where there is more uniform plant activity throughout the year and also in the southern hemisphere where there is less land for plants. A comparable steady increase is seen everywhere.

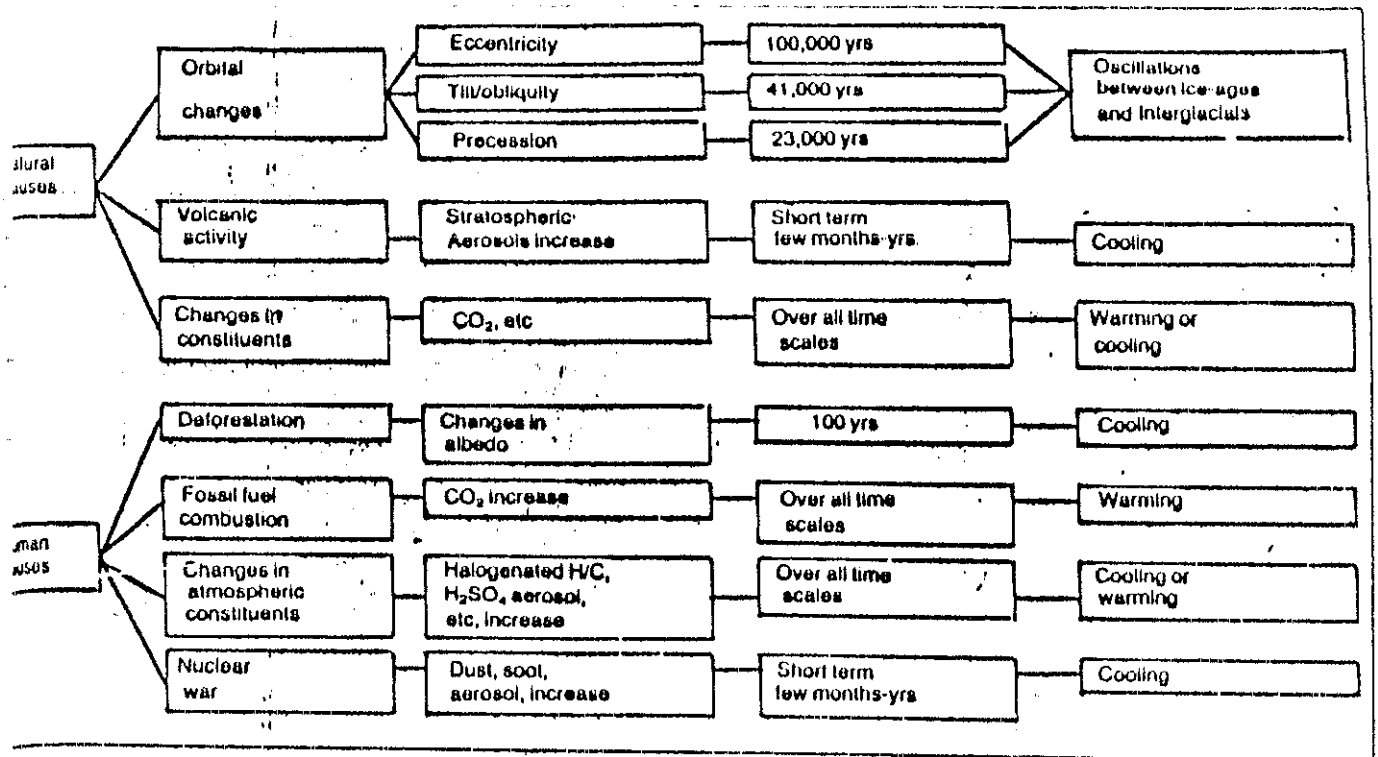


Fig 8 Schematic diagram showing linkages between the causes and their effects on climatic changes on Earth

It is conjectured that this could lead to a sudden cooling causing what is commonly called "nuclear winter".

Variations in carbon dioxide

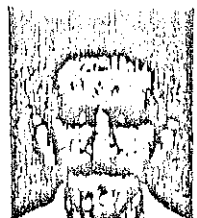
Carbon dioxide is a greenhouse molecule and plays a very crucial role in insulating the Earth. Any perturbations in its composition are likely to influence the climate. It has been observed that the carbon dioxide concentration has steadily increased over the past three decades (Fig 7). The causes for this could be: accelerated combustion of fossil fuels and deforestation. Since photosynthesis by plants is an important factor in determining the carbon dioxide content of the atmosphere, large scale destruction of forests, conversion of forest land to agricultural land with the associated oxidation of humus is likely to increase the atmospheric carbon dioxide.

The largest portion of the total quantity of carbon on Earth is held in the form of dissolved carbon dioxide in the ocean. The rate of production of the gas from fossil carbon combustion is around five billion tonnes of carbon per year, whereas the rate of its increase in air works out to only about a half of the fossil carbon burnt. This estimate however is of course based on the assumption that no other agency is contributing to the release of carbon dioxide. According to G M Woodwell and his co-workers (1983) the biotic release of carbon (partly due to deforestation) is indeed very large and is nearly half that from fossil fuels. Since the increase of carbon dioxide in the atmosphere is much smaller than all the inputs, the balance must therefore be removed by some combination of oceanic and land processes, which are not very clearly delineated yet.

Whatever be the cause of increase of carbon dioxide in the atmosphere, the climatic impact of such an increase appears to be one of warming, because of the enhanced greenhouse effect. Present day models predict an increase of from 2 to 4°C if the concentration of gas doubles.

Whither climatic prediction

Many factors can lead to climatic change over different time-scales (Fig 8). We have considered here the effect of each factor separately. We have seen that this approach has been remarkably successful in understanding and predicting the oscillations between ice-ages and interglacials. Similarly effects of an increased CO_2 and of deforestation have been predicted. However, to assess the impact of specific man-made changes or to predict future climate, it is necessary to use a model which incorporates all the important factors simultaneously. This is because in the presence of non-linear interactions and feedbacks, the results cannot be merely the sum total of the individual effects. With the vast array of tools available at present to study and model climatic changes, meteorologists hope to make a dent on this challenging problem in the near future.



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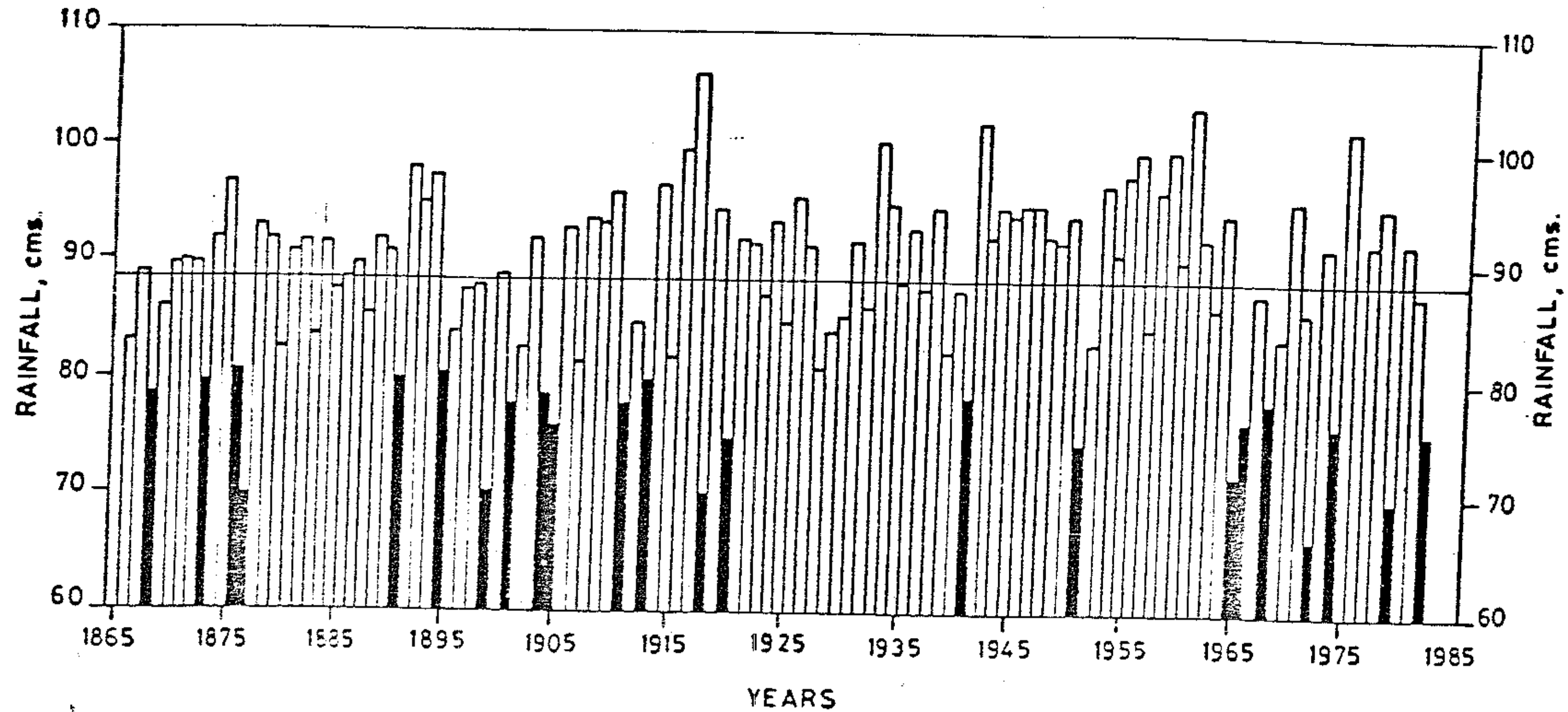
Dr (Mrs) Gadgil obtained her PhD in Applied Mathematics from Harvard University. Subsequently, she worked for one year at the Massachusetts Institute of Technology and two years at the Indian Institute of Tropical Meteorology. She is currently an associate professor at the Centre for Theoretical Studies at the Indian Institute of Science, Bangalore. Her research interests include modelling oceanic and atmospheric circulation, satellite meteorology and evolutionary biology.

HAND-OUT FOR LECTURE ON

MONSOONS

by

Prof. Sulochana Gadgil



SUMMER MONSOON RAINFALL OVER INDIA

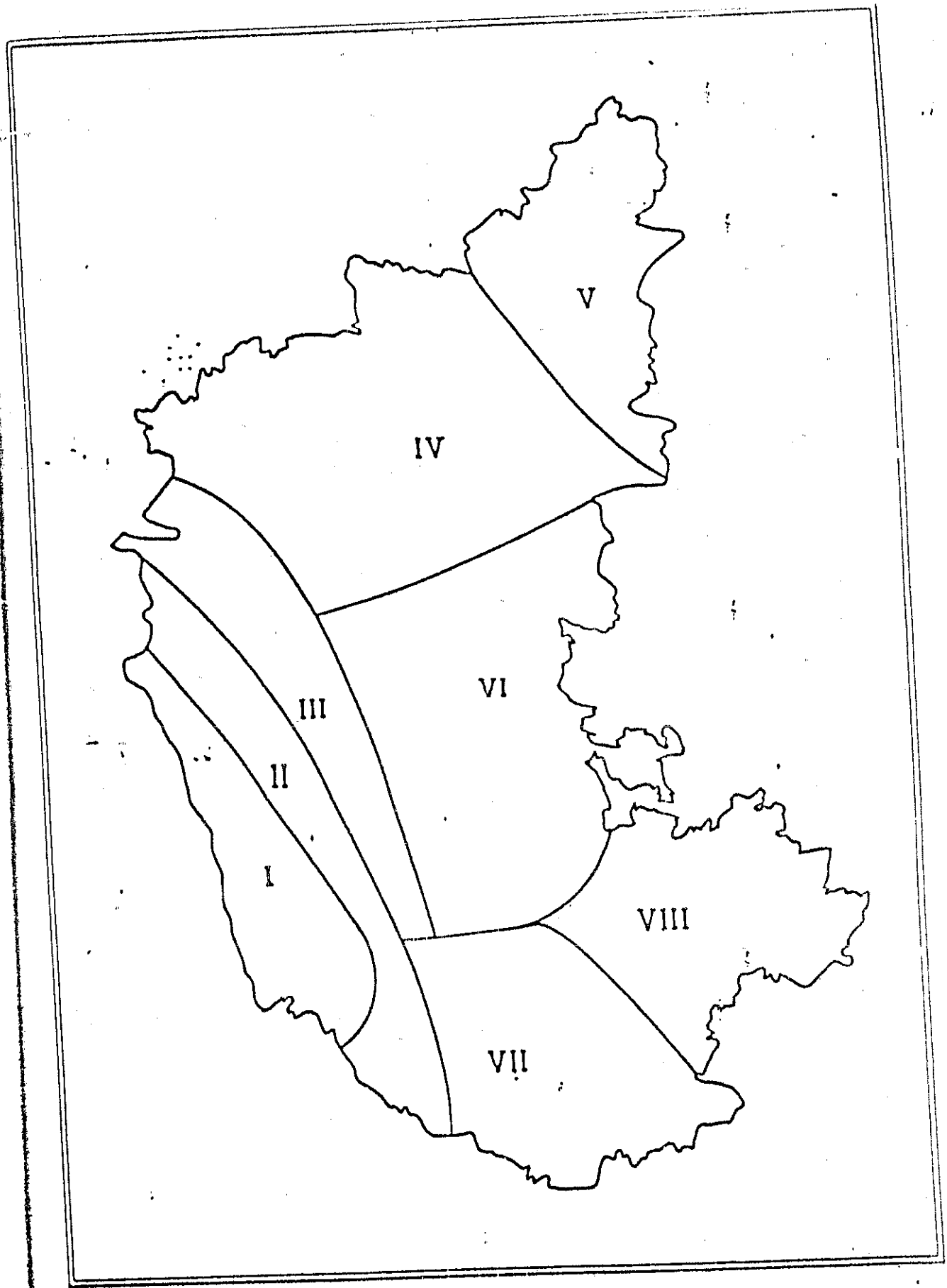


Fig.3 : Rainfall zones of Karnataka

Table 4

Percentage of years with rainfall/mean in the classes: March-May

	> 2.38	2.13 to 2.38	1.88 to 2.13	1.63 to 1.88	1.38 to 1.63	1.13 to 1.38	0.88 to 1.13	0.63 to 0.88	0.38 to 0.63	0.13 to 0.38	< 0.13
I	9	1	0	5	7	8	7	20	26	17	0
II	1	1	3	6	6	7	32	24	18	2	0
III	1	0	1	3	9	18	24	25	18	1	0
IV	0	1	5	3	7	19	25	18	20	2	0
V	6	1	2	6	7	13	15	19	17	13	1
VI	0	0	2	2	13	15	29	25	12	2	0
VII	0	0	1	1	10	20	30	27	10	1	0
VIII	0	0	0	6	10	22	19	28	14	1	0

Percentange of years with rainfall/mean in the classes: June-September

	> 2.38	2.13 to 2.38	1.88 to 2.13	1.63 to 1.88	1.38 to 1.63	1.13 to 1.38	0.88 to 1.13	0.63 to 0.88	0.38 to 0.63	0.13 to 0.38	< 0.13
I	0	0	0	0	2	18	61	18	1	0	0
II	0	0	0	1	2	20	53	23	1	0	0
III	0	0	1	0	5	20	43	29	2	0	0
IV	0	0	0	1	7	20	40	27	4	1	0
V	0	0	0	1	6	22	33	33	5	0	0
VI	0	0	0	0	10	22	39	22	7	0	0
VII	0	0	0	4	8	18	34	29	7	0	0
VIII	0	0	0	2	10	16	33	34	5	0	0

Percentage of years with rainfall/mean in the classes: October-December

	> 2.38	2.13 to 2.38	1.88 to 2.13	1.63 to 1.88	1.38 to 1.63	1.13 to 1.38	0.88 to 1.13	0.63 to 0.88	0.38 to 0.63	0.13 to 0.38	< 0.13
I	0	0	0	5	16	15	22	18	19	5	0
II	0	0	1	5	9	15	33	23	13	1	0
III	1	1	5	5	3	21	13	27	19	5	0
IV	1	1	4	6	9	13	22	20	13	7	4
V	4	1	1	6	11	14	20	13	14	9	7
VI	0	1	1	8	12	14	19	22	13	7	3
VII	0	0	1	5	9	25	21	19	14	6	0
VIII	0	2	1	6	9	12	31	18	15	6	0

Percentange of years with rainfall/mean in the classes: Annual

	> 2,38	2.13 to 2.38	1.88 to 2.13	1.63 to 1.88	1.38 to 1.63	1.13 to 1.38	0.88 to 1.13	0.63 to 0.88	0.38 to 0.63	0.13 to 0.38	< 0.13
I	0	0	0	0	2	14	65	19	0	0	0
II	0	0	0	1	2	15	63	19	0	0	0
III	0	0	0	0	5	15	53	26	1	0	0
IV	0	0	0	1	7	19	40	32	1	0	0
V	0	0	0	0	7	20	47	22	4	0	0
VI	0	0	0	0	5	22	47	22	4	0	0
VII	0	0	0	0	4	22	49	24	1	0	0
VIII	0	0	0	1	2	25	40	30	2	0	0

Table 5

Region	Season	Mean in cms	Std deviation in cms	Dependable rainfall in cms(75% Probability)	Dependable rainfall in cms(90% Probability)
I	Mar-May	18.9	16.0	8.1	4.8
	June-Sept	325.3	48.9	291.5	268.0
	Oct-Dec	28.3	11 4	18.0	15.9
	Annual	372.9	53.0	335.0	306.0
II	Mar-May	16.7	8.2	11.6	77.0
	June-Sept	202.5	40.1	177.8	165.8
	Oct-Dec	23.5	8.1	17.7	130.0
	Annual	243.2	41.8	216.6	203.0
III	Mar-May	15.0	6.4	10.5	7.9
	June-Sept	65.8	15.8	54.4	50.0
	Oct-Dec	18.2	8.6	11.80	92.0
	Annual	99.4	19.1	85.0	78.0
IV	Mar-May	7.9	3.4	5.10	4.0
	June-Sept	37.0	9.8	30.0	25.5
	Oct-Dec	13.5	7.4	8.7	5.0
	Annual	58.9	13.6	48.5	41.8
V	Mar-May	6.0	3.9	3.2	2.1
	June-Sept	60.6	15.9	48.8	41.2
	Oct-Dec	11.2	7.3	5.7	2.4
	Annual	78.9	18.6	67.2	55.5
VI	Mar-May	10.9	3.9	8.0	6.3
	June-Sept	31.0	7.9	25.6	22.0
	Oct-Dec	17.1	7.9	11.5	8.0
	Annual	59.6	12.3	51.3	42.7
VII	Mar-May	20.4	6.3	15.2	12.7
	June-Sept	31.9	9.6	24.0	20.9
	Oct-Dec	24.6	9.4	17.0	12.5
	Annual	77.8	15.4	68.0	57.0
VIII	Mar-May	13.9	5.0	9.7	7.7
	June-Sept	41.7	11.1	33.5	29.7
	Oct-Dec	21.6	9.5	14.0	9.9
	Annual	78.2	16.2	65.7	58.3

SIRSI NORTH KANARA [illegible]

SEASONS	MEAN SEASON 1	SEASON 2	SEASON 3	SEASON 4
	102.011	2220.727	164.657	2599.492

FREQUENCY TABLE FOR THE RAINFALL FROM MAR TO MAY

CLASS	INTERVAL	NO	YEARS
1	R >= 2.375	5	18 43 49 56 61
2	2.125-2.375	1	33
3	1.875-2.125	2	66 70
4	1.625-1.875	6	7 9 29 32 54 74
5	1.375-1.625	4	57 63 72 78
6	1.125-1.375	10	3 31 35 46 55 58 59 60 69 73
7	.875-1.125	14	12 15 19 25 37 40 42 46 51 67 71 77 80 82
8	.625- .875	13	1 8 14 20 21 23 24 30 34 36 68 75 81
9	.375- .625	14	4 5 13 22 27 28 35 39 44 47 50 76 79 84
10	.125- .375	9	2 10 11 16 41 45 53 62 85
11	.000- .125	7	6 17 26 52 64 65 83

FREQUENCY TABLE FOR THE RAINFALL FROM JUN TO SEP

CLASS	INTERVAL	NO	YEARS
1	R >= 2.375	0	0
2	2.125-2.375	0	0
3	1.875-2.125	0	0
4	1.625-1.875	0	0
5	1.375-1.625	5	23 59 61 80 82
6	1.125-1.375	16	4 7 8 12 14 26 31 32 33 42 46 48 50 53 54 58
7	.875-1.125	35	1 2 3 9 10 13 16 20 22 24 25 27 28 29 34 36 40 45 47 51 56 62 64 65 68 69 70 71 73 75 78 79 81 83 84
8	.625- .875	27	6 11 15 17 19 21 30 35 37 38 39 41 43 44 49 52 55 57 60 63 66 67 72 74 76 77 85
9	.375- .625	2	5 18
10	.125- .375	0	0
11	.000- .125	0	0

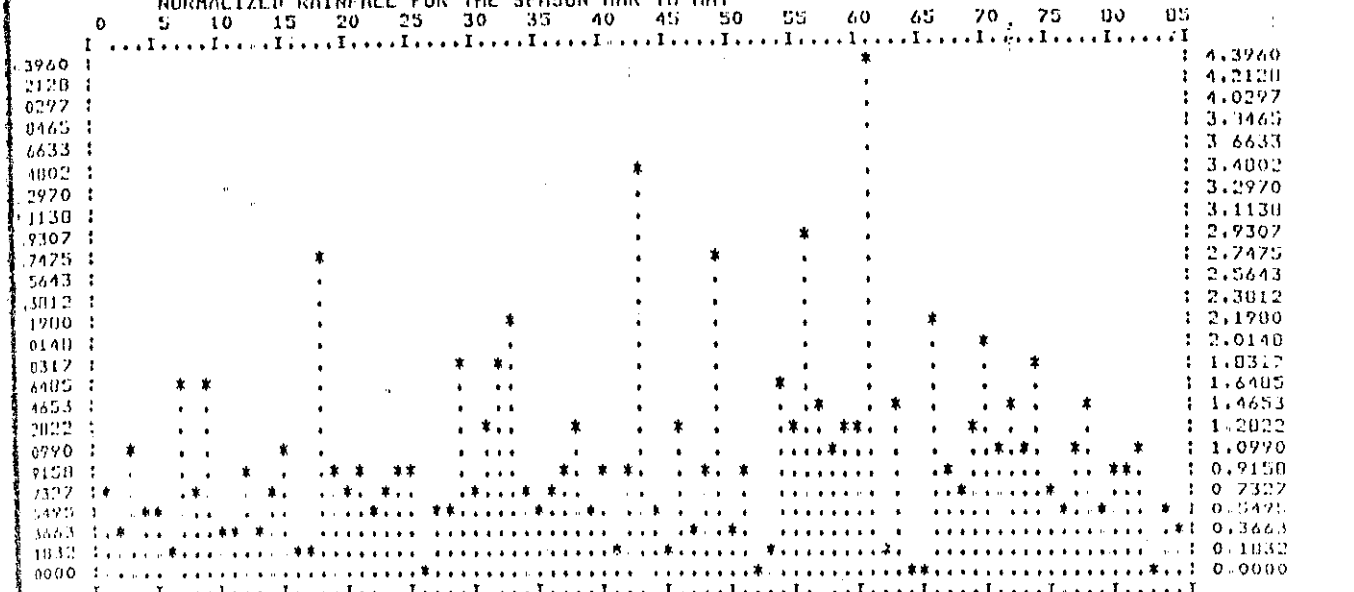
FREQUENCY TABLE FOR THE RAINFALL FROM OCT TO DEC

CLASS	INTERVAL	NO	YEARS
1	R >= 2.375	1	16
2	2.125-2.375	1	66
3	1.875-2.125	2	31 43
4	1.625-1.875	6	28 32 33 44 56 62
5	1.375-1.625	4	2 13 37 49
6	1.125-1.375	18	3 10 17 18 21 29 40 42 48 50 52 55 57 68 69 77 79 84
7	.875-1.125	17	5 6 19 24 30 34 35 38 39 41 51 53 64 73 75 78 82
8	.625- .875	18	9 11 12 22 25 27 36 46 58 61 63 67 70 72 76 80 81 85
9	.375- .625	11	1 4 7 14 15 45 54 59 60 65 71
10	.125- .375	6	20 23 26 47 74 83
11	.000- .125	1	8

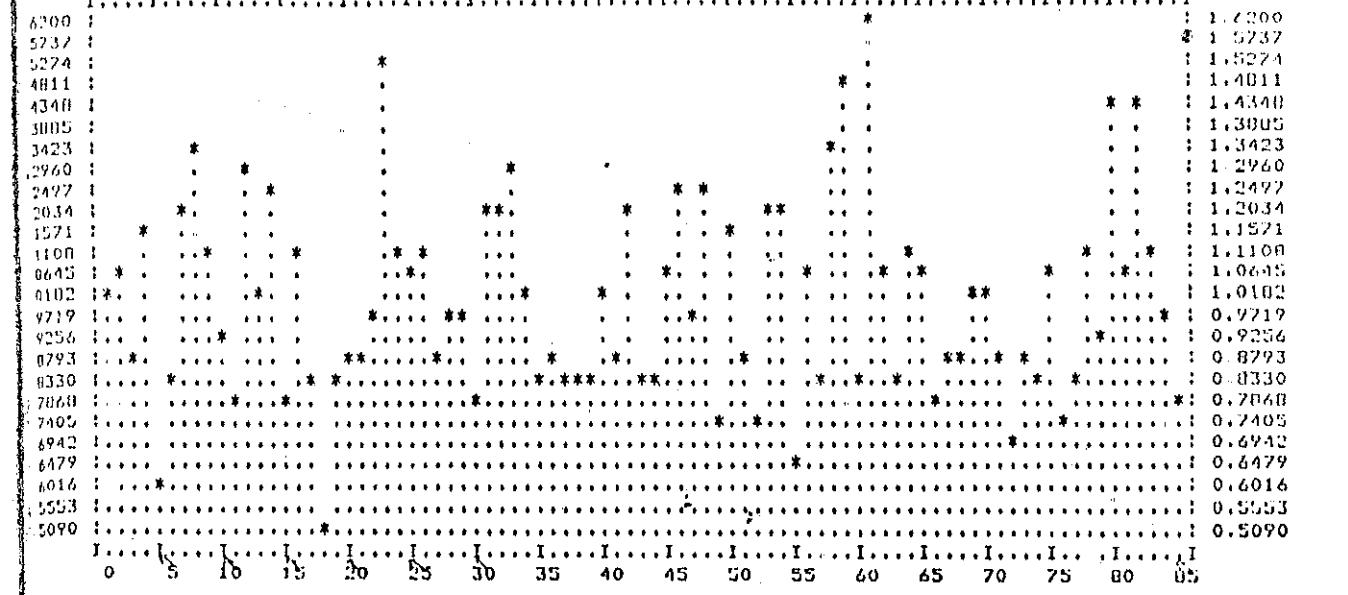
FREQUENCY TABLE FOR THE RAINFALL FROM JAN TO DEC

CLASS	INTERVAL	NO	YEARS
1	R >= 2.375	0	0
2	2.125-2.375	0	0
3	1.875-2.125	0	0
4	1.625-1.875	1	61
5	1.375-1.625	3	23 59 82
6	1.125-1.375	16	7 8 12 14 16 31 32 33 42 46 48 53 54 56 58 80
7	.875-1.125	37	1 2 3 4 9 10 13 21 22 24 25 26 28 29 34 37 40 43 44 45 47 50 51 62 64 65 66 68 69 70 73 75 78 79 81 83 84
8	.625- .875	28	5 6 11 15 17 18 19 20 27 30 35 36 38 39 41 49 52 55 57 60 63 67 71 72 74 76 77 85
9	.375- .625	0	0
10	.125- .375	0	0
11	.000- .125	0	0

SIRSI STATION
NORMALIZED RAINFALL FOR THE SEASON MAR TO MAY

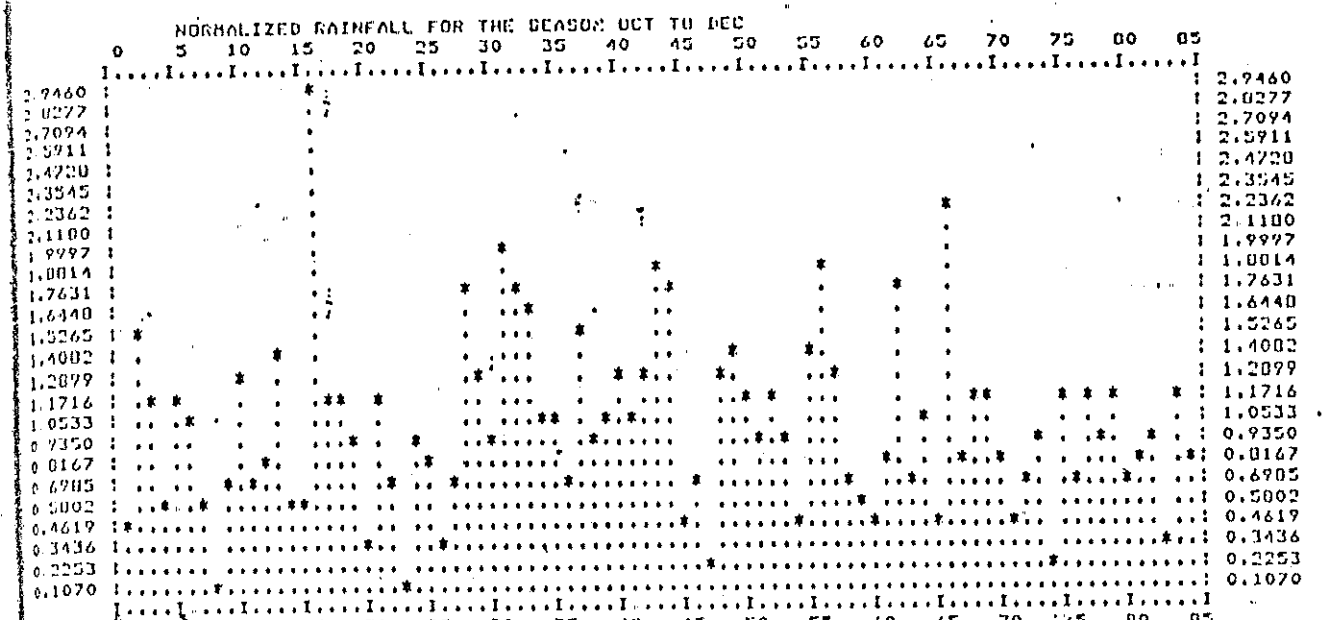


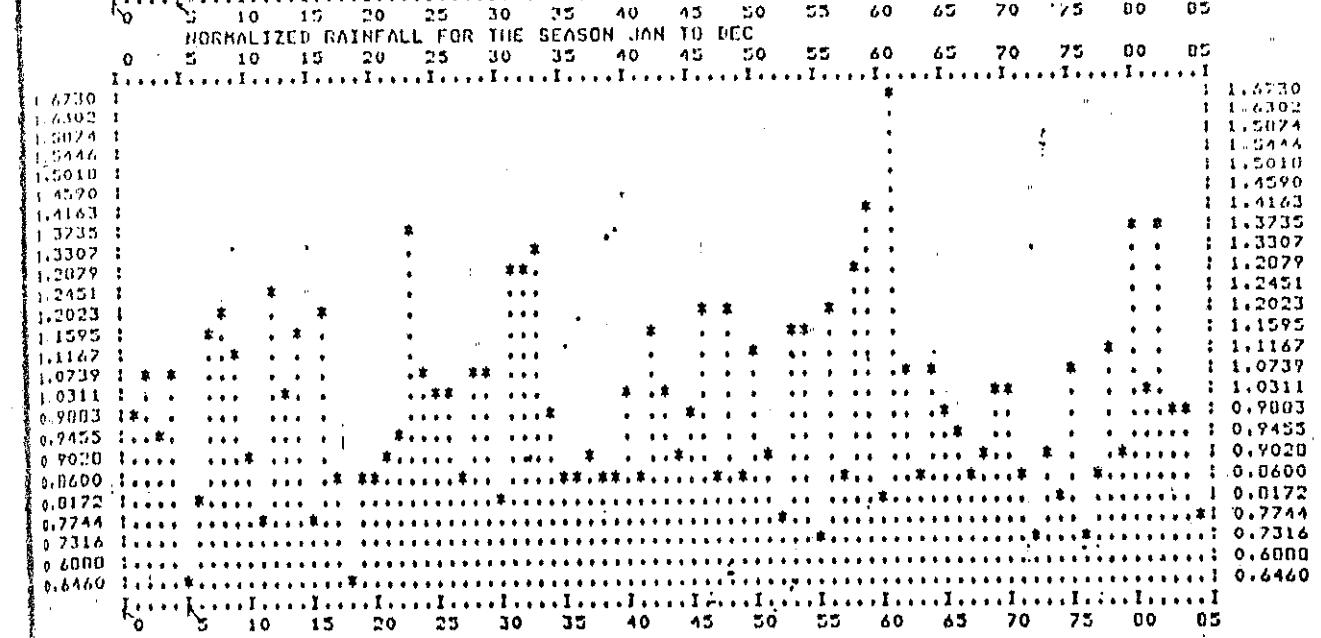
NORMALIZED RAINFALL FOR THE SEASON JUN TO SEP



X-AXIS --> TIME IN YEARS / Y-AXIS --> NORM RAINFALL

SIRSI STATION





X-AXIS --> TIME IN YEARS ; Y-AXIS --> NORM RAINFALL

ENVIRONMENTAL EDUCATION(FOCUS) - by Lingesh Sharma

You must have broadly introduced to environment at the beginning of this workshop. In practice we call surrounding atmosphere, soil, water as physical environment and plant, insect - animal kingdoms as biotic environment with this man his relations as human environment. This classification is just to specify the matters not that they inter related. If we want understand inter relations then we teachers should teach the totality of vision and understanding of environment. That is environmental education.

A question will arise why this education? We are teaching in the present syllabus about environment some aspects in science and some in social studies. But we are unable to form an overall picture about environment. We have not imagined how we are dependent on environment for daily needs. Even then there is struggle for pure drinking water in towns and cities. We feel pure air is necessary in this age of mechanisation, increase in automobiles and industries. But here water and air is available in beautiful pure natural atmosphere. We should say that availability of pure atmosphere decreased when we started cutting forests for fuel, timber industries and selling them for profit. For many of the catostrophes we are facing today our neglect itself is the reason. We are facing drought and floods generally every year. Population problem is also there. Due to poverty we are not putting our resources into use. Employment problem is due to our education system; no corelation between employment and employee. Therefore environmental education is must.

From past 38 years we are marching towards progress. Progressed heavily in industrial sector. Population also continued along with

this. It has gone upto an extent that it is a must in development projects. Increased use of chemicals and posticides due to green revolution. We are inhands of multinational companies. White revolution and blue revolution are also expected soon. These revolutions never embed poverty or population growth on degradation of soil and plant cover(forests).

We are pleading urselves for the market and benefit of the third person in the name of development. This is not the progress of population. Respect towards environment should come from to change present policies and to get minimum daily needs for every ne. Man should loose his pride of 'intelligent animal'. He should learn to live with ther living beings leaving his challenge of 'what ever he can do' cooperation with nature is only way for our existance. If we think that we can do any thing with science and technology that will be our fatal.

Therefore, environmental education means education in environment for environment and about the environment. Here different subjects have wide scope, need to have real experience of the environment. For that purpose an occassion has come to review our thinkings which we are following strongly. Till now we are dependents on syllabus or a text book. But for environment is not possible if we want a total picture. It is very necessary to have mentality and technological facilities to mingle both circular and extra curricular activities within and out side the school. This is an invitation for all of us. This is next education.

Now our education system includes population education but it is not an environmental education. It is just question of population-

problem. Wrong way to depict that is route cause for all problems.

Environmental education is that education which is necessary to consider how we have adjusted or can be adjusted population resources with physical and biotic aspects of environment.

BIRDWATCHING AS A SCIENCE

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1. INTRODUCTION

Of the various living organisms that we see around us everyday, birds are often the most noticed. Birds are conspicuous creatures to man because of their attractive colours and curious behaviour. Birds seem to tolerate the presence of man much more than the other creatures and this has led man to admire, patronize and even protect the birds living around him. Like the rest of the living creatures, birds do have very definite roles to play in the ecosystem. Some are pollinators. Some are dispersers of seed. Some help in controlling the pests that attack our crops while some are pests themselves. More than these, what seems interesting is that each species of bird has its own external characteristics like colour, size and shape and behaviour which reflect the ecosystem in which it is a part. Looking at a bird can we understand, the laws of nature? Birdwatching will become a science than just a hobby if this can be achieved.

2. EXTERNAL FEATURES

2.1. Colour

Colour is the most striking feature in any bird. The wide range of colours from full white as in the egrets to the dazzling colours of the sunbirds or peacock are all not produced the same

way. Some colours are due to pigments while the others are merely results of the feather structure or a combination of both.

2.1.1. Pigmental Colours

Brown, black, yellow and red or orange are the common pigmental colours. Examples of this can be seen in minivets, crows, orioles, drongos, etc.

2.1.2. Structural Colours

2.1.2.1. Nonirridescent colours

White, green, blue and purple are mostly results of the feather structure. When all the falling light is reflected by the feathers, the effect is white as in the egrets. Blue colour in birds is a result of a layer of dark pigments on the feathers overlaid by a thin porous transparent layer. This absorbs all the other colours and reflects blue alone. Kingfishers and some flycatchers are good examples. Green colour is produced like blue but the transparent layer on the feathers are tinted with yellow pigments. The green and blue thus produced do not change with the angle of light falling. The process of such colour production is called Tyndall Scattering. The purple colour seen in blossom headed parakeets, kingfishers and rollers are results of a combination of Tyndall Scattering and red pigments.

2.1.2.2. Irridescent Colours

The dazzling colours produced by sunbirds or the peacock, for example, are results of interference of light by thinly laminated (leaf-like) structures on the barbules of the feathers. Minute

coloured platelets are seen on the barbules of these birds. These help in producing the metallic colours that we see on their feathers.

2.2. Role of colours in birds

Knowing how the different colours are produced in the birds that we see, it is also important that we know the role these colours play in determining the success of birds in their environment. Birds normally make use of their colours in protecting themselves from enemies and in attracting their mates. Colours are also useful when birds have to differentiate their own kind from others.

2.2.1. Protection from enemies

Birds take advantage of their colours and often escape from their enemies. This they achieve through the following means.

2.2.1.1. Cryptic colouration

Many species of birds closely resemble their surroundings in their colour patterns. This makes it difficult for their enemies to locate them. These birds are called Cryptic coloured birds. We may also call this as Camouflage. Examples of such birds can be pipits, larks and some warblers in open grasslands and marshes, the green coloured chloropsis and leaf warblers among the foliage, owls resembling dead branches and nightjars blending with the laterite on which they sit.

2.2.1.2. Counter shading

Many shorebirds have the darkest colours above where most light falls and are almost white on the underside. Examples of this can be sandpipers. Any object stands out against its shadow when it is paler on the top. This effect is lost due to the countershading and therefore the predators find it difficult to locate such birds.

2.2.1.3. Disruptive colouration/patterns

This type of colouration can be seen in plovers especially the little ringed plover that we see along sandy shores. Abrupt change of colours from white to black on the face and breast of these birds distort the real shape of the birds and make them inconspicuous to their enemies.

2.2.1.4. Deflective colouration/flash colours

Some birds have white rump patches as in the pied bushchat, shama, etc. Many have their outer tail feathers white. Examples of this kind can be flycatchers, pipits and even some warblers. There are also birds which have flashing white patches on the wings like the lapwings and woodpeckers. The function of all these is nevertheless the same. When suddenly these birds open their wings or spread out their tails as they fly, these flashing colours confuse the predators following then making them miss the target often. Bright red or orange patches on the backs of some birds like woodpeckers even seem to scare their enemies if suddenly exposed to them. These are called startling colours.

2.2.2. Attracting mates

The second major role that colours play in birds' lives is helping them find mates. For example, the sole purpose of the peacocks' superb train is to attract females and after the purpose is solved, it is useless. Peacocks therefore shed their train feathers annually and regrow afresh each time before they breed. This kind of colouration is called the epigamic colouration, which means before marriage. In the tropics, not many birds are dichromatic. Dichromatic birds are those in which the males and females are differently coloured. A few examples can be sunbirds, minivets, fairy bluebirds, thrushes, trogons, woodpeckers, pheasants, some ducks etc. These birds know how to use their colours the best to improve their breeding success. For example, a male purple sunbird when it sits and singe against the sun, errects a tuft of fiery yellow and orange feathers from its armpits which are otherwise never seen. If you look at a dancing peacock you may realise it straining itself to show off every detail of its colours.

2.2.3. Species recognition

This is the third important function of colours in birds. This is more expressed in birds which live in large mixed colonies. A mixed colony is one in which more than one species of birds are present. For example, in a heronry where species of herons, egrets, storks, etc., flock to breed or among ducks and sea birds which gather in large flocks to rest or feed, colour helps in recognising one another. Distinct head colours or wing

patterns aid the birds in differentiating their own kind from the rest.

Except the nightbirds like owls and nightjars, all birds can see colours as much as we can. This has been proved by detailed anatomical studies as well as by experiments. Birds have red and yellow oil droplets in their eyes which act as camera-filters. These filter the colours of short wavelength like blue and allow those with longer wavelength like red or yellow to pass through. This explains why the colonial birds of the open shores and riverbeds like egrets, seagulls, terns, etc., have a tendency to be white in colour. White stands out well against the blue sky or water because to a bird's eyes the sky and water appear darker. Near water white is most distinct and is an advantage to the flocking birds to locate each other even from a distance and flock together.

3. SIZE AND SHAPE

The smallest bird that we commonly see may be one of the flowerpeckers and the largest an adult peacock. In size relation, a flowerpecker may hardly cover the peacock's face. In shape also, our birds vary from the long-necked herons or storks to the elegant paradise flycatchers. The size and shape of birds are very important as they determine their role in the ecosystem. The size and shape of the beak, legs and wings are usually of more interest.

3.1.Beak

What a bird eats is determined by the size and shape of its beak. The long, straight and spear-like beaks of birds like the darter, herons, egrets and kingfishers suit their fish-eating habit. The short, thick and hooked beak of the parakeets enables them to break open seeds nuts which are hard-shelled. The chisel-like beak of a woodpecker helps it find insects inside dead trees and under the barks. The sharp needle-like beaks of the sunbirds are used for taking nectar from small flowers thereby even pollinating them. Eagles, vultures, kites, hawks and owls have sharp hooked beaks which they use for tearing apart animal flesh. The conical beaks of sparrows and weaver birds are for crushing the hard grains. The massive beaks of hornbills are more a decoration than anything else. However, what should be understood from these is the uniqueness of each type of beak and that it can not be overlooked. The difference in the size and shape of the beaks of birds makes it possible for several species of birds to stay together and share the limited food resources.

3.2.Legs

We may know that ducks can swim because of their webbed feet and the egrets or herons are able to wade in water due to their long and slender legs. The eagles catch their prey with their sharp claws. The jacanas walk on the waterlily or lotus leaves since they distribute their weight over the long and spider-like toes. These are just a few common examples which illustrate how the size and shape of legs determine a bird's habitat and thus the

food it eats. For practical purposes we can visit any large reservoir with shallow water during winter. There may be hundreds of waging birds feeding together. It will be interesting to note differences in the lengths of their legs. Small plovers have legs of a little more than an inch long and the much larger blackwinged stilts have legs up to six inches in length. Though these birds feed together, the differences in the length of their legs help them feed at different depths. This reduces the competition among them for food.

Among the forest birds also the size and shape of legs play a very important role. Woodpeckers are able to sit on vertical trunks or branches because of the additional support they gain by having two of their toes turned backward. Most birds, except the woodpeckers, barbets, parakeets and cuckoos have only one of their four toes turned backward. Swifts have all their toes turned forward which permits them to only cling to some surface. Ground birds like lapwings and bustard quails have just the front three toes and therefore can run fast but can never perch on trees. Mynas, crows, pigeons and doves walk freely on the ground as well as perch on trees while many of the the tree-dwelling ,birds can only hop about if on the ground.Thus the size and shape of the legs in biras, though they do not appear significant, have a major contribution towards its success in a particular habitat.

3.3.Wings

The capacity to fly is a major asset to birds.Though we do not have any flightless bird in India,our birds are all not

equally good at flying.Some of our swifts are among the world's fastest fliers reaching speeds of 250 - 300Km per hour. Vultures are able to fly at heights of a few kilometers above ground level. However,there are birds like the crow pheasant and some babblers which fly very low and can hardly cover a few hundred meters at a stretch.Also,birds such as the partridges and the jungle fowl very quickly take off from the ground but can never sustain the flight before landing again.Why does this happen?

The flight of a bird is directly related to the size and shape of its wings. In other words, a bird's flight depends on its wing structure. Based on their wing structures our birds can be divided into four categories. They are as follows.

3.3.1.Elliptical wings

Birds that live in the forests or on the ground viz., jungle fowl, doves, woodpeckers, warblers, flycatchers, etc., have short rounded wings with variable spaces between the primary feathers. This structure enables them to take off rapidly and also make quick twists and turns that enable them to avoid any obstacles while flying. These birds are suited to living in areas with dense vegetation.

3.3.2.High-speed wings

These are relatively long and slim without any space between the primary feathers. Swifts and terns are good examples. These birds spend most of their time in the air. They can fly fast and at the same level. Also, they are good at making twists and turns

in the air. Such birds prefer open areas for dwelling.

3.3.3.High-aspect ratio wings

Some seabirds like the shearwaters and the albatrosses, have very long and slender wings. In such birds, the aspect ratio, that is, the span divided by the square root of the wing area, is high. These birds can glide for long distances at high speed in steady strong winds. (Shearwaters are found in the Indian ocean but albatrosses are not found anywhere near our coasts).

3.3.4.Slotted high-lift wings

Birds that soar over land have this type of wings. Vultures, eagles, kites, storks, etc., are examples. These birds have long wings with wide gaps between the primary feathers. This enables the birds to fly high up in the sky gliding upward along with the warm air currents. The air becomes warm and starts rising up at about 10.00 a.m. Therefore we see the soaring birds only around that time usually.

4.BEHAVIOUR

4.1.Flocking and Communal roosting

Flocking and communal roosting are two common behaviours that we see in the birds around us.Why do birds try to build up in numbers like that?

4.1.1.Flocking

We often see a group of herons, egrets and other waterbirds near a pool of water or just some babblers in our gardens. Such

groups are called flocks. A flock may contain only birds of one species or they may have several. The purpose of flocking nevertheless remains the same.The following are the advantages of flocking.

4.1.1.1.Better predator detection

Where there are more than one bird at any time, there are more than one pair of attentive eyes. Therefore, any danger is detected faster by a flock than by a single bird. In some birds like the jungle babblers, one bird may even sit up on a tree as a sentinel and keep warning the other birds of any approaching danger. The common danger can be a cat, a snake or a hawk.

4.1.1.2.More feeding time

Once a bird is not so much worried about approaching danger it can feed comfortably. The time it would otherwise waste in trying to be watchful, is thus added to its feeding time.

4.1.1.3.Mobbing

Sometimes a flock is an advantage if the birds decide to resist the enemy. An owl out in daylight is invariably attacked by a group of crows or mynas. This is a very familiar scene and a typical example of mobbing.

4.1.1.4. Easy food detection

Birds feeding in flocks take advantage of the relative ease in finding food. A big flock of birds along a sea-shore attracts more birds to join it as it is a kind of advertisement for food

availability. Similarly, in forests, we find mixed feeding flocks. These generally move in a particular direction through the forests. Most of the birds in such a flock are insect-eating. The advantage is that when a flock works through the foliage, it disturbs more insects than a bird working alone. Moreover, a bird does not have to waste time trying to find food in areas where already other birds have fed.

Apart from these there is a kind of flocking that we see though not commonly. This is the pre-migratory flocking. Thousands of swallows sitting on electric or telegraph wires is a sight to see. In the north, birds gather together before they start their southward flight. However what we see is usually a preparatory gathering before the birds once again fly north after the winter is spent. Occasionally these birds do remain as a flock for a while just after arriving from their northern homes. The purpose behind such a flocking behaviour may not be different from what has already been discussed. An additional advantage can be an assured safe journey either way.

4.1.2. Communal roosting

A big banyan or peepal tree in the heart of the village or town with thousands of mynas on it is not uncommon. A stream of egrets or crows flying out in a direction in the morning and returning in the evening is also a common sight. These birds spend the nights together and go out to feed at daybreak. A common sleeping place of this sort is called the communal roost. Communal roosts may contain birds belonging to just one species or there

can be several sharing the same roost at any one time. Communal roosting has the following advantages.

4.1.2.1.Warmth

Excess warmth is required during winter nights. Thousands of birds roosting together can easily keep their immediate surroundings warm through the night.

4.1.2.2.Information centre

For birds feeding sociably this is an advantage as they find out where they can easily get their food. Thus a communal roost becomes an information centre.

4.1.2.3. Safety

Predators generally try to take the isolated birds and not from the group. Predator detection is also as efficient as in the case of flocking. It is normal for mynas to keep flying in wide circles around their roosts till they finally settle to sleep. This behaviour is believed to confuse the predators. Moreover, predators themselves are usually careful not to get into a crowd and injure themselves.

4.2. Song

None can deny the fact that birds are the best singers of all creatures. Though people believe that birds sing when they are happy, it is not really so. Birds sing very vigorously when angry! The males do most of the singing though females can also sing. The

main function of song in birds is to attract a mate and to keep away rival males.

We start hearing bird songs in Southwest India by the end of January or early February and this continues on through summer till the monsoon starts. Some birds like the magpie robin start early. By March, most birds will be singing their best. Song and breeding success are much related in birds. The change in the daylength with the approaching summer stimulates the birds to breed. The birds shed their feathers and grow a fresh set. Then the males begin to sing. They locate a suitable area and sit on top of a tree or bush and sing loudly and cheerfully. This is a kind of advertisement which impresses the female but it keeps the other males away. A male maintains a territory to itself and does not allow any other male of the same species to come into it. Song plays an important role in territory holding as other males understand that someone is already there. After this the impressed female joins the male and they build a nest, lay eggs and raise chicks. Most birds do this together. In some birds, however, most of the work is left to either the male or the female with not much sharing of responsibilities.

All birds cannot sing equally well. The passerines (songbirds) are the best singers. Of the birds that we commonly see around us along the Western Ghats, the malabar whistling thrush and the shama are the best. These are thrushes. Thrushes in general are the best singers of all birds. Birds learn to sing. They try to reproduce the sounds that they most often hear around them. This is how birds like mynas and parakeets learn to repeat

what we teach them.

5. SUMMARY

In summary what we should keep in mind is that every aspect of birdlife that we notice in our day to day life has a special meaning to birds. The survival and success depends largely on the external characteristics like colour, size and shape and also their behaviour. A lark coloured like dry grass trying to hide among green leaves is as safe as a bright red minivet seeking shelter among the grass. The lark belongs to the grasslands and the minivet to the forest. Similarly a kingfisher trying to break open a hard seed is as much futile as would it be if a parakeet decided to catch fish. Birds that are not very colourful make up for it by singing better. Each species can do something better than the other.If it does so it is successful in its environment and that is what a bird does.

The whole earth is like a big theatre. There are several seats in it. Each seat has been shaped such that only a particular organism can fill that seat. This is nature's design and the different organisms have been made to fit into it perfectly. Birds are just one class of the several. However, they do help us understand the complexity of nature.

ECONOMIC USES OF PLANTS

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Quite a large number of plants exist in this world of nature. More than nearly 3,40,000 plants have been identified, described and named by the botanists and a pretty large number still remain unknown. Thus they are not only large in number but equally varried in nature. They inhabit all the conciovable places in the world and can often withstand extreme unfavourable conditions. We are surrounded by a world of plants and have to depend on them for all most all our daily necessities of life. The primary necessities of man are three fold a) Food b) clothing and c) Shelter. All these are extensively supplied by the plant kingdom.

The most essential need of man is food and comes from plants in the form of cereals, millets, pulses, vegetables, fruits etc., For clothing again plants are indispensable sources of fibres- coarse or fine for the manufacture of garments. Then again shelter from the inclemencies of the weather and protection against natural enemies have been sought after from the time immemorial. In this respect the values of wood, bamboo, cane reed, thatch grass etc., are inestimable.

The primary needs of mankind are supplied by nature in their basic forms and subsequently improved upon by man by the application of his scientific knowledge. For example - man was accustomed to eat raw materials, but later started to cook the food. Even the logs are slit to specific sizes and used for construction purposes. The methods commonly employed for improvement of crops with regard to their quality, yield etc., are-

I Pure line selection ,
II Breeding,
III Improved method of cultivation
IV Selection and use of quality seeds
V Proper use of adequate amount of manures and chemical fertilizers,
VI Judicious selection of crops for a particular locality.
VII Introduction of high yielding and disease resistant varieties,
VIII Protection against pests, diseases and destruction,
IX Intensive and extensive cultivation,
X Proper irrigation.

Eqnomic plants are numerous and have a variety of uses. Many of them occur in a natural state, particularly in forests, while good number of them are cultivated. According to one estimation the number of species on records are -

Algae	20,000
Fungi	73,500
Bacteria	1,500
Lichens	15,000
Bryophyta	23,525
a. Liver wort	8,550
b. Mosses	14,975
Pteridophytes (ferns + allies)	10,000
Gymnosperms	700
Angiosperms	1,99,000
a. Dicots	1,59,000
b. Monocots	40,000
Total:	3,43,225

On the other hand other estimation s tates that -

7,00,000	- Total plants species
80,000	- Plant species - edible
3,000	- Species are crop plants
300	- Species or genera supply man with 90 percent of his food.

PARTS OF AN ANGIOSPRMIC PLANT:

Before we start with the various uses of plants it is better to know the plant parts and what is its main function-. Parts of the plant body mainly concerned with the nutrition and growth are called- "vegetative parts", they comparise the root system and the shoot system (partly). The shoot system with its differentiated parts perform the primary functions- i. Fixation ,ii. absorption.

The shoot system may be vegetative or reproductive. The vegetative shoot - consisting of main stem, branches and leaves - has three functions -

i. Support, ii. conduction iii. food manufacture (primarily by leaves). The reproductive shoot is the "flower" with its differentiated organs and is essentially concerned with the reproduction.

For different uses different plant species and the parts thereof are tapped. For example- roots of many species are rich reserves of starch and other materials. The common examples are-

Radish, carrot, sweet potato, beet, tapioca etc.. The stem portions are also used as store houses by plants in the form of rhizomes as in Zinger, Turmeric, root stocks as in Alocacia indica. Stem tuber as in - potato, Helianthus tuberosus, Bulb, - as in onion, garilic. Corm - as in Amorphophalus.

Stem and twigs are the major fuel materials apart from construction and other uses. Stem exudes are used as rubber, resin etc., and leaves constitute the volatile oil green vegetable, and also the fodder. They are the sources of maintaining carbondioxide and oxygen ratio in the universe. The flowers are used to extract scent and dye. The fruits are the delicious edibles and several spices and condiments are obtained from various species in the form of seeds and kernels.

So the man-kind started to depend totally on the wild resources to a little extent and started to cultivate and improve the species.

COMPOSITION OF THE PLANT:

Plants in general are found to contain a high percentage of water - in woody parts about 75 percent, in succulent parts about 85 - 95 percent, and in water plants 95-98 percent when the plant is charred we get charcoal. The main bulk of this charcoal is carbon; infact allmost half of the dry weight of the plant carbon. The organic compounds such as proteins, carbohydrates, fats and oils etc., which constitute often over 90 percent of the dry matter of plants, being combustible, are, converted into carbon dioxide, water vapour, sulfer dioxide, amonia or free nitrogen. Proteins when analysed are seen to contain C,H,O,N,S and P. The carbohydrate fats and oils found to contain CHO. The inorganic materials which are incombustible remain as "ash". Analysis of the ash shows that of the 92 well known chemicials occuring in nature, about 40, possibly more are present in it. The following 13 elements are constant in all the plants-

K, Ca, Mg, Fe, Na - metals

C,H,N,O,P,S,cl and Si - Non - metals

Besides these some of the trace Elements which are unknown to be
Constant in green plants are —

Boron, Zinc, copper, Molybdenum add Aluminium though not constant is also very wide spread in plants.

The average chemical composition of plant body may be given thus - Carbon=45 percent oxygen 42 percent Hydrogen 6.5 percent nitrogen 1.t percent ash 5 percent (after maximov)

Among land plants, the soil is the usual source for all these elements except carbon and some of the oxygen. Although soils are composed largely of oxygen, silicon and aluminium plants growing in soil by no means reflect this composition.

MAN'S INTEREST:

Because of different elements present in plants and in different proportions, man started using these parts which meeting his requirements. He use particular plant parts as food, timber and so on. Why it is so? So it is better to deal one by one starting with food.

FOOD: The energy value of food is expressed interms of calories. (Acalorie is the amount of heat needed to raise one Kilogram of water through $1^{o}c$). It may be noted that one gram of carbohydrate yeilds about 4 calories and one gram of fat about 9 calories. The daily requirement of a man of average weight, doing moderate work is about 3000 calories, which must be obtained from the food he eats. Average Indian diet, it may be noted that xx produce only 1,620 calories. For proper nutrition of human body a balanced diet consisiting of Cereals, vegetables, pulses, etc., are necessary. So the diet should involve -

a. Heat or Energy producing food having high calorific value such as carbohydrates and fats.

b. Body building food such as proteins.

c. Protection food such as vitamins and some minerals.

d. Luxury food such as confectionaries.

It is evident that food plants must contain sufficiently high percentage of carbohydrats, proteins, fats and oils, together with vitamins and minerals. They are obtained by-

Cereals like- Rice, Wheat, maize, Barley and millets,

Pulses like - peas, Grams, Beans, Soyabeans etc.,

Vegetables like- Potato, Beet, Carrot and portrlaca etc.,

Nuts like- Coconut, Cashew and Almand etc.,

Fruits like- Apple, Orange, grape Jack fruit etc.,

Species and and condiments like- Black pepper, Red pepper, Cardamum Cinamoum etc.

FIBRES AND FIBRE PLANTS: The second important and useful plants for the civilized man are the fibre yeilding plants which complete the necessary of clothing. In addition, they are also utilized in paper industry, in preparation of mats, baskets, chair seats brushes etc.

Fibres are thread like tissues obtained from different parts of the plant body as-

a. Flose fibres or lint which are outgrowth of the seeds. E.g.cotton, silk cotton and madar.

b. Bast fibres which are the sclerenchymatous tissue of the secondary phloem or bast.

E.g. Jute, hemp and rhea,

c. Coir fibres- which are the fibres husk of coconut fruits.

d. Leaf fibres which are the sclerenchymatous tissue of the leaf.

E.G. Pineapple, Bowstring hemp and American aloe.

Fibres are mostly madeup of sclerenchymatous cells, strongly lignified and thickned. Cotton fibres are however madeup of cellulose. The quality of fibres depend on their length, strength, fineness lustre, reaction to high temperature and water etc.

Cotton constitutes more than 60 percent of the total world consumption of fibres. It has been produced in Indian since very early times and spread to china and Egypt. Indian cottons are poor inrespect of length having a Short Staple - 12.7 - 25.4 mm while Egyptian cotton is having Staple length 38 - 58.8 mm.

Cotton grows well in black soil and in India, - Gujarat, Maharastra, Punjab, MP, Karnataka are the important cotton growing area.

JUTE: It is a valuable bast fibre obtained from - Corchorus Capsularis and Corchorus olitorius - belonging to family tiliaceae. It grows readily on rich, loamy, alluvial soil of warm climate. It is grown in West-Bengle, Assam, UP, Orissa, and near Ganga and Brahmaputra river valley.

The fibres are very long 6-10 feet in length quite stiff lignified with silklustre. Fibres are used for rough weaving.

COIR:

Apart from the cultivated plant fibres, some wild plants are also tapped for fibres. e.g., Helictoris isora, Caryota urens etc.

PAPER: Cellulose is the basic constituent of paper and various raw materials are used for paper pulp. - viz- wood of conifers and other trees, variety of bamboo, various grasses and Bagasse.

Plants which produce more cellulose a e soft stemmed and grow very fast. So it has become a practice to grow those species and harvest.

TIMBER AND WOOD

The third necessity of man is fulfilled by wood and timber. Botanically wood is a collective term synonymous with secondary xylem, which comprises cellular elements (trachieds wood fibres, vessels and parenchyma cells) derived from the activity of the vascular cambium. These elements function jointly in conduction and storage and imparting strength and regidity to plants.

Wood is the most familiar and important product of forest and has manifold uses. The quality of the timber depends on its hardenss, strength, weight, presence of natural preservatives like tanin, resin oil etc., durability against heat, moisture and insect attack, workability, grains, colours, capacity to take polish and varnish etc.

Over 2000 species of wood are found in Indian forests and timber trees number over 75 (species). The most common species are- Teak, Indian Red wood, Sal, mahogany, Nacked lady of the forest (Lagerstroemia) Terminalias - (T. paniculata; T. tomentosa; T. arjuna Etc.)

A very large proportion of wood (over 85 percent) is used as fire wood or charcoal. The heating value of wood is determined by measuring the quantity of heat generated by a unit weight of wood in oxygen and expressed in calories. So people are interested towards the plants which give steady heat for a long time, less smoky, without offensive smell, not throwing out sparks etc. The following are plants used as fuel wood with the calorific values-

Species	Calorific values
Acacia arabica	4870 Kcal/Kg.
Casuarina	4934
Eugenia Sp.	4934
Lagerstroemia panriflora	4918
Shorea robusta	5264
Terminalia tomentosa	5210
Boswellia serrata	4955
Maduca indica	5101
Mangifora indica	4610
Pinus roxburgii	5015
Bombax malabarica	4885
Leucaena leucocephole	4200-4600
Glyricidia species	4900
Pongamia glabra	4600
Trema orientalis	4500
Gmelina arborea	4800
Acacia ariculiformis	4800-4900
Calliandra callothyrus	4500-4750
Albez zia lebbeck	6200
Anogeisse latifolia	4900

VEGETABLE DYES

These are obtained from different plant parts and are secretary products. The color of the dye is due to the presence of various pigments in the cells of the plants. More than 200 different plant pigments are secreted by plants. Dyes are used mainly in paper and textile industries, medicine and food preparation.

Using different mordants (metal salts) various colors can be obtained e.g. Maclurin dye (obtained from Chlorophora tinctoria) with an alum mordant yeilds a yellowish color, with iron gray, with chromium - yellowish green.

The following species and the parts thereof are the sources of dye-

Bark- Kino, casuarina, T.Tomentosa, Mimusop elengi

Pith- Cathu, Haematoxylon compechianum

Flowers- Butea, Saff flower (carthamus tinctorius)

Saffran (crocus sativus)

Fruits- Mallotus philipphinensus,

Roots- Berberis aristata, turmeric.

GUMS AND RESINS:

Gums are abnormal products resulting from pathological conditions brought about either by injury or by unfavourable conditions of growth and are usually formed by changes in existing cell wall. They are produced by the conversion of the cell walls of the tissues into gum (gummosis) by the activity of an enzyme.

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Gums are yeilded by trees and shrubs belonging a number of families like leguminosae, Rosaceae, Anacardiaceae combretaceae and streculiacea. Gums are useful in printing and finishing textiles and also in medicines. The following are the common examples-

Gum arabic (Acacia-senegal) Gum tragacantha (Astragalus gummifer) Karayan gum (sterculia urens) Bengal kino gum (Butea frondosa kino gum (pterocarpus marsupium)

Resins are oxidation products of various essential oils. They are secreted in definite cavities and parts and are typically derived from stems and roots by exudation following clipping, incission and bruishing. Resins show biological significance by preventing decay in plants due to their antiseptic qualities. Further they may tend to lessen the amount of water lost from the tissue. They burn in air with a smoky flame, They are useful in making soaps, varnishes, plastics and medicines.

All the members the family Dipterocarpaceae are the sources of damar's and they are abundantly found in Balanocarpus, Hopea

Shorea, Ailanthus, Vateria indica etc.

Turpentines- are obtained from coniferous trees.

Canada balsm- is obtained from balsam fir (Abies balsamea)

Asafoetida- It is a perennial herb which is commonly cultivatedin Iran, Afganistan, Europe, USA and in India Punjab and Kashmir. Mily juice collected from roots, used for flavouring and in medicine for coughs, Asthama and nervous afflictions.

SPICES AND OTHER FLAVOURING MATERIALS:

All aromatic vegetable products which are used for flavouring foods and drinks are called "spices". Condiments are spices or other flavouring substances that have a sharp taste and are added to food after it has been cooked.

Flavouring materials are in use since olden days. They are accessories or adjucts to food. They give odor and aroma to food and thorby overcoming the odor of badfood. India was a larger exporter of these in oldendays and because of it only Europeans started to sail towards India under the pritext of East India company. Later these people established the commerce and finally ruled us for a period of three centuries.

The spices can be obtained from the -

Roots - of - Alpina officinarous, A. Galarnge Zinger, Turmeric.

Bark-of- Cinnamomum z cylanica, C.tamala,
Flowers and Flowerbuds- of-safron and clove,

Fruits-of-Chilli, coriander, Black pepper, Xanthoxylon rhetsa

Seeds and arils- Myristica, Cardamoum

Leaves- Peppermint, Basil etc.,

FATS AND OILS

Like other necessities, oils and fats are also required by man in the daily life. These are found in all groups of plants and in all most all living cell of the plant body, when oil is in great preponderance usually very little carbohydrate is present. Similarly when very little oil is found Starch is abundant.

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There is only physical difference between the two- at ordinary room temperature fats are solid and oils are liquid. Oils and fats may be obtained from seeds, fruits, flowerparts, leaf, bark, root, rhizome i.e., from any part of the plant. Usually they are extracted by three methods-

1. Distillation
2. Expression (pressing)
3. Solvents.

Two types of oils are found-

1. Essential oils
2. Volatile oils (fatty acids)

1. Essential oils-

They evoporate when they come in contact with air and consist a pleasant taste and strong aromatic odour. These oils can be obtained from any organ such as flowers of roses, leaves of mint, lemon grass, ciltronella Eucalyptus, bark of cinnamomum, rinds of citrus, orange, leman etc. Seeds of cardamomum and wood of cedar, wood camphar, sandal wood etc.

They occur in large number of plant of the families-

Compostae, Labitae , Lauraceae, Myrtaceae, Umbelliferae, Oleaceae, Rosaceae.

Essential oils are used in the manufacture of perfumes, sachets, soaps and other toilet preparations. Some are used as Flavouring substances or essence for candy and icce creames cooking, liquors. Many have antisaptic and bactericidal properties and are used in tooth paste and medicine e.g.Neem, clove oil etc.

ii. Volatile oils:

They do not evaparate or become volatile when they came in contact with air and they can not be distilled without being decomposed. Fatty acids are accumulated often in large amount in seeds and to less extent in other parts. They are often associated with proteins. They are used as-

1. Cooking medium

e.g., Ground nut oil, coconut oil, mustard oil, saffl-
ower oil etc.
2. In paint and Soap Industry—

Castor oil, linseed oil, hemp, Soyabean oil.

3. Vanaspathi (vegetable ghee)

Sunflower, Palm oil etc.,

4. Margarine (imitation of butter)

E.G. Basia (Mohwa), Garcinias etc.,

Ground nut oil obtained from seeds yield of oil is 43-46 percent nuts nutritious and contain 31 percent protein.

Sesame oil - Seeds yield 45-50 percent oil

Mustard oil- seeds yield 35 percent or more oil

Castor oil - Seeds contain 40-50 percent oil

Sunflower- Seeds yield 32-45 p ercent oil.

TANNINS:

Tannins are astringent products secreted in the bark, wood and other parts of many plants. The presence of tannin makes the wood hard and durable by keeping away the fungi and insects. Mixed with iron salts they are used in the manufacture of ink. Extensively used in tanning i.e., converting hide into leather.

Tannins are abundant in the

i. Fruits of myrobalons- phyllanthus enblica, Terminalias T. Chebula T. bellerica etc.,

ii. Bark of- Acacia arabica,
- Bridelia retusa
- Cassia fistule
- Casuarina equisetifolia,

iii. Leaf of - Anogissis latifolia & Tea

MEDICINAL (DRUG) PLANTS:

The medicinal property is due to the presence of some chemical substance in the plant or plant parts which have some definite physiological action on the body. When a substance is known to posess remedial properties- produced either by external application or by internal administration and it is desired to introduce it into general use, the first problem to be solved is to determine its

biological source, and country of origin. Once the biological source is known and the geopraphical source is studied man starts to cultivate the plants. After cultivation tries to improve the quality using various techniques. Finally the plant materials are in use untill replaced by synthetic material.

India's forests abound in medicinal herbs, shrubs, and trees. It is estimated that they number over 4,000 species. Of them, 2500 to 3000 species are in general use in some form or other. The Eastern and Western Himalays, western-ghats and the Nilgirs are known to be the natural abodes of many such plants.

Both higher and lower plants are useful as medicinal plants. The most common lower plants used are - Gellidium - to obtain mucilage like agar - agar.

"Chlorellin" - which is obtained from unicellular green alga (Chlorella vulgaris) used to control bacterial diseases.

Penicillin- obtained from penicillium notatum

Steptomycin- obtained from Streptomyces greiseus used as antibiotics

Among the higher plants many are useful for various treatments.

Ranwol fine, serpentine, serperstinine - obtained from Ranwolfia serpentina used in blood - pressures., reducing.

Strychnine- obtained from strychnos nuxvomica

used in treatment of paralysis and nervous disorders.

Quinine- obtained from Cinchona bark, and roots used for malaria

Digitalin- obtained from leaves used as heart (cardiac) stimulent and tonic.

Morphine- is obtained from opium. Opium contains about 9.5 percent morphine and it is obtained from the latex of unripe capsules, used to induce sleeps and relives pain.

The other common medicinal plants are holy basil, phyllanthus emblica, Piper nigrum, castor etc.

BEVERAGE PLANTS:

Beverages are mild, agreeable and stimulating liquors meant for drinking. They are of two kinds a) non alcoholic b) Alcoholic.

Of the non-alcoholic kinds, Tea, Coffee and Cocoa are the common beverages. They do not contain alcohol but contain "caffeine" which is an alkaloid. Caffeine is harmful when it is taken in large quantities. It is found in so small amounts in beverages (usually less than two percent) that it has no bad effect on the body part of an average adult man.

COFFEE:

Coffee is brewed from the groundup seeds of several species of "coffee" chiefly C.arabica, a small tree native to Ethiopia, and now cultivated in the tropics of both the hemispheres. It prefers hill slopes with abundant rainfall. Main coffee plantations are in the low hills of south-India-Kerala, Mysore and Madras. It was first introduced into India by a muslim piligrim more than 250 years ago. Regular cultivation however dates from 1830.

Brazil and Kenya are the world's largest supplier of Coffee.

The roasting of beans develops certain aromas, flavour and colours. The roasted beans possess from 0.75 - 1.5 percent coffeine, ($C_8 H_{10} N_4 O_2$), and a volatile oil- "caffeol" - which is the stimulating substance and responsible for the aroma and favour.

TEA:

Tea is made from the dried leaves of Thea (camellia) assamia and T.Sinensis and several hybrids of family Theaceae. It is native to South-Western China or North-Eastern India. It is Chiefly cultivated in China, India, Pakistan and Ceylon etc. In India it is cultivated in Assam, Darjeeling and Malbar.

It was a wild plant and firest noticed by charles Alexander Bruce, an army man in 1826. In 1834, Lord william Bentink appointed a committee to enquire the possibility of profitable cultivation of Tea in India.

The manufactured tea contains 4-5 percent tannins (catechins), which is responsible for color and strength, 3.3- 4.7 percent caffeine - which is a stimulant for the heart, little valatile oil because of which the aroma of te a is due, 8 percent resindus matter which gives reddish brown Cedur.

COCOA:

The plant is a native of tropical America, mainly cultivated for seeds, which contain-theobromine and caffeine (1 percent or less) proteins 15 percent starch 15 percent fats and oils 30-50 percent.

Cultivated in Brazil, Ghana and Kenya.

Cocoa powder is used in making of chocolates, fruit and pods are used as good fodder.

ALCOHONLIC BEVERAGE: contain "alcohol". Those types are obtained by-

1. Fermentation-
2. Distillation.

The first type are called as fermented liquors and the other is called as distilled liquors.

The fermented liquors are-

i. Wines - obtained from vitis vinifera-cashew etc.,

ii. Beer - obtained from grains of Barley, rice, maize and rye.

iii. Toddy- obtained from the slit inflorescence of coconut, caryota urens etc.

The distilled liquors are-

1. Whisky- distilled from a fermented mash of malted or unmalted cereals or potato.
2. Brandy- Is obtained by distillation of the fermented juice of various fruits and it contains 65 to 75 percent alcohol.
3. Rum - It is distilled from many products of sugar cane chiefly the juice and molases.

Gin- It is distilled from fermented mash of malt or raw grain of barley and rye.

Arrack- Obtained by distilling the fermented jaggery.

MASTIGATORIES, FUMITORIES:

These have stimulating or narcotic effects due to the presence of several alkaloids. These substance have been used in all ages and in all countries by man for pleasure, some flight from reality.

The most commonly used materials are - catechu, Arecanut, Hemp,

Stramonium (Datura stramonium), Tabacco, Opium, Betel leaf etc.

Catechu - it is obtained from the heart wood of the plant.

Areca nut- Originated in Malaya and cultivated in various parts. Nuts contain 15 percent tannin, 14 percent fat and important alkaloids like arecoline, arecaidine, guvaine etc., powdered seeds used as verrifuge.

Hemp: It is of Eurasian origin. The female flowering tips and the leaves are sources of resin which is known as "charas" or "hashis". Bhang and ganja are the other forms of canabis. It produces good fibres. Causes hypnotic effect and erotic dreams.

Stramonium: It is used to effect sense illusion and motor disturbances together with sense loss activities and also loss of memory.

Tobacco- Dried leaves and other parts contain- "nicotine" used as an easily nervous tension, and promoting a sense of well being.

Opium poppy- It is the source of "opium". Crude opium is the dried juice that exudes from injured capsules of the opium popy fruits. The exudate contains a number of narcotic alkalods inculding "morphine" and "codeine". "Heroin" is a chemical derivative of morphine which has the most interational trafficing when properly used relievices the pain but continued use leads to addiction, physiological deterioration and premature death.

Betel leaf- Leaves contain organic acids and some mild alkolaids and used as ingradient along with areca nut.

INDUSTRIAL PRODUCTS:

Apart from fibres and wood the other most important plant products used as the raw materials for indusstries are- rubber and sugars.

RUBBER:

Rubber is obtained from the milky juice or latex which is a milky liquid, a complex colloidal mixture of water, salt, hydrocarbon and other organic compounds (alkaloids resin s, oils, proteins,

starch etc.,). The biological import nce of latex is obscure, but possibility it helps in closing and healing injured parts and as a storage medium for nutrients. Leaf, stem, or even roots yeild latex. The plants which yeild rubber belong to family- Moraceae, Euphorbiaceae, Asclepiadaceae.

The name rubber first used by priestley in 1770, refers to the use of the substance in earsing the pencil marks. A process for water proofing cloth with rubber was invested by Mackintosh in 1823 and vulcanizalion was discovered by Good year in 1839. Its plasticity, elasticity, resistance to abrasion and olectric current and its impermeability to liquids and gases all contribute to its values.

Hevea brasilensis is native to tropical south-America, is vastly more important than all other rubber producing species. It is called hevea rubber or para rubber (from the state of that name in Brazil).

Other rubber yeilding plants are Manihot glaziovilceara rubber
Castillea elastica- panama rubber,
Ficus elastica- India rubber.

SUGAR PLANT:

Sugar is present in the form of preserved food material in-

roots- as in beet, Carrots etc.,

Stems- as in palmyra palm, canyota urens, Maize Sugarcane Sorghum, etc.,

Fruits of many species.

It is a carbohydrate possessing C H and O in the ratio 1:2:1 (viz - Glucose $C_6H_{12}O_6$, ssucrose $C_{12}H_{22}O_{11}$)

SUGAR CANE:

It is the traditional source of sucrose, app arently originated in East-India. It has been in cultivation in India since 300 B.C.

The solid stems contain 20 percent sugar by weight. It is cultivated in tropical and subtropical Countries. The juice is

used to prepare gur (jaggery).

By products- like leaves used as fodder,

Bagasse- used as fodder, fuel, paper making.

Molasses- Used in manufacture of alcohol, cattle feed manures, fertilizers and curing tobaco.

SUGAR BEET:

It is the source of sugar in cold countries like Russia, Canada and other parts of Europe. It is a native of Northern-Europe. In 1947 a German chemist Marggaf pointed out that beet is identical to sugar. Sugar is extracted from the roots which contain 10-20 percent of sugare.

Russia is the biggest producer of sugar beet.

Sof far we are considering the direct uses of plants to mankind. But man being a rational ānimal his foresight made him to use the plant which help indirectly. They are used as fodder, agents to check gullying and soil eroison, as an aesthetic means. Like parks, natural beauties, Santnaries, bioreserves etc. But the most important contribution by plants, especially green plants is the exchange of oxygen and carbon dioxide which provide us the fresh air to breathe. Even because of man's intellectual sensing he uses the plants as the indication of water, polution and drought. At the same time he tries to use the plants to enhance the productivity of crop lands by introducing nitrogen fixing agents, like bacterias, algal and other cultural organisms like blugreen algae, Azolla etc.

Before concluding the most important thing to be rembered is that "no plant no life".

SUMMARY

Several plants exist around us and we have to depend on them for all most all our daily needs. Principal items of our food are derived directly or indirectly from plants. Various plants and their parts used for a particular purpose depend upon the constituents. They are used as industrial raw materials like Sugar cane, paper , pulp, fibres etc. They provide life saving drugs, dyes and wood for human uses.

Apart from the direct uses, plants have the aesthetic values and soil binding capacity. They provide fresh air (oxygen) which all things generally need. Choice of habitat by plants is used as a tool to indicate pollution and availability of water, fitness of the land for cultivation, and the richness of the minerals. So the dependency of man on plants is total and indespensable. Therefore, judicious use of the renewable and valuable resources benifits the human race as the whole and supports the wildlife in particular.

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SCHOOL NURSERY ORGANISATION

Hemant G. Hegde, CES, SIRSI

Nurseries are the areas where the plants are raised for eventual planting out in the field. Nurseries occupy an important place in artificial regeneration. The sucess of a tree plantation depends upon the stock produced in the nursery and the success of the nursery depends upon the skill of the nursery man.

There are some important factors to be considered while establishing a nursery theyare :

1) Selection of site.
2) Water facility.
3) Protection from browsing.

Selection of Site:- The nursery site should be selected on a land having gentle slope (about 2-4) with good drainage. The soil should be good preferably sandy loam with good water holding capacity. It should be accessible and easily approachable by roads and paths.

Water facility:- The nursery should be selected near a perinial water source in order to facilitate proper irrigation.

Protection from Browsing:- The nursery site must be well fenced and totally protected against browsing by cattle and wild animals.

Area of the Nursery:- The area of the nursery depends upon the species to be raised, the time the plants are to remain in it and the area to be planted up. It should also include roads paths, irrigation and drainage channels. Approximately 50sqm will be required for raising about 5000 seedlings in polythene bags of 13 X 20 cm size.

Layout :- It is most appropriate to divide the nursery into rectangular blocks. In between these blocks the irrigation channels, pipelines, paths are to be accommodated. These blocks are further subdivided into smaller blocks. Irrigation channels or pipelines should run along the paths. When a nursery is developed on a hilly area the land should be terraced, so as to accommodate at least one bed. The bed should be laid out in east west direction so as to facilitate uniform distribution of sunlight.

Seedling nurseries can be raised on beds or in containers

Nursery beds: The nursery beds are of two types.

1) Primary
2) Sucondary

Primary bed is the one of which seeds are sown first and allowed to germinate. Then germinated ones are transplanted on the secondary beds or in containers. This will help in choosing only healthy and vigorous seedlings for raising the required stock.

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Preparation of Nursery beds:- The nursery beds can be constructed in two ways.

1) Raised beds.
2) Sunken beds.

Laying out the bed:- The soil is dug up to a depth of 30cm, all stones, pebbles and roots are removed. The land is then levelled and beds are made. The beds should be preferably 1 M in width and of any convenient length. The standard size adopted by most of the nurseries is 1 m X 10m. To this a mixture of red soil or forest soil, sand, well rotted farmyard manure in the ratio of 2:1:1 (can be varied according to the local soil) is spread and worked into the ground at the rate of 350Kg - 400Kg per bed.

In places having high rainfall usually raised beds 10 to 15 cm above the ground level is prefered. This helps in better drainage and prevents water stagnation.

In areas where water stagnation is needed or the seeds are to be kept wet, the beds are kept 10-15cm below the ground level. These are called as sunkenbed.

Raising seedlings in containers:-

The practice of growing seedlings on beds now a days has been taken over by growing seedlings in containers like, seed cups, paraffined paper bags, bamboo baskets, tins, clay pots, plastic containers, polythene bags etc.

The method of raising seedlings in containers has many advantages as follows:.

1) the percentage of survival in the field of container raised seedling are greater than seedlings grown on bed.
2) The seedlings in containers can be transported to long distances and can also stored for a few days before planting without much mortality.
3) Seedlings get adequate nutrients as there is no competation by other seedlings.
4) Operation like weeding, watering etc., can be carried out with ease.

Dis-advantages:-

1) The process of raising seedlings in containers is costly.
2) Root spirilling occurs if seedling are held too long in container before transplating such spirilling roots retain this shape after planting and are unable to firmly anchor the tree in the ground.

Raising seedling in polythene bags:-

This is the most common container used for raising seedlings in recent times. Polythene bags are used because they are cheap, easy to handle and store, durable and light in weight.

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The size of the bags depends upon the species to be raised and the duration the seedlings remain in the nursery. If the seedlings are to be retained in the nursery for a long period then larger size polythene bags will be required.

The standard size of the bags in 13 X 20cm of 200 gauge thickness. Bags of 15X23cm and 23X28cm are also used.

Soil mixture used for filling the polythene bags:- The soil mixture must have the following characteristics, :

1) The medium must be sufficiently firm and dense to hold the seeds in place during rooting.
2) Its volume must be fairly constant when either wet or dry.
3) It should be sufficiently retentive in moisture that watering does not have to be too frequent.
4) It must be sufficiently porous that excess water drains away, permitting adequate airation.
5) It must be free from weed seeds, nematodes and various noxious organisms.
6) It should not have a high salinity level.
7) It should have adquate nutrients.

The ingredients required for preparing such a mixture are soil sand and farmyard manure. Various combination are adopted by different nurserymen depending upon the types of soil available. In general a soil mixture consisting of 2 parts of red soil 1 part sand and 1 part farmyard manure are adequate for growing the forest nursery seedlings.

The ingredients are preferably sieved through a 1cm sieve and mixed thoroughly. Sufficient water is sprinkled over the soil the time of mixing to moisture the soil but not wet it. This process helps to avoid shrinkage of the soil when put into the bag care must be taken to see that no air cavities are left at the side of the bags.

These bags are arranged in rows of 10 each in a rectangular block. Watering is done before sowing the seeds or transplanting progerminated seedlings.

Irrigation:- This is a very important operation. The bags must be irrigated twice a day so as to keep the seeds moist at the time of germination The moisture must be maintained at an optimum level through out the seedling stage as excess water may cause damping off disease.

Weeding:- Weeding operation should be carried out regularly as weeds rob away much of the nutrients effecting the growth of the seedlings.

Shifting:- Once the seedlings start growing the bags are shifted from one place to another with in the same plot so as to prevent roots piercing into the ground. For this polythene sheets can be used as bedding material.

Estimated cost of the ingredients required	Rs.	Ps.
Polythene bags/1000	120 -	00
Manure 0.37 cartloads/1000	11 -	00
Sand 0.37 " /1000	7 -	33
Red earth. 28 " / 1000	3 -	52

Hamant G. Hegde

An attempt has been made in this lecture to uses school nursery as an aid to understand the process of propogation of plants through seeds involving the process of germination and dormancy.

SEED : A seed is a reproductive unit formed from a fertilized ovule.

The seed has thru basic parts,

1) Embryo
2) Food storage tissue
3) Seed covering

Embryo: The embryo is a new plant resulting from the union of a male and female gamete during fertilization. Its basic structure consist of an axis with growing points at each end, one for the shoot and one for the roots and one or more for the seed leaves (cotyledons) attached to the embryo axis. Plants are classified by the number of cotyledons mono cotyledonous plants example grasses, onion have a single cotyledon, dicotyledonous plants such as beans have two and gymnosperms such as pine have as many as fifteen.

Storage tissue: The storage tissues of the seeds may be the cotyledons, the endosperm the perisperm or in gymnosperms the haploid female gametophyte.

Seed covering: The seed covering may consist of the seed coats the remains of the nucellus and endosperm and some times the parts of the fruit. The seed coats, or testa usually one or two in number, derived from the integuments of the ovule. The seed covering provides mechanical proection for the embyo, making it possible to handle seeds without injury, and thus permitting transportation for long distances and storage for long periods of time.

A seed thus consists of an embryo and its stored food supply surrounded by protective seed covering. At the time the seed seperates from the parent plant, metabolism is at a low level and there is no apperent growth activity within the seed. During seed germination, cell metabolism increases, the embryo resumes active growth, seed covering ruptures and the seedling plant emerges.

Seeds of most plants are unable to geminate while they are enclosed within the fruit attached to the parent plant or for a period of time after fruit ripening and seed dispersal seeds whose germination is prevented by their own internal mechnism are said to be dormant. If the seed is capable of

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immidiate germination when subjected to proper environmental condition the seed is said to be quiescent or non-dormant.

For germination to begin three conditions have to be fulfilled,

1) The seeds must be viable

2) Internal condition of the seed must be favourable for germination (physical or chemical barriers to germination must have disappeared)

3) The seed must be subjected to appropriate environmental condition (water, proper, temperature, supply of oxygen and sometimes light)

The Germination Process

The first stage of germination-awakening or activation-may be complete within a matter of minutes or hours.

Water is absorbed by the dry seed and the moisture content increases rapidly, then stabilizes. Initial water absorption involves the imbibition of water by colloids of the dry seed, which softens the seed coverings and causes hydration of the protoplasm. As a result the seed swells and the seed coats may break.

Components (i.e., various DNA and RNA molecules) of the protein synthesizing system of cells become active. These were formed during seed development and become inactive as the seed mature. After uptake of water however this system is reactivated to permit protein synthesis to continue. The enzymes produced by protein synthesis control metabolic activities of the cell. Some enzymes were produced during seed development and must be reactivated. Others are synthesized after germination begins.

Energy becomes available for protein synthesis from high-energy bonds in adenosine triphosphate (ATP) located in the mitochondria. Some of these systems were formed during seed development, preserved in the dormant seed, and reactivated during cell hydration.

The second stage of germination involves digestion and translocation. Water uptake and respiration now continue at a steady state. The existing cell systems have been activated and the protein-synthesizing system is functioning to produce various new enzymes, structural materials, regulator compounds, nucleic acids, etc., to carry on the cell functions and syntesize new materials. Enzymes appear and begin to digest reserve substances (fats, protein, carbohydrates) in the storage

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tissues (cotylodons, endosperm, perisperm, or megagametophyte) to simpler chemical compounds are then translocated to the growing points of the embryonic axis to be used for growth and the production of new plant parts.

The metabolic patterns in different plant species depend largely upon the type of chemical reserves in the seed. Fats and oils-the major food constituents in the seeds of most higher plants are converted enzymatically to fatty acids and eventually to sugar. Storage proteins, present in most seeds, are a source of nitorgen essential to the growing seedling. Starch, present in many seeds as an energy source, is converted to sugar.

The third stage of germination consists of cell division in the separate growing points of the embryo axis. Once growth begins in the embryo axis; fresh weight and dry weight of the seedling increase but weight of storage tissue decreases. Respiration, as measured by oxygen uptake, increases steadily with advance in growth.

As germination proceeds, the structure of the seedling soon becomes evident. The embryo consists of an axis bearing one or more seed leaves, or cotyledons. The growing point of the root, the radicle, emerges from the base of the embryo axis. The growing point of the shoot, the plumule, is at the upper end of the embryo axis, above the cotyledons.

The initial growth of the seedling follows one of two patterns.

1) Epigeous germination the hypocotyl elongates and raises the cotyledons above the ground.

2) Hypolotyl does not raise the cotyledons above the ground and only the epicotyl emerges hence cotyledons do not perform the process of photosynthesis but simply act as food reserves.

This role of cotyledons reflects the relative dependance on light for early growth in the two groups. Seeds with few resources of their own need to photosynthesize immidiately after they germinate and so they use their cotyledons for this purpose. Seeds which follow a hypogeal pattern achieve initial increase in height without having to photo synthesize and use their cotyoedons to provide the resources, to do this Epgial seedlings therefore tend to be light demading and hypogial ones shade tolarent.

Regulation of germination : Dormancy

Ripening of seeds includes the development of internal

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mechanism that controls the onset of germination so as to coincide with periods during the year having environmental conditions most likely to favour survival of the seedlings. In most plants reduction in moisture to a level below that required for germination is one method of control, but most freshly harvested seeds have additional regulating mechanisms that prevent germination even if environmental conditions are seemingly favourable. Thus dormancy is a delaying mechanism which prevents germination under conditions which might prove to be unsuitable for establishment. Or ecological dormancy in seed is an adptation for natural survival.

Categories of Seed dormancy :

Group I Seeds where regulation occurs in the nonliving external seed coverings but the embyo itself is quiescent.
A) Hard seed covering impermeable to moisture (seed coat dormancy). Seeds fail to absorb water until the covering is modified by natural or artificial methods.
B) Hard seed covering resistant to embryo expansion.

C) Seed covering containing chemical inhabitors-Specific chemical substances found in the pericarp or in dry covering or in seed coats, endosperm etc., may cause dormancy.

Group II Seeds with morphologically undeveloped embryo (rudimentary) Embryos. Embryos that are small and undeveloped at the time of fruit ripning must increase in size at the time of germination.

Group III Seeds with internal dormancy - Germination is regulated by the inner tissue of the seeds that is the embryo the enclosing endosperm and inner integumental layers.

Group IV Combined double dormancy Both seed coat (external) dormancy and embryo (Internal) dormancy occurs, and the required treatments must be given sequence to break dormancy.

Dormancy factors affecting seed germination:

Impermeability to water Impermeability of the seed coats to water is a major factor in maintaining seed dormancy in species of certain families. The embryo is quiescent (non-dormant) but is sealed inside a water impermeable covering that can preserve the seed at low moisture content for many years even at warm temperatures.

Impermeability of the seed coat is due to a layer of palisade-like macrosclereid cells, especially thick walled on their outer surface and having a layer of waxy, cuticular

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substances external to this. In some species a small opening near the hilum (point of attachment between seed and funiculus) is sealed with a cork like plug which can be dislodged with vigerous shaking or impaction.

Chemical inhibitors :Naturally occuring plant harmones are responsible for controlling germination in seed of some species.

Model to explain chemically controlled dormancy

	Gibberellin	Cytokinin	Inhibitor	
1	+	+	+	Germination
2	+	+	-	"
3	+	-	+	Dormancy
4	+	-	-	Germination
5	-	-	-	Dormancy
6	-	-	+	"
7	-	+	-	Dormancy
8	-	+	+	"

According to this model, germination occurs only in the presence of gibberellin. If an inhibitor ispresent it off sets the effects of gibberellin and germination does not take place. But if cytokinin is then added it blocks the effect of inhabitors and permits germination to take place.

Presence of rudimentary embryos In some species the embryos are not compleatly developed morphologically at the time of seed ripening and normally undergo further growth within the seed after its removal from the plant. In most seeds of this group, however the rudimentary or partly developed embryos are embedded in adequate reserve food materials in the endosperm.
Example: Coconut, Anona squamosa, etc.,

Presence of Physiologically Active Seed Layers

Most of the freshly harvested seeds have physiologically active seed coverings, made up of the inner seed coat and the endosperm. Germination control by these two layers tends to disappear with time, particularly if the seeds are in dry storage. Seeds with this charecteristics are sensitive to various environmental influences such as light, temperature, concentration of gases and presence of various chemicals. Excision of the embryo avoids these germination blocks producing immidiate germination.

Preconditioning seeds to stimulate Germination :

i) Mechanical Scarification : Mechanical scarification is done to modify hard or impervious seed coats. Scarification is any process of breaking, scratching, or mechanically altering

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the seed covering to make it premeable to water and gases. Although some scarification probably occurs during harvesting extraction, and cleaning, germination of most hard-coated seeds is improved by additional artificial treatment like rubbing the seeds on sand paper, cutting with file or cracking the seed covering with a hammer. Care should be taken that seeds are not injured during the process.

ii) Soaking the seeds in water : Soaking seeds in water is done to modify hard seed coats, remove inhigitors, soften seeds, and reduce the time of germination. This treatment will overcome seed coat dormancy and stimulate germination in most cases.

Some impermiable seed coats can be softened by placing the seeds in four to five times their volume of hot water (77°-100°C) The heat is immidiately removed and the seeds allowed to soak in the gradually cooling water for 12 to 24 hours. Exp: Acacia species.

Soaking seeds prior to germination may shorten the time for emergence if the seeds are normally slow to germinate.

iii) Acid Scarification This procedure is useful in modifying hard or impermeable seed coverings. Soaking seeds in concentrated sulfuric acid is effective in doing this. (Sulfuric acid must be used with care, because it is strongly corresive and reacts violently with water causing high temperature and splattering.

Dry seeds are placed in glass or earthenware containers and covered with concentrated sulfuric acid in the ratio of 1part seed to 2 parts acid. The mixture should be stirred Continously. The length of the treatment should be standardized for different seeds. (may vary from a few minutes to a few hours) At the end of the treatment the acid is poured off, and the seeds are washed with copious amounts of water to dilute the acid. Washing for ten minutes with running water should be sufficient. The seeds can immidiately be planted when wet or dried and stored for later planting.

In these 3 lectures, we shall learn about fuel quality, Science of Combustion, heat extraction, principle of controlled combustion and finally see how the simple scientific principles can lead to a more efficient wood burning stove.

2. Fuel and Combustion:

Any substance that burns and generates heat can be called a fuel. Chemically, combustion process is an oxidation reaction. Generally, combustibles are burnt in air eg. methane can be burnt to give H_2O & CO_2:

$$CH_4 + 2O_2 (g) \longrightarrow CO_2 (g) + 2H_2O - 889 \text{ KJ/mole}$$

Similarly, Carbon monoxide burns to give CO_2

$$CO(g) + 1/2\ O_2 (g) \longrightarrow CO_2 - 283 \text{ KJ/mole}$$

Hydrogen burns to give water;

$$H_2 + 1/2\ O_2 \longrightarrow H_2O - 285 \text{ KJ/mole}$$

Similarly, glucose burns in air to give H_2O & CO_2

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O - \text{heat.}$$

In this case, Oxygen present in the compound is utilized for producing CO_2 and H_2O but it dose not add to the production of heat. However, Oxygen atoms add to the total mass of the fuel. Therefore, heat produced per unitweightages reduced. When we want to compare the fuel value of different compounds, we need to find the heat produced per kg of each of the above fuel.

We can do this as follows:

Heat produced per 1 gm mole of H_2 is 285 KJ. This means 2 gms of Hydrogen produced 285 KJ. Therefore 1000 gms (1 kg) produces 142 MJ. Quantity of heat produced by burning 1 Kg of fuel is called its calorific value. In early days, calorie was used as the unit of heat (1 calorie = heat required to raise 1 gm of water form 14.5 ^{o}C to 15.5 ^{o}C) 1

kalorie = 4.18 joules. 1 MJ = 10^6 joules.Similarly, 16 gms of CH_4 produces 809 KJ of heat. Therefore, 1000 gms of CH_4 produces (809 X 1000)/16 = 55.6 MJ.Thus, knowing the heat of a chemical reaction involving combustion, calorific value of a fuel can be found out.

How the heat of a chemical reaction or combustion can be measured?

This is done by employing a bomb calorimeter. A known amount of substance is burnt under Oxygen at 25 atmospheres. The bomb where substance is burnt is kept in a vessel with known quantity of water. Heat generated is exchanged with water and the rise in temperature is measured. From the value of specific heat of water, the heat librated is found out for 1 kg of fuel.

In figure 1, heat of combustion or calorific value of hydrocarbon with increasing carbon to hydrogen ratio is plotted. The first point is for hydrogen itself. In the same figure, the values of kerosene and wood are also shown.

We will be surprised to note that hydrogen is a very good fuel. It produces heat about 3 times that of methane per kg. As the carbon to hydrogen ratio increases, calorific value decreases. The wood (containing mostly cellulose) has lower calorific value.

Chemical identification of wood is rather complicated. It contains mostly cellulose and lignin. Wood contains 50% wt of carbon, 43% of oxygen and 6% hydrogen. Thus, carbon to hydrogen ratio is much higher than in hydrocarbons and hence calorific value is low. Oxygen present in cellulose and other organic compounds do not add to its heat of combustion.

3. Pyrolysis of wood

Decomposition of wood in absence of air is called. pyrolysis. This method helps identify different products comming out of wood.

The following table gives the different chemical products of pyrolysis of wood.

Product	Yield/1000 kg
Charcoal	275 kg
Terpentine	26
Pine oil	7.5
Resin oil	87
Resin spirit	13
Creosote oil	28
Methanol	3.75
Acetic acid	11.75
Pitch	89.5

Gases	by volume
Carbon dioxide	30%
Hydrocarbon(C_nH_m)	8
Carbon monoxide	35
Hydrogen	8
Nitrogen	4
Methane	12

As can be seen from the table, charcoal constitutes about 27% of the products. All the organic compounds are combustible. Non combustible gases like CO_2 and nitrogen are also liberated in large quantities. When the wood is not burnt efficiently, the organic liquids evoparate

and vapours of these liquids add to the smell of the smoke.

4. Combustion proiducts of wood

Hard wood (matti, jambe and the like) gives al out 0.5% of ash. Ash is chemically alkealine and the most important chemical in it is K^V2^VCO^V3^V. Other than this it also contains minerals such as ZnO in small quantities. CO_2 formed reacts with K O to form K_2CO_3. This is why ash gives sopy touch as soda ash. Husks contain silica to form fibrous structures. When rice husk is burnt, 22% of its weight forms. This ash largly contains SiO_2. SiO_2 is in the amarphous form. The rice husk ash moxed with $CaCO_3$ (lime) and heated and rolled, gives good quanlity cement. Presently, technology to produce good cement from rice husk is attempted in many laboratories. Ash from rice husk therefore does not gave high mennure value as that of ash from wood (potash). Similarly, Coconut husk, arecanut husk give more ash containing SiO_2. That is why the calorific values of husks is low. For example, calorific value of rice husk is only 12.5 MJ as against 18 MJ in the case of wood.

5. Forms of heat

a) Radiation: When fuel is burnt, the most important form of energy generated is radiation. Radiation is emitted primarily due to deexitation of electrons in excited CO_2. During combustion of wood, in addition to just CO_2, carbon particles also get heated and they also emit light. It is wellknown from Bohr's stheory that when electrons jump from higher level to lower electron level, light is emitted. Since a single atom or a molecule is not involved here it is difficult to say which light is due to what transition. The light emitted from the flame

from wood or charcoal can be considered as a black body radiation. In fig 2, we have shown the distribution of radiation energy for different frequencies. Here, the temperature of the flame is taken as 1000 ^{o}K which is equal to 727 ^{o}C. This is a arealistic temperature and the peak energy is emitted at about $\nu=0.7 \times 10^{14}$ sec^{-1}. This corresponds to infrared radiation. However, we do see colour of such a flame as red. This is due to other frequencies in the flame. This is the major source of energy given out by the flame.

Second source of energy is the flue gas (CO_2 & H_2O) which are generated during the combustion. Due to the high temperature of the flame, the gases get heated. The gas temperature at the combustion zone is equal to the flame temperature itself. As the flue gas rises to atmosphere, it gets mixed with fresh air which is at lower temperature and hence the flue gas temperature gets reduced. Even then it is higher than 200-300 ^{o}C above 30-50 cms of flame and this hot gas can also heat any substance. Thus, flue gas is also a source of energy from combustion processes.

6. How to measure temperature?

Ordinary mercury thermometers can be used to measure upto 360 ^{o}C. For higher temperature measurements, we can use thermocouples. When two dissimilar metals are welded together at one end and this junction is heated, a voltage is developed on the free ends. The voltage developed is related to the temperature. Platinum-Rhodium alloy with platinum forms a thermocouple. This can be used upto 1600 ^{o}C. Chromel-alumal is another junction (Chromel:Ni 90%, Cr 10%; Alumel Ni 94%). For every 100 ^{o} rise in temperature, about 4 mv is genetated. We can thus diectly measure the temperature of the flame. Contanten (53% Cu, 45% Ni) and Cu

forms a good junction.

$$\text{Voltage } E = T^2 + X\,T.$$

This is the relation between the voltage and temperature.

7. Principle of controlled combustion.

We have shown that heat can be generated by burning the fuel. However, when wood is burnt in open air, the amount of oxygen available is too much. Consider the following reaction.

$$C + O_2 \longrightarrow CO_2$$

Ideally, for 1 gm of atom of carbon, one mole of oxygen is sufficient. But to make this reaction complete, a slight excess of oxygen may be provided. If this oxygen is from air, the flue gas contains 1 mloe of Carbondioxide in addition to about 4 moles of nitrogen. This means, the heat generated has to heat nitrogen as well. If we have excess air, say 100%,

$$C + 2O_2 \longrightarrow CO_2 + O_2$$

is the reaction. Now the flue gas 1 mole of CO_2 1 mole of oxygen and 8 moles of nitrogen. Thus, heat generated is shared by 10 moles of gases as against just 1 mole of CO_2 when oxygen present is just what is required. In ordinary open air fire, 7 times more than the required amount of oxygen is present. This is why temperature of the flame come down. We can get higher temperature by controlling the air input. This is called controlled combustion.

Mixing fuel with air:

Any chemical reacation take place faster if we mixed the chemicals intomately. In combustion process also fuel when mixed with air, the fuel burns properly. We can see this effect in daily experience. Rice husk heaped in a corner when fired, it slowly burns over a week. But

the same husk slowly spread as is done in rice mills, it catches fire easily. Similarly, wood sticks stacked without any air gap does not burn easily. One easy way to mix fuel wood and air is to lay wood sticks on a cast iron grate and allow the required amount of air from bottom of the grate. This ensures good mixing of air and fuel.

Flue gas is lighter than cold air

If the flue gas is lighter than the surrounding air, than it will go up. The reason for this is that flue gas temperature is higher than the surrounding air. The ideal gas law states:

$PV = nRT$; P = pressure, V = volume, n = no. of moles of gas, T = absolute tempetature. Thus $n/V = P/RT$. n/v = density of the gas. Therefore for a costant pressure, density is inversly proportional to temperature. Since flue gas temperature is high ($\sim 500^{o}$ C), flue gas density is low. Therefore, flue gas rises above. This principle can be easily used to take out the flue gas through a chimney out of the roof thus removing smoke from inside the house.

8. Heat transfer process

For our purpose of using wood as a fuel, it is not sufficient if we generate heat efficiently. We should also entract heat efficiently. We normally keep a vessel containing raw food over a stove. How the heat generated is transferred to the vessel?

a) Radiative heat transfer:

Radiation is mainly from glowing wood; the gases also generate radiation as discussed earlier. The bottom of the pan can see the flame or radiation. Higher the bottom area, it can see more radiation.

Amount of heat transfered from radiations is given by the equation:

$Qr = F A (T_2^4 - T_1^4)$

Qr = heat transferred to the vessel ($W/m^2/K^{-4}$)

F = geometric factor

A = area of the surface receiving radiation (in M^2)

T_2 = temperature of radiation zone

T_1 = temperature of the bottom of the vessel.

Thus, if area of the pan is more, more heat can be entered. Also, if the temperature of the combustion zone (where radiation is emitted) is high, heat transfer is high. This is more important because, it is in T^4 power. We can clearly see here an advantage of producing flame at a higher temperature. One way, was to reduce the amount of free air as discussed earlier.

b: Convection:

Convective heat transfer is the collective name given to the processes of heat transfer from flowing gas or liquid. Here, flue gases generated can pass below the pans and heat the pan. Quantity of heat transfered by this process is given below.

$Qw = A (T_{fluegas} - T_{pan})$

Qw = convective heat flow (watt)

= heat transfer coefficient ($WM^{-2}K^{-1}$)

A = Surface area in contact (M^2)

$T_{flue\ gas}$ - flue gas temperature and

T_{pan} - temperature of the bottom of the pan.

Again, if the surface area of the pan is high, more heat can be extracted. If the heat transfer coeff is high, more heat can be extracted. Also, if the temperature of the flue gas is high, more heat can be extracted. Thus, if we allow just required amount of air to the

fuel, the flue gas temperature remains higher. The liquid inside the pan also get heated by convection process.

c)Conduction

Conduction is responsible for heat transfer in solids. One end of iron when heated, the other end gets hot by the conduction process. Heat transferred by conduction is given by

$$Qcd = A(T\ hot - T\ cold)/L$$

Qcd = conductive heat flow W

A = crosssection area

= thermal conductivity of the solids W/M/K

L = length or thickness of the wall

The mud stove walls are heated through the conduction process. Since very little part of the vessel is in contact with the stove, vessels do not receive much heat by this process. Thus conduction process is mainly the heat loss process. If we reduce the loss of heat to the stove walls, we will have more heat through radiation and also flue gas convection to the pan. Some simple experiments are shown to demonstrate to heat transfer processes.

Yet another point for heat transfer is that the black body absorbs radiation of all wavelengths just as it emits radiation of all wavelengths. Therefore, if the bottom of the pan is covered with carbon black, more heat will be absorbed by the vessel. In fact, in the villages the bottom of the rice and other pans are lightly covered with jaggery. Jaggery burns forming carbon and thus the bottom becomes a black body. The villagers know all these laws by experience.

9. Efficient wood buring stoves

With the scientific background we now have, we can design an efficient wood burning stove.

What is efficiency?

Percentage of heat extracted for useful purposes from the total amount of heat generated is called efficiency. If 10 calories is used for heating water out of 100 calories generated, efficiency of the heater is only 10%. Efficiency of a stove can be measured by water boiling test. The wood stove which are common in Uttara Kannada are only about 15% efficient. The rest of the heat goes out through flue gas, wall loses etc. If we can build say 30% efficient stove, half the amount of wood is sufficient to cook the same amount of food. This means half the amount of wood is saved. Wood required for one year can be used for 2 years.

Astra Ole

Astra Ole is one such stove where the scientific principles discussed earlier is applied and efficiency of the stove is measured from 15% to 45%. The principles used are:

i) Use of grate for mixing fuel with air,

ii) controlled combustion (only required amount of air is let in),

iii) secondary air-hole is provided to burn the gases generated,

iv) the distances between the pot and the flame is adjusted to have heighest tempetature below the pan for higher radiation heat transfer,

v) flue gas generated heats second and third pans,

vi) chimeny is used to take off the flue gas out of the house.

vii) alluminium pans are used to have higher thermal conductivity,

viii) heat insulation in the stove wall provided to reduce condutive heat loss to the stove walls,

ix) inside of the stove is shaped for proper radiation transfer and convection heat transfer,

x) pans are dipped to have higher heat transfer through more surface area exposed to the radiation as well as flue gas,

xi) wood size is monitored to have a good rate of burning.

A careful study of each of these points can now tell us how the scientific principles behind this helps us to produce a better wood burning stove. We shall discuss each of the above points and also demonstrate to you the importance of this in our every day life.

10. Hosa Bachhala Ole

Based on similar principle a 40% efficient bath room stove has been designed and are used in many villages of Uttara Kannada. This will be discussed and demonstrated.

11. Fuel efficient Jaggery making unit

Using bagasse as fuel, the principles as in (9) was first used in 2 pan jaggery furnace. This is now quite common in Uttara Kannada. All the wood can be saved . We shall discuss this also.

12. Materials and construction

Apart from the scientific principles discussed study of materials for construction is also important. Cost of materials can be brought down if we adopt locally available materials in the construction. There are a number of simple engineering techniques known to the people who may not have formal education. For example carpenter knows how to produce a long beam joining two small pieces. Each of the principles can be tested and we shall demonstrate them. We shall see how the

scientific principles underlying the stove can be translated into practice by constructing stoves with locally available materials.

Fig 1. Heat of combustion vs no. of carbon atoms in the hydrocarbon.

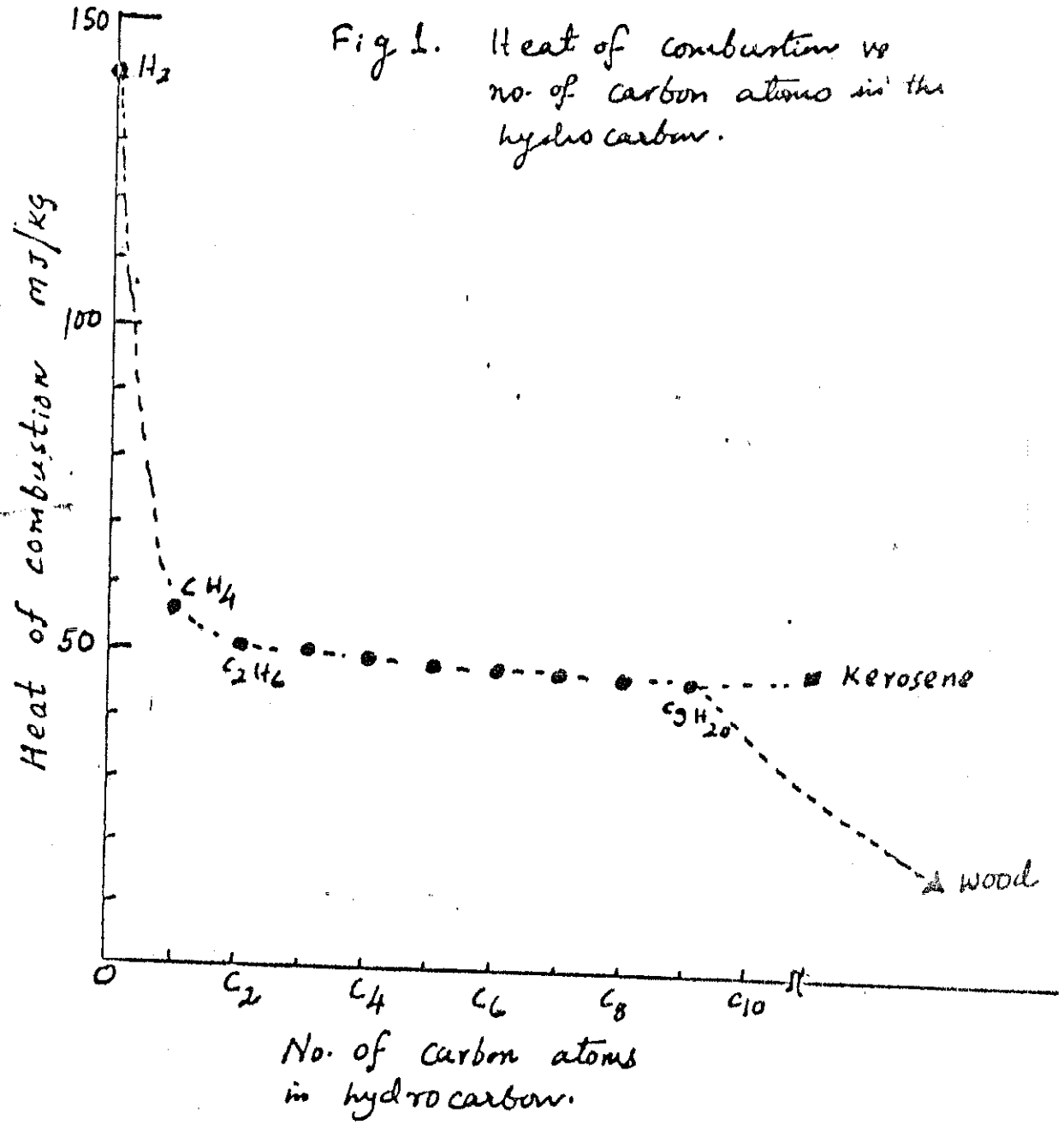
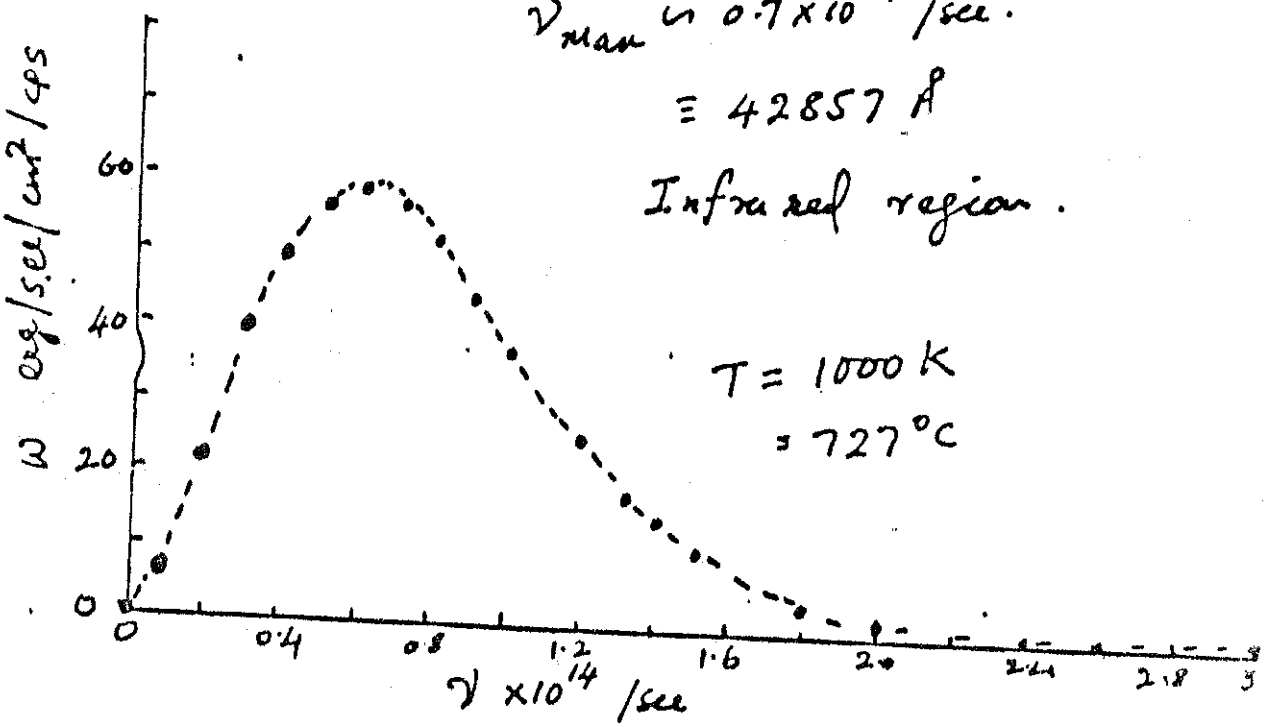


Fig. 2: Radiation law for $T = 1000°K$.



$\nu_{max} = 0.7 \times 10^{14}$ /sec.

$\equiv 42857$ Å

Infrared region.

$T = 1000$ K

$= 727°C$

Plank's equation for Black body radiation:

$$\text{Energy flux } W = \frac{2\pi h \nu^3}{c^2} \times \frac{1}{\exp(h\nu/kT) - 1}$$

h - 6.625×10^{-27} erg.sec

ν - frequency of radiation $\nu = \frac{c}{\lambda}$ $c = 3 \times 10^{10}$ cm/sec

k - Boltzmann const $(1.38 \times 10^{-16}$ erg.T^{-1} λ - wavelength

T - Temperature of the flame.

A New Fuel Efficient Bath Room Stove

M. S. Hegde*

Introduction

Many people in India and children in particular prefer hot water for bathing. Large quantities of fuel wood are needed to heat this water. Studies in energy consumption and attempts at designing energy saving devices were therefore attempted to improve fuel utilisation in this domestic sector. A case study of one coastal village Unchagi in Uttara Kannada district of Karnataka was undertaken as part of this attempt.

Out of 363 people of Unchagi, 300 are found to take hot water bath once every day and the rest at least twice a week. Only in summer (April and May), a few people are known to take cold water bath. Our survey showed that the temperature of the bath water varied from 36° to 46°C and the quantity varied from 20 to 60 litres per person per bath. A study of fuel requirements in this village showed that 1.29 kg/day/person are required for cooking food and 1.0 kg/day/person for heating bath water. Other fuel requirements are for parboiling rice, processing agricultural produce, heating food for cows and buffalows.[1] Due to usage of a new 2 pan bagasse fuelled community jaggery unit introduced in this village by Hegde et al.[2] in 1981, wood for jaggery making is totally replaced by bagasse. Our survey showed that a total of 325 tons of fuel per annum in the form of cut wood (35%), shrubs and twigs (30%) and agricultural residue such as arecanut husk, coconut tree products (15%) are required to sustain domestic life in this village. Out of this, about 115 tons of fuel are required for heating bath water alone. This village has about 100 hectares of Minor Forest land from which the fuel is collected. Due to excessive exploitation, almost all the Minor Forest area is denuded. Even roots of shrubs are being removed for fuel. This is the fuel scene in this village.

A house survey in Sirsi town in Uttara Kannada district showed that 80% of the houses in the town area use fuel wood for heating bath water. Reddy et al [3] have studied fuel wood consumption in Bangalore and report that over 20% of the population in Bangalore use fuel wood for the same purpose. Our case study of Sanjay Nagar, a colony of Bangalore showed that 99% of the people take a hot water bath but 60% of them use electricity. These observations suggest that since the quantum of fuel for heating bath water is very large, fuel efficiency in this heating process is worth looking into.

This report presents a study of existing bath room stoves and proposes a design for a new fuel efficient bath room stove. Working of the new stove has been demonstrated in Unchagi and in several other villages of Uttara Kannada. Compared to only 15% efficiency of the conventional bath room stoves, 40% efficiency is achieved in this stove and a saving of over 60% of fuel is realised.

Conventional Bath Room Stoves

Efficiency

Fuel efficiency of a stove is commonly evaluated by the water heating test. Heat gained by a known amount of water is measured by burning a given quantity of wood. Hard fuel wood such as *Casuarina*, sun dried for 30 days contains about 10% moisture. Calorific value of this type of wood

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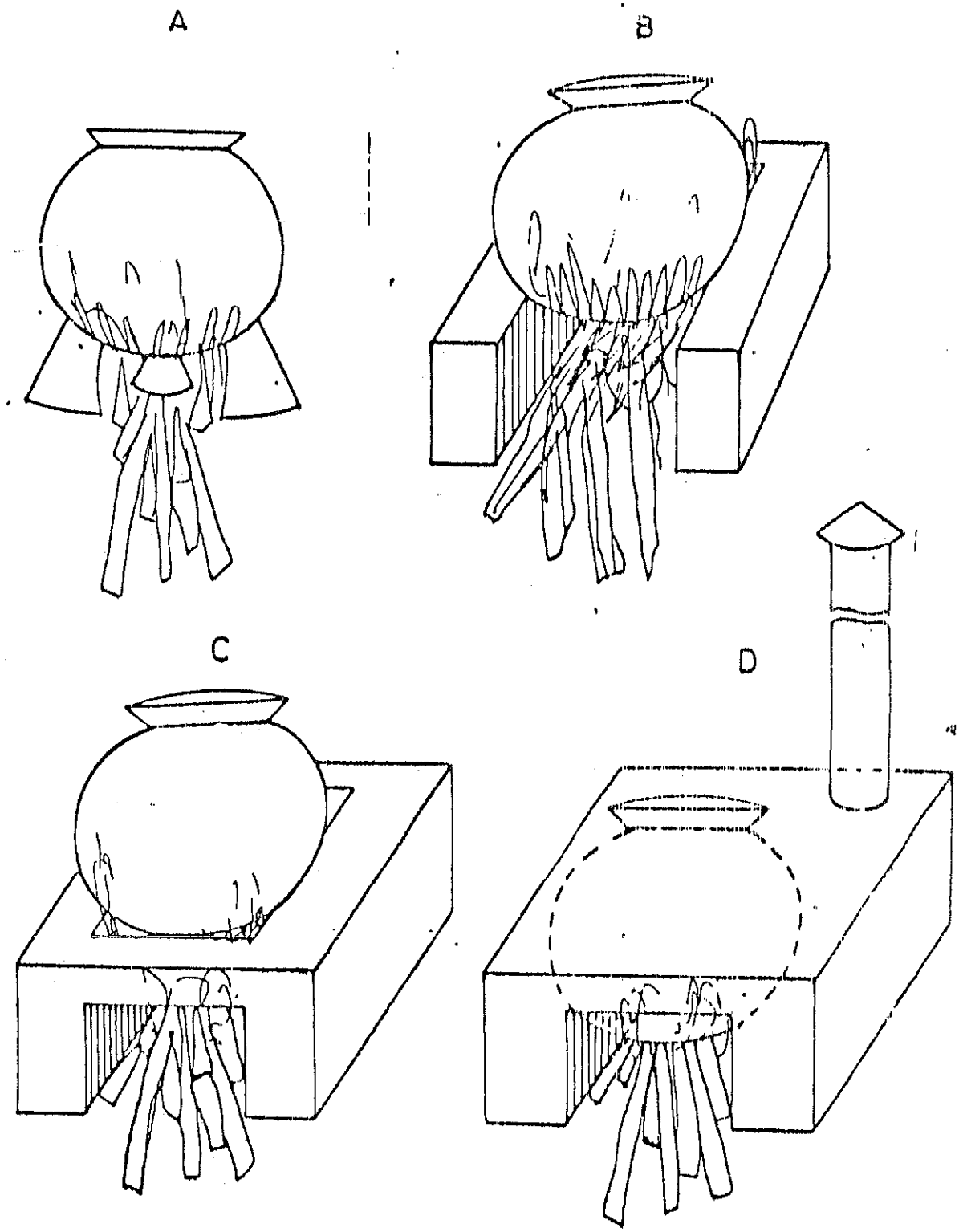


Fig. 1 Schematic diagrams of tradional bath room stoves in Uttara Kannada District.

is 3800 Kcals/kg. Efficiency is obtained as follows:

$$\% \text{ heat utilization} = \frac{(\text{wt. of water in Kg})\ (\Delta T)}{(\text{wt. of wood burnt in Kg}) \times 3800} \times 100$$

where ΔT is the rise in water temperature after burning. In traditional bath rooms, unburnt charcoal is not collected. Therefore, in evaluating the efficiency, we allowed complete burning and recorded the highest temperature attained by the water. As generally bath water is heated to 60°C and bath is taken after mixing fresh water, we have also heated water to about 60°C in our experiments.

Conventional stoves

A survey of bath room stoves in the villages of Uttara Kannada showed that no family used more than one vessel. The 4 main types of stoves found in these areas are sketched in Fig. 1. Efficiencies for each of these types were measured. The values are given in Table 1 along with percentage occurance and brief descriptions of each type. Invariably, a round vessel made of copper is used, the size of this vessel depending upon the family size. For a family of 6 members, 50 to 60 litres capacity vessel is in use.

Table 1

Efficiency and percentage occurrence of the existing bath room stoves*

Type (see Fig. 1)	Percentage occurrence in a typical village Unchagi; out of	Percentage heat utilisation	Special features
A	25	10-12	no grate, no chimney
B	30	12-15	no grate, no chimney
C	40	14-16	no grate, no chimney
D	5	16-22	no grate, chimney of 3 in-4 in dia. 10 ft. height

* Efficiency presented here is an average of 5 stoves of each type.

From Table 1 we can see that efficiency of the stove increased when a chimney was used. Highest efficiency of the traditional bath room stove with a chimney is only 22%. However, most stoves do not have a chimney and their efficiency is less than 15%. Yet another observation is that these stoves emit smoke. Bath room walls and roofs are generally covered with dark tarry layers. It is uncomfortable to bathe while the stove is burning. Therefore there was a demand by the villagers for a new smokeless, fuel efficient bath room stove.

Design considerations of a new stove

Based on the observations on the conventional stoves and the discussions we have had with the villagers, the desired characteristics for a new stove were:

(a) the existing single vessel type be used;

(b) locally available material be used for construction;

(c) the stove be easy to construct, easy to light, easy to extinguish and smokeless;

(d) rate of burning be such that in about 30 min, about 50 litres of water be heated to 60°C;

(e) cost of the stove be kept at a minimum;

(f) high fuel efficiency be achieved.

With these constraints in view, design parameters were calculated as follows:

(i) The fuel is allowed to burn over a cast iron grate. Air required for burning is allowed through the grate so that combustion is controlled. (ii) Taking 50 litres round bottom vessel to be heated from 25°C to 60°C in 30 minutes and assuming 35% efficiency, quantity of wood with calorific value of 3800 Kcals/kg is calculated. Thus 1260 Kcals of heat is required for heating 50 litres of water from 25°C to 60°C and the wood required for this is 1260/ (3800 x 0.35) = 0.940 kg. (iii) This wood should be burnt in 30 minutes. It is known that about 2.5 kg of wood can be burnt in one hour over an effective grate area of 5 in x 5 in (6). Hence a kg of fuel can easily be burnt in about 30

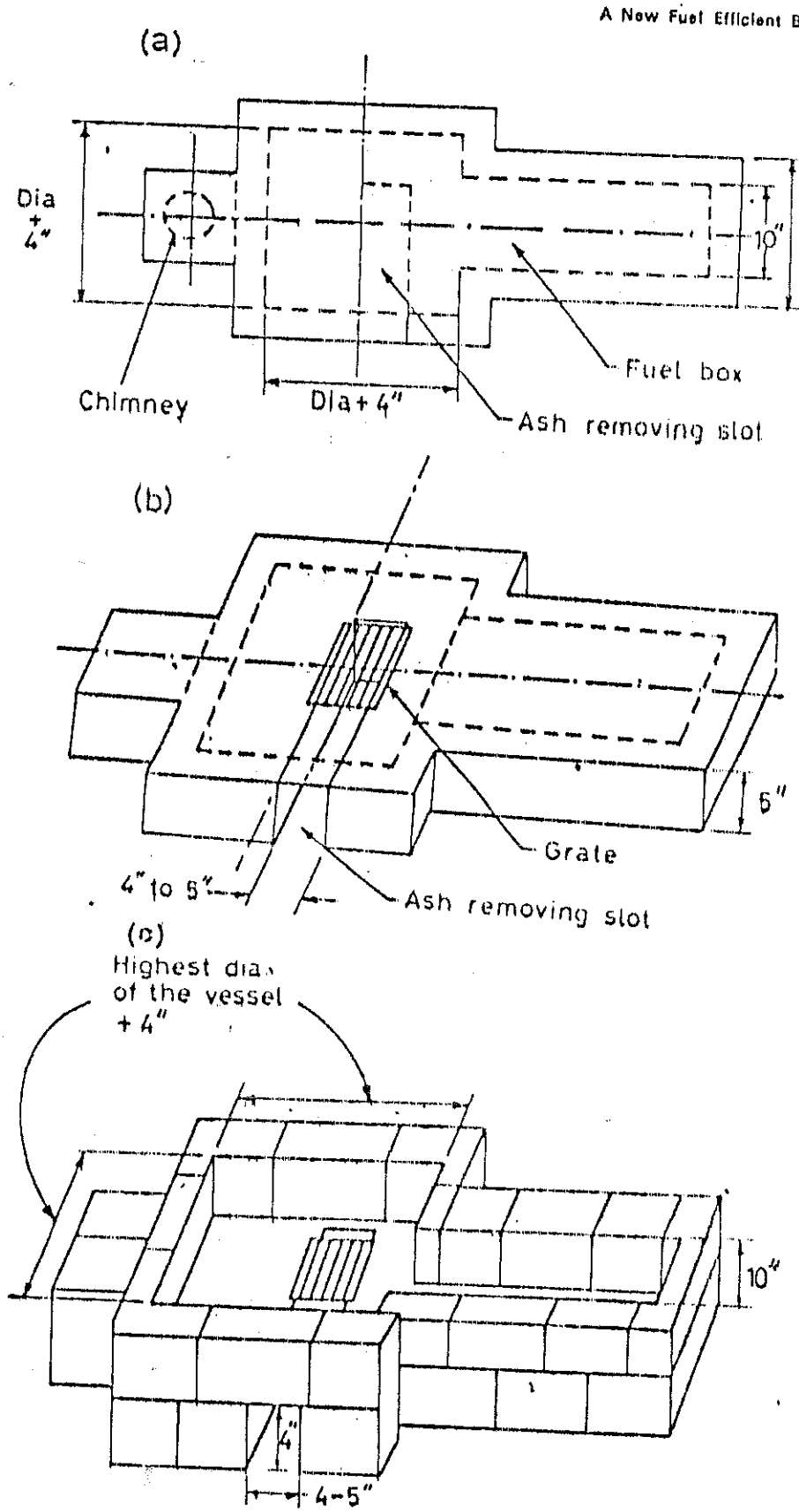


Fig. 2. Design for the new fuel efficient bath room stove.

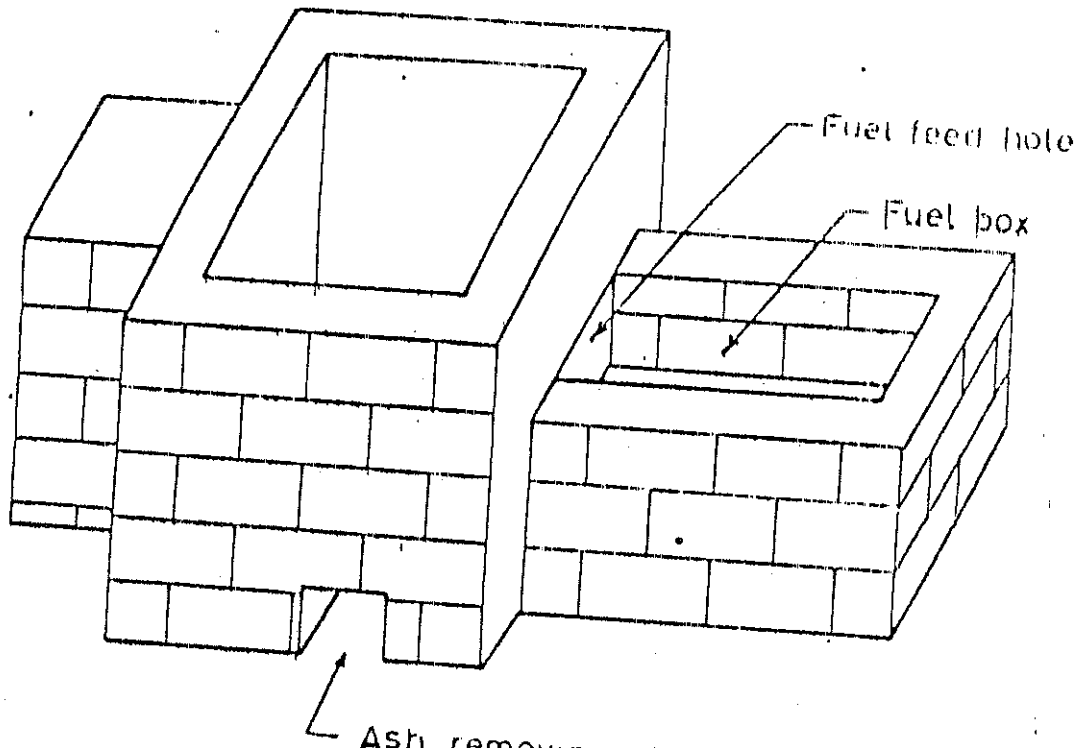


Fig. 2 (a) Design for the new fuel efficient stove

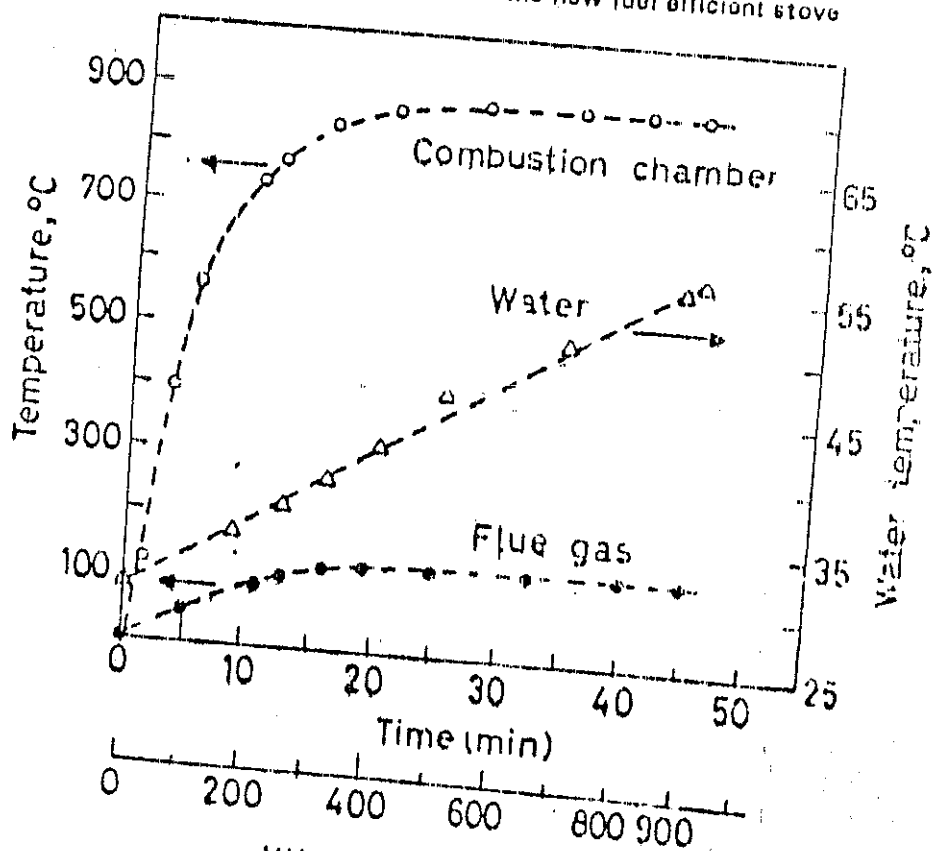
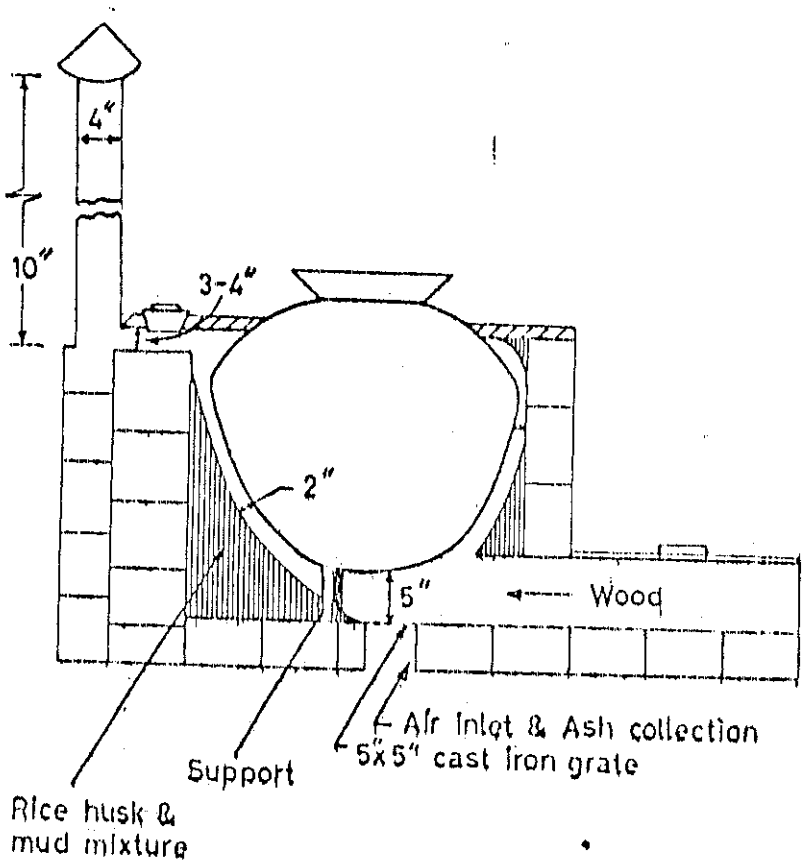


Fig. 3 Temperatures on the new stove



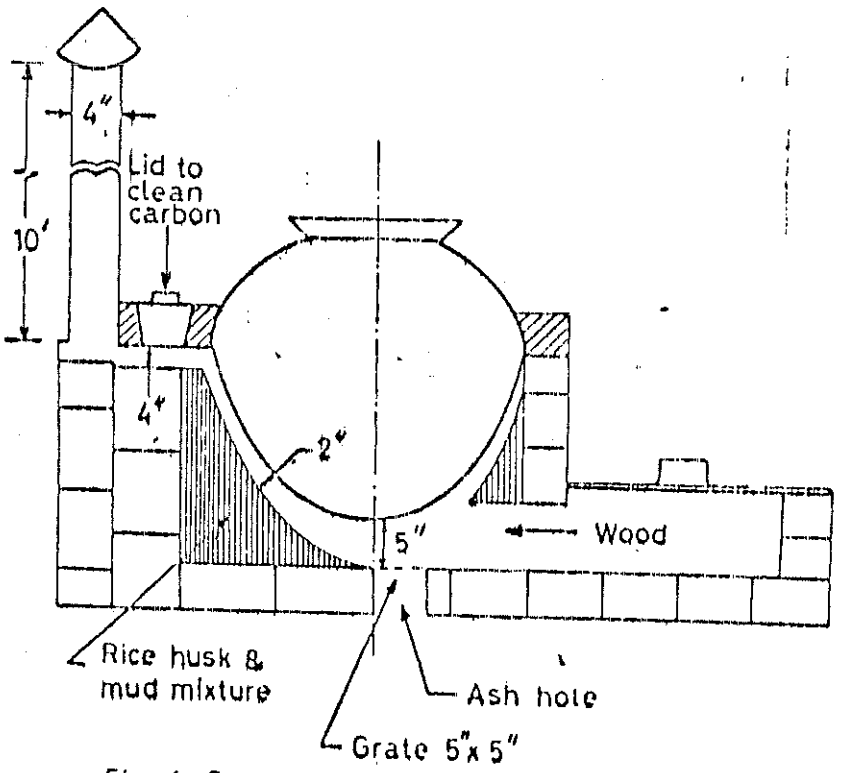


Fig. 4. Cross sections of two variations of the stove

minutes over this grate area. Therefore a 6 in x 6 in cast iron grate is fixed. (iv) Fuel gas generated has to be drawn out through a chimney. A chimney of 4" x 10' is considered adequate for this purpose. Standard 4" x 10' asbestos cement pipe is available in the market. The fuel is to be laid on the grate and the fuel can be kept closed so that air required for burning is allowed only through the grate. Thus, the final design parameters were:

(i)	Grate	6 in x 6 in
(ii)	Chimney	4 in x 10 ft
(iii)	Vessel size	50 lit capacity
(iv)	Fuel	1 kg of wood
(v)	Distance between the grate and vessel bottom	To be fixed after the experiments

Efficiency of experimental new stove

In order to examine the effect of various stove parameters on efficiency, an experimental stove was constructed at Unchagi. The stove was constructed out of laterite stone and mud. Over 30 efficiency measurements were carried out by varying (a) the distance between the grate and the pot bottom, (b) distance between the wall of the vessel and the vessel and the stove wall, (c) duct size for fuel gas. The air gap below the grate was kept the same, viz 6 in x 1 in by partially closing the hole below the grate which hole can also be used for removing the ash. The result of these experiments are summarized in Table 2. We can see from the results that the most important parameter is the distance between the grate and the pot bottom. At 6 in the highest efficiency of 40% was achieved when the wall gap was only 2 in. The duct size was only 4in x 4in. We have also measured the variations of water temperature, fuel gas temperature and the temperature of the combustion zone (1 in abbve the grate) as a functioning time. The results are given in Fig. 3. We can clearly see that the stove can de operated at fuel gas temperature as low as 130°C. The results also show that in about 45 min, 0.9 kg of wood can be burnt and 60 litres of water can be heated from 28° to 55°C with 4°% efficiency. The desired characteristics have thus been incorporated in the design of the new stove. The stove was smokeless. The cooling rate of water was 1° per hour at 60°C initial temperature

Table 2 : Variation of efficiency by varying the critical parameters; air gap below the gate (1 in x 5 in)

No.	Distance between pot bottom and grate	Annular space between vessel and wall of the stove	Efficiency (PHU)
1	8 in	3 in	25%
2	7 in	3 in	32%
3	6 in	3 in	36%
4	6 in	3 in	32%
5	5 in	2 in	40%

Fabrication of the new bathroom stove

Steps to construct the stove are given below:

(a) Firstly, choose the direction of the fuel feed, chimney and the ash removing place as shown in Fig. 2a. Measure the largest diameter of the vessel which we call 'dia'. Consider the stove wall thickness of about 6 in. Then accordingly, mark the space as shown. Mark the positions of the grate such that the grate is placed from the centre towards the fuel feed hole.

(b) Construct a platform 6 in height leaving the grate mounting place along with ash removing place as shown in Fig. 2b. Place a 6 in x 6 in grate on the channel. Make sure that channel direction in the grate is perpendicular to the fuel feeding direction.

(c) Next construct the walls as shown in Fig. 2c. Keep the inner distance between the square walls equal to dia + 4 in for vessel and the air gap. Keep the channel for removing ash free. The fuel chamber could be 10" wide. Continue to increase the wall height keeping about 10 in x 10 in gap for the fuel chamber as in Fig. 2d.

(d) Give a brick support at the bottom at the center (towards chimney side) and keep the bottom of the vessel 5" above the grate. Adjust the height of the wall. Then remove the vessel.

(e) Shape the bottom and the inside of the stove so as to conform with the shape of the

sel keeping 2" gap uniformly between the sel and the inside wall. This is the most ortant step in the stove construction. The ng should be done with mud and rice husk ture (50:50). Support the vessel by giving packing on the wall side and the bottom brick h that the distance between grate and the om of the vessel be 5 in. Then at the chimney keep 3" × 4" gap and lead it to chimney. se the top now by covering with tile or asbestos os and finally with mud. Fig. 4 gives a cross- ion of the stove. One can provide a lid in the gas duct to collect accumulated carbon.

(f) Alternately the vessel could be supported ts maximum diameter. Although the iency of this is about 1% lower, construc- is easy and suited for villages.

(g) Make the fuel box about 10" wide and long. Cover it with a lid of 18-20 gauge G.I. et.

(h) Finally, plaster the outside walls and top ne stove with a mixture of mud, sand and lime. fuel box also needs plastering. Make sure the lid of the fuel box does not leave a gap. top of the stove needs cement plaster since er should not enter the stove.

Firing procedure

The stove should be allowed to dry for 8-10 days. Initial firing of the dry stove can be with light material like palm leaves followed by twigs and suitable logs. The fuel chamber should be closed with the lid so that air enters only through the grate and the fuel gas escapes through the chimney. The fire needs to be tended every 10-12 minutes.

4. A Comparison of the traditional stove with the new stove

In order to evaluate the utility of the new stove a comparison between the old and the new is in order. This is given in Table 3. In over 10 villages of Uttara Kannada, the new stoves are working and the method of construction is found satisfactory. Efficiencies are uniformly above 38%. The new bath room stove has relevance even in cities like Bangalore. The old stove with chimney (Fig. 1d) can be easily modified to incorporate the new design. This can save 60% fuel. It has been done in one house in Bangalore (A-43, CIL Colony, Sanjay Nagar, Bangalore-24). The results show that 1 kg. of fuel is sufficient for bath for 4 people. This is cheaper than electricity.

Table - 3

Details	Old stoves	New stove
Materials for construction	Stone/brick, mud chimney (if there is one)	Stone/brick, mud, rice husk, chimney, 6 in x 6 in cast iron grate, wood box cover
Fuel	Wood, twigs, dry leaves, dung cakes	Wood, twigs, dry leaves, dung cakes, coconut husk, arecanut husk
Comfort	Types A, B, C, are smokey only type D emits less smoke	Totally smokeless; easy to light, easy to maintain fire (by fanning through ash removing space)
Cost	Cost is due to bricks/stone chimney (if there is one) and labour	Same as traditional ones except grate, chimney (if it is not there), wood box cover
Efficiency	10-22%	40%
Fuel saving	—	Over 60%
Time for heating	About 60 min to make 50 lit. of water ready for bath	Only 25 min. to make 50 lit. of water ready for bath
Cooling rate	About 2° per hour (initial temp. 60° C)	Less than 1° (initial temp. 60° C)
Fire hazard	High	Nil

Table 3, shows the advantages of the new bath room stove. More than 60% of fuel can be saved in the villages. More than this, any kind of fuel can now be burnt efficiently. In Unchagi and other villages where the stoves are now in use, mainly agricultural residues such as coconut tree products are burnt without smoke and with higher efficiency.

5. Concluding Remarks

The new bath room stove (Bachhala Ole) has been constructed at Unchagi in more than 10 houses. It has also spread to over 10 villages of Uttara Kannada. Any kind of fuel except rice husk and saw dust can be burnt efficiently. Fuel efficiency is 40% and saving in fuel is over 60% compared to conventional bath room stoves. Efforts are needed to propagate this stove through a training programme for its construction.

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