knowledge of the Earth, its bounty and need to properly manage its resources while preserving the sanctity of its environment are among the important issues which should be suitably introduced.

As the knowledge and expertise of geosciences need to be utilized for sustainable and eco-friendly development of the country and gainful employment generation, it is essential that during educational career itself the students are exposed to different requirements of related industries and user agencies.

The awareness of Earth Sciences and the consequences of their neglect must spread to a broader base. Ways and means need to be devised to educate (i) general public, (ii) media, (iii) legislators and parliamentarians, (iv) industry managers, (v) bureaucrats, and (vi) voluntary agencies.

I have tried to briefly outline an approach which may be considered for the geoscientific education pattern in the coming decades. The bases for this are the requirements of (i) keeping in view the crucial coupling between litho–bio–hydro–atmosphere and space and bring in a holistic approach towards better understanding and management of natural resources, hazards and environment, (ii) developing far stronger links between education and needs of the society, industry and user agencies, and (iii) making both public and decision makers aware of the crucial role of geosciences in the socio-economic growth of our country and need to support it.

For this, geoscientific education and awareness has to begin right from the school level. In case of specialized needs such as petroleum, groundwater, instrumentation and environment, certain focused technological courses on the pattern of IITs could be considered. The University curriculum needs to be made more flexible and dynamic, specially with regard to the optional courses. And it should put more stress on application of newer knowledge, and concepts to certain unique geological and geophysical characteristics of our Indian lithosphere.

It is strongly felt that in addition to the formal education, there is also an urgent need to enhance the perspective and information level of our planners, decision makers and general public about the geosciences and their application. Because of grossly inadequate appreciation of the potential of earth sciences hitherto prevailing over the past five decades of our independence, this socially most vital subject has not received the attention and support that it deserves. This neglect has already proved quite costly to the nation with respect to exploration and integrated management of our natural resources. The ever-increasing import bill of the fuel energy needs of the country, never-ending river water disputes, droughts and floods are some of the obvious results of this neglect. The protection of environment and mitigation of natural hazards are also among the essential ingredients for survival and growth.

Educational pattern for any forthcoming era has to be evolved based on the proper anticipation of the problems and demands likely to be posed by that era. We have to very quickly establish this phase-lead for education *vis-à-vis* the Society. Only that education can sustain or keep the Society and its individuals 'alive' in the very best sense of this word which adequately respond to their ever-changing problems and demands. If the Society and the individual are not able to achieve a positive growth against modern day competition and requirements, then that education pattern is not worth it and the Society may slowly decay.

Actually the approach presented above is not new. It was enunciated long long back very succinctly in this land through the immortal saying *vidyaya-amrut-a-shnute*. It means that only that 'learning' is worthy of being called 'vidya' which can keep us as individuals and society moving eternally on the path of progress. This indeed is the ageless formula to design an educational pattern.

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SCIENTIFIC CORRESPONDENCE

Citral: A cytotoxic principle isolated from the essential oil of *Cymbopogon citratus* against P388 leukaemia cells

Higher plants are reservoirs of various valuable secondary metabolites which can be exploited for different biological properties. During recent years many kinds of compounds of plant origin have shown antitumour activity. Taxol from *Taxus brevifolia*, vinblastine and vincristine from *Vinca rosea* and curcumol from *Curcuma aromatica* have been demonstrated to have promising anticancerous activity during clinical trials[1]. In the present investigation, the essential oil of *Cymbopogon citratus* and its isolated active principle have been tested for cytotoxicity against mouse P_{388} leukaemia cells. This plant has already shown promising insecticidal and antifungal activity against storage pests[2]. *Cymbopogon citratus* (*Andropogon citratus*) is known only in cultivated state. The Ayurveda describes this grass as pungent, bitter, sharp and hot. It is a medicinal plant used in fever, vomiting and rheumatism[3].

The leaves of *C. citratus* were collected from Medicinal Plant Garden, Banaras Hindu University. These were washed

Table 1. Physico-chemical properties of essential oil of *Cymbopogon citratus*

Parameter	*Cymbopogon citratus* oil
Colour	Pale yellow
Specific gravity	0.8875
Optical rotation	– 6.5 at 32°C
Refractive index	1.496 at 29°C
Acid number	7.84
Saponification value	98.76
Ester value	90.92
Carbonyl percentage	56.296
Phenolic content	Nil

with distilled water and were subjected to hydrodistillation in Clevenger's apparatus. The volatile fraction containing the pale yellow essential oil was extracted. The essential oil was standardized by gas liquid chromatography and by different physico-chemical properties, viz. specific gravity, acid number, optical rotation, refractive index, saponification value, ester value, carbonyl percentage and phenolic contents (Table 1) following Guenther[4].

The crude essential oil was subjected to TLC in different gradients of *n*-hexane and ethyl acetate. The oil was further subjected to column chromatography (in a silica gel column) with *n*-hexane-ethyl-acetate (48:2, 9:1 and 8:1). In the gradient system 9:1, a light yellow oily fraction with lemon odour was eluted as a major fraction. The elute was completely evaporated of the solvents. During TLC only one peak was observed in the isolated fraction. This fraction was then subjected to ^{1}H and ^{13}NMR studies using Bruker AM-400 instrument with chemical shifts reported in ppm and measured with $CDCl_3$. The NMR study indicated this fraction to be citral(3,7-dimethyl-2-6-octadienal, molecular formula $C_{10}H_{16}O$) having a mixture of two geometric isomers – geranial and neral (7.5:2.5) with the following configuration (Figures 1 *a*, *b*). The cytotoxicity of citral was tested by the MTT [3-(4,5-dimethyl thiazol-2yl) 2,5-diphenyl tetrazolium bromide] colorimetric assay on a 96-well plate following Morita *et al.*[5]. P_{388} cells, supplied by Dr S. Tsukagoshi of the Japan Foundation for Cancer Research, were maintained in RPMI-1640 medium (Nissui Pharm Co.) supplemented with 5% fetal calf serum (Mitsubishi Chemical Industry Co.) and kanamycin (100 µg/ml). The cells (3×10^3 cells/well) were cultured in Corning disposable 96 well plate containing 100 µg/ml of growth medium per well and were incubated at 37°C in a humidified atmosphere of 5% CO_2. Citral (10 µl) was added to the cultures at day 1 after the transplantation. At day 3, 20 µl MTT solution (5 mg/ml) per well was added to each cultured medium. After a further 4 h of incubation, 100 ml of 10% SDS-0.01 N HCl solution was added to each well and the formazan crystals in each well were dissolved by stirring with a pipette. The optical density was measured by using a microplate reader (Tohso MPR-A4i) with a two-wavelength system (550 and 700 mm). In all these experiments, 3 replicate wells were used to determine each point. The cytotoxic potency was observed in the form of IC_{50} value (µg/ml), which was defined as the concentration of sample that achieved 50% reduction of viable P_{388} mouse leukaemia cells (Figure 2).

The gas liquid chromatography of the cymbopogon oil indicated it to be a mixture of two major components. Its physico-chemical properties (Table 1) indicate absence of phenol in it and its having high saponification and ester values. The IC_{50} value of citral, the active

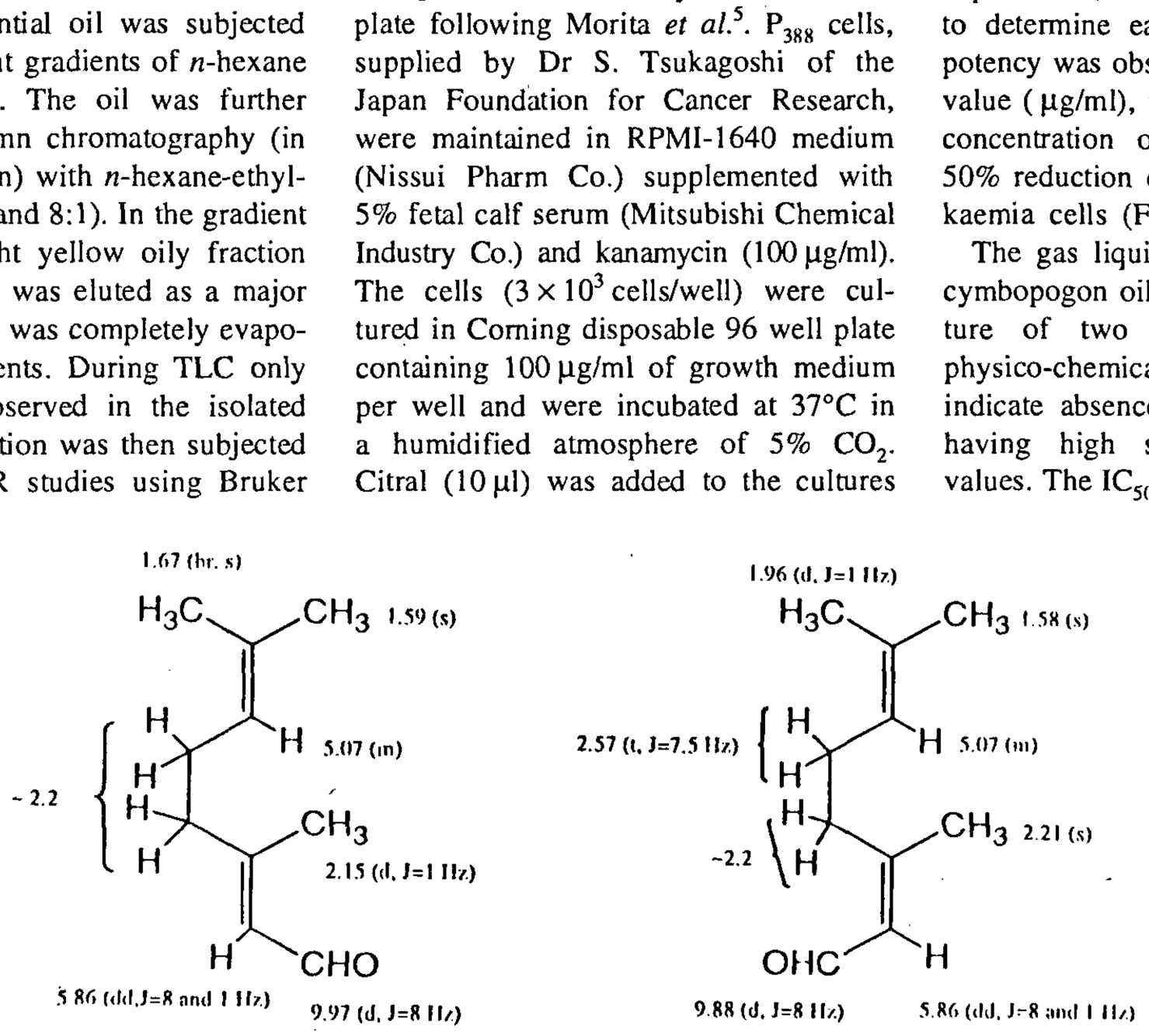

Figure 1 *a*. ^{1}H NMR signal assignments in citral.

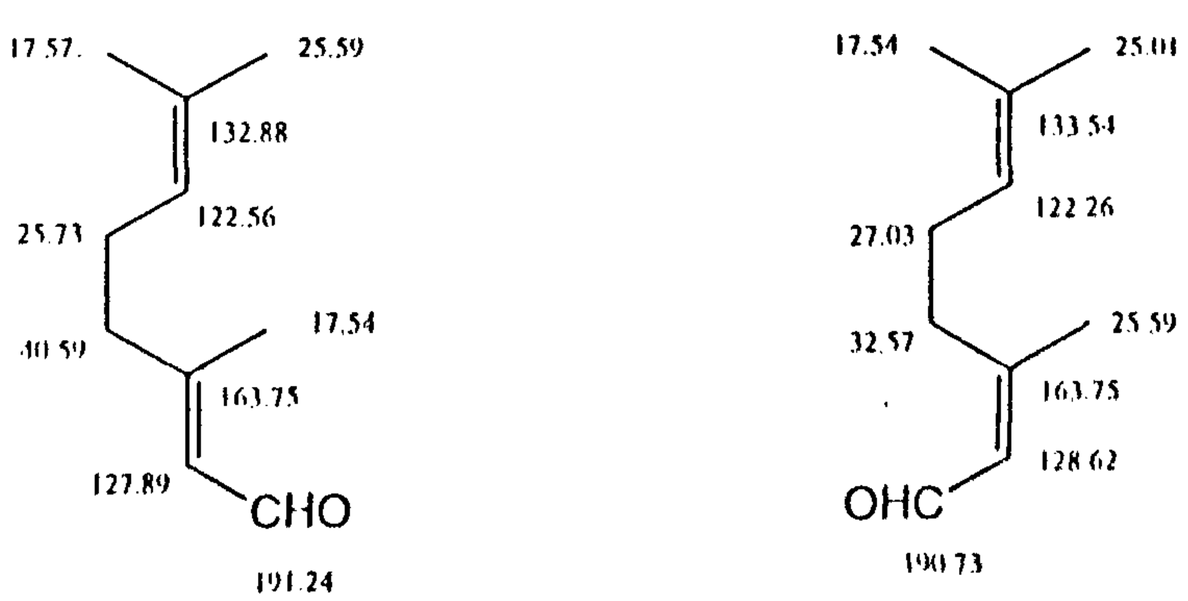

Figure 1 *b*. ^{13}C NMR signal assignments in citral.

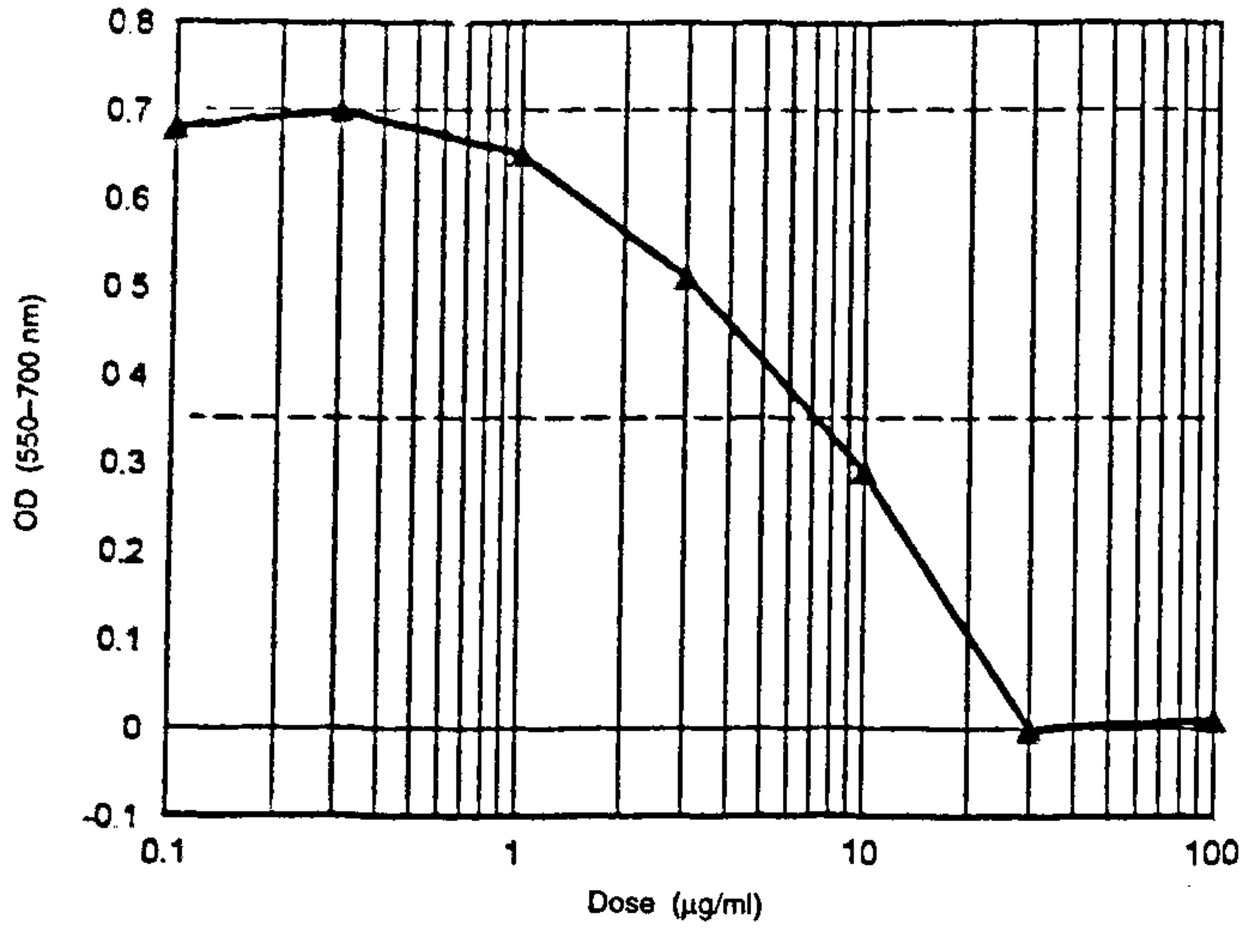

Figure 2. Cytotoxic activity of citral against P_{388} cell line by means of MTT assay method.

principle of cymbopogon oil, against P_{388} mouse leukaemia cells was 7.1 µg/ml.

This is the first report on cytotoxicity of citral against P_{388} mouse leukaemia cells. It is one of the major constituents of several aromatic plants, particularly of the family Lamiaceae. Its earlier recorded biological properties as a fungicide, insecticide and its cytotoxic potency against P_{388} cells indicate the possibility of its exploitation as a pesticidal and chemotherapeutic agent. More research through clinical trials is warranted to find out its antitumour promotion effects.

1. Itokawa Hideji and Takeya Koic *cycles*, 1993, **35**, 1467–1501.
2. Mishra, A. K. and Dubey, N. *Environ. Microbiol.*, 1994, **60**,
3. Kirtikar, K. R. and Basu, B. *Medicinal Plants*, M/S Bisan Sir dra Pal Singh, Dehradun, India, iv.
4. Guenther, E. (ed.), *The Esse* Robert E Krieger Publishing ington, New York, 1972, vol. 1,
5. Morita, H., Kayashita, T., Shim Takeya, K. and Itokawa, H., *J.* 1996, **59**, 280–282.

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MEETINGS/SYMPOSIA/SEMINARS

8th ISMAS Workshop on Mass Spectrometry

Date: 4–9 August 1997
Place: Mumbai

Topics include: Fundamental aspects and applications of mass spectrometry; Inductively coupled plasma source mass spectrometry (ICP–MS); Glow discharge mass spectrometry (GDMS); Laser-based mass spectrometry (RIMS, MALDI, etc.); Accelerator-based mass spectrometry (AMS); Liquid chromatography–mass spectrometry (LC–MS); Electrospray mass spectrometry (ES–MS); Tandem and hybrid mass spectrometry (MS–MS); Mass spectrometry in nuclear, geological, biological, environmental and forensic sciences; Mass spectrometry in industry (petroleum, textile, agriculture, pharmaceutical, etc.); Quantitative analysis in inorganic and organic mass spectrometry; Other topics (TIMS, SSMS, SIMS, KCMS, EGA, etc.).

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Silver Jubilee Conference on Trends and Tech Transportation (TETRA 97)

Date: 23–25 August 1997
Place: Warangal

Themes include: Transportation planning, Transportati management, Infrastructure development and Private pa in transport sector.

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