# ICV 5

# ANTIMICROBIAL ACTIVITY AND PHYTOCHEMICALS FROM VETIVER *Chrysopogon zizanioides*

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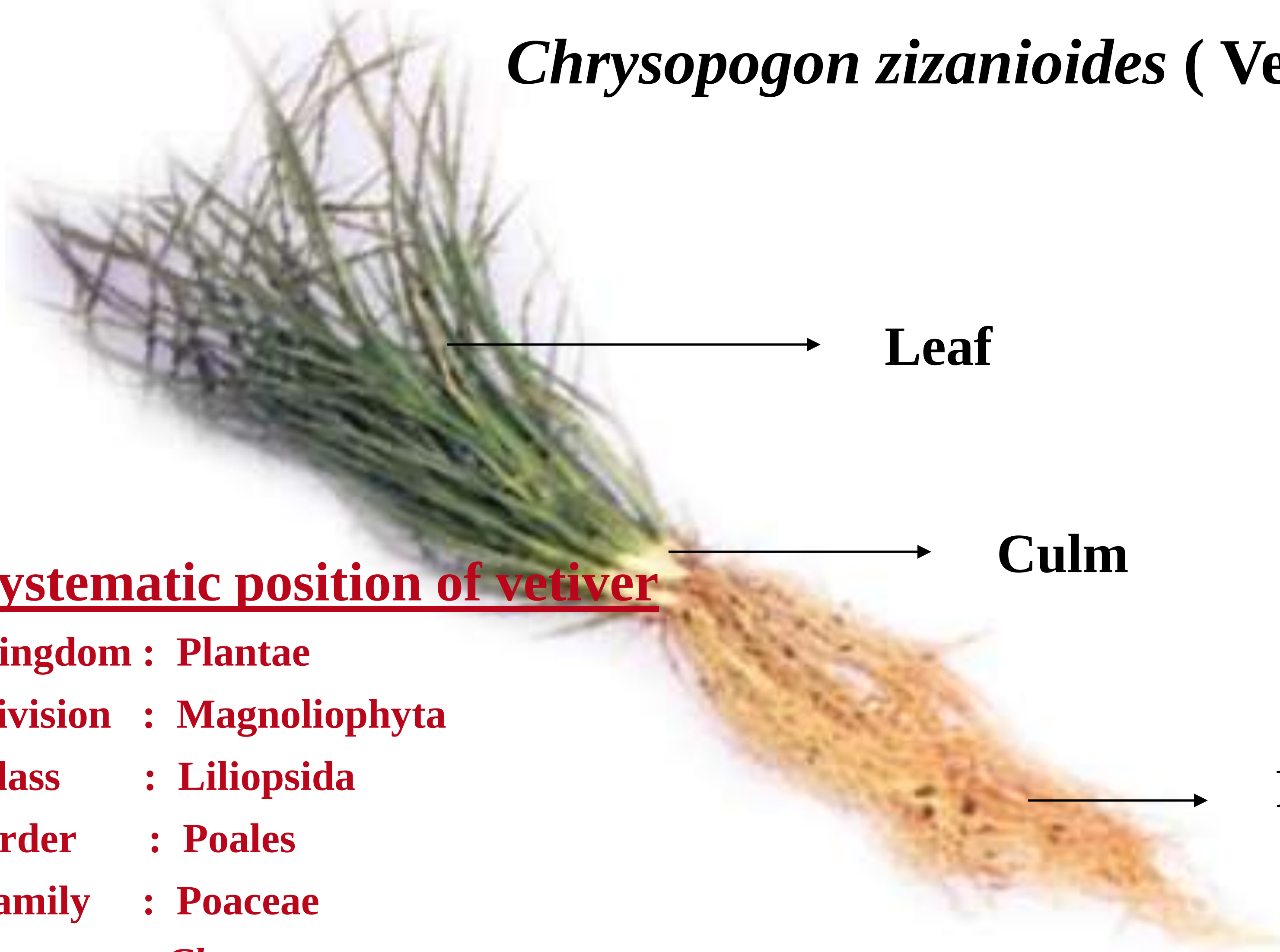
# *Chrysopogon zizanioides* ( Vetiver)




## Systematic position of vetiver

**Kingdom : Plantae**

**Division : Magnoliophyta**

**Class : Liliopsida**

**Order : Poales**

**Family : Poaceae**

**Genus : *Chrysopogon***

**Species : *zizanioides***

**Binomial name : *Chrysopogon zizanioides* (L.) Roberty**

# *Chrysopogon zizanioides*

**VETIVER IS A NATIVE GRASS OF INDIA, HAS TRADITIONALLY BEEN IN USE FOR DECADES.**

- ***Vetiveria zizanioides* - Old name**
- **Common name vetiver**
- **Flowering and non-flowering**
- **Perennial grass - thick fibrous, adventitious roots**
- **Aromatic**
- **Partial hydrophyte & Xerophyte**
- **With stands pH 4 to pH 9**
- **Temperature – 9 °C to 45°C**
- **Does not encroach farmland**

# COLLECTION OF THE PLANT

## Foot hill of Maruthamalai, CBE.

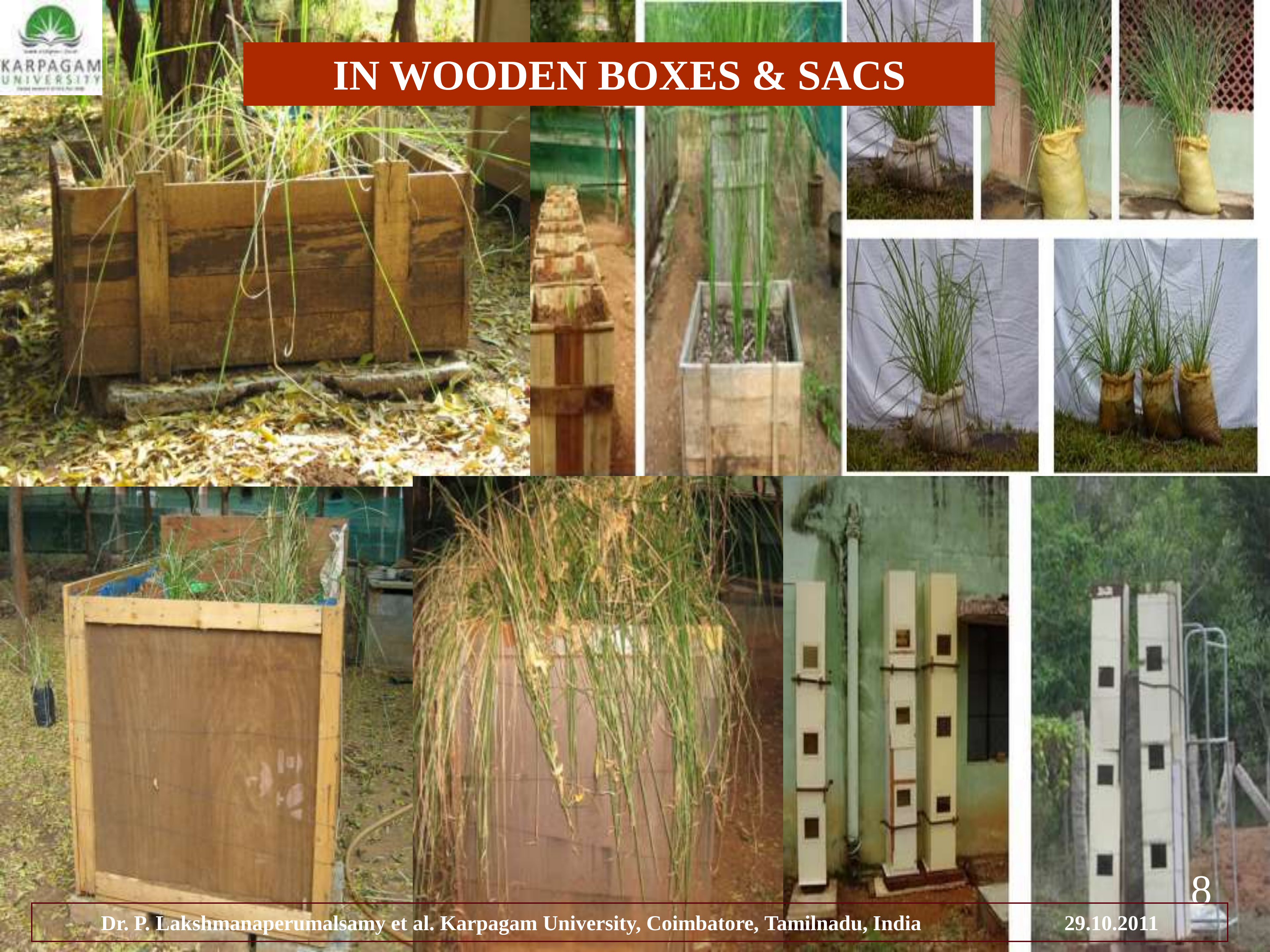
# The objective of the study

- ✓ Biomass production - using
  - Vermicompost (VC)
  - Coir pith (CP)
  - Cow dung (CD)
  - Bio inoculants
  - Soil types

- ✓ Screening for the bioactive compounds
- ✓ Phytoremediation (contaminated water and soil)
- ✓ Evaluating the economic potential of vetiver

# PROPAGATION OF VETIVER CULMS IN THE LAB

# IN WOODEN BOXES & SACS



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# Propagated in the Department garden.

# Lab study – in the experimental tank

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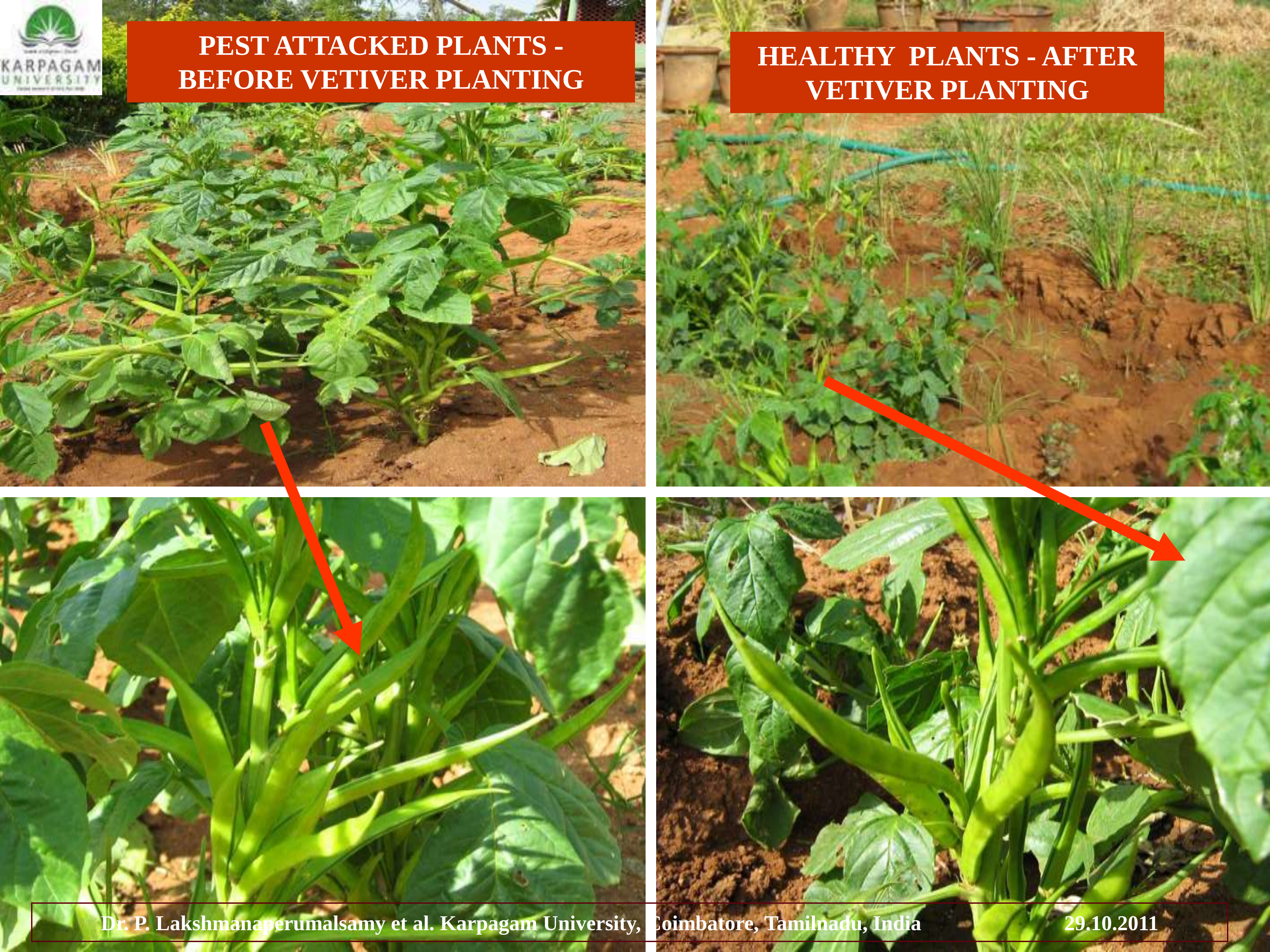
# VETIVER TO CONTROL SOIL EROSION IN THE UNIVERSITY CAMPUS

# SLOPE STABILIZATION

# SLOPE STABILIZATION IN THE CAMPUS

# Vetiver as an intervening crop as a pest control – in the Department of Environmental Sciences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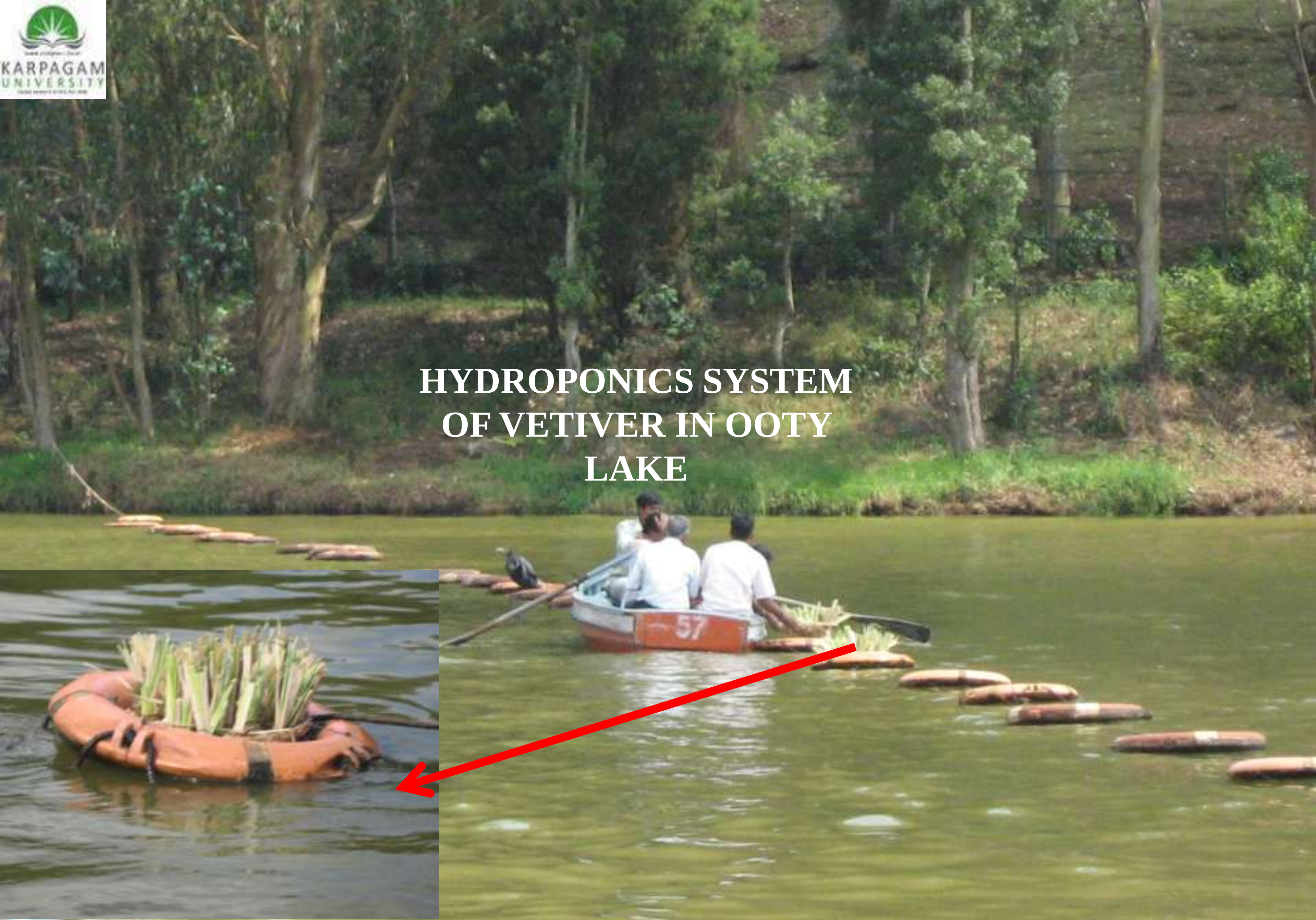
PEST ATTACKED PLANTS - BEFORE VETIVER PLANTING
HEALTHY PLANTS - AFTER VETIVER PLANTING

# HYDROPONICS SYSTEM OF VETIVER IN OOTY LAKE



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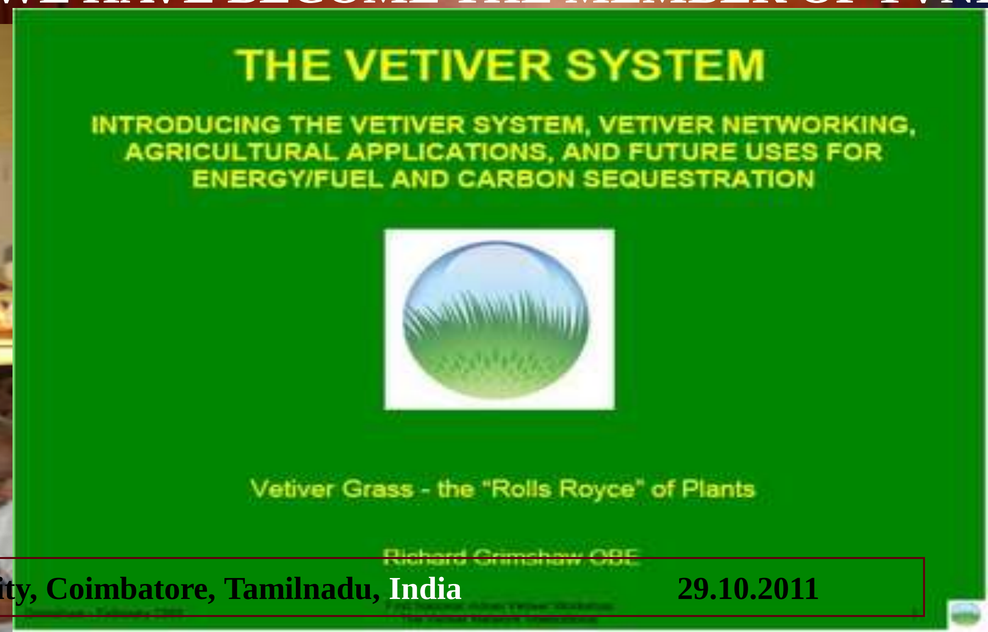
# VETIVER FOR MUNICIPAL WASTEWATER TREATMENT



# WORK SHOP ON VETIVER - 19.06.2008


# BOOK RELEASE ON VETIVER


**WE HAVE BECOME THE MEMBER OF TVNI**



**THE RESEARCH WORK WAS PUBLISHED IN THE FARMER'S MAGAZINE WHICH IS ABOUT THE GROWTH OF 8 Ft VETIVER PLANT**

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# ECONOMIC USES OF

# *C.zizanioides*

- ✓BIOETHANOL PRODUCTION
- ✓ MUSHROOM CULTIVATION
- ✓ ANTI TERMITE PROPERTY

# MUSHROOM CULTIVATION

- ❖**Mushroom production (Chomchalow, 2003).**
- ❖***Pleurotus sp*** **– chosen for the study.**
- ❖**Third largest cultivated mushroom in the world and contribute 16.3 % of the total world mushroom production.**
- ❖ **Paddy straw – largest used cereal straw for the cultivation of Oyster mushroom, next to that are wheat straw, maize straw, sorgam straw etc.**

**Since vetiver leaves can be used as an alternate substrate for mushroom culturing the work has been carried out.**

# ANTITERMITE PROPERTY


- Plants produce many natural compounds that are repellent to many insects

Earlier reports showed that vetiver oil has been tested to control termites but no study has been carried out to test the vetiver roots and leaf powder on tunneling activity, wood consumption and termite mortality.

Control

Container with vettiver root powder

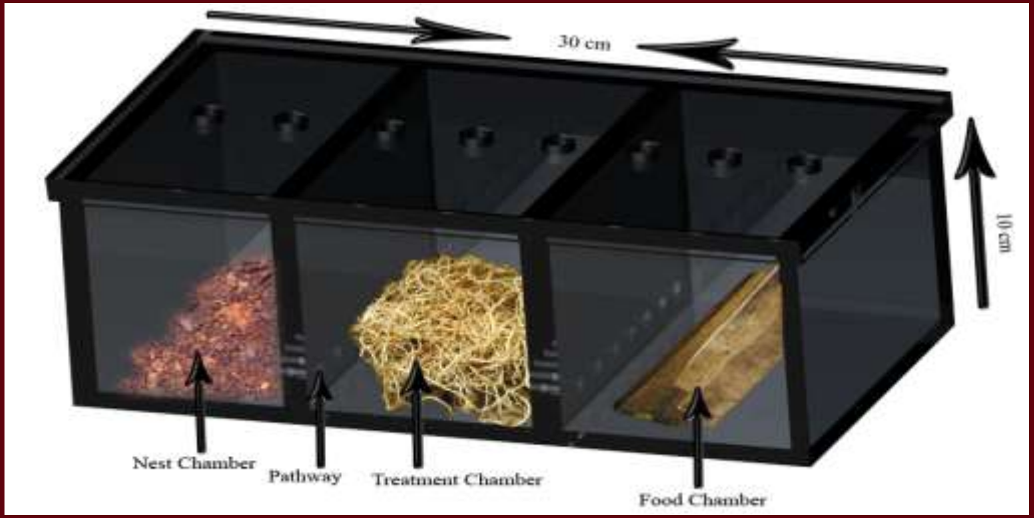
Container with vettiver leaf powder

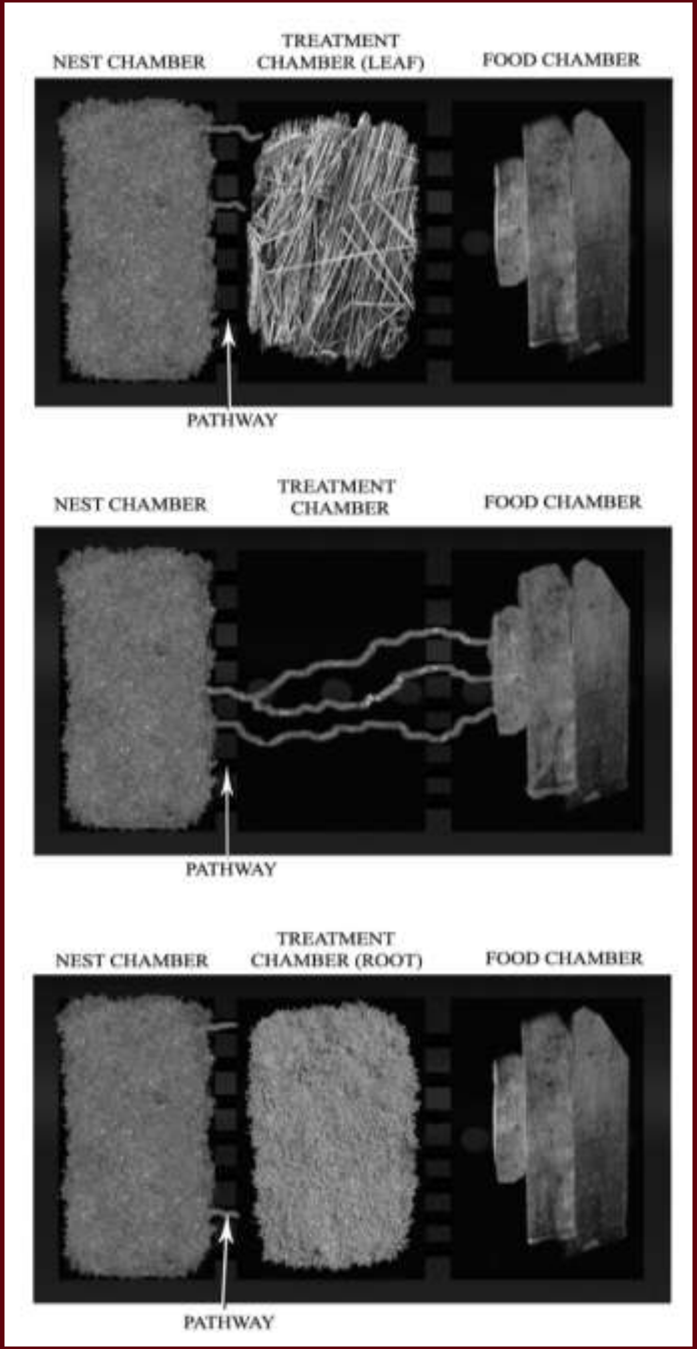
# Experimental containers 30cm x 10cm x 10cm size –with 3 compartments.

**Chamber 1 - Nest chamber (N) - Sieved soil + 100 termites (Queens, workers & Soldiers)**

**Chamber 2 – Treatment Chamber (S)**

**Chamber 3 - Food Chamber (F) – Wood pieces of Ravi tree**



**The study indicated that the tunneling and consumption of food by the termites was more in control sets, whereas the mortality rate was more in the container with vetiver root powder (VR). Similar observations were made earlier (Maistrello *et al*., 2000; Maistrello *et al*., 2001; Zhu *et al*., 2001a, 2001b, Maistrello *et al*., 2002; Nix *et al*., 2003; Ibrahim *et al*., 2004).**

# PHYTOREMEDIATION

Phytoremediation is an emerging technology which uses plants and their associated rhizosphere microorganisms to remove, degrade, or contain chemical contaminants located in the soil, sediments, groundwater, surface water, and even the atmosphere.

PHYTOREMEDIATION

WATER

SOIL

# MUNICIPAL WASTEWATER TREATMENT




**S1 – Control (Tap water + Vetiver)**

**S2 – Municipal waste water + Vetiver**

**S3 – Diluted Municipal water 1:1 + Vetiver**

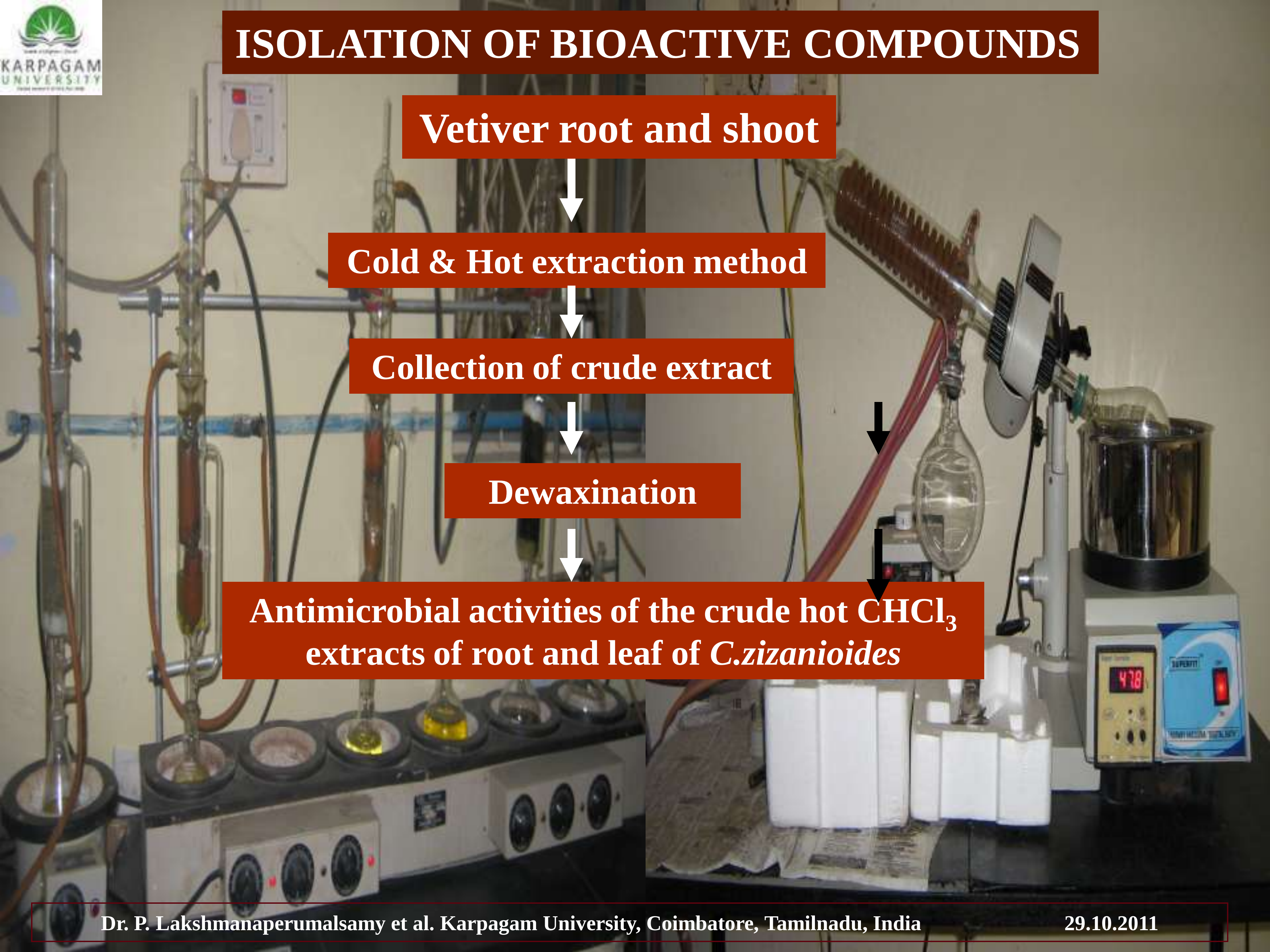
# The objective of the study

Antibacterial activity

Screening for the bioactive compounds

Phytochemicals

# ISOLATION OF BIOACTIVE COMPOUNDS



Vetiver root and shoot

↓

Cold & Hot extraction method

↓

Collection of crude extract

↓

Dewaxination

↓

Antimicrobial activities of the crude hot $CHCl_3$ extracts of root and leaf of *C.zizanioides*

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# Yield % of crude cold and hot extracts of root and leaf

| Sample | | Cold | | | | Hot | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Hexane | $CHCl_3$ | Ethanol | Water | Hexane | $CHCl_3$ | Ethanol | Water |
| E1 | Root | 1.18 | 2.28 | 1.60 | 1.16 | 3.2 | 7.08 | 3.6 | 3.4 |
| | Leaf | 0.76 | 1.80 | 1.52 | 1.40 | 2.1 | 7.04 | 4.7 | 4.5 |
| E2 | Root | 1.01 | 1.17 | 1.24 | 0.98 | 1.89 | 3.20 | 1.29 | 1.27 |
| | Leaf | 0.34 | 1.08 | 1.34 | 1.21 | 0.76 | 2.89 | 1.9 | 2.2 |
| E3 | Root | 1.08 | 2.07 | 1.49 | 0.78 | 2.7 | 5.28 | 3.2 | 3.1 |
| | Leaf | 0.70 | 1.71 | 1.38 | 0.99 | 2.2 | 5.19 | 3.1 | 3.3 |

# The wax content of roots and leaves of *C.zizanioides*

| Sample | | Wax from cold extract (g) | | | | Wax from hot extract (g) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Hexane | $CHCl_3$ | Ethanol | Water | Hexane | $CHCl_3$ | Ethanol | Water |
| E1 | Root | 0.18 | 0.29 | 0.11 | 0.06 | 0.23 | 0.35 | 0.18 | 0.12 |
| | Leaf | 0.83 | 1.10 | 0.68 | 0.11 | 0.98 | 1.37 | 0.75 | 0.22 |
| E2 | Root | 0.23 | 0.31 | 0.22 | 0.20 | 0.68 | 0.78 | 0.52 | 0.58 |
| | Leaf | 0.80 | 0.9 | 0.5 | 0.4 | 0.93 | 1.48 | 0.67 | 0.62 |
| E3 | Root | 0.28 | 0.46 | 0.36 | 0.29 | 0.72 | 0.78 | 0.56 | 0.65 |
| | Leaf | 0.82 | 0.98 | 0.62 | 0.53 | 0.97 | 1.58 | 0.68 | 0.78 |

E1- Grown in Soil , E2 – Grown in Water, E3- Grown in waste water

# Phytochemicals

| S.No | Name | Root | Leaf |
|---|---|---|---|
| 1 | Saponins | + | + |
| 2 | Tannins | - | - |
| 3 | Triterpenes | + | - |
| 4 | Steroids | + | - |
| 5 | Flavanoids | + | + |
| 6 | Rotenoids | - | + |
| 7 | Phenols | + | + |

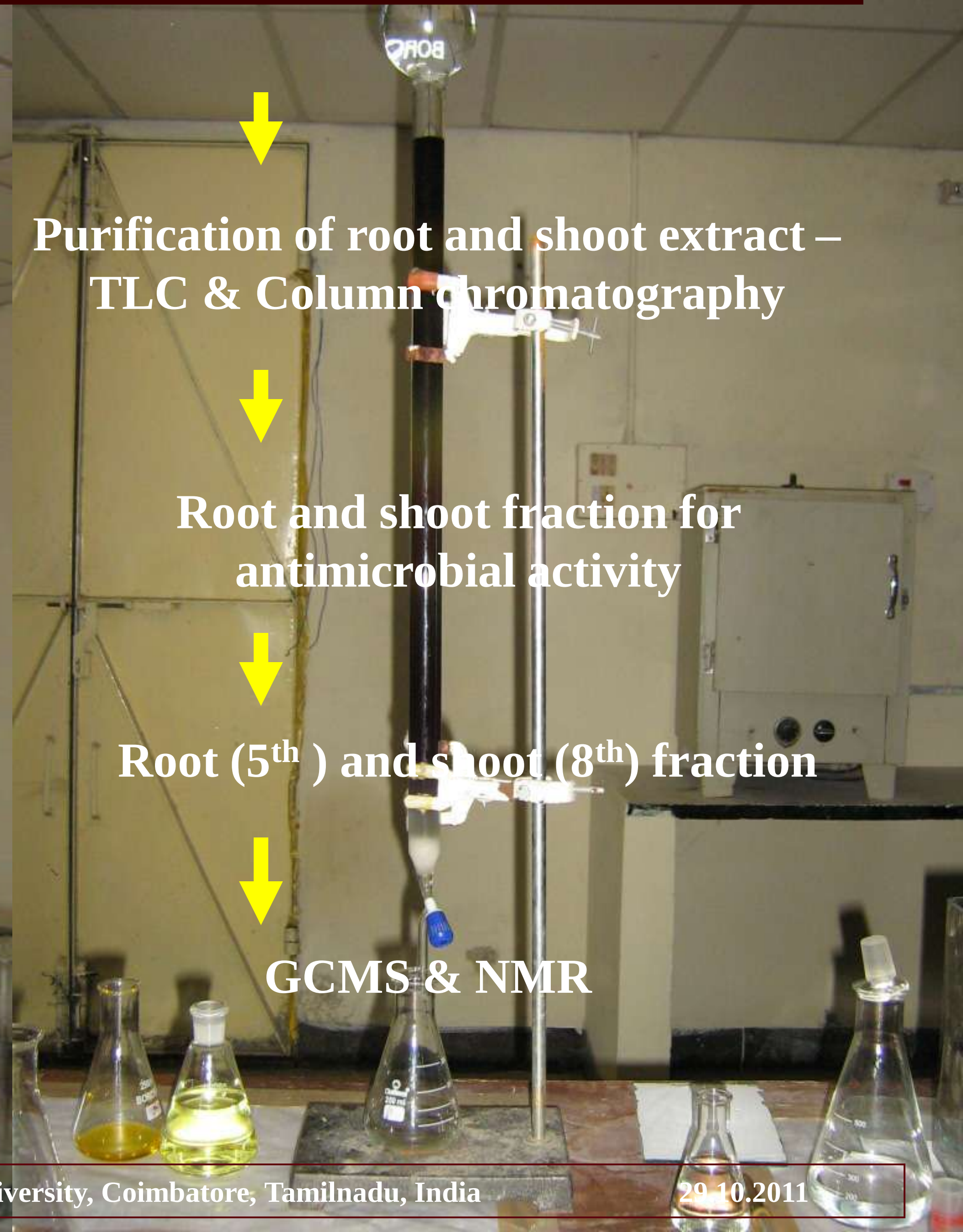
# Test Microorganisms

| **Bacteria** | **Fungi** |
| --- | --- |
| *Escherichia coli* | *Candida albicans* |
| *Salmonella typhi* | *Cryptococcus neoformens* |
| *Klebseilla pneumoniae* | |
| *Vibrio cholerae* | |
| *Pseudomonas aeruginosa* | |
| *Staphylococcus aureus* | |
| *Streptococcus fecalis* | |
| *Enterococcus fecalis* | |

# Antimicrobial activity

| Bacteria/ Fungi | +ve cont | -ve cont | E1 | | E2 | | E3 | |
|---|---|---|---|---|---|---|---|---|
| | | | Root | Leaf | Root | Leaf | Root | Leaf |
| | Zone of inhibition in mm | | | | | | | |
| *E.coli* | 25 | 9 | 20 | 18 | 12 | 10 | 16 | 15 |
| *K.pneumoniae* | 24 | 10 | 21 | 17 | 11 | 12 | 20 | 12 |
| *S. typhi* | 22 | 11 | 21 | 13 | 11 | 10 | 17 | 12 |
| *S. aureus* | 22 | 9 | 24 | 24 | 14 | 16 | 22 | 18 |
| *V.cholerae* | 20 | NI | 5 | NI | 3 | NI | 4 | NI |
| *S.faecalis* | 25 | 12 | 21 | 19 | 11 | 12 | 19 | 15 |
| *P.aeruginosa* | 26 | 11 | 25 | 15 | 12 | 11 | 22 | 13 |
| *E. faecalis* | 28 | 10 | 21 | 14 | 16 | 12 | 18 | 12 |
| *C. albicans* | 25 | 12 | 28 | 25.5 | 13 | 10 | 20 | 17 |
| *C.neoformens* | 23 | 13 | 22 | 20 | 10 | 8 | 18 | 16 |

# TEST FOR ANTIMICROBIAL ACTIVITY



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**Purification of root and shoot extract – TLC & Column chromatography**

↓

**Root and shoot fraction for antimicrobial activity**

↓

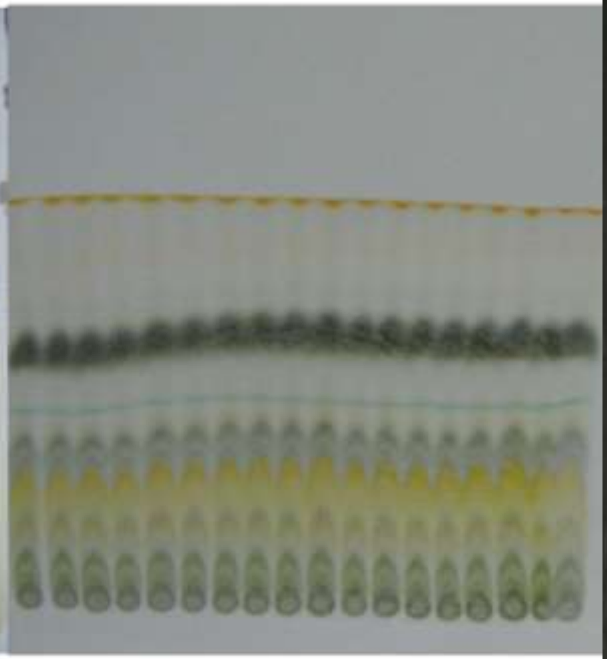
**Root ($5^{th}$ ) and shoot ($8^{th}$) fraction**

↓

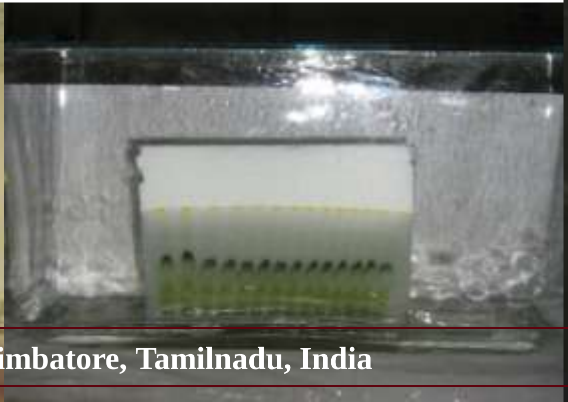
**GCMS & NMR**

# SEPARATION OF BIOACTIVE COMPOUNDS

TLC - Root extract



TLC - Leaf extract



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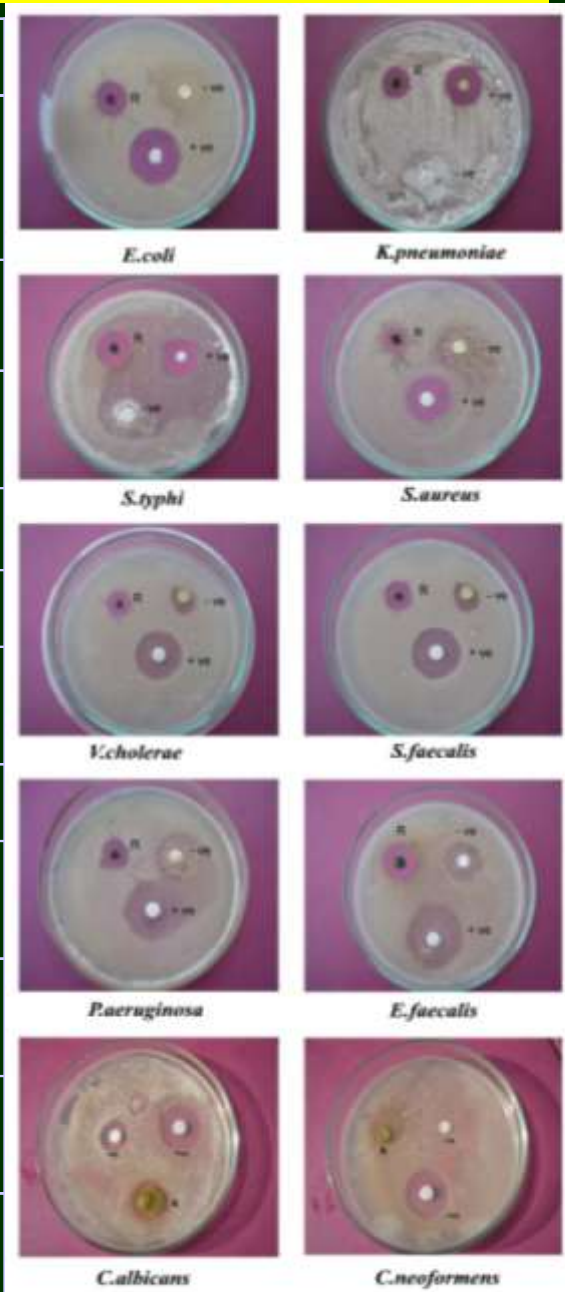
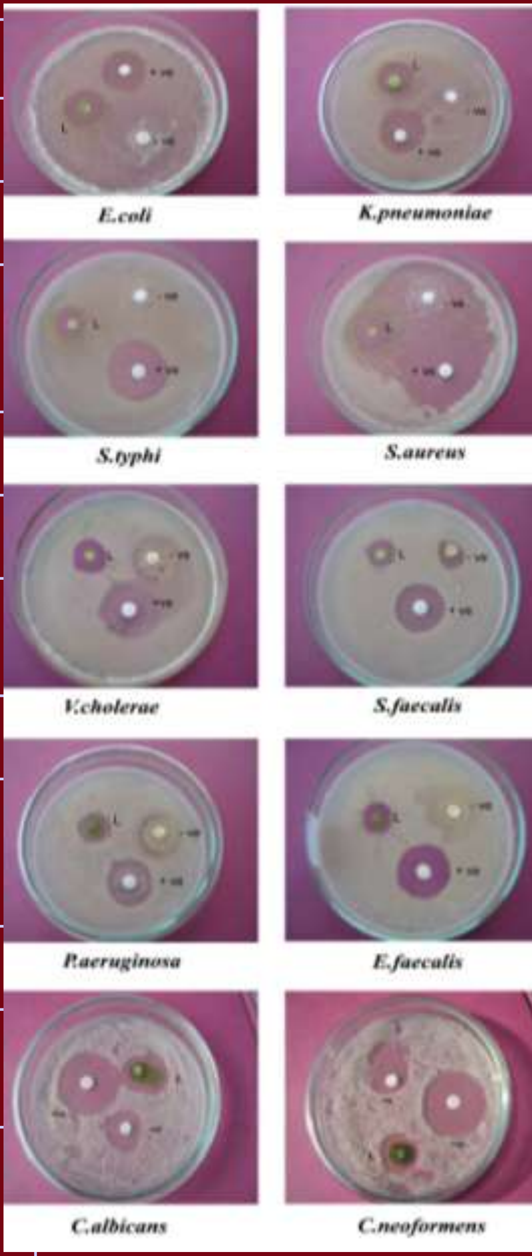
# Antimicrobial activity of purified root extracts of *C.zizanioides*

| Bacteria / Fungi | Average zone of inhibition (mm) | | | | | |
|---|---|---|---|---|---|---|
| | F 1 | F 2 | F 3 | F 4 | F 5 | F 6 |
| *E.coli* | 20 | 17 | 5 | 21 | 24 | 12 |
| *K.pneumoniae* | 16 | - | - | - | - | - |
| *S. typhi* | - | - | - | - | 13 | - |
| *S. aureus* | - | 15 | 15 | 30 | 30 | 18 |
| *V.cholerae* | - | - | - | - | - | - |
| *S.faecalis* | 17 | - | - | - | 18 | - |
| *P.aeruginosa* | - | - | - | 31 | 18 | - |
| *E. faecalis* | - | - | - | 25 | 16 | - |
| *C.albicans* | 15 | - | 15 | 33 | 33 | 19 |
| *C.neoformens* | 5 | 5 | 17 | 28 | 28 | 19 |



# Antimicrobial activities of purified leaf extracts of *C.zizanioides*

| Bacteria / Fungi | Average zone of inhibition (mm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | F 1 | F 2 | F 3 | F 4 | F 5 | F 6 | F 7 | F 8 |
| *E.coli* | 11 | 5 | 10 | 20 | 17 | 14 | 12 | 22 |
| *K.pneumoniae* | 13 | - | 10 | 21 | 20 | 13 | 12 | 13 |
| *S. typhi* | 24 | 7 | - | 12 | 21 | 12 | 11 | 16 |
| *S. aureus* | 15 | 12 | 8 | 13 | 22 | 14 | 22 | 18 |
| *V.cholerae* | - | - | - | - | - | - | - | - |
| *S.faecalis* | 20 | 13 | 7 | 17 | 18 | 15 | 19 | 19 |
| *P.aeruginosa* | 15 | 20 | 12 | 22 | 17 | 17 | 17 | 17 |
| *E. faecalis* | 17 | 20 | 15 | 23 | 18 | 21 | 18 | 18 |
| *C. albicans* | 20 | 27 | 17 | 24 | 33 | 22 | 23 | 34 |
| *C.neoformens* | 20 | 27 | 18 | 25 | 34 | 24 | 26 | 32 |



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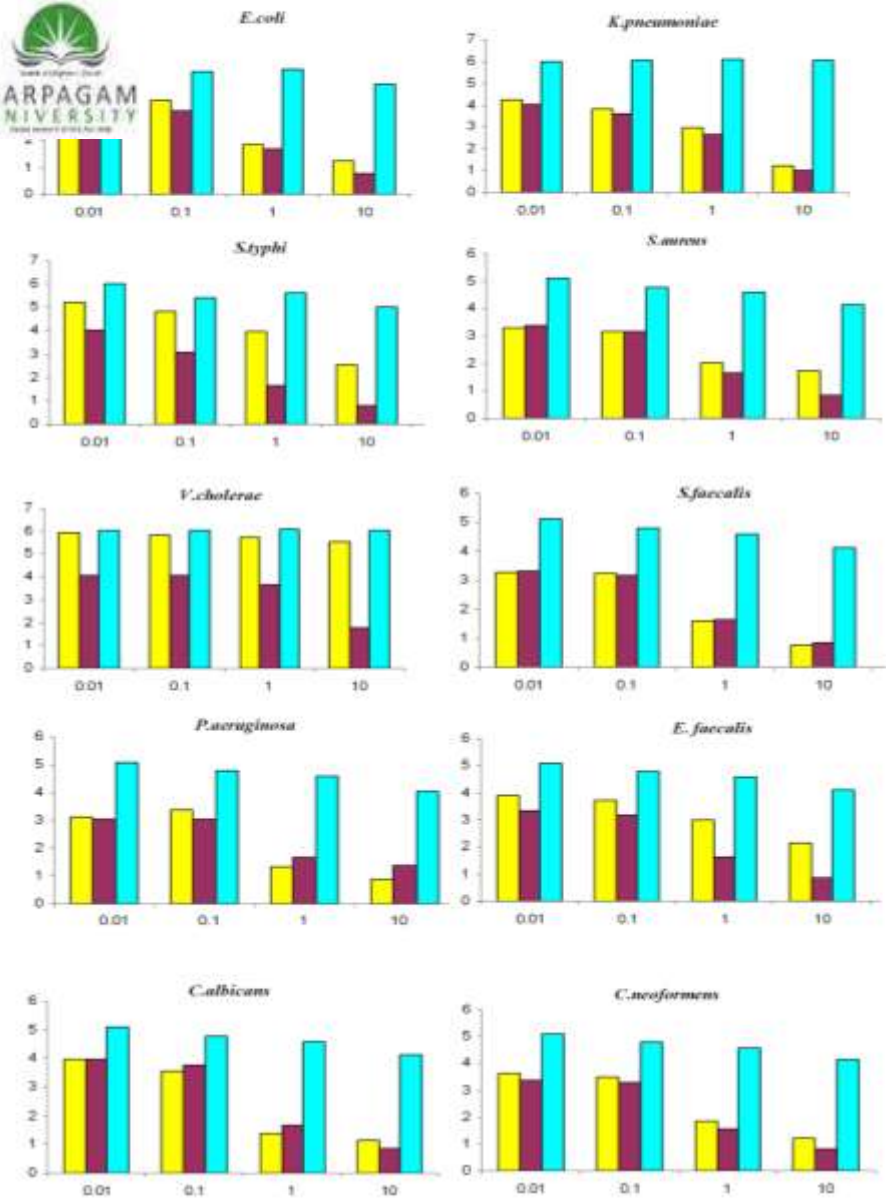
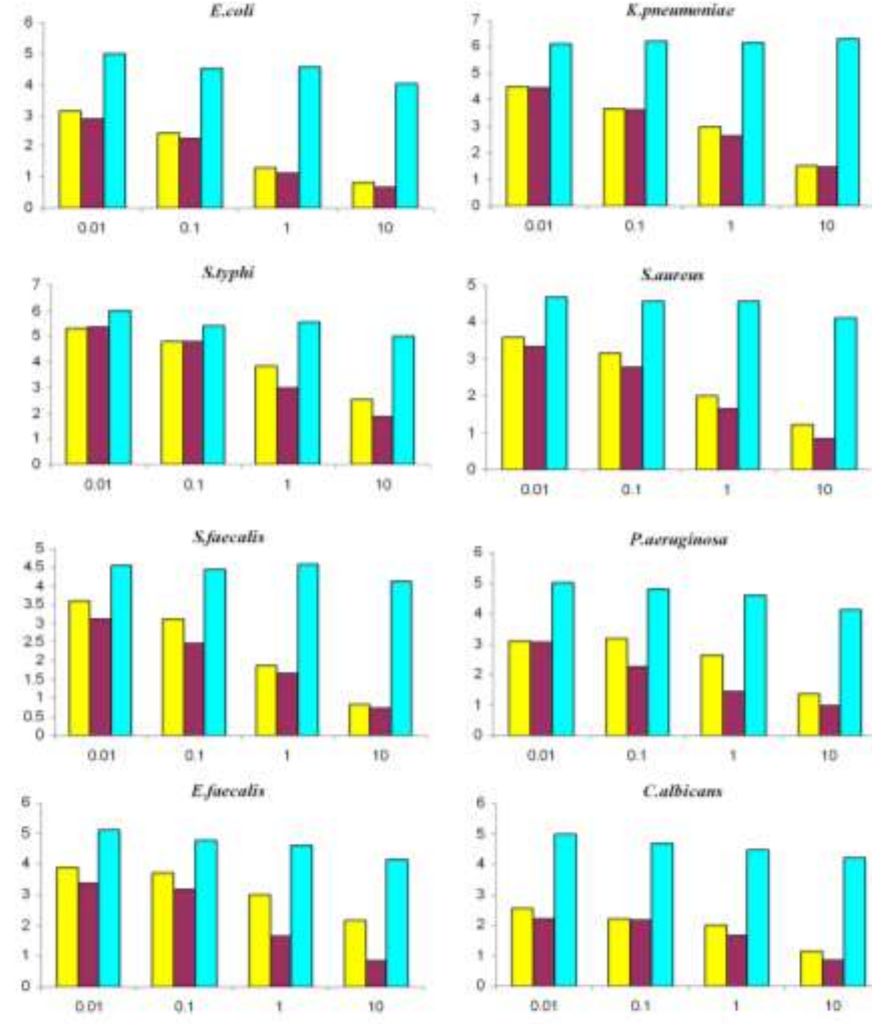


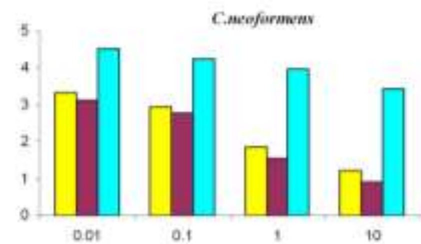

MIC of Root extract

Extract
+ ve Control
- ve Contrpl

X axis - Concentration in mg

Y axis - OD value at 655 nm




Extract
+ ve Control
- ve Control

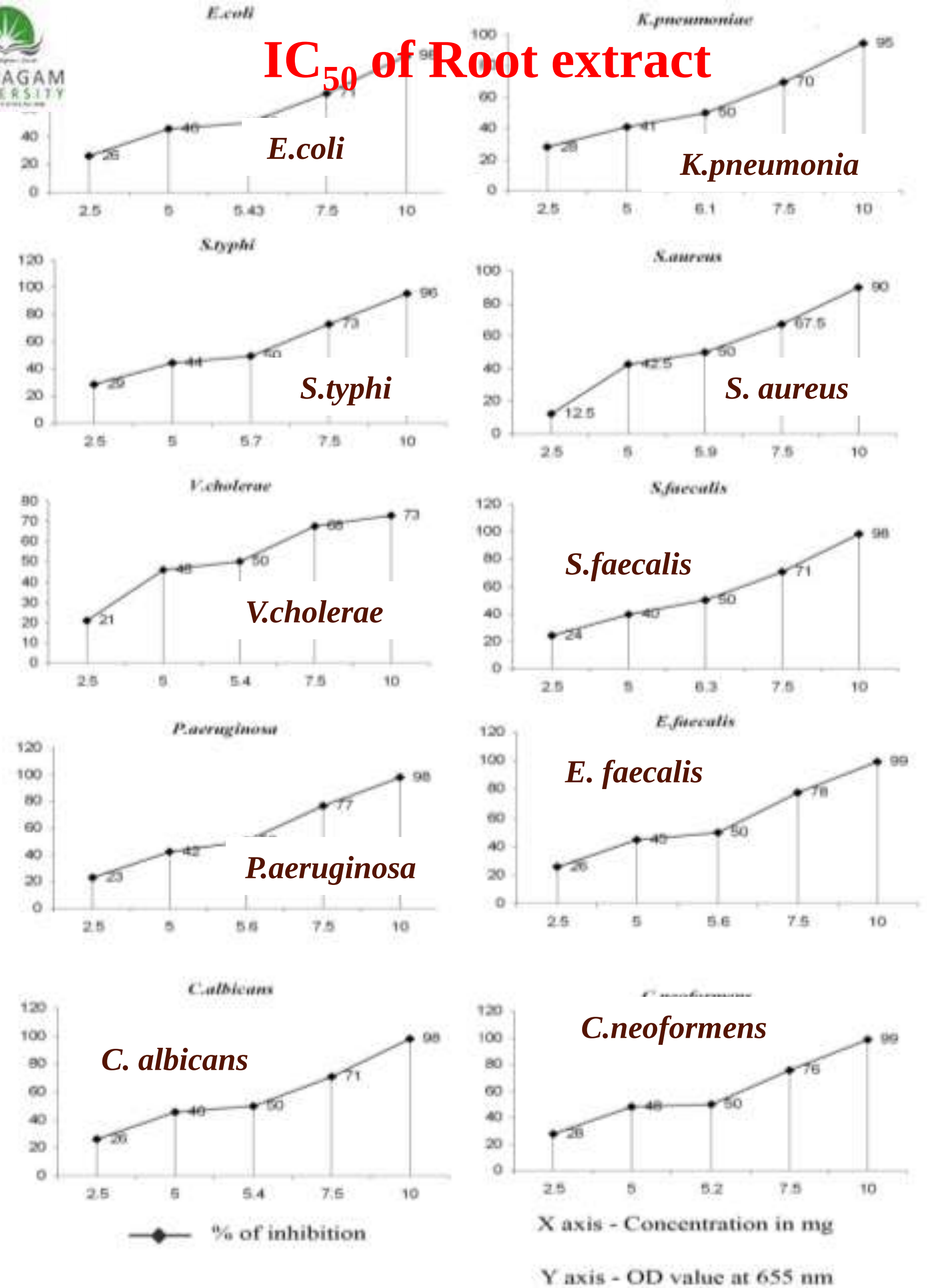
MIC of Leaf extracts

X axis - Concentration in mg

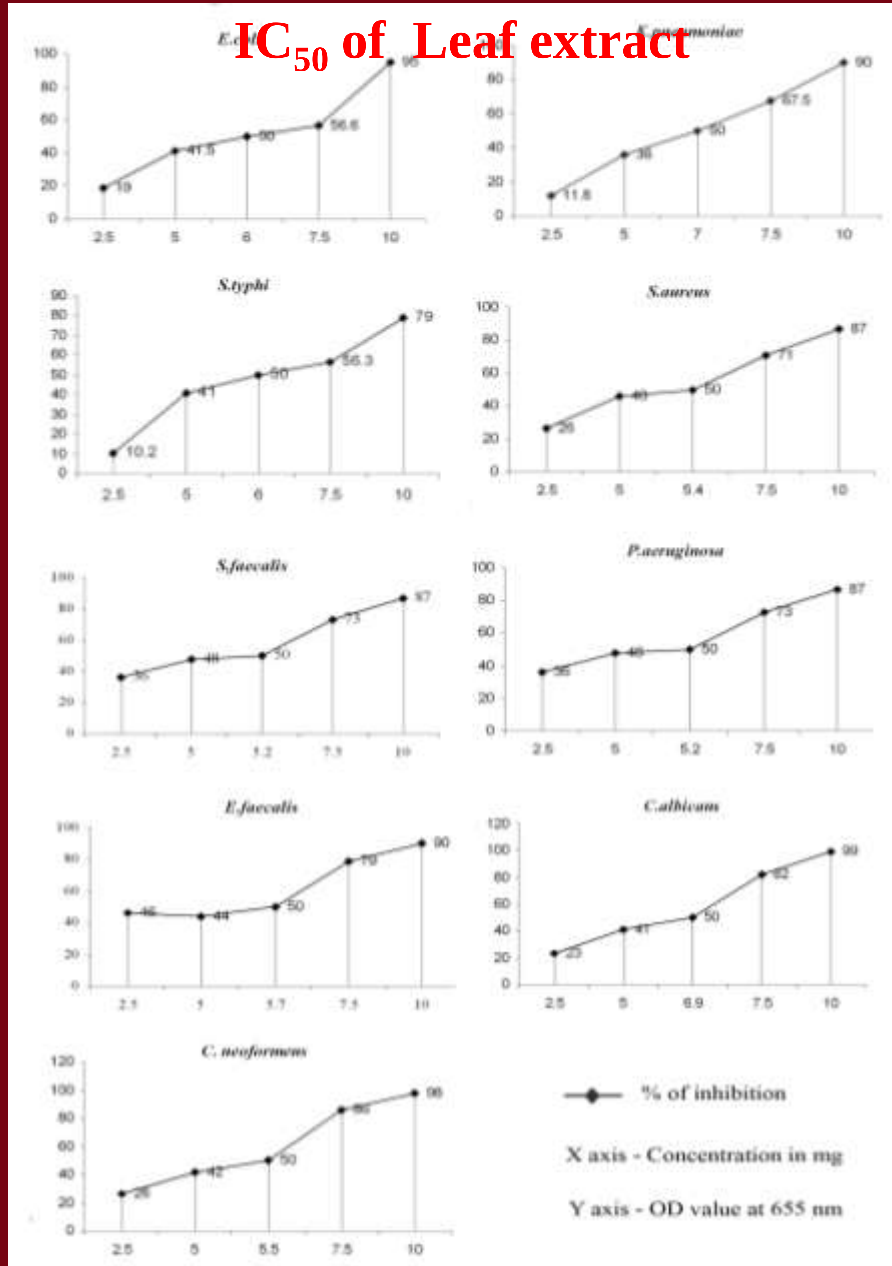
Y axis - OD value at 655 nm

**MIC was 10 mg / mL concentration of the extracts**

## $IC_{50}$ of Root extract




## $IC_{50}$ of Leaf extract



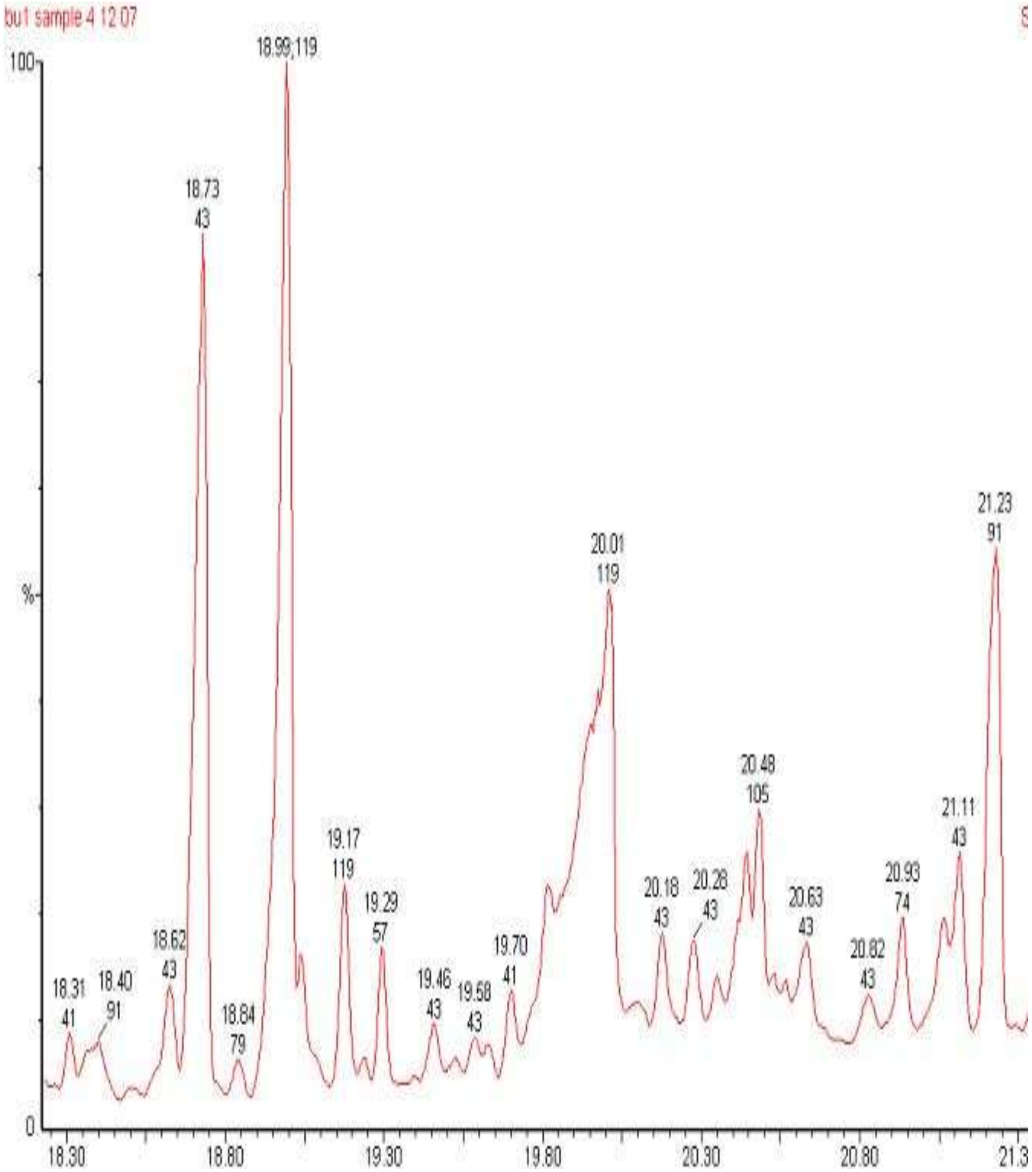

**$IC_{50}$ was 5 mg / mL to 7.5 mg / mL concentration of the extracts**

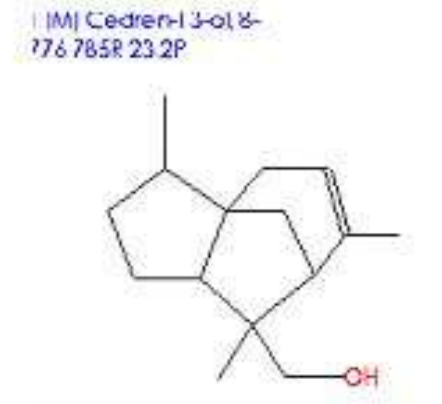
| | Compound | Retention time | %peak area |
|---|---|---|---|
| | 3-Isopropyltricyclo[4.3.1.1(2,5)]undec-3-en-10-ol Formula: $C_{14}H_{22}O$ MW: 206 | 13.06 | 0.126 |
| 2 | Tetradecane Formula: $C_{14}H_{30}$ MW: 198 | 13.19 | 0.886 |
| 3 | Vanillin Formula: $C_8H_8O_3$ MW: 152 | 13.28 | 0.274 |
| 4 | 7-Heptadecene, 17-chloro- Formula: $C_{17}H_{33}Cl$ MW: 272 | 14.43 | 0.147 |
| 5 | (+)-Ledene Formula: $C_{15}H_{24}$ MW: 204 | 14.87 | 0.305 |
| 6 | 7-Oxabicyclo[4.1.0]heptane, 2,2,6-trimethyl-1-(3-methyl-1,3-butadienyl)-5-methylene- Formula: $C_{15}H_{22}O$ MW: 218 | 15.31 | 0.372 |
| 7 | Hexadecane Formula: $C_{16}H_{34}$ MW: 226 | 16.41 | 2.859 |
| 8 | Ledene oxide-(II) Formula: $C_{15}H_{24}O$ MW: 220 | 17.96 | 6.505 |
| 9 | Aromadendrene oxide-(2) Formula: $C_{15}H_{24}O$ MW: 220 | 18.62 | 2.567 |
| 10 | **1-Cyclohexanone, 2-methyl-2-(3-methyl-2-oxobutyl) Formula: $C_{12}H_{20}O_2$ MW: 196** | **18.73** | **19.833** |
| **11** | **Cedren-13-ol, 8- Formula: $C_{15}H_{24}O$ MW: 220** | **18.99** | **23.105** |
| **12** | Octadecane Formula: $C_{18}H_{38}$ MW: 254 | 19.29 | 3.070 |
| 13 | 2-(4a,8-Dimethyl-1,2,3,4,4a,5,6,7-octahydro-naphthalen-2-yl)-prop-2-en-1-ol Formula: $C_{15}H_{24}O$ MW: 220 | 19.46 | 1.191 |
| 14 | **Tricyclo[5.1.0.0(2,4)]oct-5-ene-5-propanoic acid, 3,3,8,8-tetramethyl- Formula: $C_{15}H_{22}O_2$ MW: 234** | **20.01** | **9.951** |
| **15** | Spiro[4.5]decan-7-one, 1,8-dimethyl-8,9-epoxy-4-isopropyl- Formula: $C_{15}H_{24}O_2$ MW: 236 | 20.18 | 2.108 |
| 16 | Cyclopropanebutanoic acid, 2-[[2-[[2-[(2-pentylcyclopropyl)methyl]cyclopropyl]methyl]cyclopropyl]methyl]-, methyl ester Formula: $C_{25}H_{42}O_2$ MW: 374 | 20.93 | 2.625 |
| 17 | 2(1H)Naphthalenone, 3,5,6,7,8,8a-hexahydro-4,8a-dimethyl-6-(1-methylethenyl)-Synonym:Nootakone Formula: $C_{15}H_{22}O$ MW: 218 | 21.11 | 4.049 |
| **18** | **1-Butyn-3-one, 1-(6,6-dimethyl-1,2-epoxycyclohexyl)- Formula: $C_{12}H_{16}O_2$ MW: 192** | **21.23** | **11.119** |
| 19 | Azuleno[6,5-b]furan-2,5-dione, decahydro-4a,8-dimethyl-3-methylene-, [3aR-(3aà,4aá,7aà,8á,9aà)]- Formula: $C_{15}H_{20}O_3$ MW: 248 | 22.52 | 0.978 |
| 20 | Octadecanoic acid, methyl ester Formula: $C_{19}H_{38}O_2$ MW: 298 | 23.36 | 0.757 |
| 21 | Campesterol Formula: $C_{28}H_{48}O$ MW: 400 | 24.21 | 2.662 |
| 22 | Cholesta-22,24-dien-5-ol, 4,4-dimethyl- Formula: $C_{29}H_{48}O$ MW: 412 | 25.93 | 2.879 |
| 23 | 9-Octadecenamide, (Z)- Formula: $C_{18}H_{35}NO$ MW: 281 | 26.14 | 0.298 |

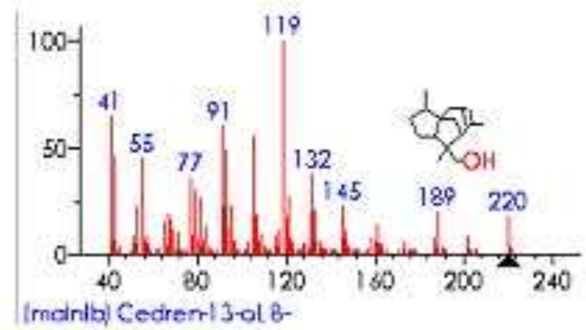
# GCMS analysis of the root 5th fraction

| S.No | Compound | Retention time (min) | Area % |
|---|---|---|---|
| 1 | Cedren – 13-ol-8, | 18.99 | 23.105 |
| 2 | 1-Cyclohexanone, 2 methyl-2- (3 methyl –2- oxobutyl) | 18.73 | 19.833 |
| 3 | 1-Butyn-3-one, 1-(6,6-dimethyl-1, 2-epoxycyclohexyl | 21.23 | 11.119 |
| 4 | Tricyclo(5,1.0.0 (2,4) oct – 5-ene-5-propanoic acid, 3,3,8,8- tetramethyl- | 20.01 | 9.951 |
| 5 | Ledene oxide – (II) | 17.96 | 6.505 |

# GC analysis of the root 5th fraction



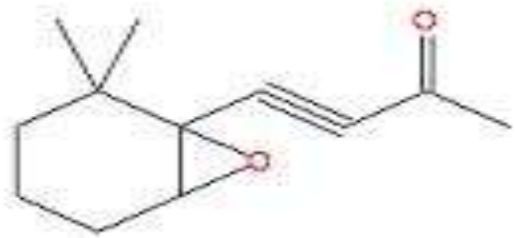



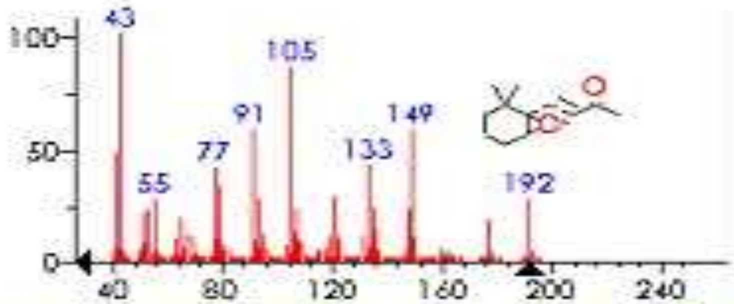




Name: Cedren-13-ol, 8-
Formula: $C_{15}H_{24}O$
MW: 220 CAS#: 18319-35-2 NIST#: 141107 ID#: 71326 DB: mainlib
Other DBs: None
Contributor: Mark Whitten, Florida Museum of Natural History, U. o
10 largest peaks:

| | | | | |
|---|---|---|---|---|
| 119 999 | 41 639 | 91 591 | 105 548 | 93 463 |
| 43 452 | 55 446 | 132 368 | 77 349 | 79 294 |

(M) 1-Butyn-3-one, 1-(6,6-dimethyl-1,2-...
743 767R 13.1 P



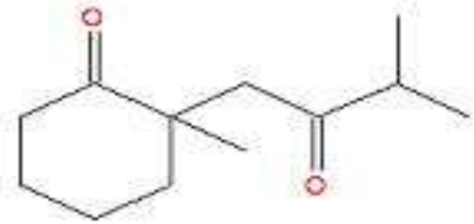


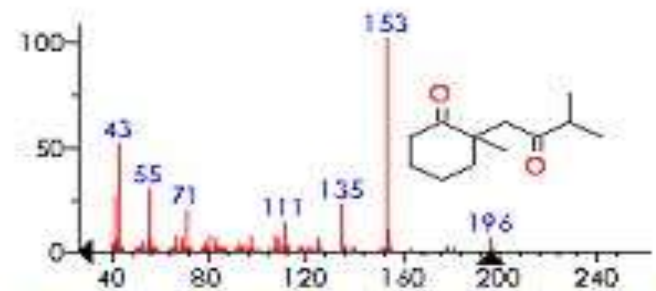
(mainlib) 1-Butyn-3-one, 1-(6,6-dimethyl-1,2-epoxycyc

Name: 1-Butyn-3-one, 1-(6,6-dimethyl-1,2-epoxycyclohexyl)
Formula: $C_{12}H_{16}O_2$
MW: 192 CAS#: N/A NIST#: 196972 ID#: 9655 DB: mainlib
Other DBs: None
Contributor: Chemical Concepts
10 largest peaks:

| | | | | |
|---|---|---|---|---|
| 43 999 | 105 846 | 91 576 | 149 574 | 41 475 |
| 133 414 | 77 407 | 39 375 | 79 325 | 121 280 |

(M) 1-Cyclohexanone, 2-methyl-2-(3-m...
722 785R 21.1 P

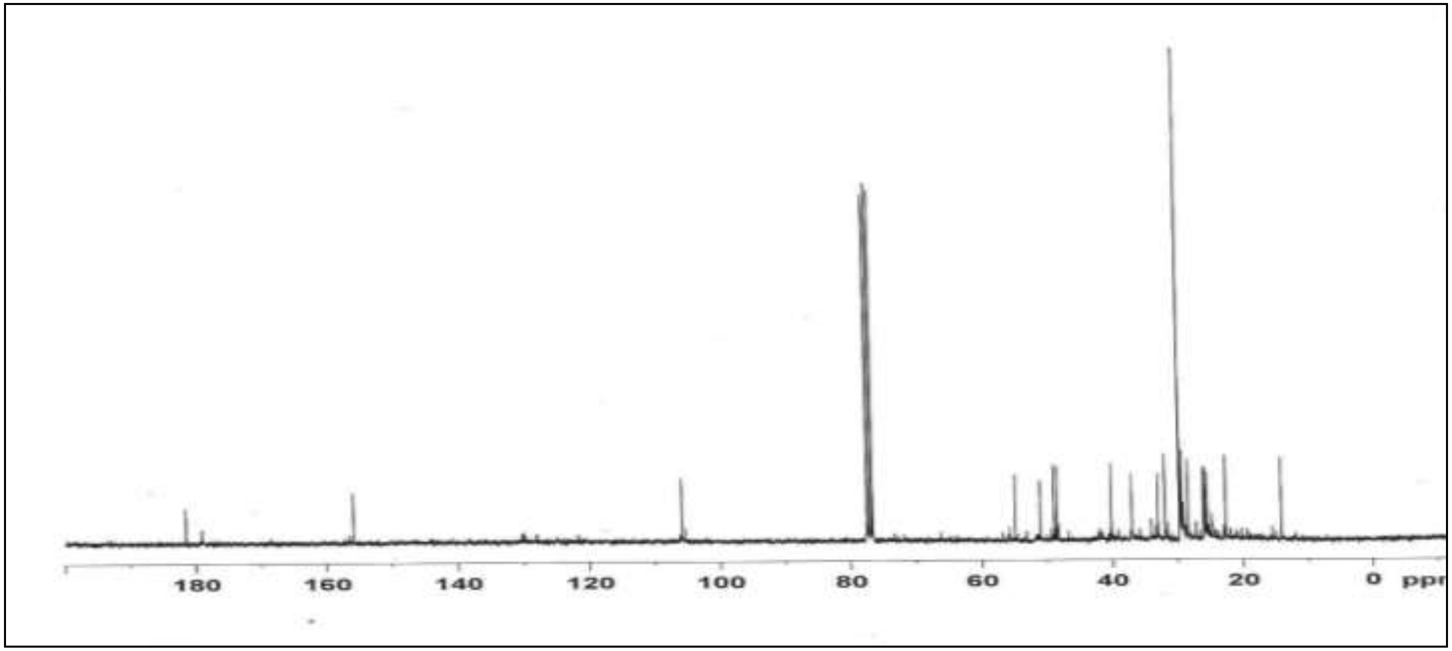




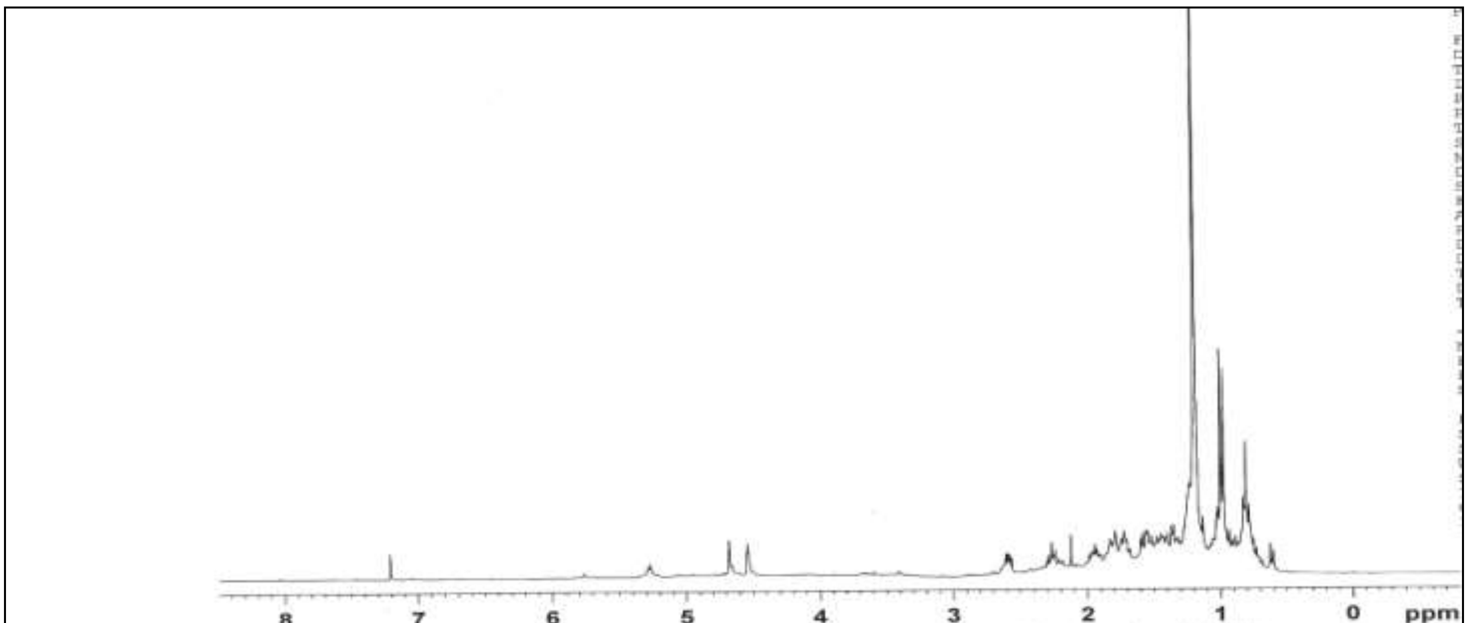
(mainlib) 1-Cyclohexanone, 2-methyl-2-(3-methyl-2-o

Name: 1-Cyclohexanone, 2-methyl-2-(3-methyl-2-oxobutyl)
Formula: $C_{12}H_{20}O_2$
MW: 196 CAS#: N/A NIST#: 196694 ID#: 98988 DB: mainlib
Other DBs: None
Contributor: Chemical Concepts
10 largest peaks:

| | | | | |
|---|---|---|---|---|
| 153 999 | 43 497 | 55 291 | 41 254 | 135 220 |
| 71 190 | 111 131 | 27 103 | 39 101 | 154 98 |




**Root - carbon**



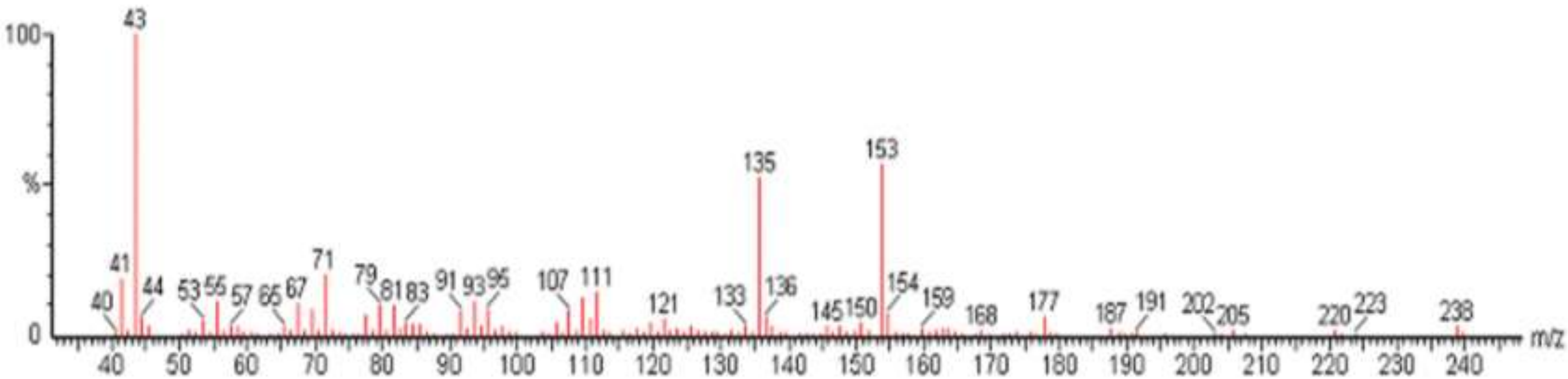

**Root - proton**

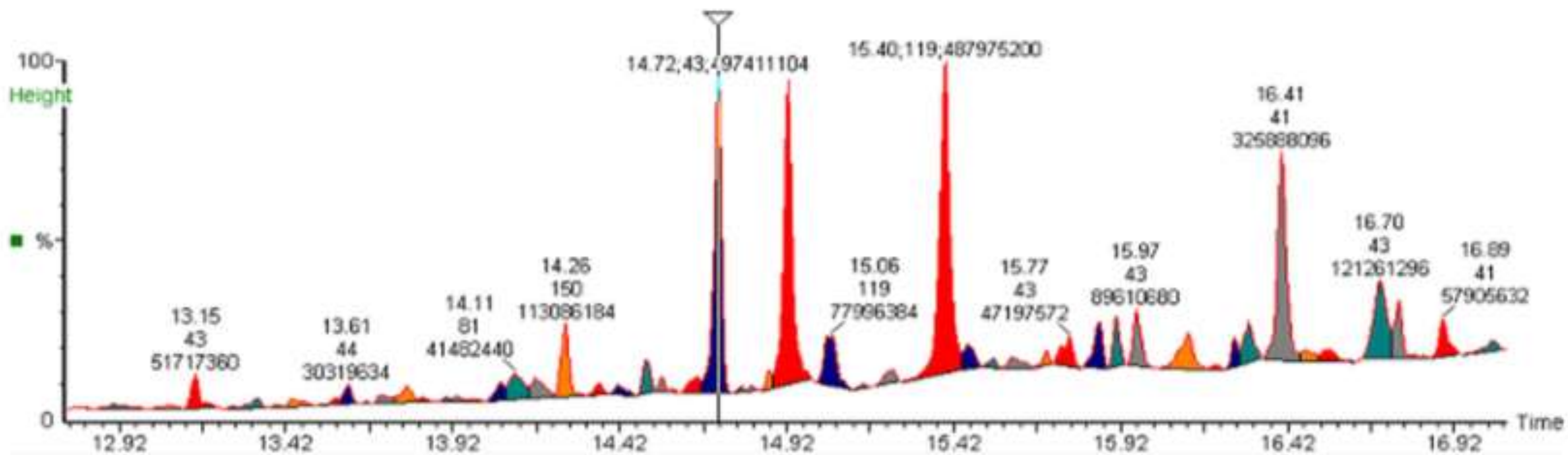
# GCMS analysis of the leaf 8th fraction

| S.No. | Compound | Retention time | %peak area |
|---|---|---|---|
| 1 | Nonadecane Formula: $C_{19}H_{40}$ MW: 268 | 13.15 | 2.194 |
| 2 | Tricyclo[5.3.1.1(2,6)]dodecan-11-ol, 11-methyl-12-methylene- Formula: $C_{14}H_{22}O$ MW: 206 | 13.61 | 1.286 |
| 3 | **Ledene oxide-(II) Formula: $C_{15}H_{24}O$ MW: 220** | 14.26 | 4.798 |
| 4 | **1-Cyclohexanone, 2-methyl-2-(3-methyl-2-oxobutyl) Formula: $C_{12}H_{20}O_2$ MW: 196** | **14.72** | **21.105** |
| 5 | **Cedren-13-ol, 8- Formula: $C_{15}H_{24}O$ MW: 220** | **14.93** | **20.139** |
| 6 | Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro-4a,8-dimethyl-2-(1-methylethenyl)-, [2R-(2à,4aà,8aá)]- Formula: $C_{15}H_{24}$ MW: 204 | 15.06 | 3.309 |
| 7 | **4,7-Octadecadiynoic acid, methyl ester Formula: $C_{19}H_{30}O_2$ MW: 290** | 15.40 | 20.705 |
| 8 | 2,2,7,7-Tetramethyltricyclo[6.2.1.0(1,6)]undec-4-en-3-one Formula: $C_{15}H_{22}O$ MW: 218 | 15.86 | 3.025 |
| 9 | Naphthalene, 1,2,3,5,6,7,8,8a-octahydro-1,8a-dimethyl-7-(1-methylethenyl)-, [1R-(1à,7á,8aà)]- Formula: $C_{15}H_{24}$ MW: 204 | 15.91 | 3..351 |
| 10 | 2,2,6,7-Tetramethyl-10-oxatricyclo[4.3.1.0(1,6)]decan-5-ol Formula: $C_{13}H_{22}O_2$ MW: 210 | 15.97 | 3.802 |
| 11 | 4-(3,3-Dimethyl-but-1-ynyl)-4-hydroxy-2,6,6-trimethylcyclohex-2-enone Formula: $C_{15}H_{22}O_2$ MW: 234 | 16.41 | 13.827 |
| 12 | 2(1H)-Naphthalenone, 4a,5,6,7,8,8a-hexahydro-6-[1-(hydroxymethyl)ethenyl]-4,8a-dimethyl-, [4ar-(4aà,6à,8aá)]- Formula: $C_{15}H_{22}O_2$ MW: 234 | 16.89 | 2.456 |

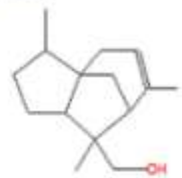
# GCMS analysis of the leaf 8th fraction

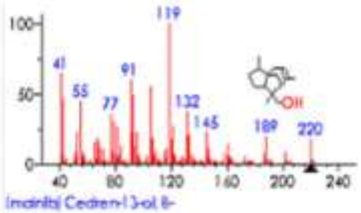
| S.No | Compound | Retention time (min) | Area % |
|---|---|---|---|
| 1 | 1-Cyclohexanone, 2 methyl-2- (3 methyl – 2- oxobutyl) | 14.72 | 21.105 |
| 2 | Cedren – 13-ol-8, | 14.93 | 20.139 |
| 3 | 4,7 – Octadecadiynoic acid, methyl ester | 15.40 | 20.705 |
| 4 | Ledene oxide – (II) | 14.26 | 4.798 |


100
%
0
43
135
153
41
44
53
55
57
65
67
71
79
81
83
91
93
95
107
111
121
133
136
145
150
154
159
168
177
187
191
202
205
220
223
238
40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240
m/z


100
Height
%
0
14.72;43;497411104
15.40;119;487975200
16.41
41
325888096
16.70
43
121261296
16.89
41
57905632
15.97
43
89610680
15.77
43
47197572
15.06
119
77996384
14.26
150
113086184
14.11
81
41482440
13.61
44
30319634
13.15
43
51717360
12.92 13.42 13.92 14.42 14.92 15.42 15.92 16.42 16.92
Time

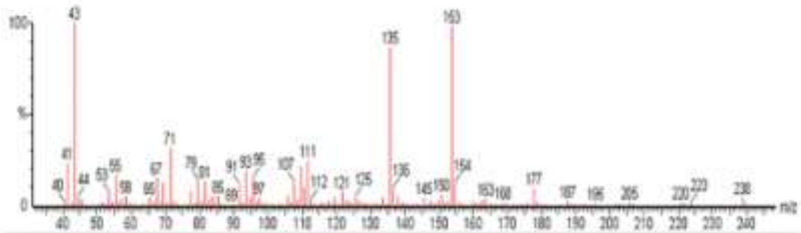
1 (M) Cedren-13-ol, 8-
776 765R 23.2P



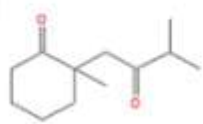



Name: Cedren-13-ol, 8-
Formula: $C_{15}H_{24}O$
MW: 220 CAS#: 18319-35-2 NIST#: 141107 ID#: 71326 DB: mainlib
Other DBs: None
Contributor: Mark Whitten, Florida Museum of Natural History, U. o
10 largest peaks:

| | | | | |
|---|---|---|---|---|
| 119 999 | 41 639 | 91 591 | 105 546 | 93 453 |
| 43 452 | 55 446 | 132 386 | 77 349 | 79 294 |



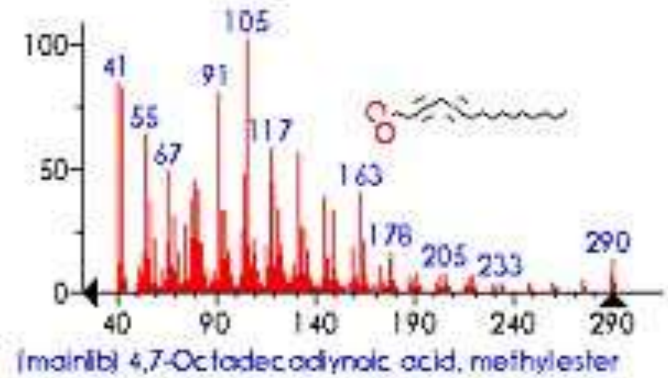

1 (M) 1-Cyclohexanone, 2-methyl-2-(3-m...
722 765R 21.1P




Name: 1-Cyclohexanone, 2-methyl-2-(3-methyl-2-oxobutyl)
Formula: $C_{12}H_{20}O_2$
MW: 196 CAS#: N/A NIST#: 196694 ID#: 98988 DB: mainlib
Other DBs: None
Contributor: ChemicalConcepts
10 largest peaks:

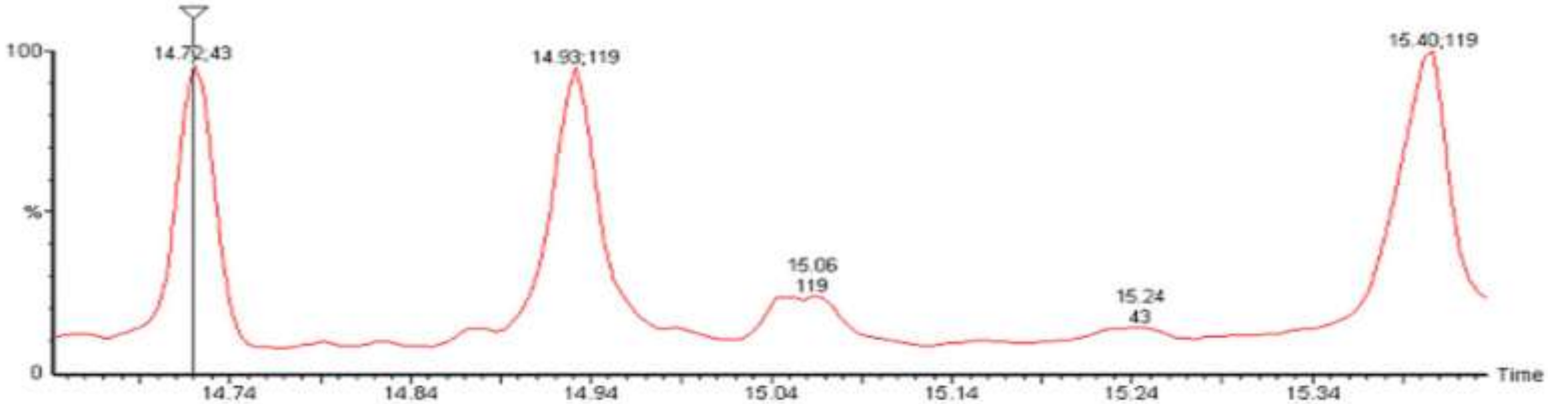
| | | | | |
|---|---|---|---|---|
| 153 999 | 43 497 | 55 291 | 41 254 | 135 220 |
| 71 190 | 111 131 | 27 103 | 39 101 | 154 98 |

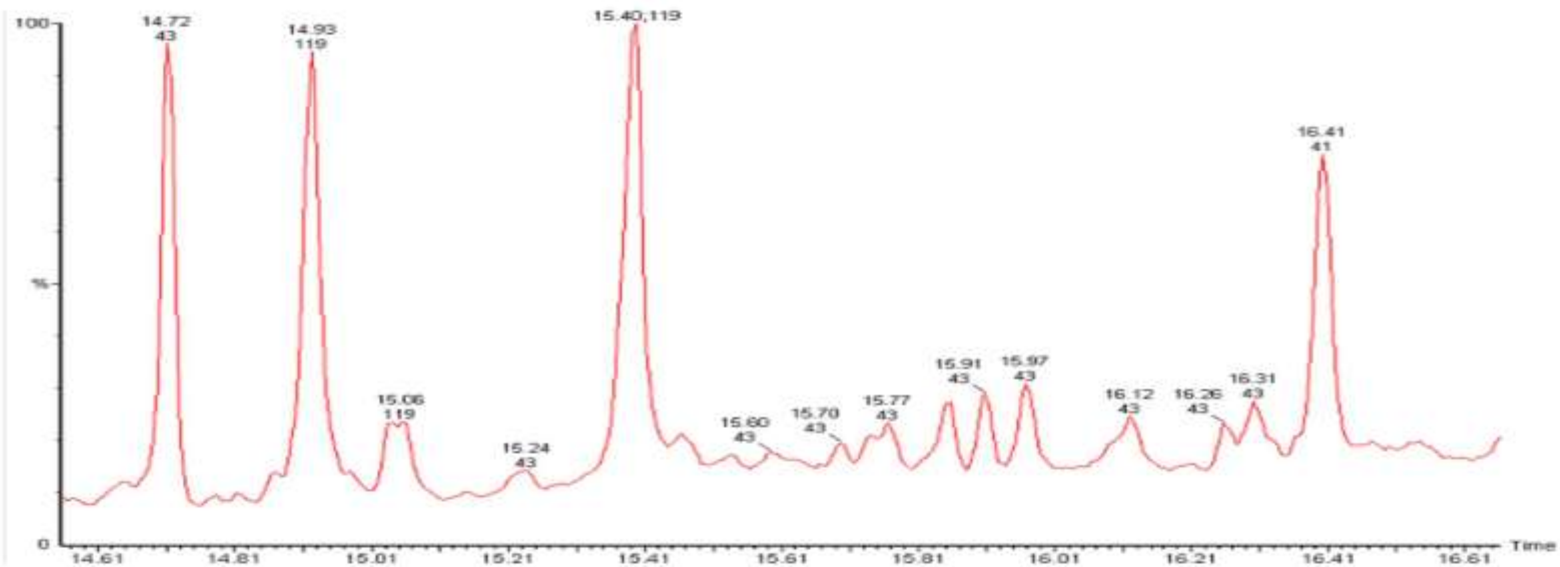
1 (M) 4,7-Octadecadiynoic acid, methyl ...
741 745R 21.1P




Name: 4,7-Octadecadiynoic acid, methylester
Formula: $C_{19}H_{30}O_2$
MW: 290 CAS#: 18202-20-5 NIST#: 36078 ID#: 59260 DB: mainlib
Other DBs: None
Contributor: R.T.HOLMAN,UNIVERSITY OF MINNESOTA
10 largest peaks:

| | | | | |
|---|---|---|---|---|
| 105 999 | 41 820 | 43 800 | 91 780 | 55 620 |
| 117 560 | 131 550 | 67 470 | 104 460 | 79 440 |

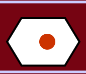

100
%
0
14.72;43
14.93;119
15.06
119
15.24
43
15.40;119
14.74
14.84
14.94
15.04
15.14
15.24
15.34
Time


100
%
0
14.72
43
14.93
119
15.06
119
15.24
43
15.40;119
15.60
43
15.70
43
15.77
43
15.91
43
15.97
43
16.12
43
16.26
43
16.31
43
16.41
41
14.61
14.81
15.01
15.21
15.41
15.61
15.81
16.01
16.21
16.41
16.61
Time

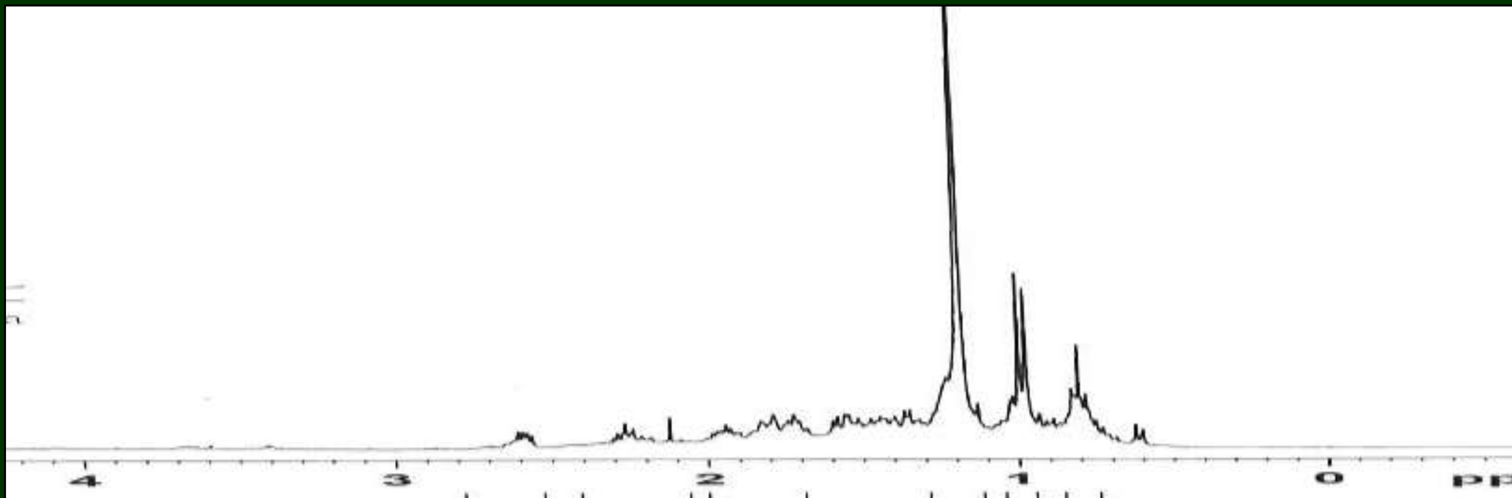
# Carbon 13C NMR ($CDC_{l3}$) 300 MHz

| δ Value ppm | Possible Carbons |
|---|---|
| 0.7 to 0.9 | Aliphatic protons |
| 1.2 to 1.4 | R – $CH_2$ – R |
| 2.1 | OH proton |
| 4.6 | Amino or amide Nk2 |
| 5.3 and 5.8 | Aromatic CH protons |
| 3.5 | Methoxy $OCH_3$ |
| 2.3 | CH- |
| 6.4, 6.5, 6.6, 6.7 | Aromatic ring protons (H) |
| 9.3, 9.6, 9.7 | Amine may be Primary Amines |
| 10.2 | CHO |
| 7.5, 7.7 | Aromatic Protons |

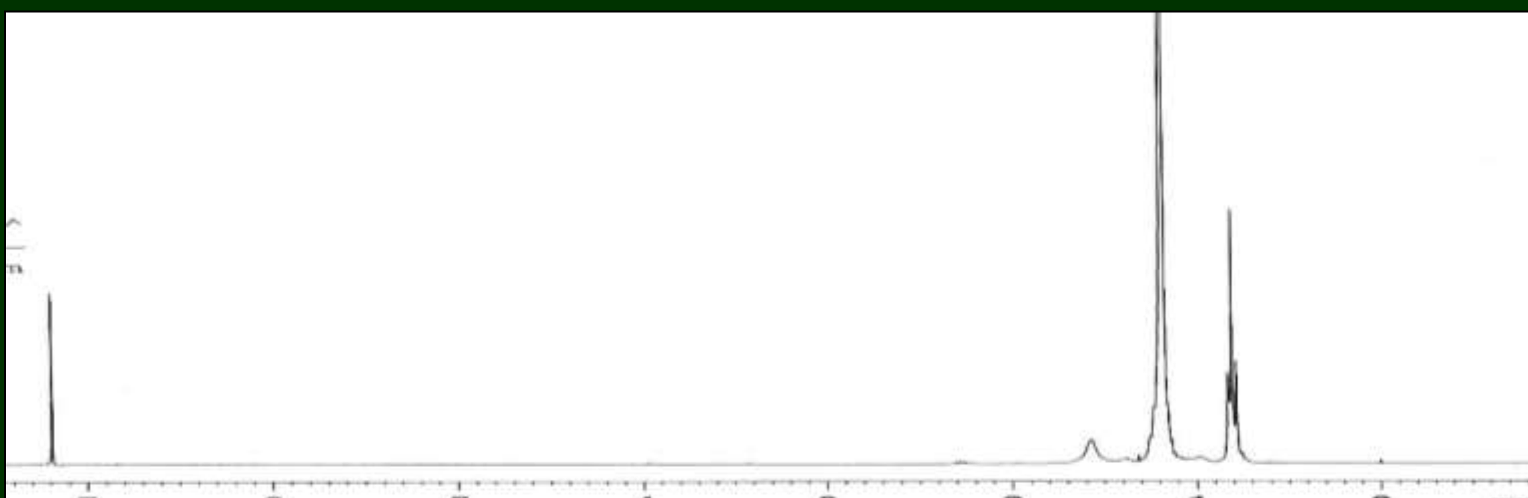
# Proton 1H NMR ($CDC_{l3}$) 300 MHz

| δ Value ppm | Possible Protons |
|---|---|
| 0.7 | R-$CH_3$ |
| 0.8 | Methyl Protons $CH_2$ – $CH_2$ – R |
| 1.2 to 1.4 | R- $CH_2$ -R |
| 1.57 | R-C=C=C-H |
| 2.3 | CH -  phenyl |
| 3.5 | Methoxy protons |

Shoot - carbon




Shoot - proton



# VETIVER GRASS THE “ROLLS ROYCE” OF PLANTS

## ORIGIN - SOUTH INDIA –APPLY IT !!

THANK YOU