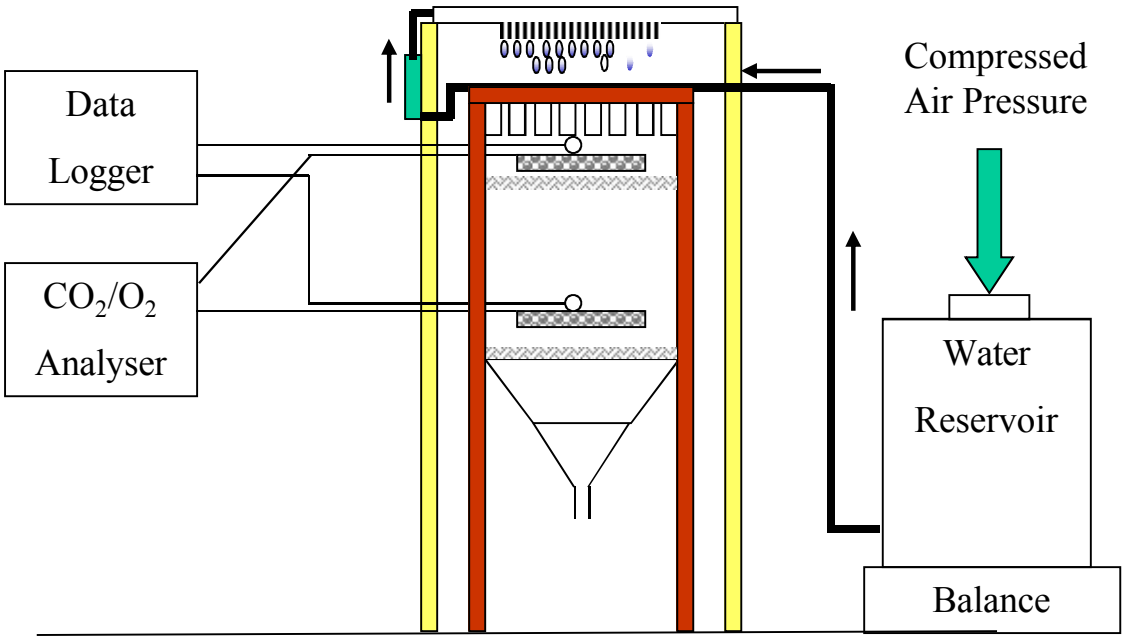
Pervious Pavements
Coventry's Interdisciplinary Approach


Data
Logger
CO_2/O_2
Analyser
Compressed
Air Pressure
Water
Reservoir
Balance


Emergency
stop push-button

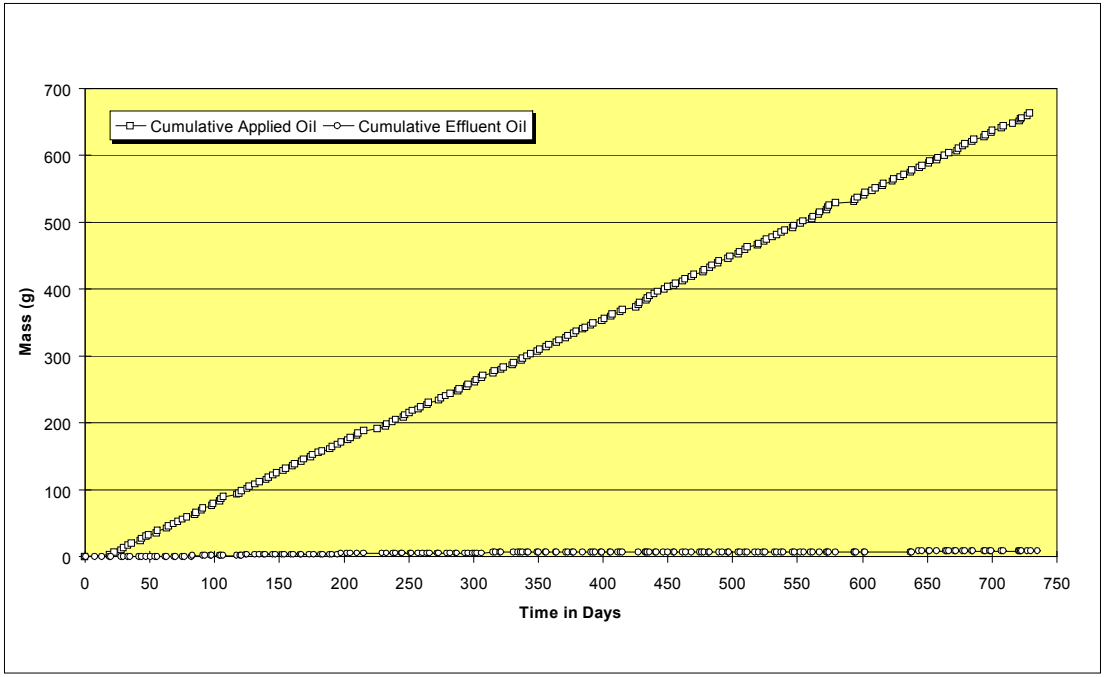
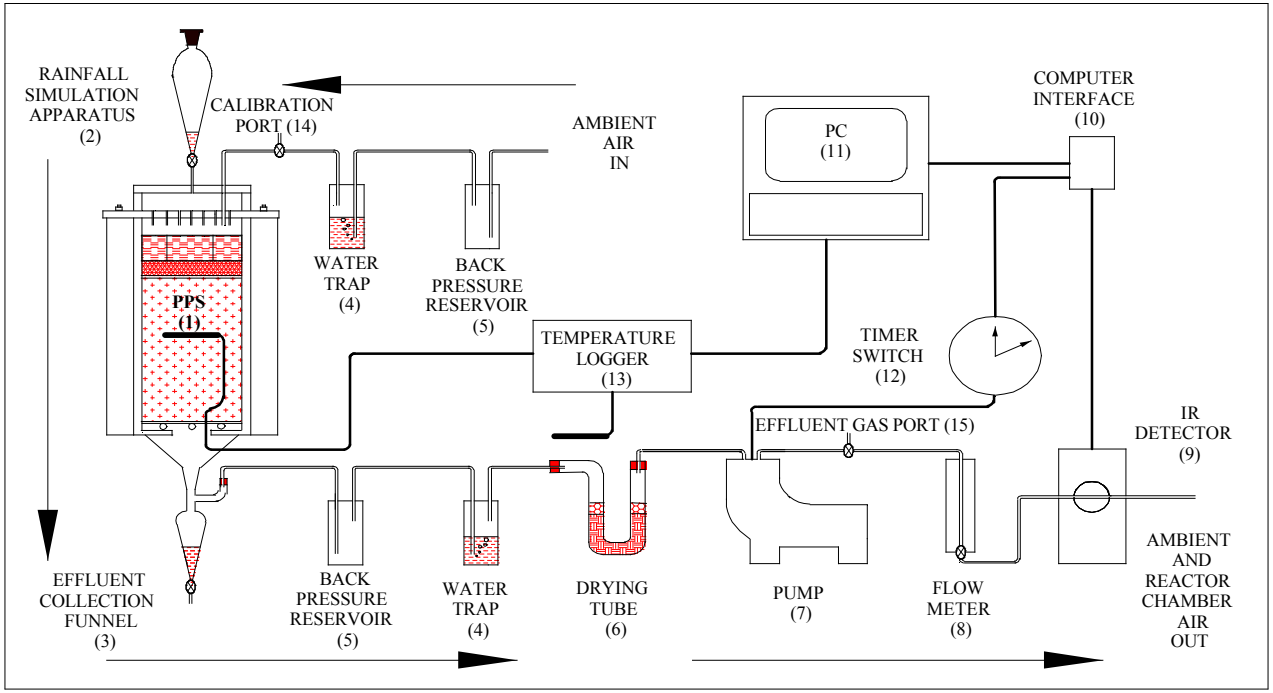
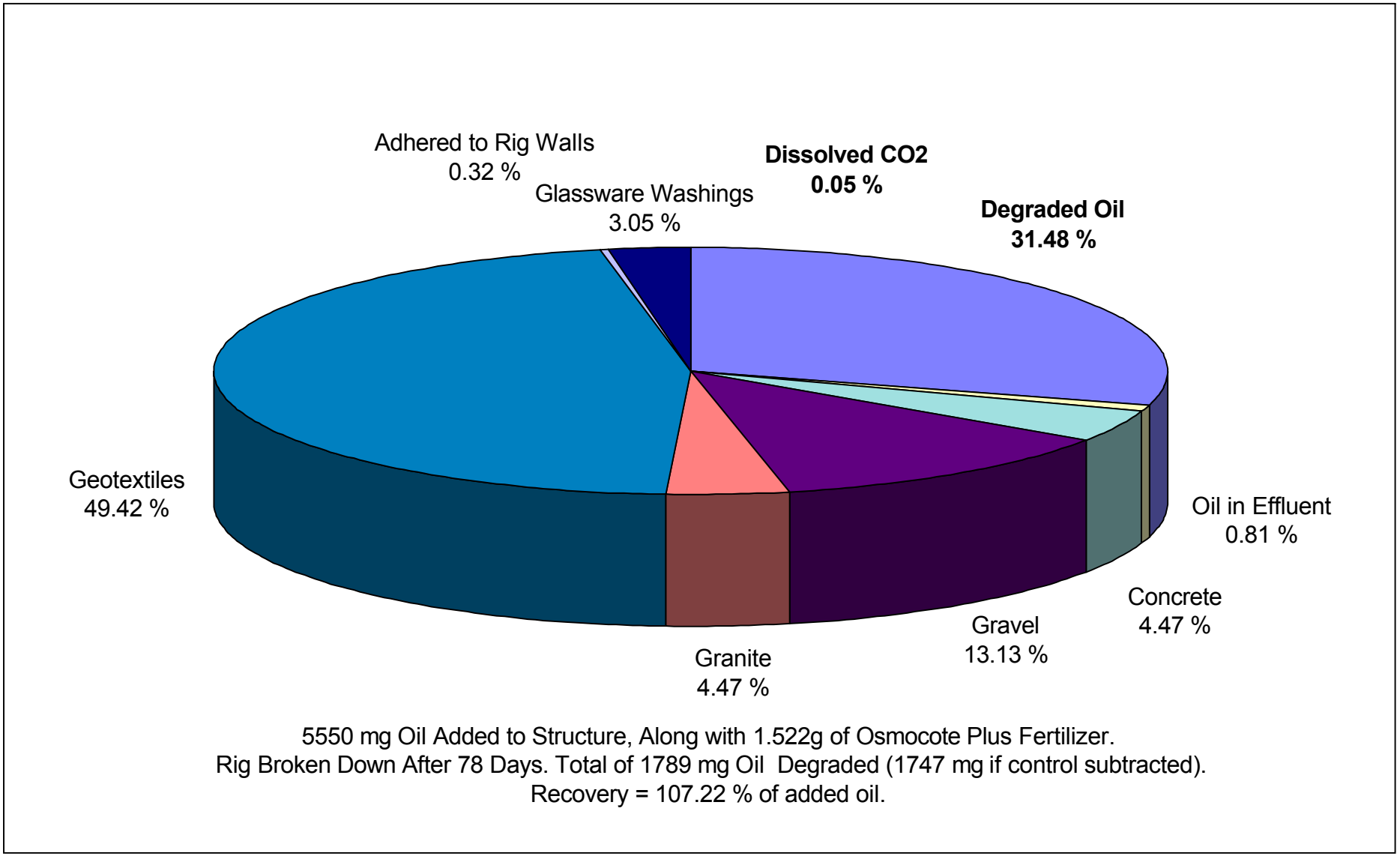


Figure 4.19. Cumulative Oil Application and Recovery Masses for Large Rig PPS



Small Rig Design for Total Carbon Mass Balance Studies: Principle of Operation



5550 mg Oil Added to Structure, Along with 1.522g of Osmocote Plus Fertilizer.
Rig Broken Down After 78 Days. Total of 1789 mg Oil Degraded (1747 mg if control subtracted).
Recovery = 107.22 % of added oil.

Fate Of Oil In The System

Large Spillages

Compacted sand bedding layer below installation

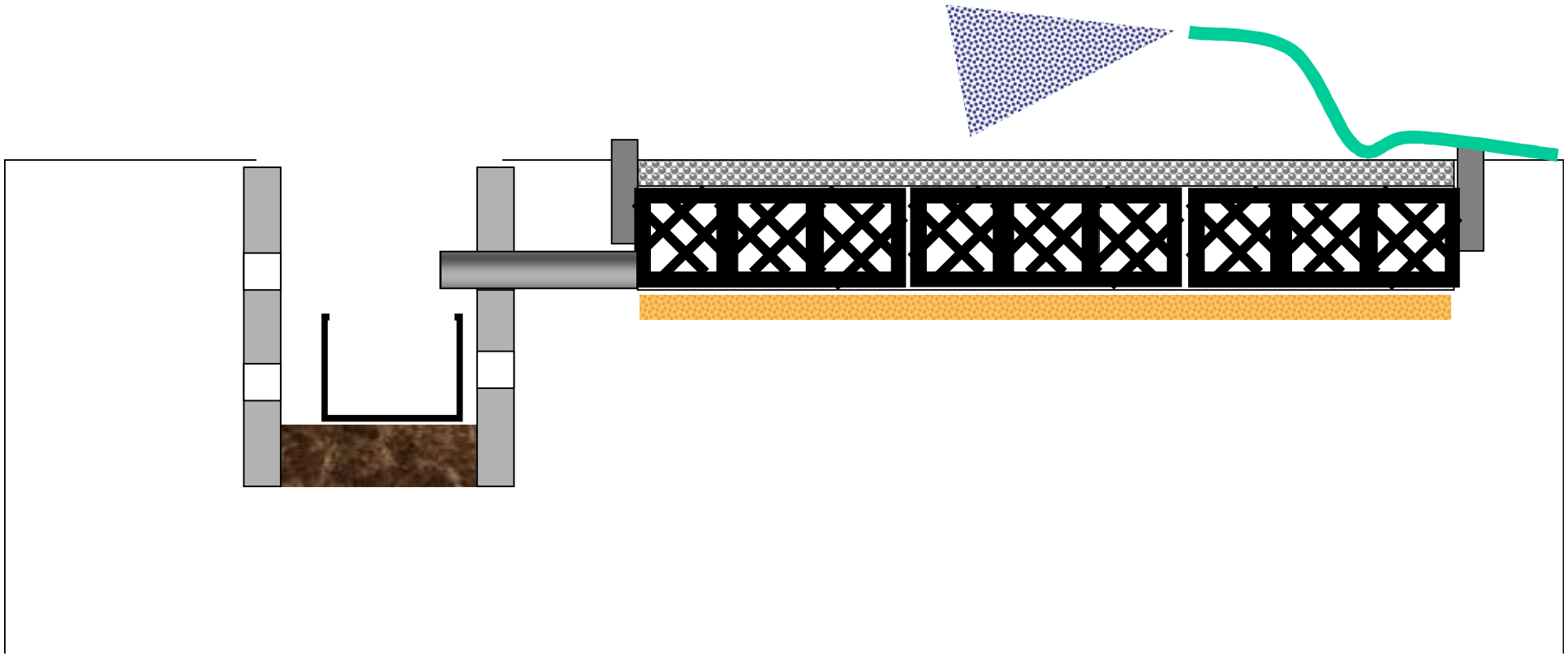
PERMAVOID™ laid within geomembrane

Effect of 150 ml/m^2

5 litre Experiment

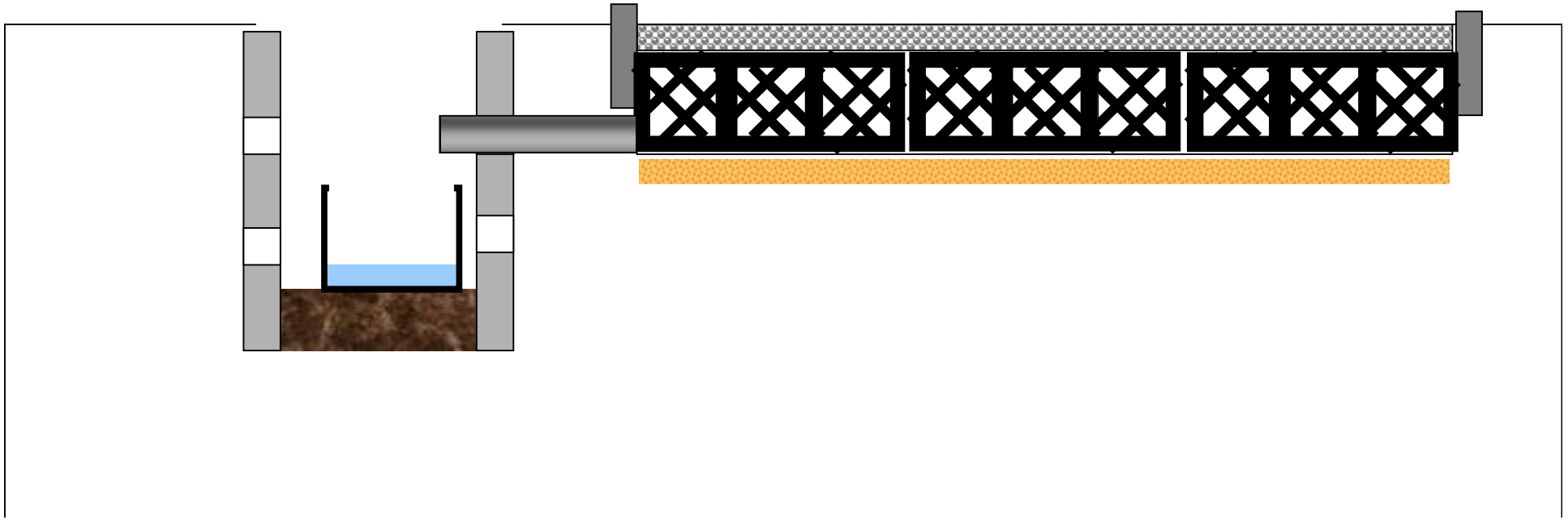
Experiment

13mm Rain Applied



Experiment

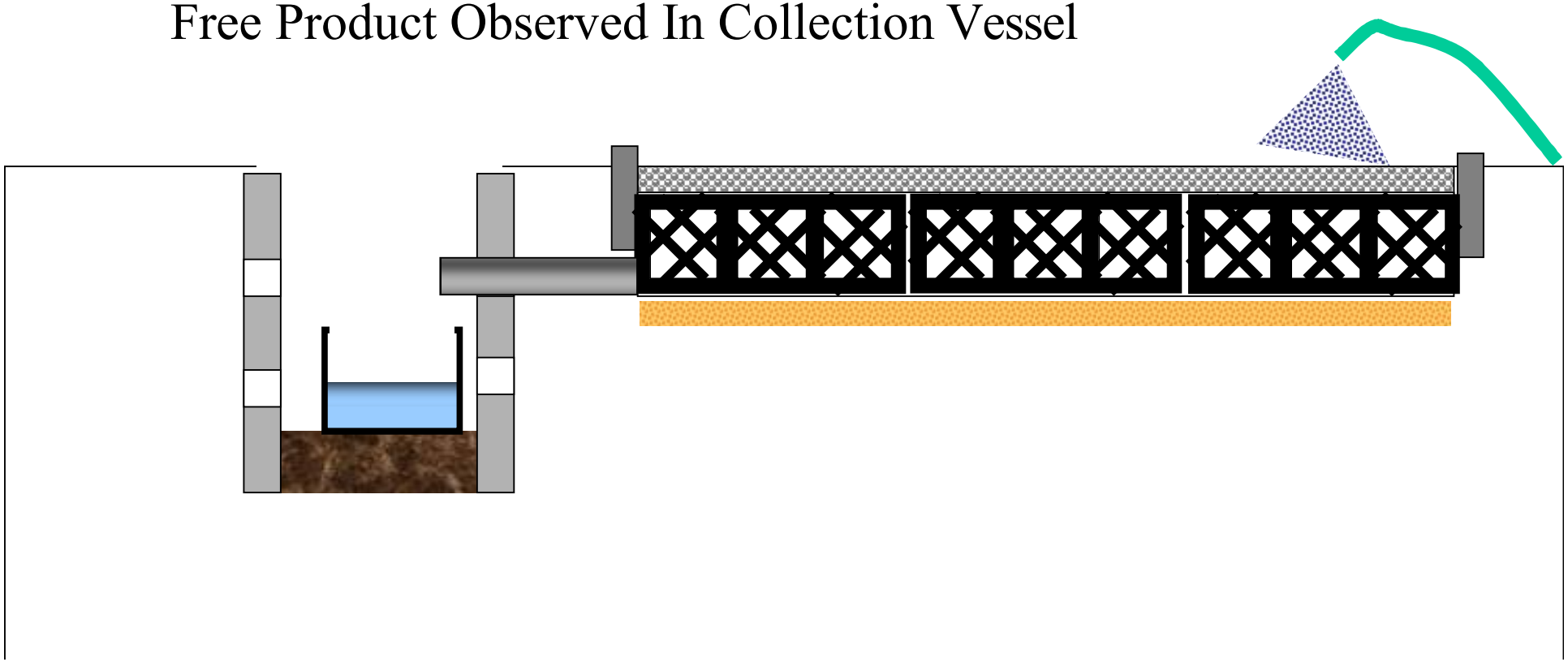
System allowed to drain overnight



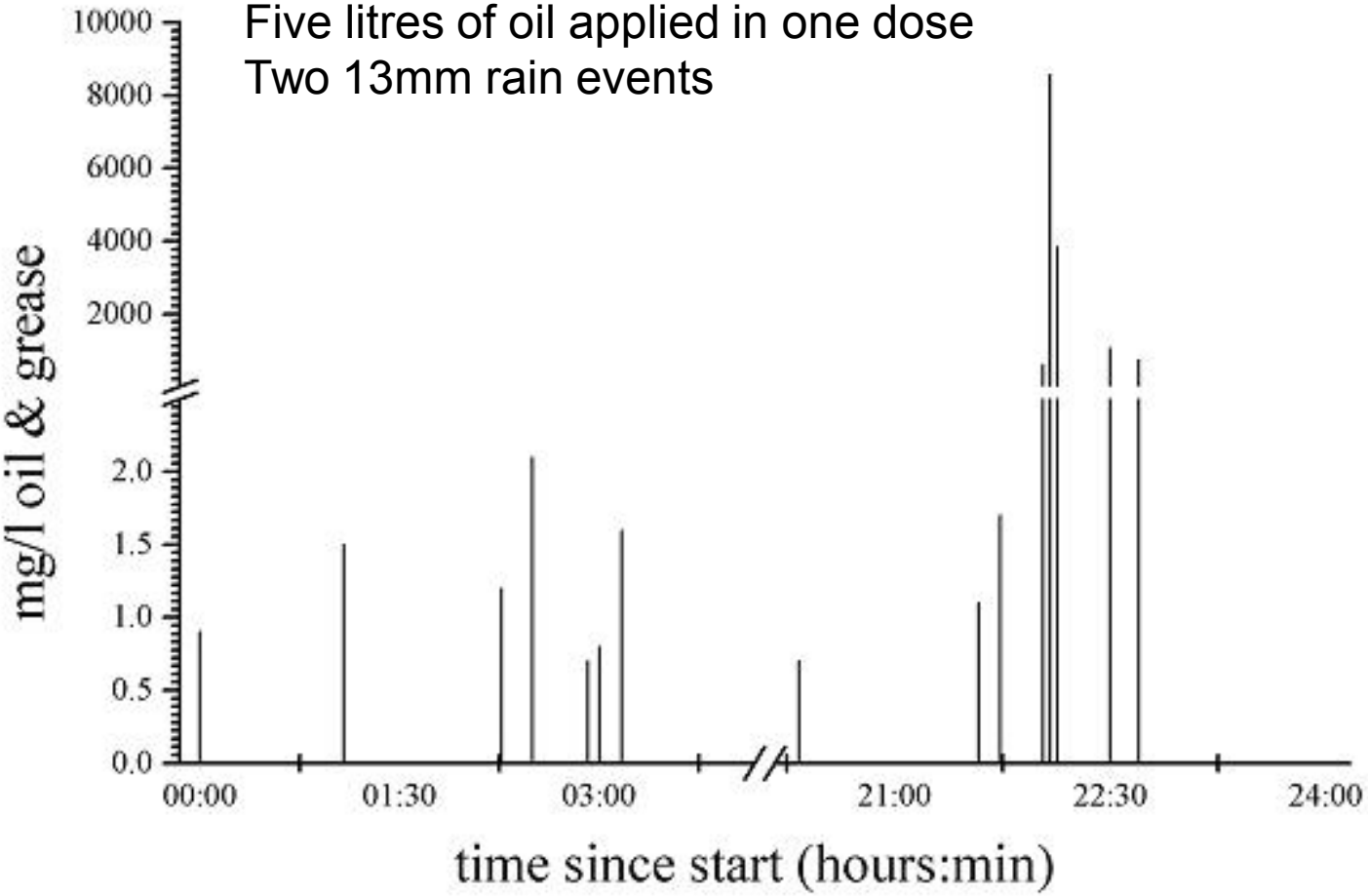
Experiment

Another 13mm “Rain”

Free Product Observed In Collection Vessel



Four bay car park-pervious block paving
Five litres of oil applied in one dose
Two 13mm rain events



The Answer- Incorporate a Separator Into the Pavement

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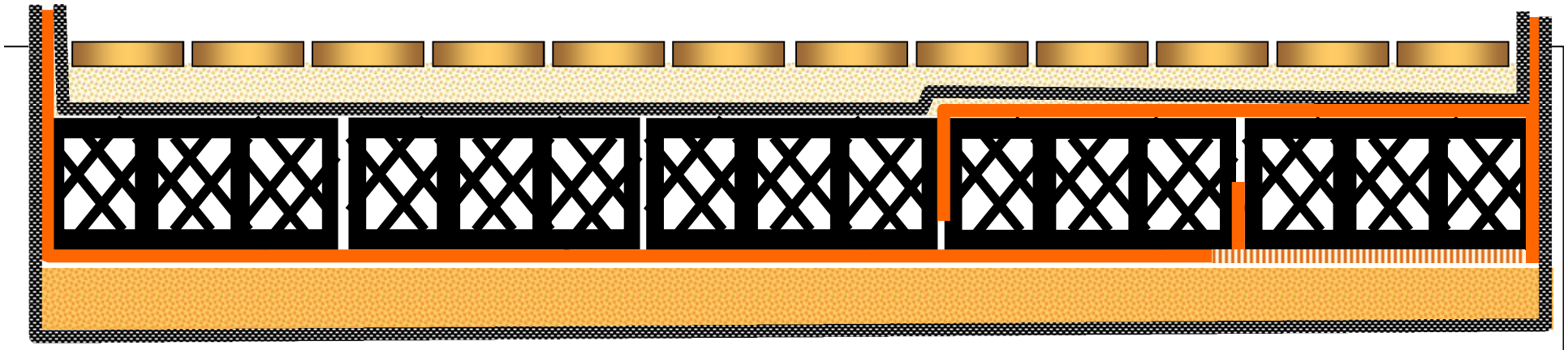
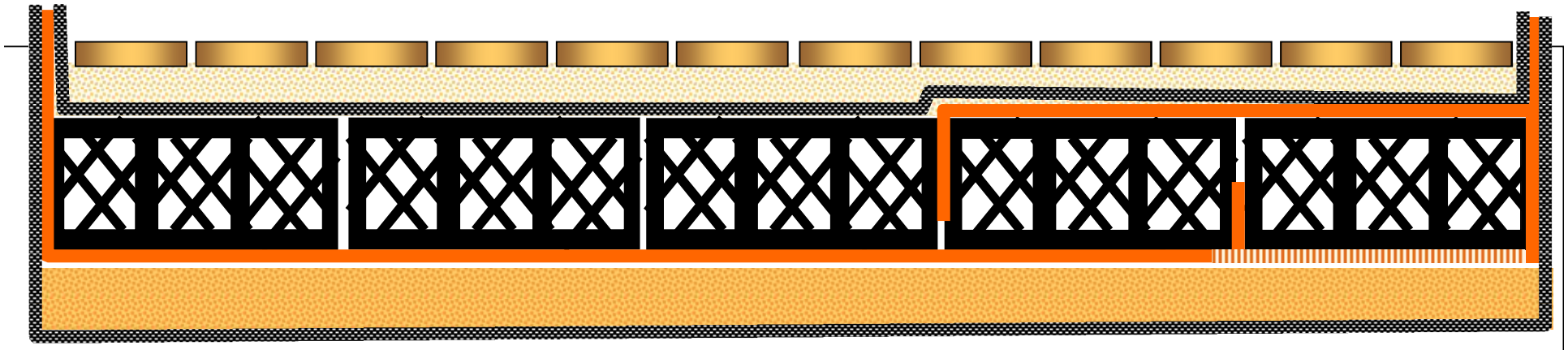
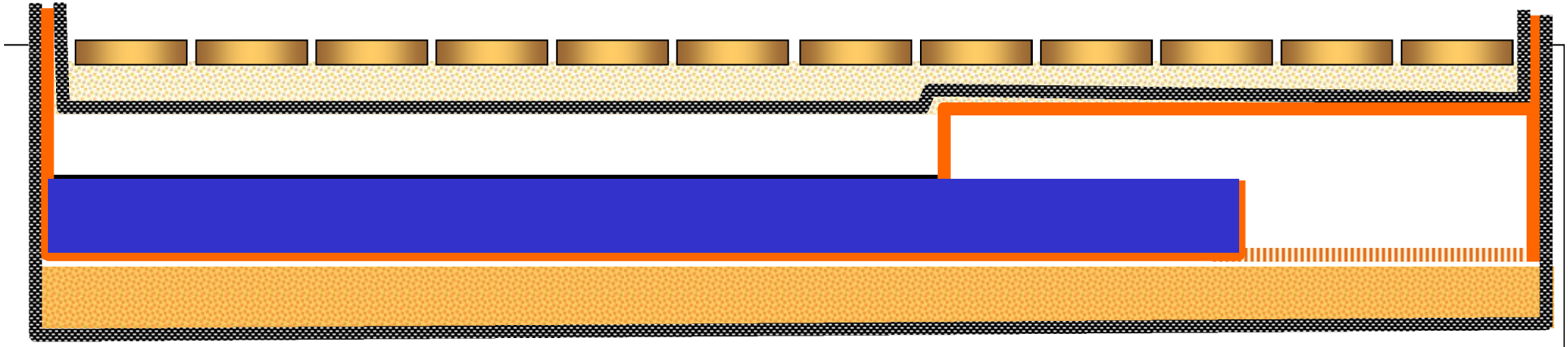


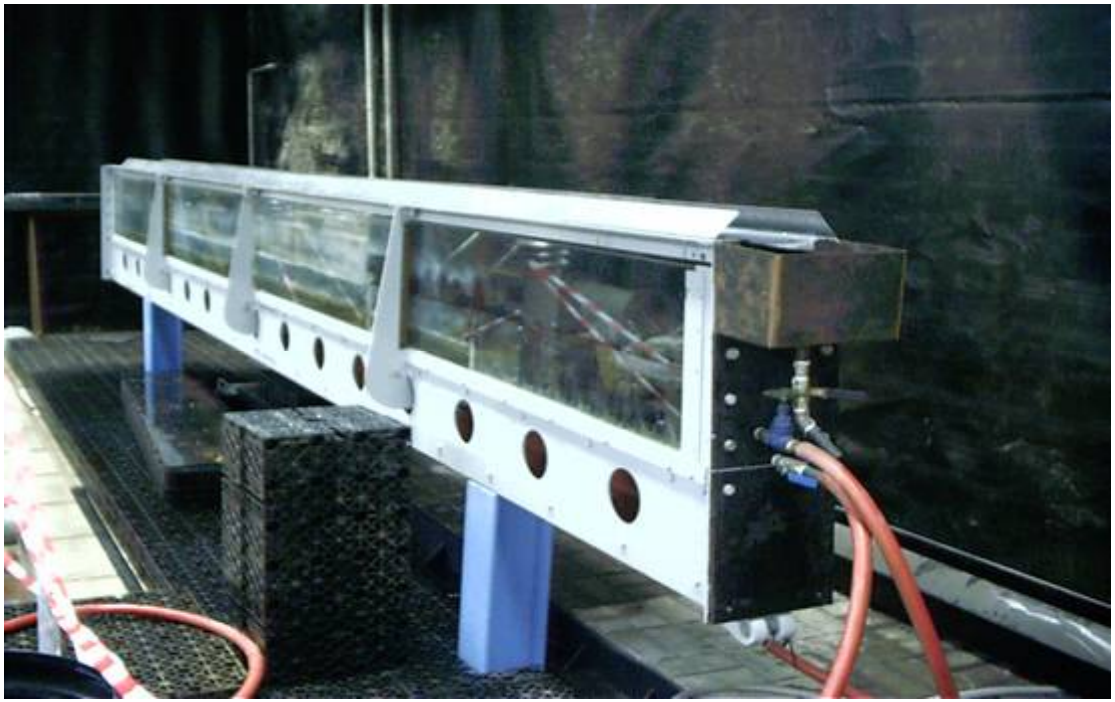
The Answer- Incorporate a Separator Into the Pavement



How It Works



Flume Experiments



Mechanisms of Pollution Prevention

- Primary
  - Sorption on gravel layer
  - Filtration by gravel layer
  - Sorption on Geotextile
  - Filtrationon Geotextile
- Secondary
  - Oil trapped as floating body
  - Oil sorption on secondary geotextile
  - Ability to recover free product
  - Biodegradation on water body

The Porous Pavement as a Bioreactor

Requirements For Biodegradation

- Sufficient retention time to allow degradation to proceed.
- Organic food supply.
- Microorganisms.
- Oxygen.
- Inorganic nutrients NPK(trace elements).

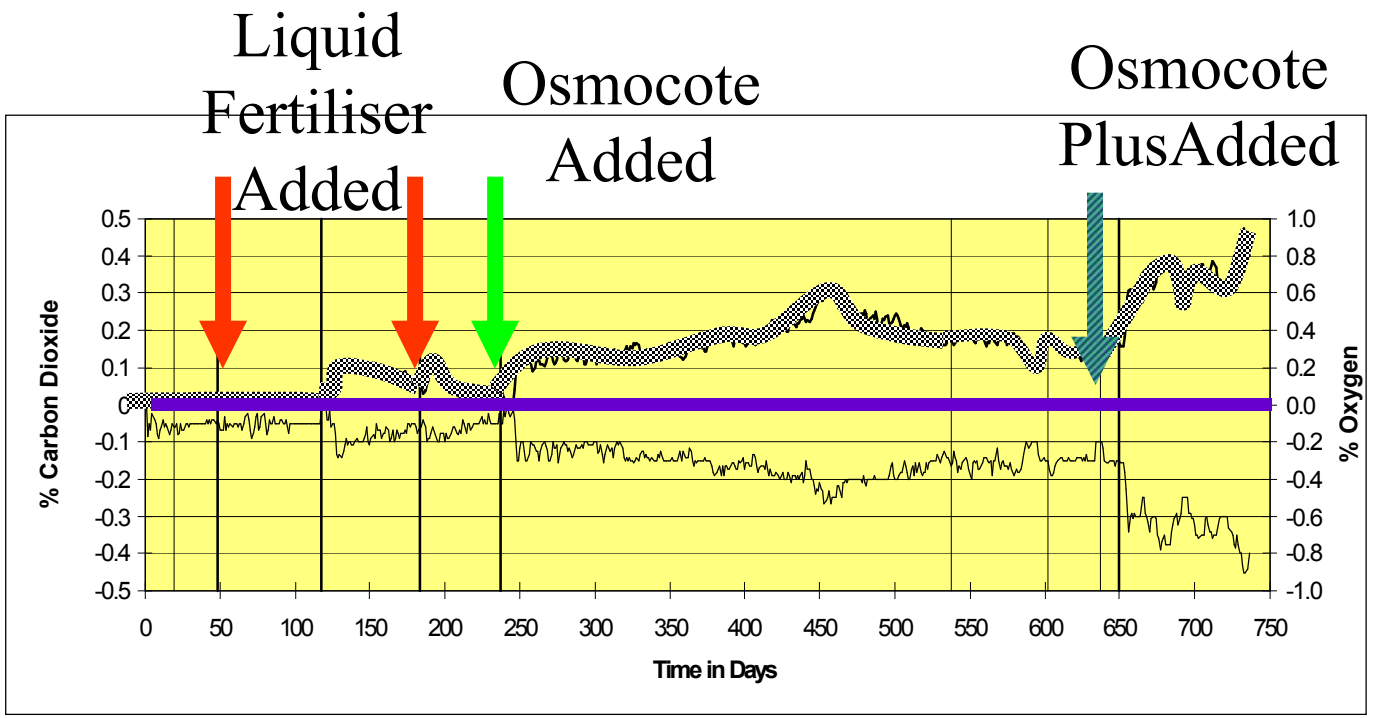
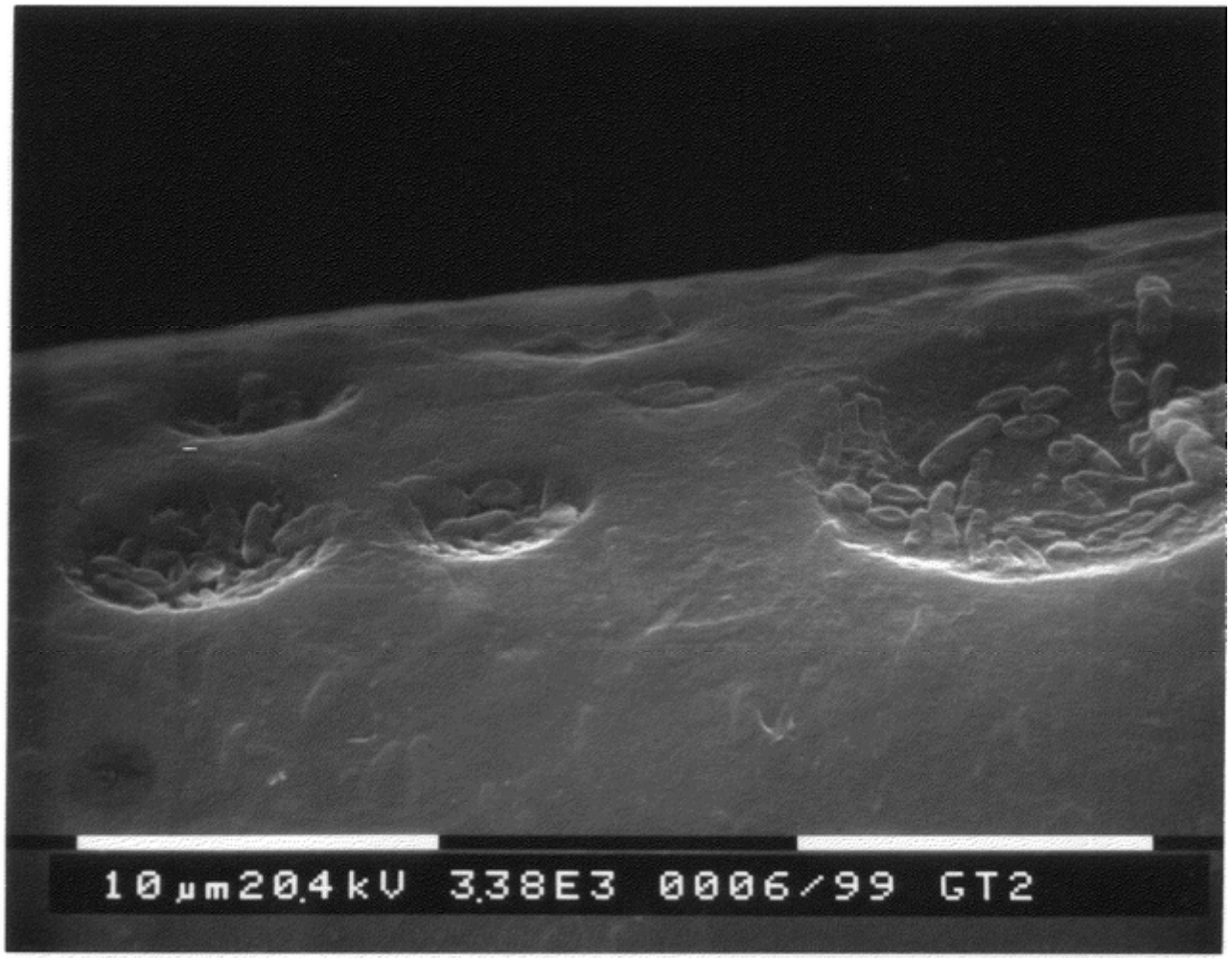


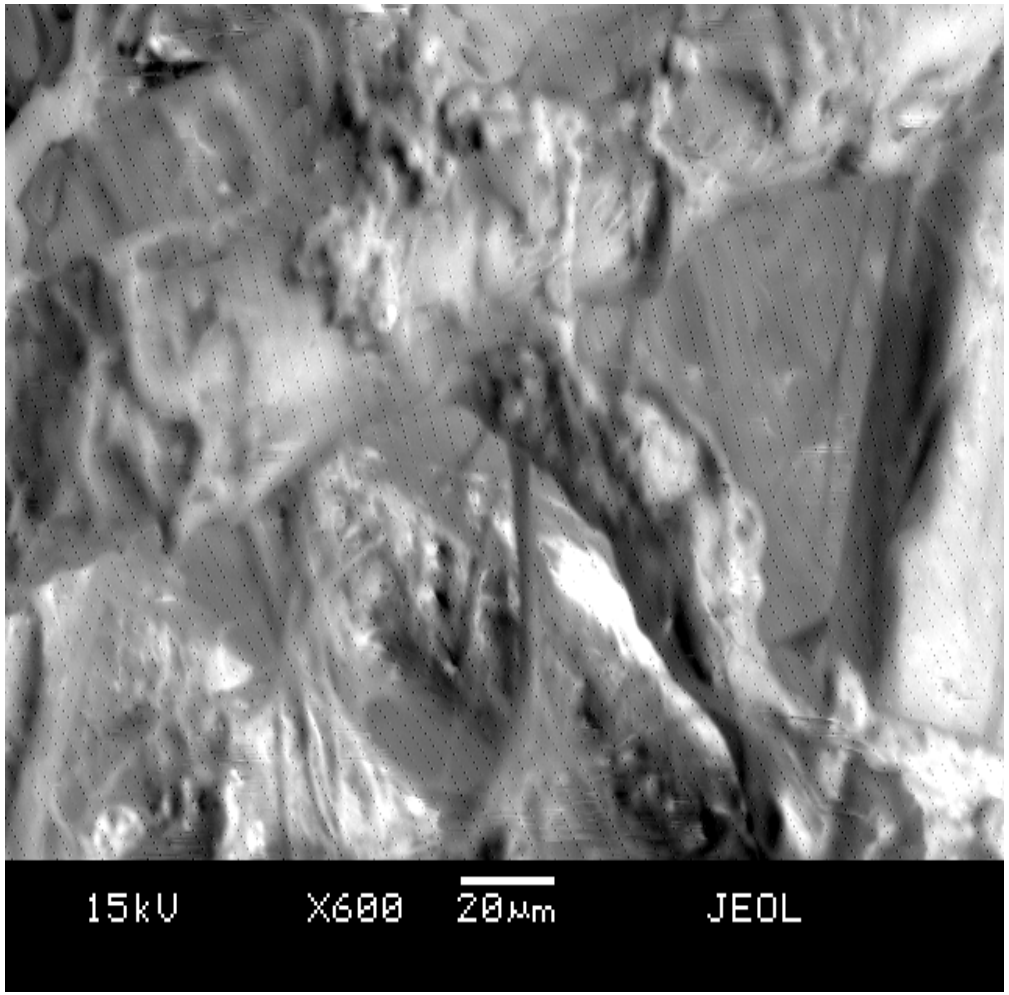
Figure 4.6. *Δ Gas Measurements from Large Rig Sub-Base Probe*

High-lighted days indicate the following: ***Day 0*** *(22/05/96) = commenced "average rainfall";* ***Day 19*** *(10/06/96) = commenced oil applications;* ***Day 48*** *(09/07/96) = Bio-Treat and Bio-Activator application;* ***Days 118*** *(17/09/96) and* ***183*** *(21/11/96) = Bio-Activator applications;* ***Day 237*** *(11/01/97) = Osmocote application;* ***Day 537*** *(10/11/97) = commenced increasing rainfall intensity;* ***Day 603*** *(15/01/98) = commenced drought;* ***Day 637*** *(18/02/98) = first-flush followed by "average rainfall";* ***Day 650*** *(03/03/98) = Osmocote Plus application.*

Strand of geotextile after 24 hours incubation



Several Months In A Test Rig



Microbial Ecology

- Identification and counting of oil degrading organisms.

- Measurement of microbial activity.

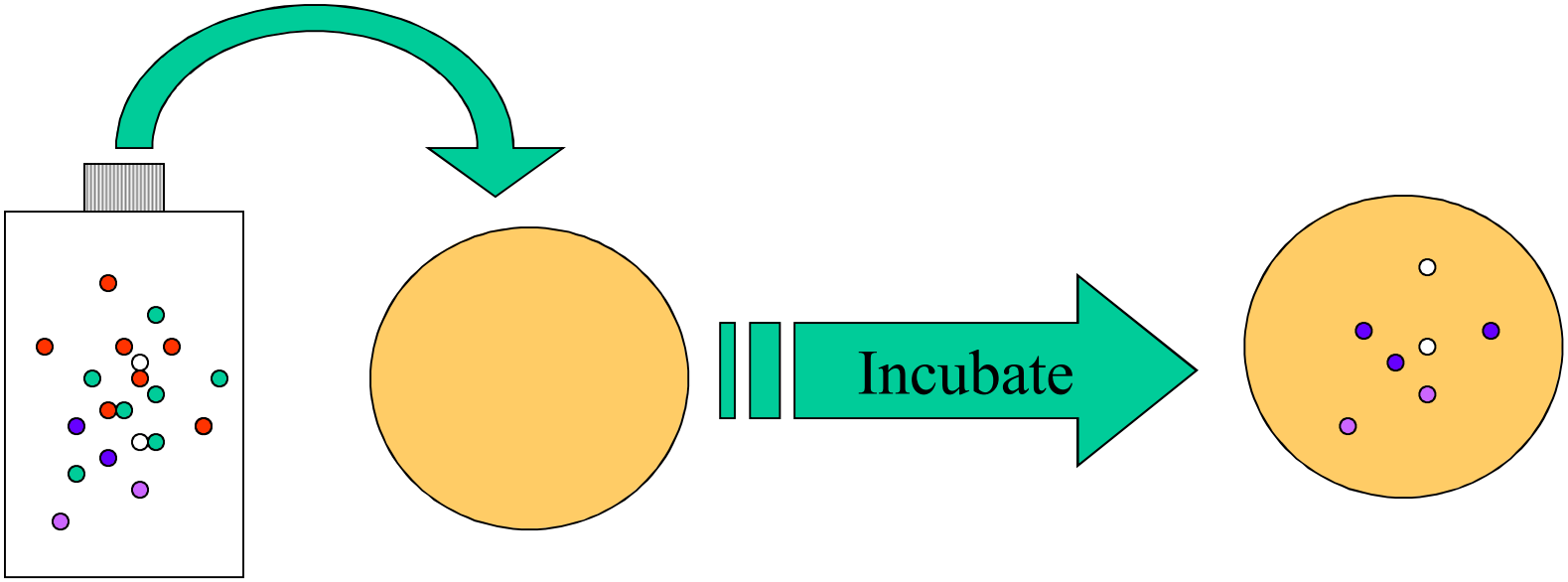
Estimation of Microbial Diversity.

- Fatty Acid Methyl Esters

- Molecular biology
- Targetting DNA which codes for ribosomal RNA.

- Microscopic Methods

Traditional Approach

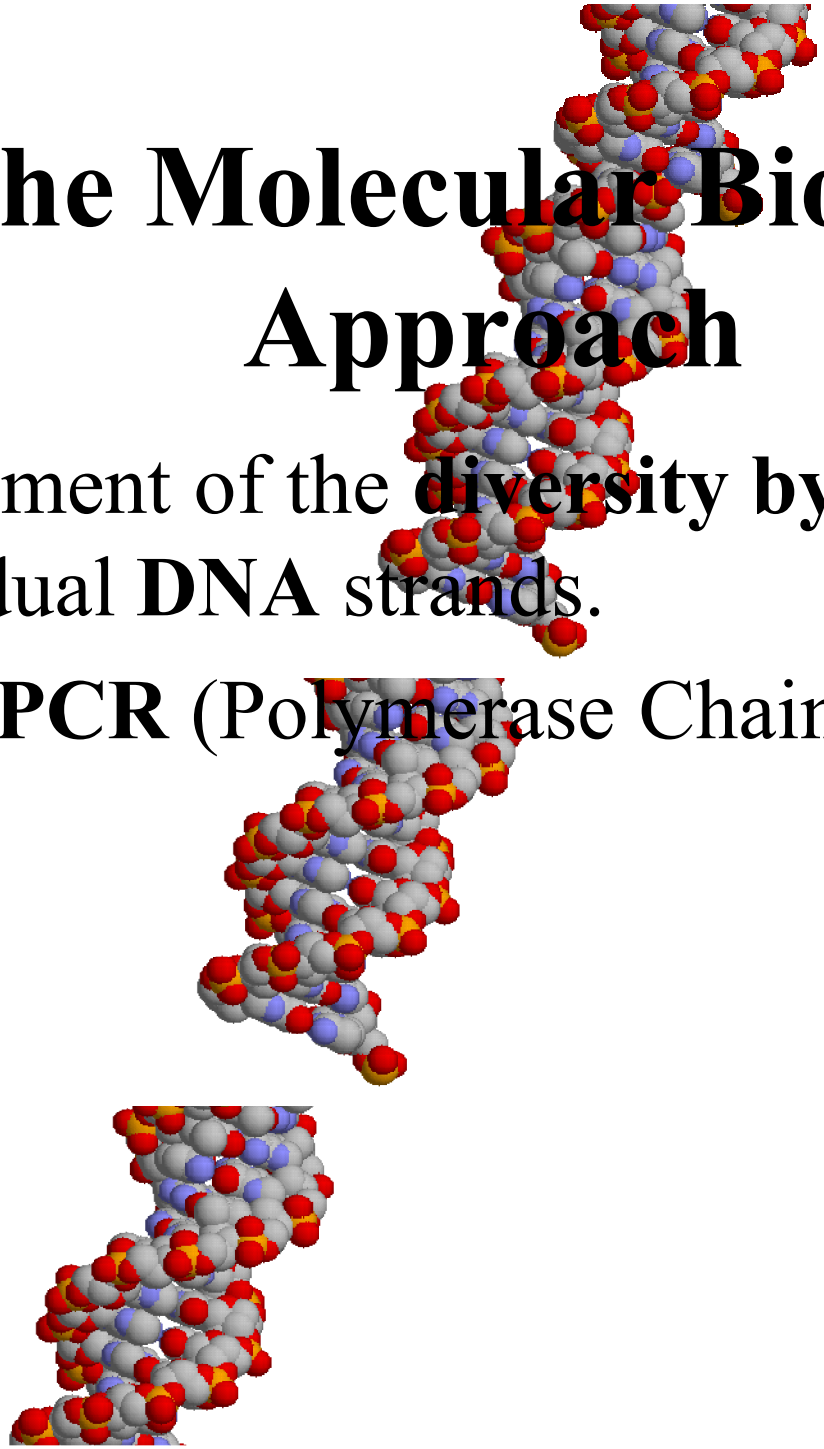


Inoculate

Only A Small Proportion Of Bacterial Species Grow

The Molecular Biology Approach

- Assessment of the **diversity by** the individual **DNA** strands.
- Using **PCR** (Polymerase Chain Reaction).



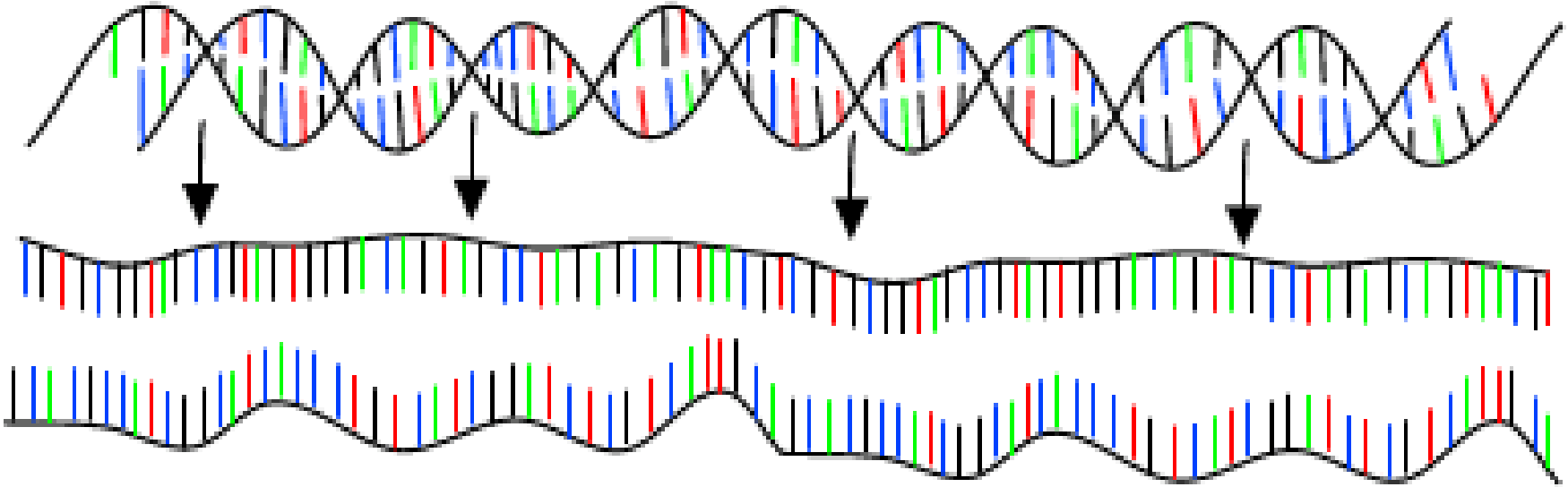
PCR

- PCR is:
  - inexpensive
  - simple method of producing relatively large numbers of copies of DNA molecules

     sensitive
- PCR involves
  - preparation of the sample,
  - the master mix
  - and the primers, followed by
- detection and analysis of the reaction products.

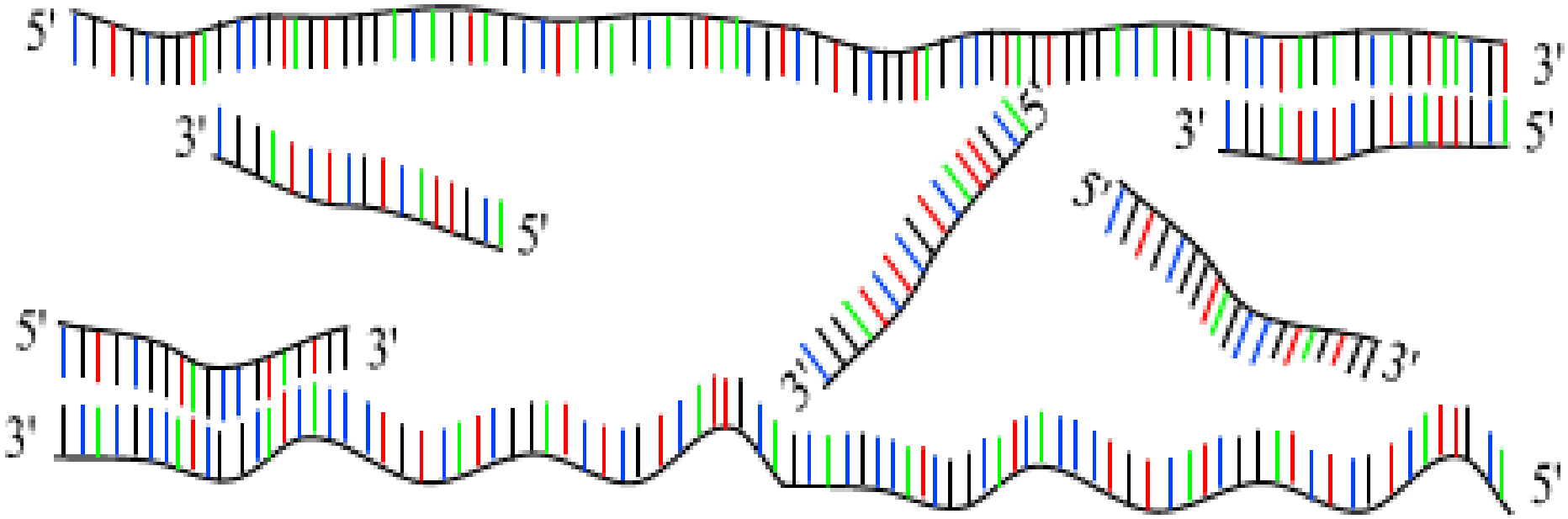
PCR

Step1: Denaturation of DNA 94°C, 1 Cycle, 15 sec



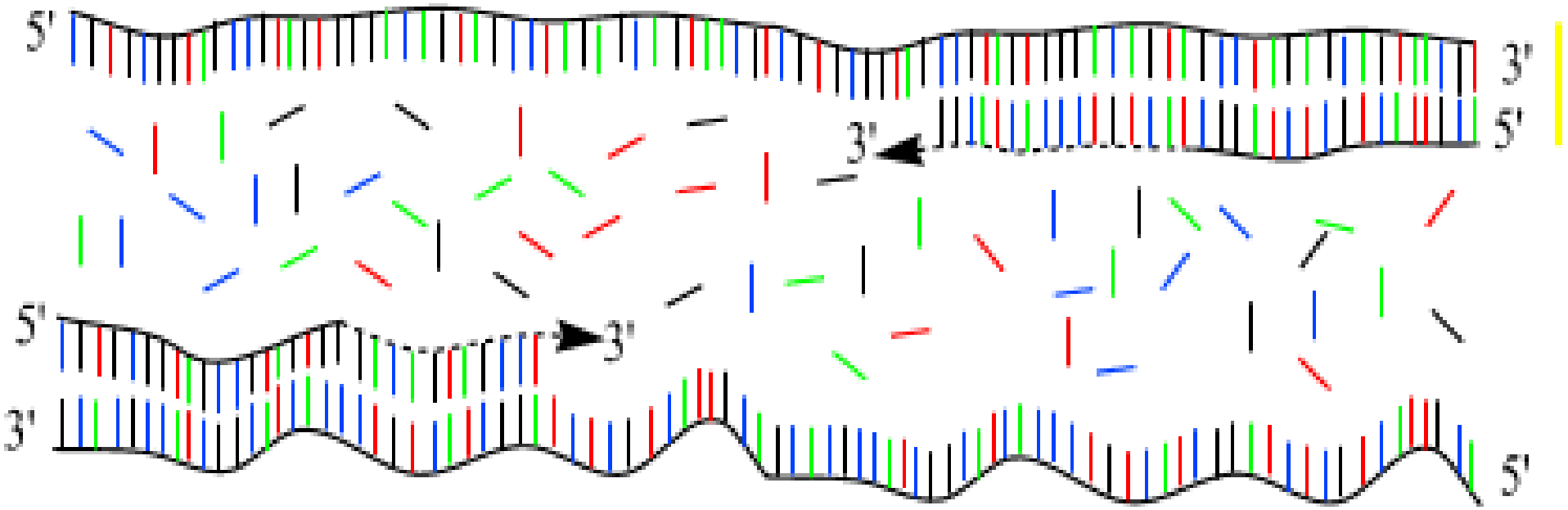
PCR

Step 2: Annealing of the primers, 57°C, 15 seconds



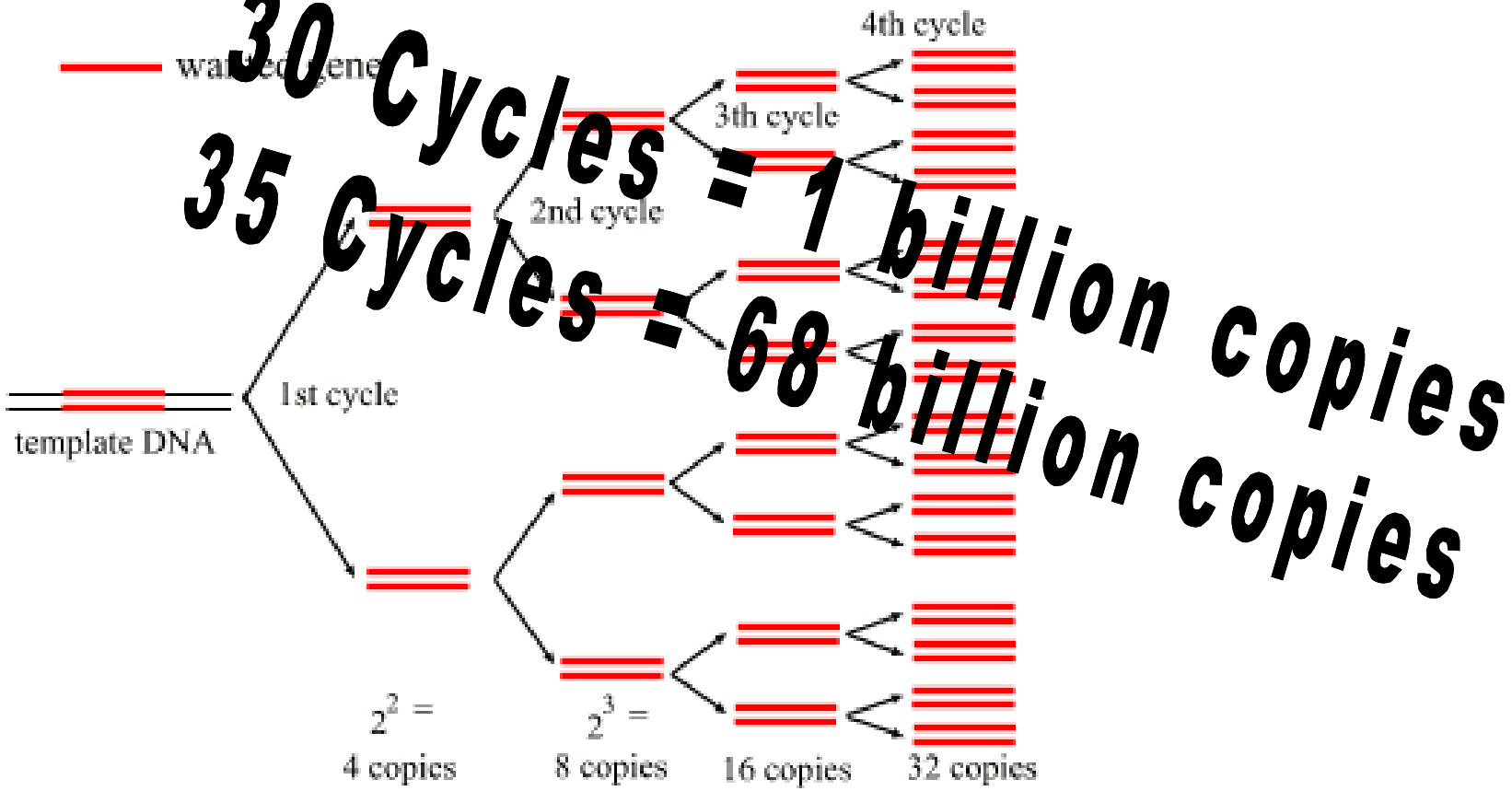
PCR

Step 3: Enzymatic Extension, 72°C , 2 minutes



PCR

Exponetial increase of copies



30 Cycles = 1 billion copies

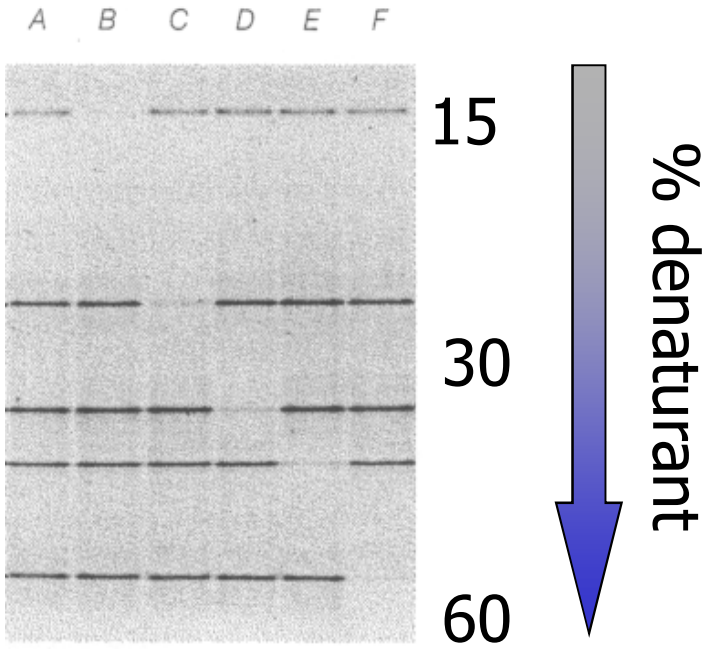
35 Cycles = 68 billion copies

PCR - DGGE

- The theory behind DGGE is very simple, the two strands of a DNA molecule separate, or melt, when heat or a **chemical denaturant** is applied.
- Separated by electrophoresis through a gradient of increasing chemical denaturant (usually formamide and urea)

PCR - DGGE

The branched structure of the single stranded part of the molecule becomes entangled in the gel matrix and no further movement occurs.



DGGE

- Tells you how many different types
- But not what they are.
- For that we need TA Clonining

(a) Gel Photograph (b)Schematic

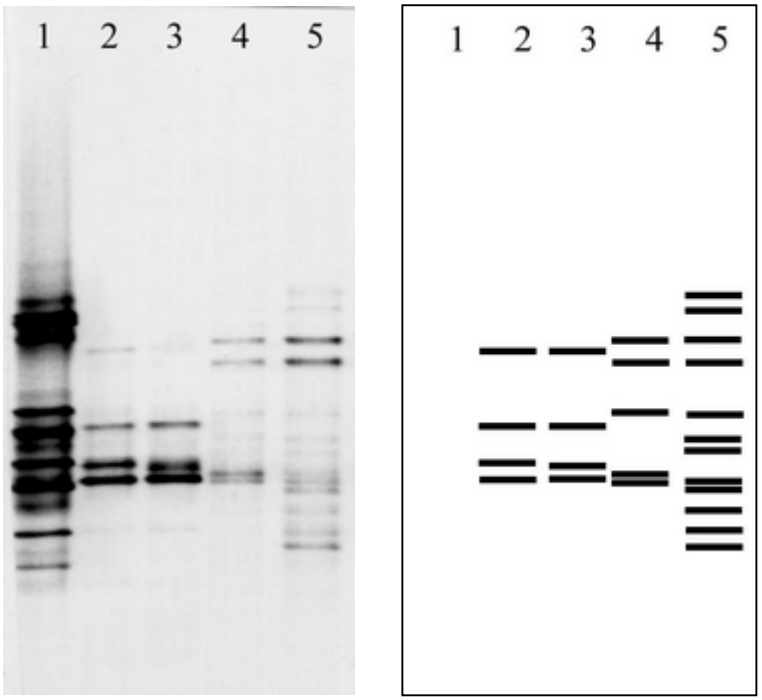
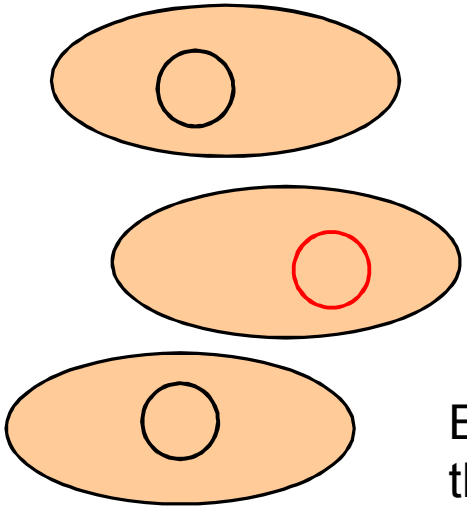
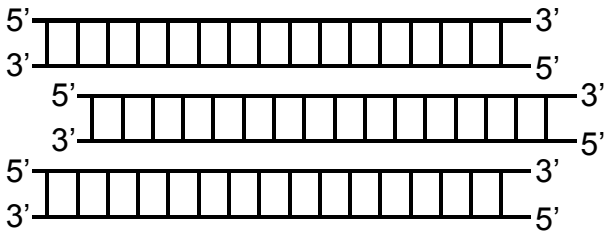


Figure 2.
DGGE analysis of DNA samples. Lane 1, laboratory strain makers; Lane 2 initial inoculum extracted using freeze thaw; Lane 3, initial inoculum extracted using bead beating; Lane 4 long term porous pavement bacterial population extracted using freeze thaw; Lane 5 long term porous pavement bacterial population extracted using bead beating.

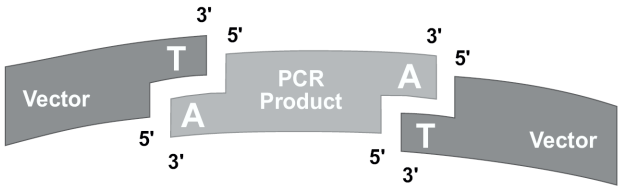


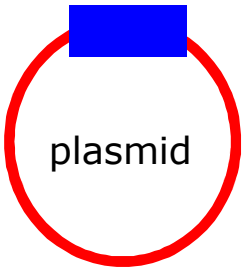
Extract DNA from the community

PCR with 16S rRNA primers



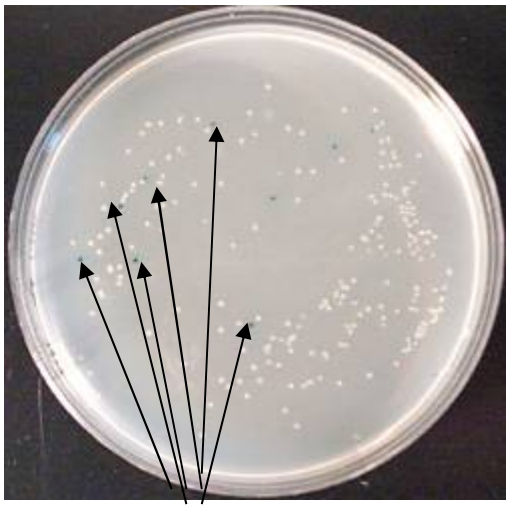
TA Ligation





Electroporation

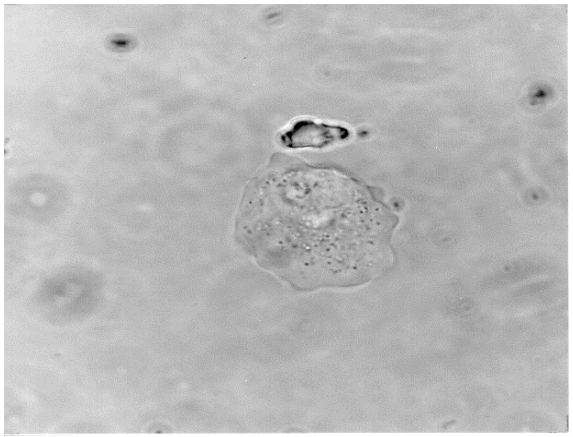
E. Coli

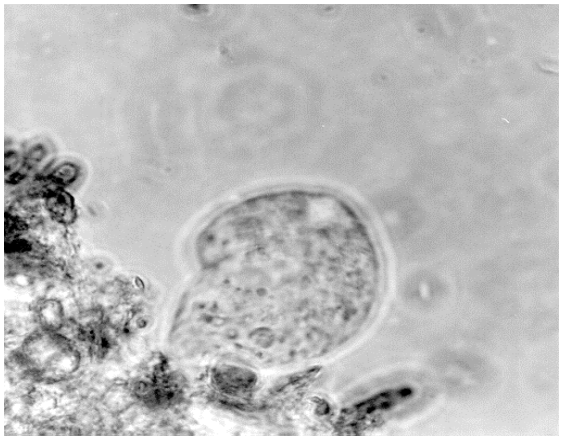


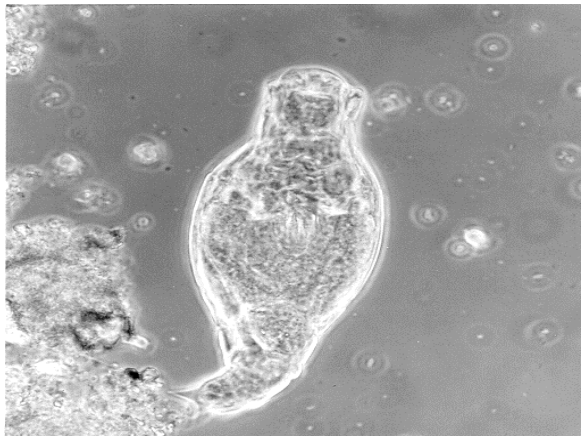
Blue colonies presumed not to carry an insert

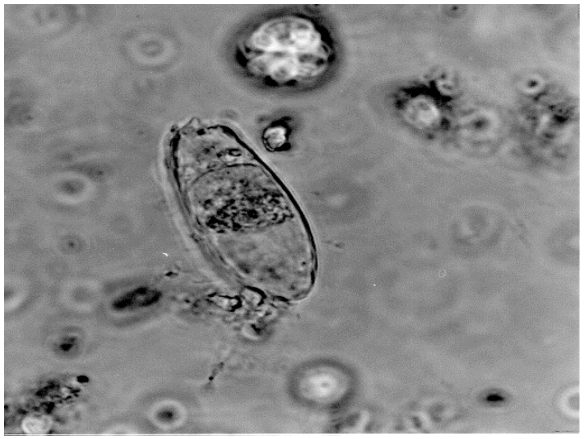
- In the Permaceptor model 40% of identified clones are from oil degrading species.

Protozoan/Metazoan Colonisation

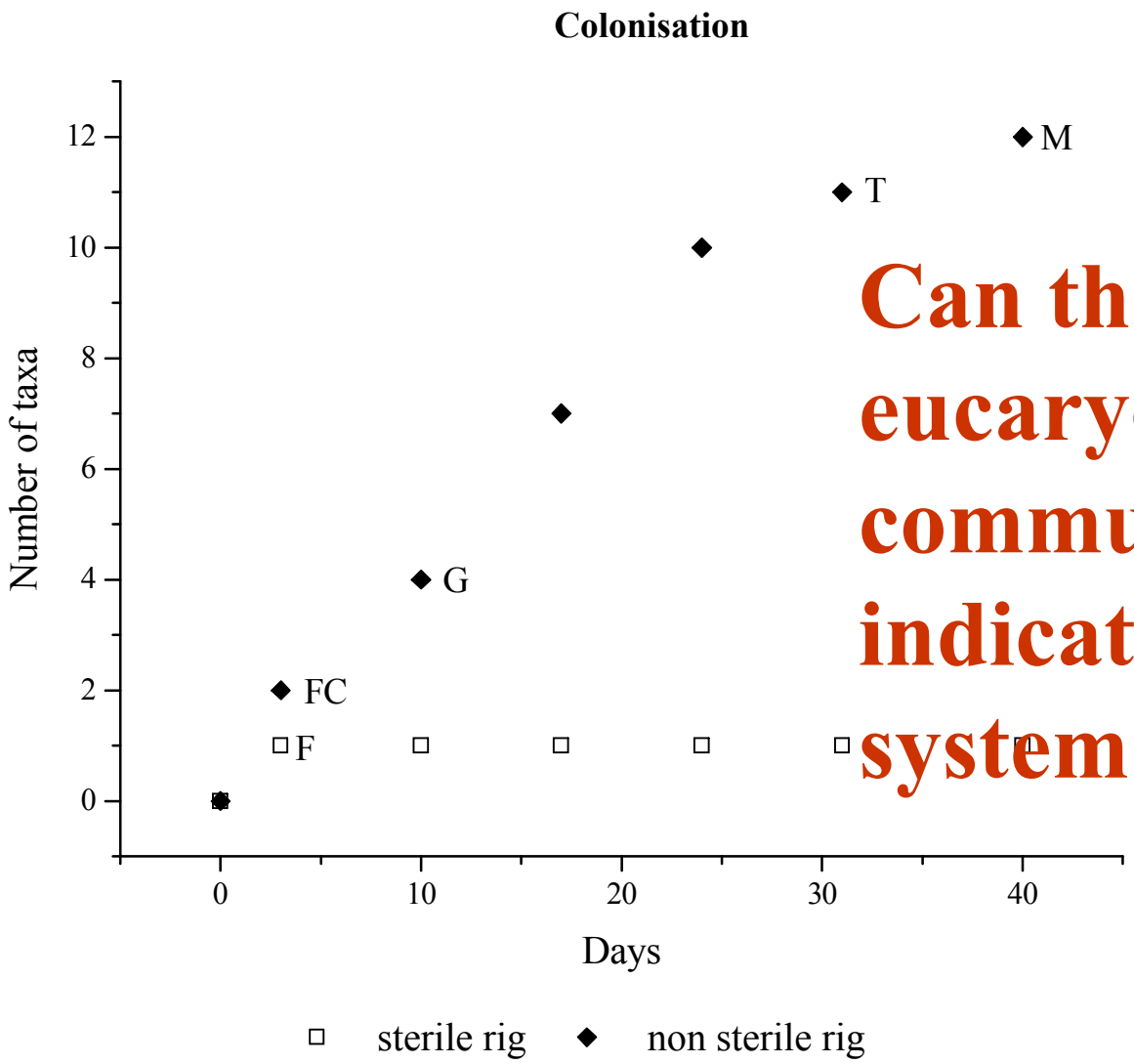








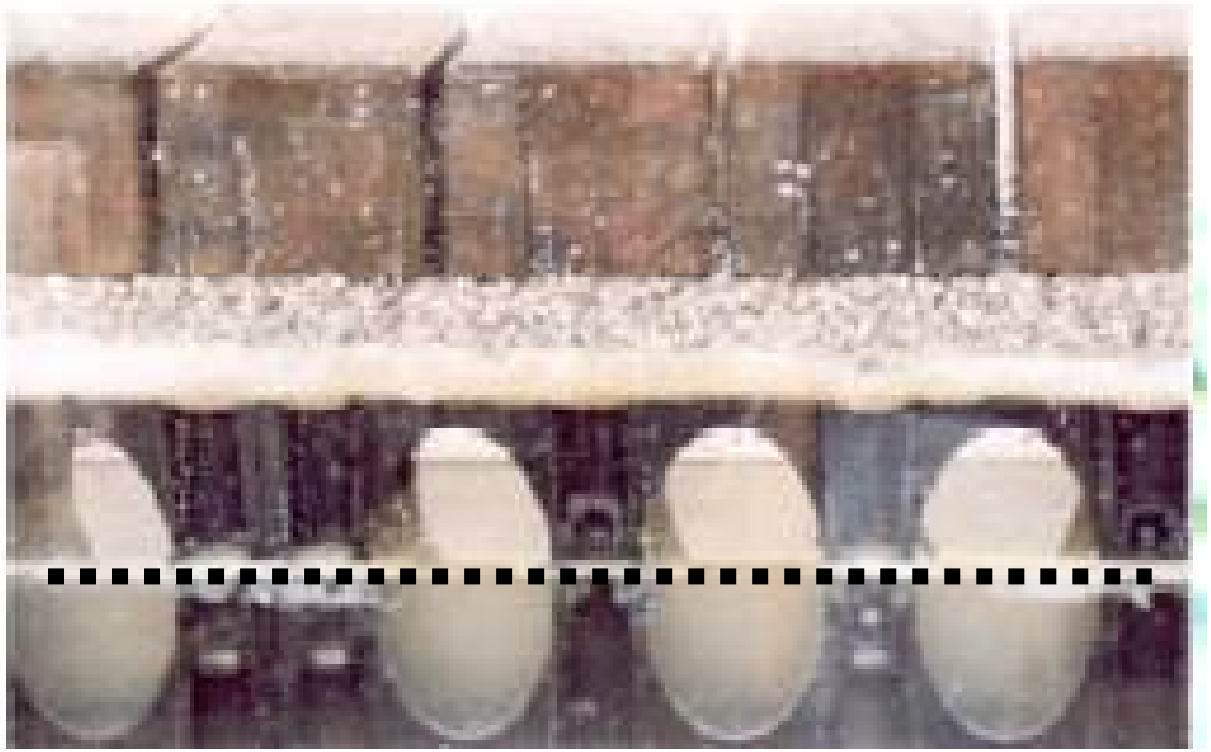
How fast does diversity develop ?



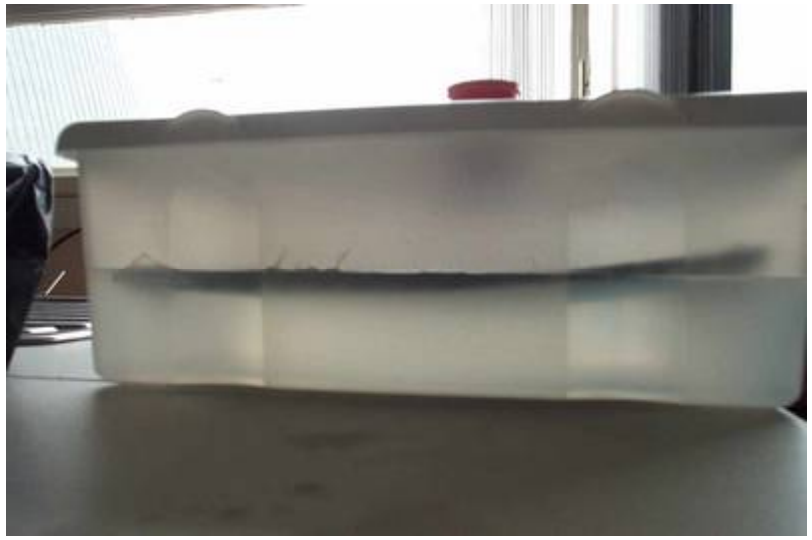
Can the eucaryotic community indicate system health?

New Developments

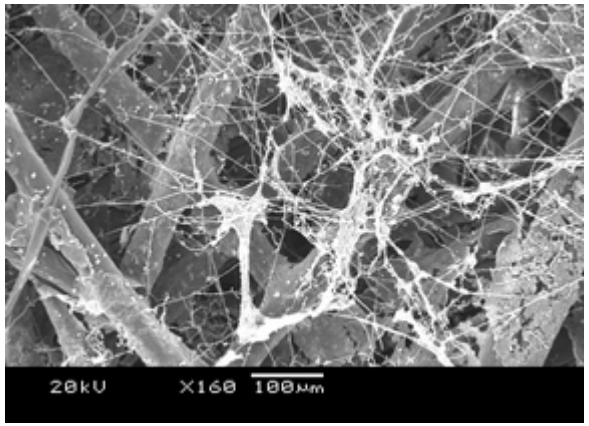
Floating Mat

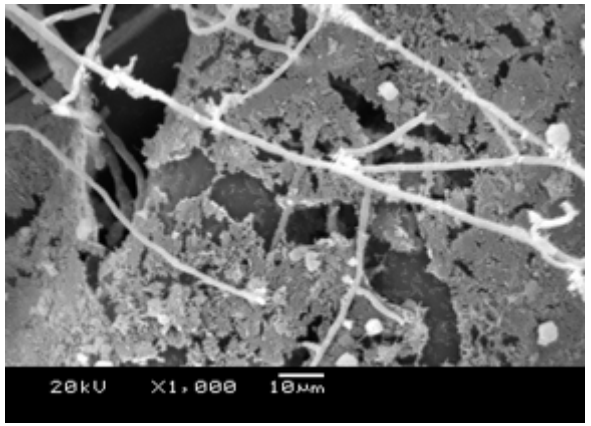


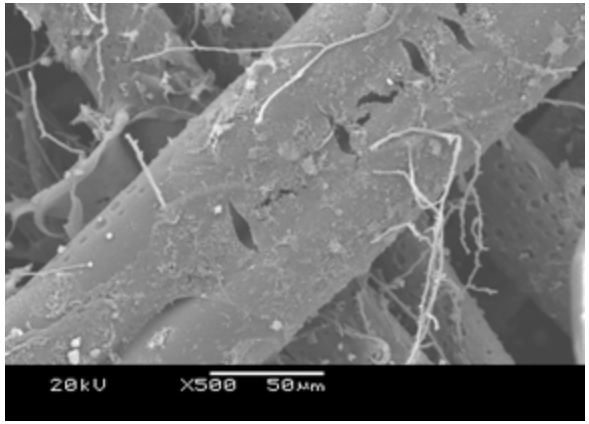
Floating Mat Expt. –10g/m^2 Oil

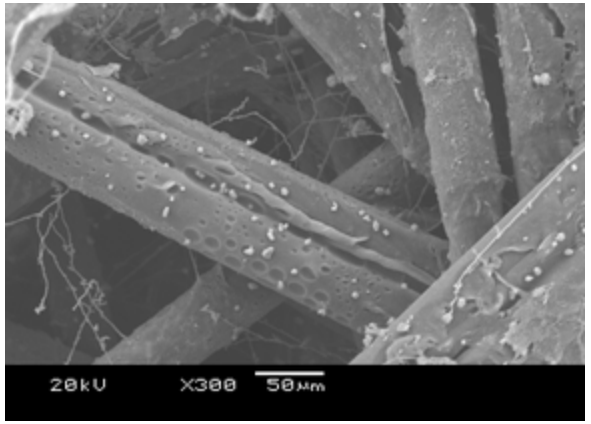


Floating Mat









Relative Biomass Levels

- Mats extracted in chloroacetic acid
- ATP content measured using firefly luciferin.
- ATP proportional to biomass.

Nutrient sample 30 times more biomass

New Test Beds

Other Avenues

Disciplines Involved

- Engineering

- Analytical Chemistry
- Synthetic Organic Chemistry

- Bacteriology
- Protozoology
- Biochemistry
- Plant Sciences
- Electron Microscopy

Current Incumbents

- Engineering-Chris Pratt , John Davies

- Analytical Chemistry-Alan Newman
- Synthetic Organic Chemistry- Danny Lynch, Gillian Spicer
- Bacteriology – Tim Puehmeier
- Protozoology-Steve Coupe, Humphrey Smith
- Biochemistry-Jackie Wong
- Plant Sciences-Michelle Barrett, Janey Henderson
- Electron Microscopy-Neil Cresswell

Acknowledgements

- DTI
- EPG
- EPSRC
- Formpave
- SEL Environmental
- Waste Recycling Group