AGRICULTURAL UNIVERSITY OF GEORGIA

Durmishidze Institute of Biochemistry and Biotechnology

Laboratory of biological oxidation

Tamar Varazi

Phytoremediation Technologies

- Biochemical criteria for selection of plants for phytoremediation
- Development of new approaches of phytoremediation

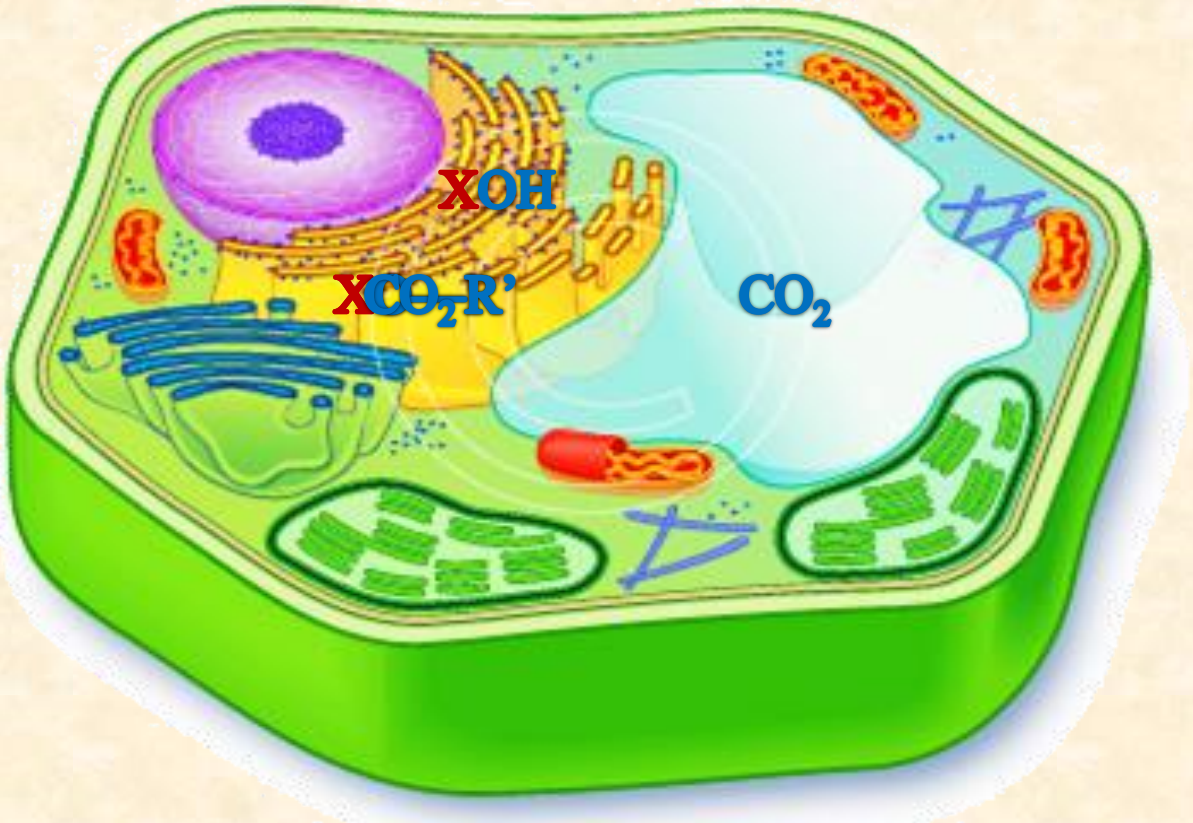
Investigation of Detoxification Potential of Plants

- Mechanisms of uptake and transformation of environmental pollutants in plant
- Plant enzymes (cytochrome P450-containing monooxygenases, peroxidases, phenoloxidases, transferases, etc.) participating in detoxification of environmental pollutants
- Plant response to environmental stresses

Transformation of xenobiotics in plant cell

XH

Deep oxidation

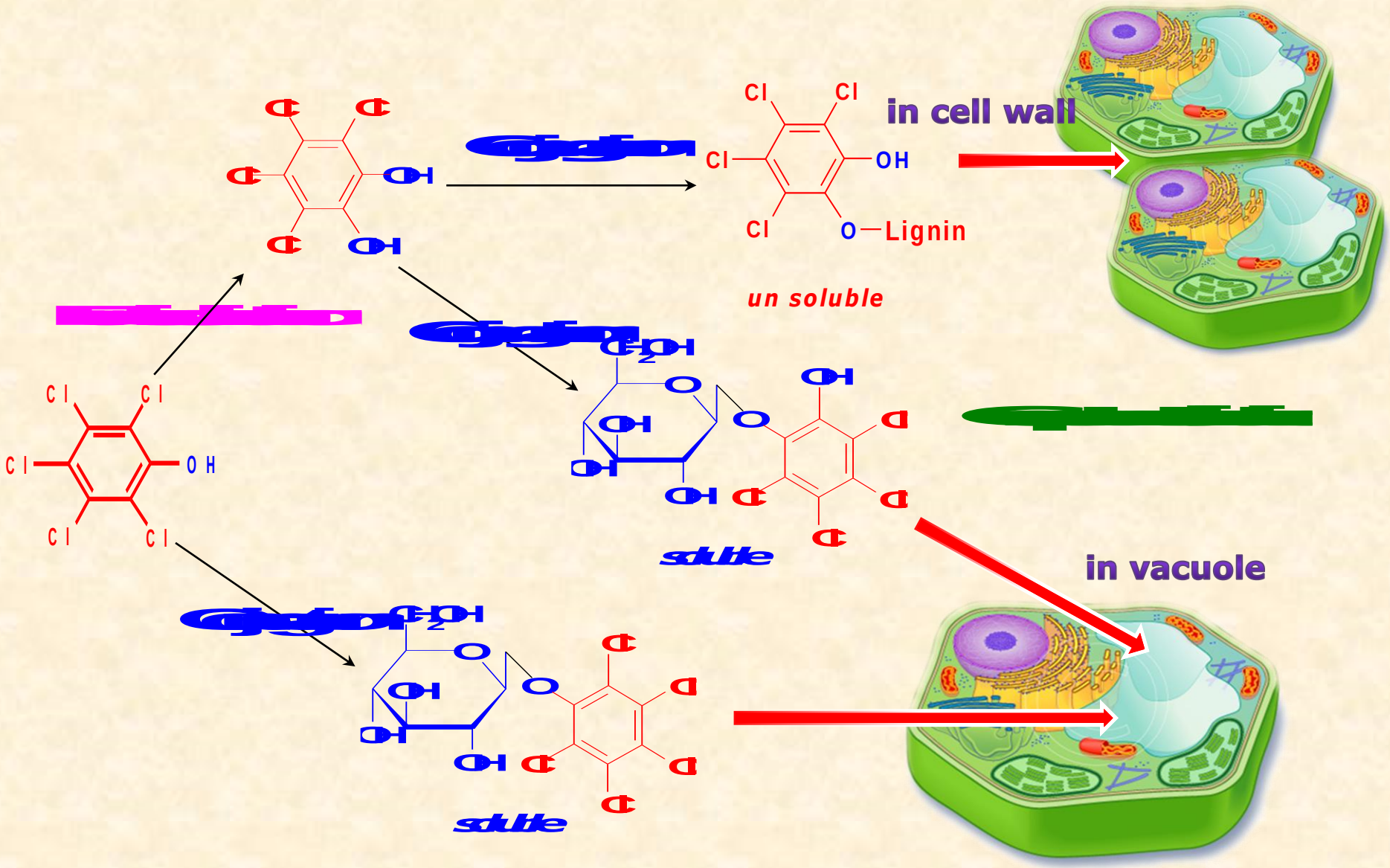


I Phase: Functionalization

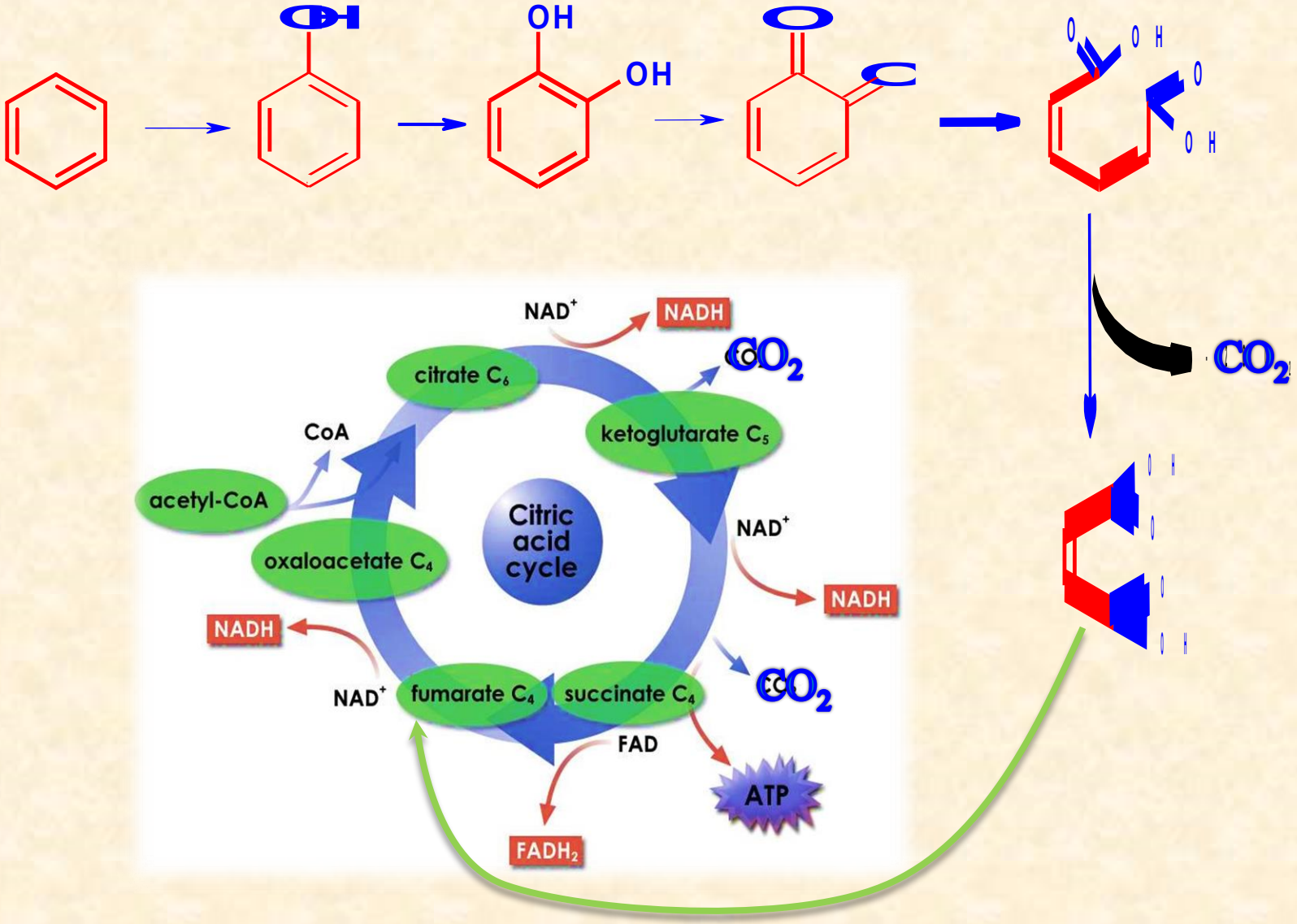
II Phase: Conjugation

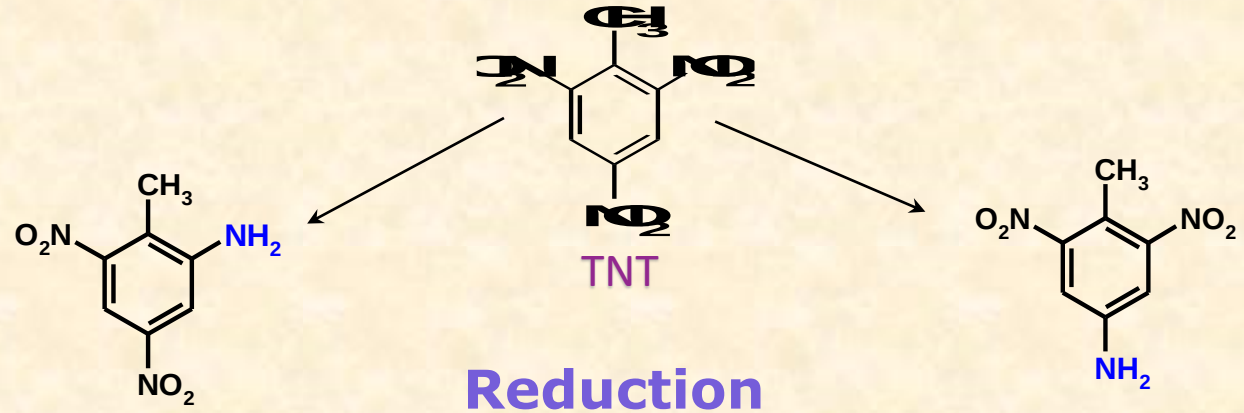
III Phase: Compatrmentalization

Pentachlorophenol Transformation and Deposition in Plants

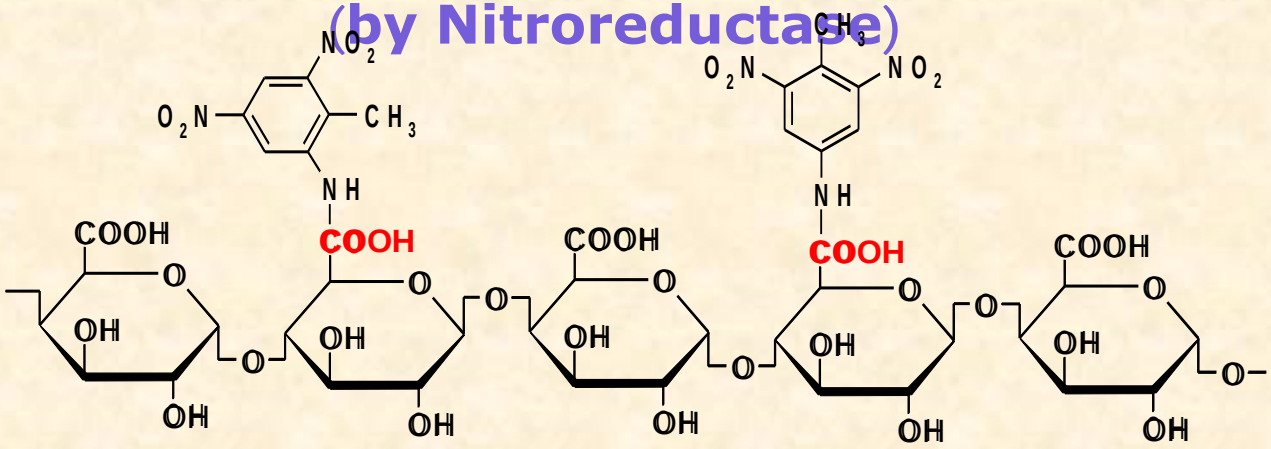


Deep Oxidation



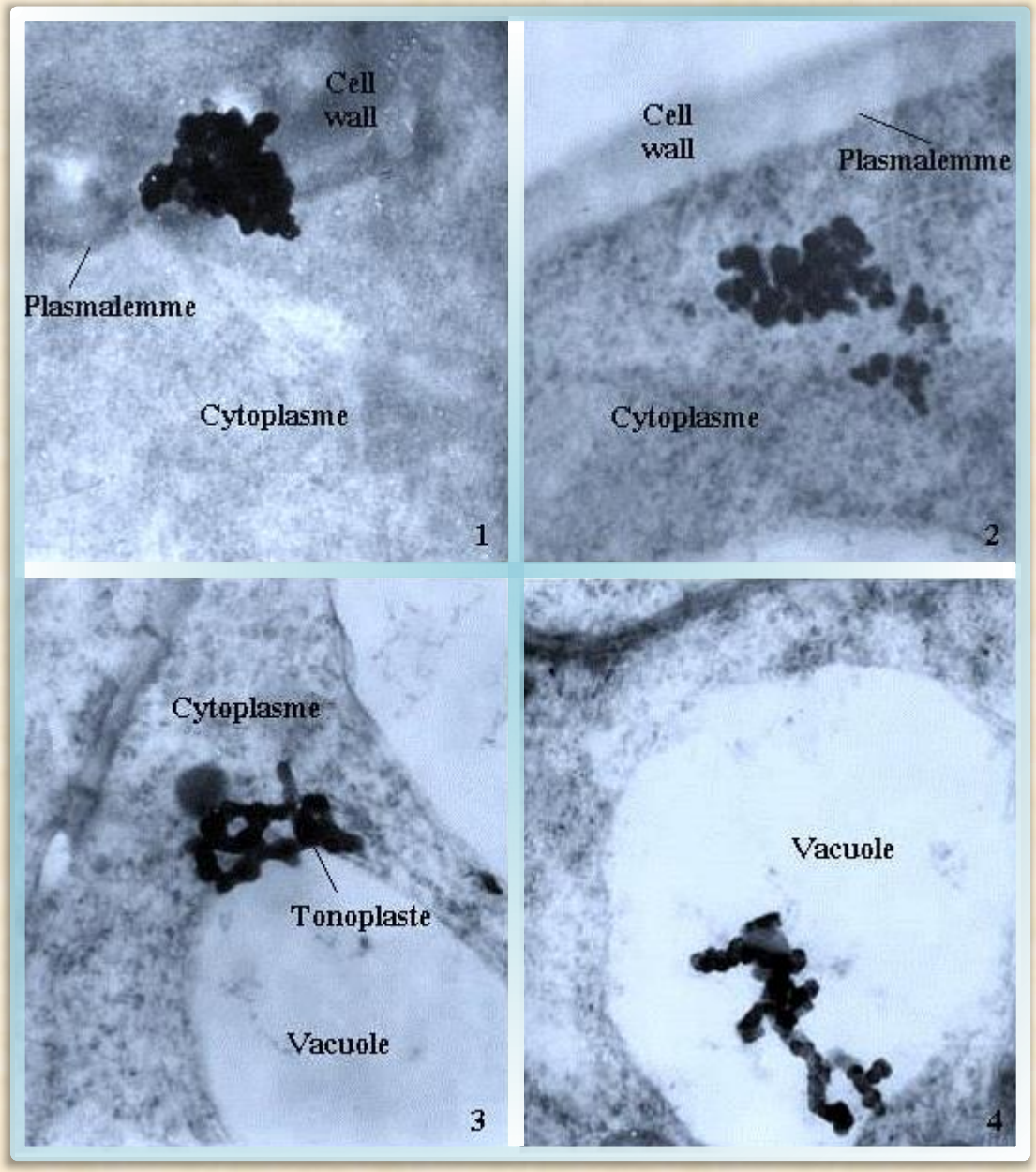


Reduction
(by Nitroreductase)



Conjugation with hemicellulose

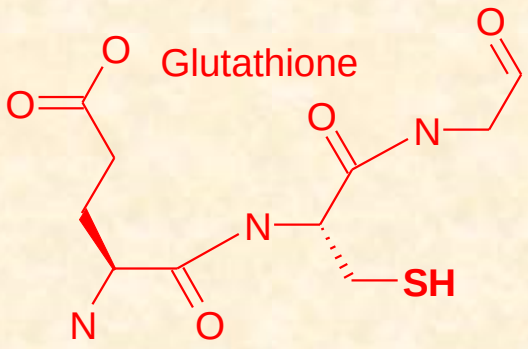
Movement of xenobiotic in plant cell

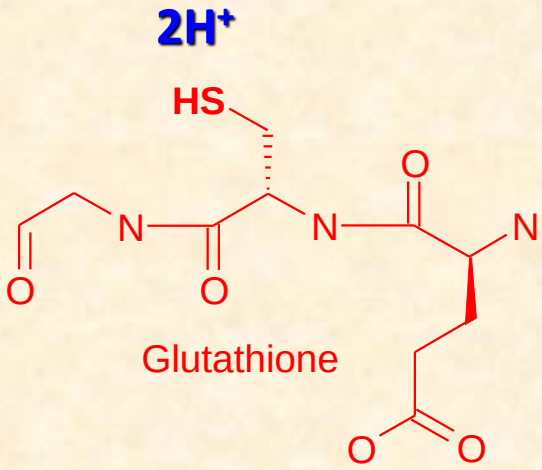


Enzymes participating in transformation

I phase Functionalization	II phase Conjugation	III phase Compartmentalization
Oxidases: *Cytochrome P450-containing monooxigenase (EC 1.14.14.1)* *Peroxidase (EC 1.11.1.7)* *Phenoloxidase (EC 1.14.18.1)* **Reductases**: *Nitroreductase (EC 1.6.6)* **Dehalogenases** **Esterases** *Arylesterase (EC 3.1.1.2)* *Lysophospholipase (EC 3.1.1.5)* *Acetylesterase (EC 3.1.1.6)* *Carboxylesterase (EC 3.1.1.1)* *Acid phosphatase (EC 3.1.3.2)* *Alkaline phosphatase (EC 3.1.3.1*	**Transferases**: *Glutathione S-transferase (EC 2.8.1.18)* *O-glucosyl-transferase (EC 2.4.1.7)* *N-glucosyltransferase (EC 2.4.1.71)* *N-malonyltransferase (EC 2.3.1.114)* *Putrescine N-methyl-transferase (EC 2.1.1.53)*	ATP-binding cassette (ABC) transporters

Bind of Heavy Metal Cation by Glutathione





Me^{2+}

Advantages of Phytoremediation:

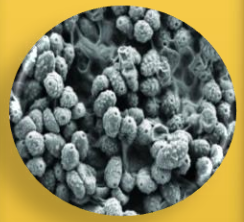
Cost effective
Universal to different chemicals
Universal to contaminated object
Ecologically friendly
Landshaft design
Erosion control
Long term protection

Shortcomings of Phytoremediation

Duration
Toxicity of plants after remediation
Residual contamination
(e.g. resin mass of oil hydrocarbons)

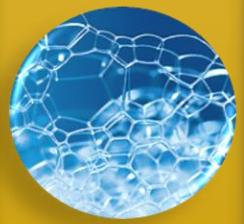
Biological and chemical tools

Highly active microbial preparations based on strains from different taxonomic groups for degradation of oil hydrocarbons



Fungi

Local (endemic) plants tolerant to oil pollution for extraction of oil degradation products resulted from the microbial activity followed by their metabolic digestion, as well as promotion of microbial degradation in rhizosphere



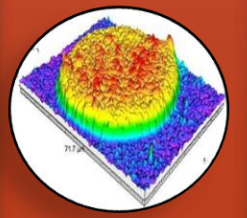
Biosurfactants (surface-active substances of microbial origin) for desorption and solubilization of hydrocarbons as well as the increase of their bioavailability for biodegradation and elimination by plants. Biosurfactants are easily biodegradable unlike the available chemical surfactants currently used for such purposes

The following biological and chemical tools will be used in the new technology:

Plant nutrition preparations for enhancement of the plant metabolic activities

Chemical oxidants for partial decomposition of contaminants and provision of additional aeration stimulating the bioremediation process

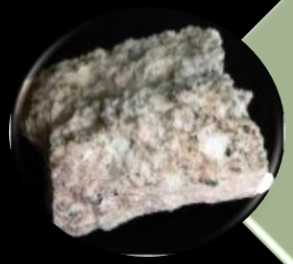
Natural sorbents for prevention of the distribution of pollutants and products of their partial degradation (often toxic)



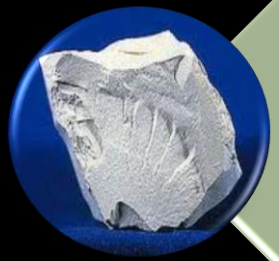
Biochips – Strategy of Bioaugmentation

TESTED SORBENTS

Klinoptilolite – Sodium Potassium Calcium Aluminum Silicate Hydrate
Class – Silicate Subclass – Tectosilicate
Group – Zeolite
Application – Chemical filter, Absorbent, Water cleansing



Montmorillonite – Sodium Calcium Aluminum Magnium Silicate Hydrate
Class – Silicate Subclass – Phylosilicate
Group – Cley – Smektites Aplication – Water cleansing



Bentonite – Aluminum silicate
Class – Silicate Subclass – Phylosilicate
Group – Cley – Caolinite
Aplication – Preparation ceramic products, Paper production, Fillers to paints

Vinobent – Sorbent

Litobente – Detergent

TESTED PLANTS

Maize (*Zea mays*)

Soybean (*Glycine max*)

Alfalfa (Medicago sativa)

Chickling vetch (*Lathyrus sativum*)

TESTED PLANTS

Ryegrass (Lolium multiflorum)

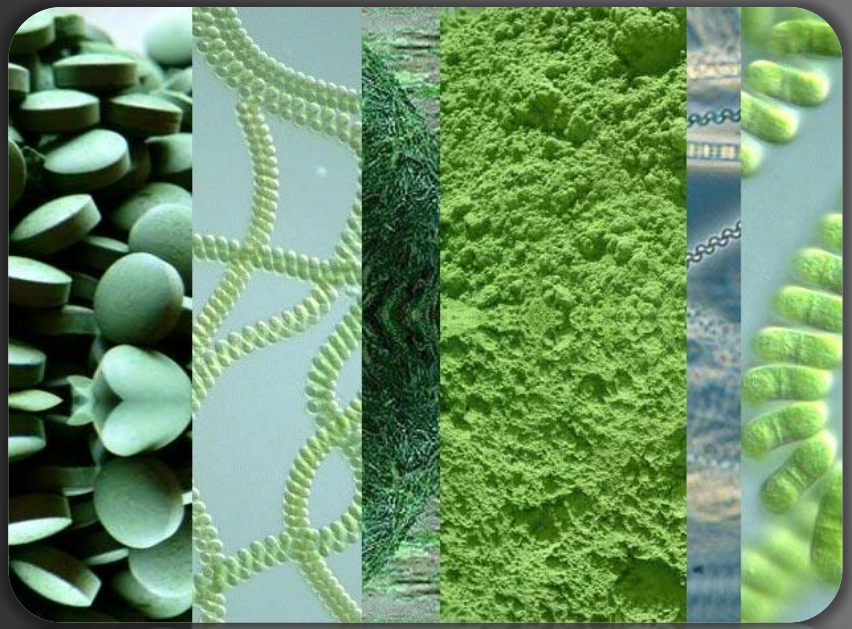
Chickpea (Cicer arietinum)

China bean (Vigna sinensis)

Mung bean (Vigna radiata)

Development of a novel technology for cleaning chemically polluted waters by using algae Spirulina

Spirulina



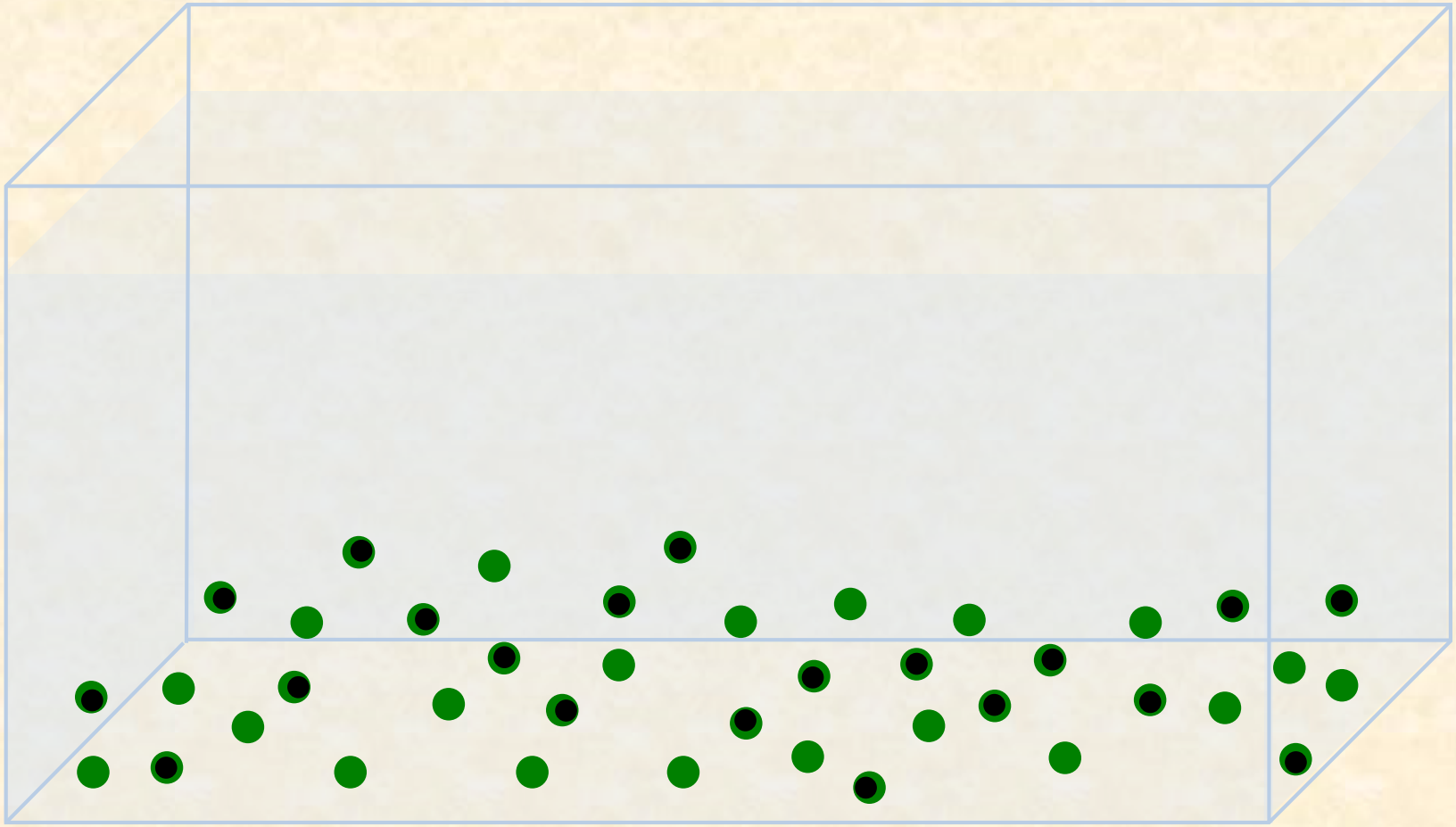
Evaluation of Remediation Potential of Cyanobacteria Spirulina (Arthrospira platensis)

- Study of enzymes:
  - Oxidative enzymes (P450, Peroxidase, phenoloxidase)
  - Glutathione S-transferase
  - Nitroreductase

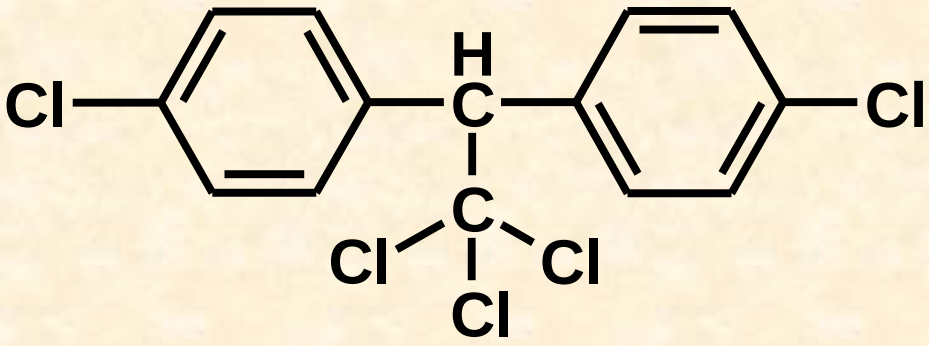
- Enhancement of remediation abilities of Spirulina
  - by biosurfactants (in case of organic pollutants)
  - by polysaccharides (in case of heavy metals)

TECHNOLOGICAL SCHEME

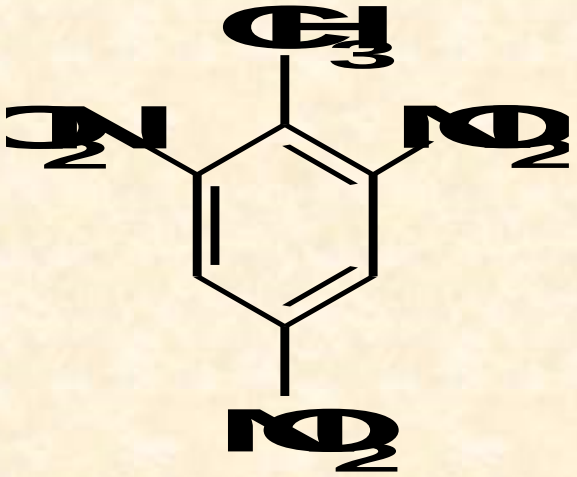
- Pollutants
- Spirulina



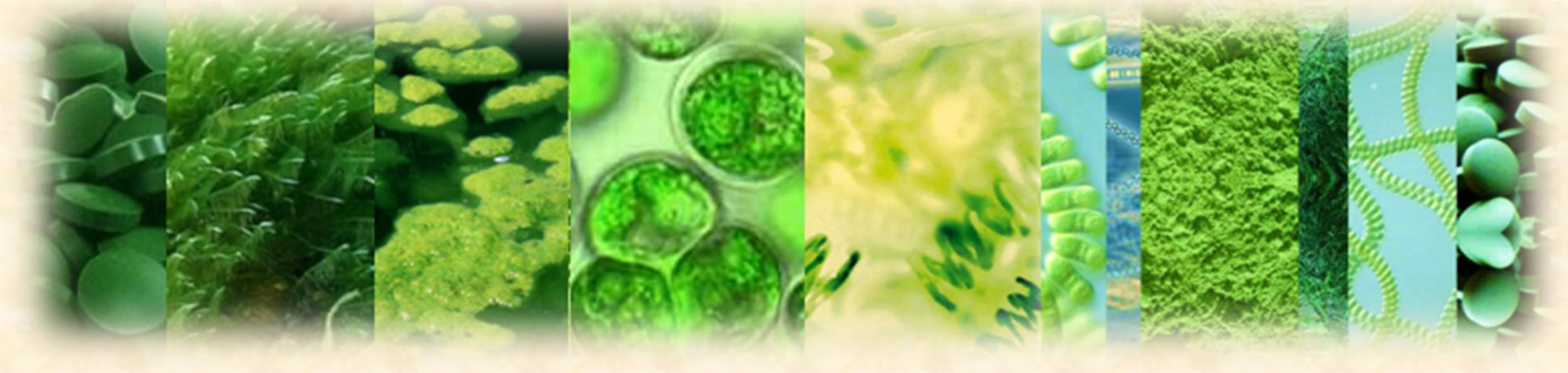
ENVIRONMENTAL POLLUTANTS



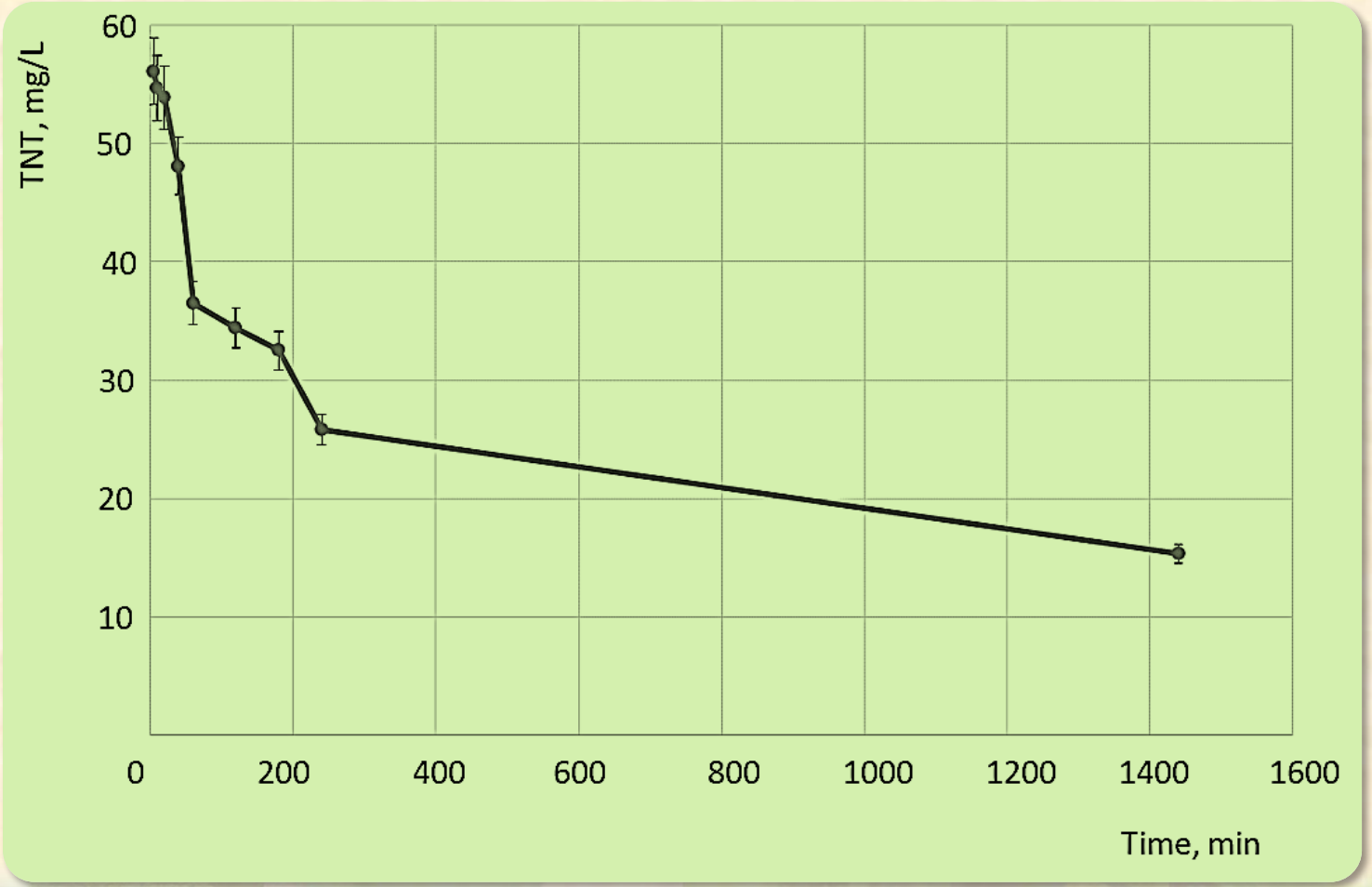
DDT

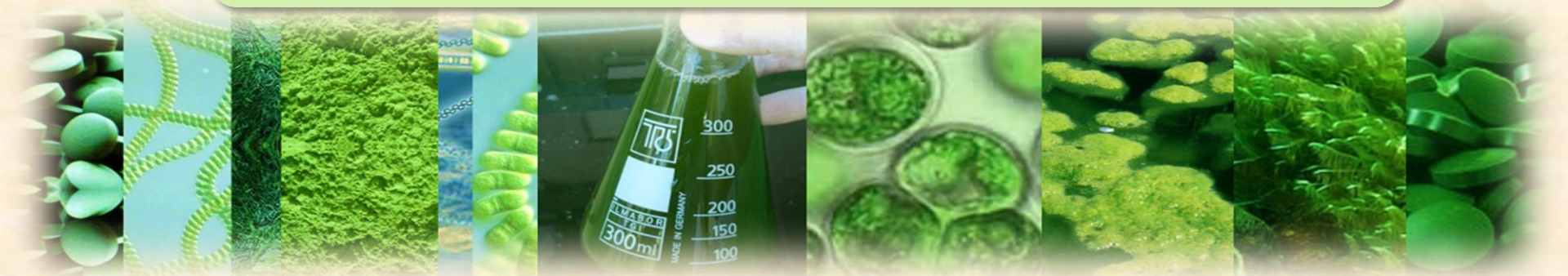


TNT

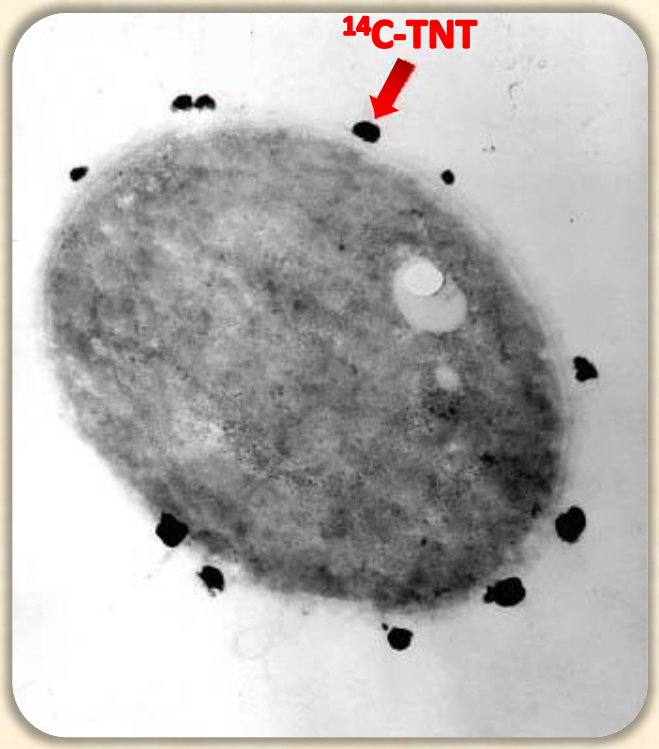


TNT utilization by Spirulina

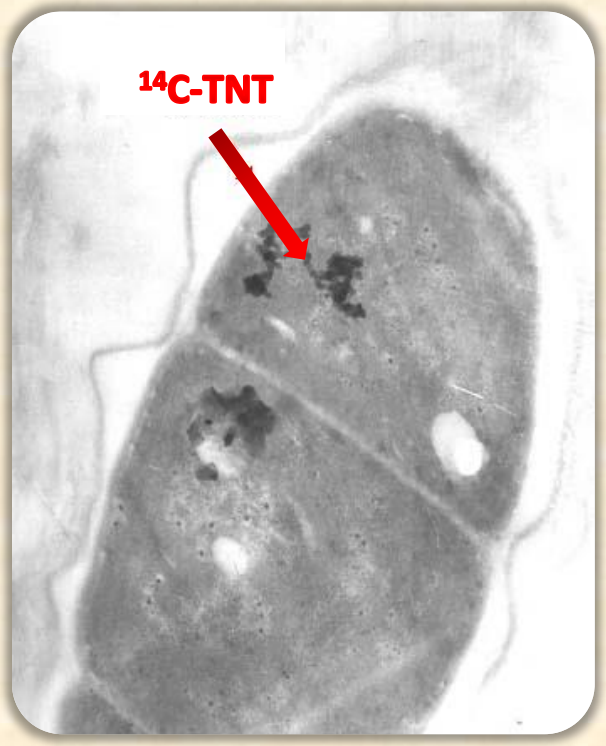




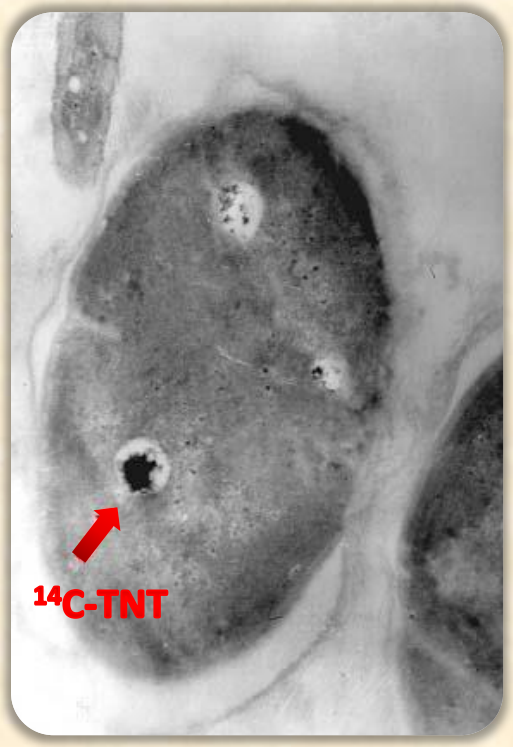
^{14}C-TNT utilization by Spirulina



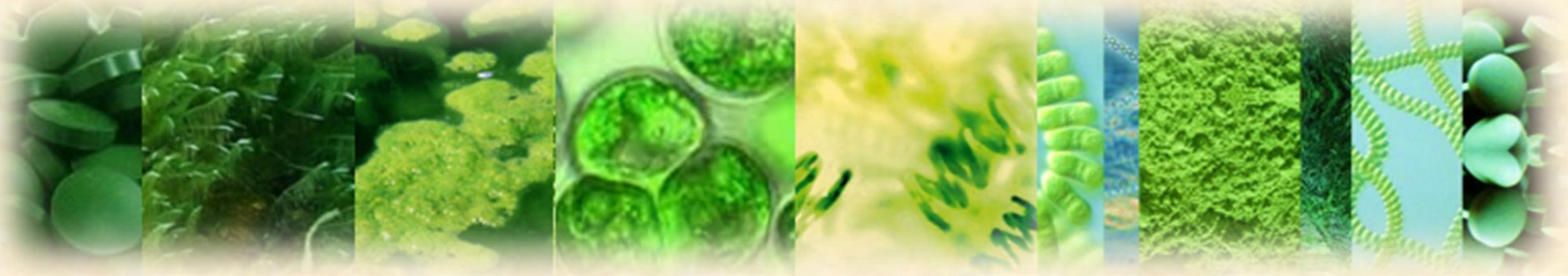
After 30 min



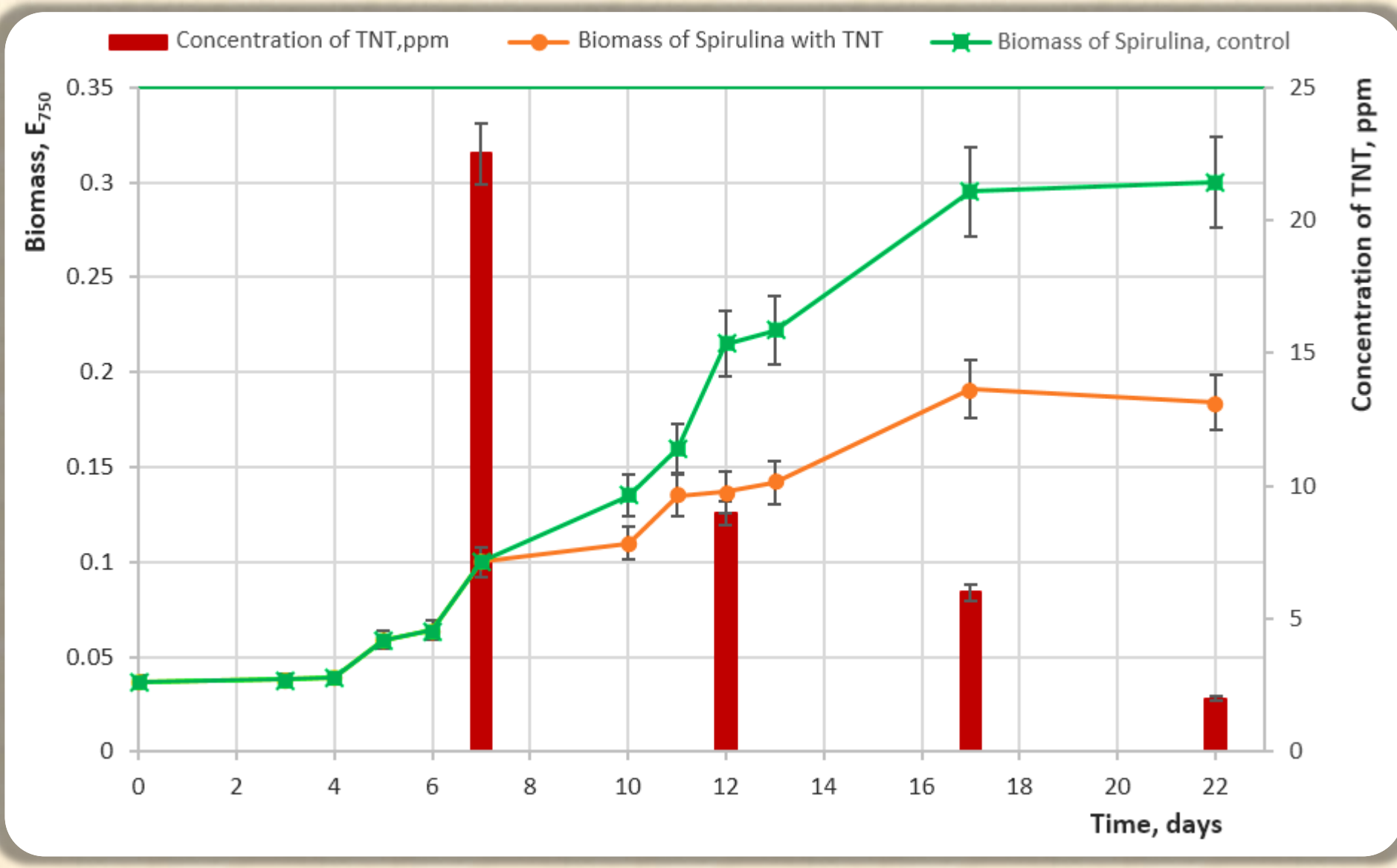
After 1 h



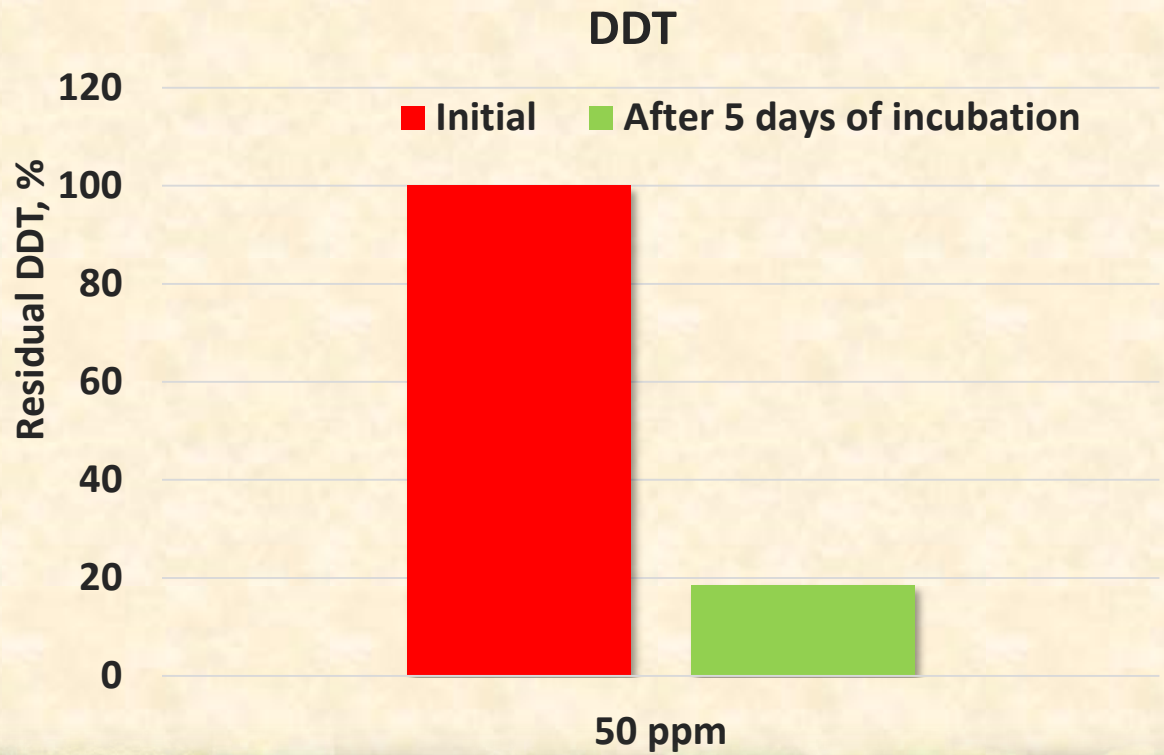
After 1 day

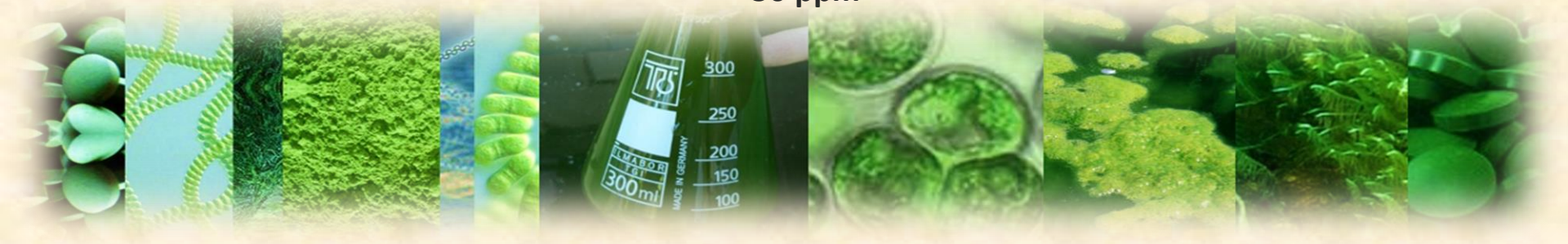


Cleaning TNT containing water by using Spirulina

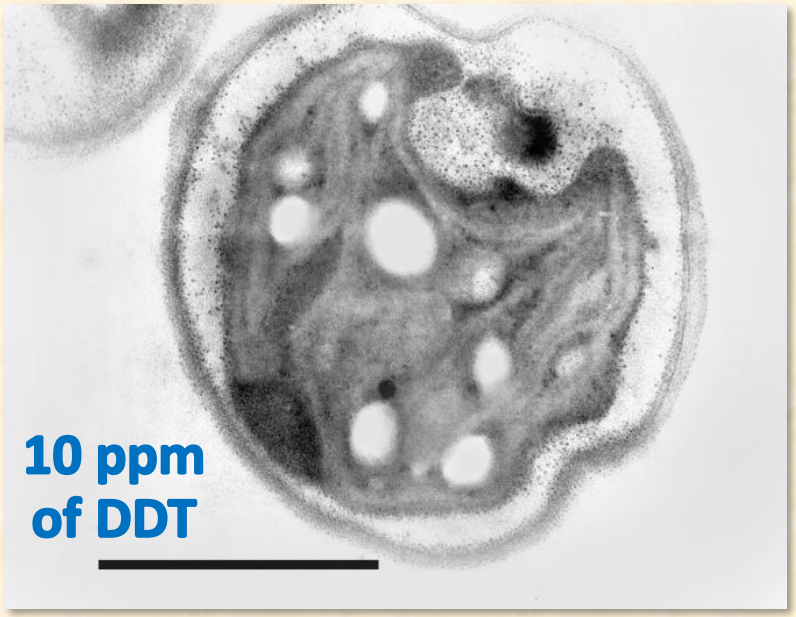


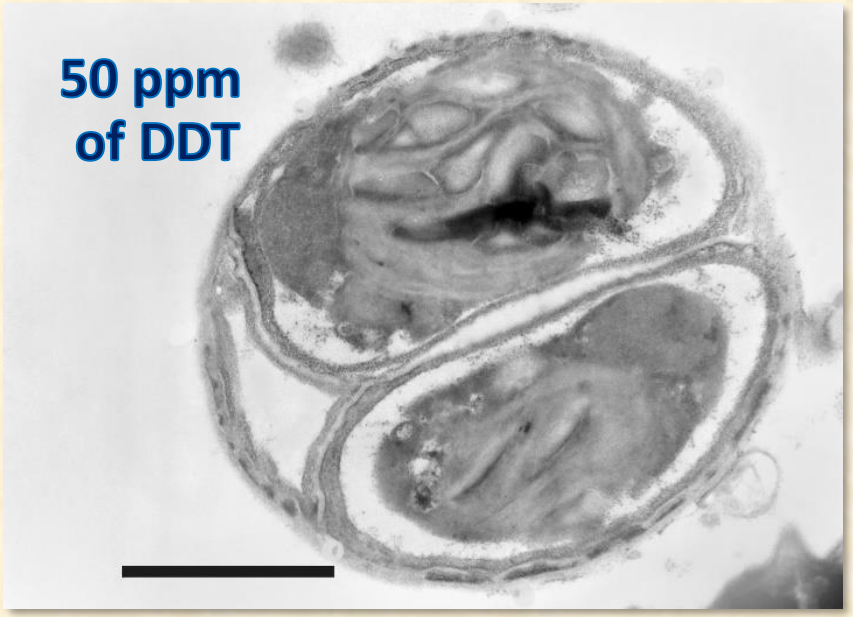
The uptake of different concentrations of DDT from cultivation area by *Spirulina*. The control sample didn't contain algae *Spirulina*



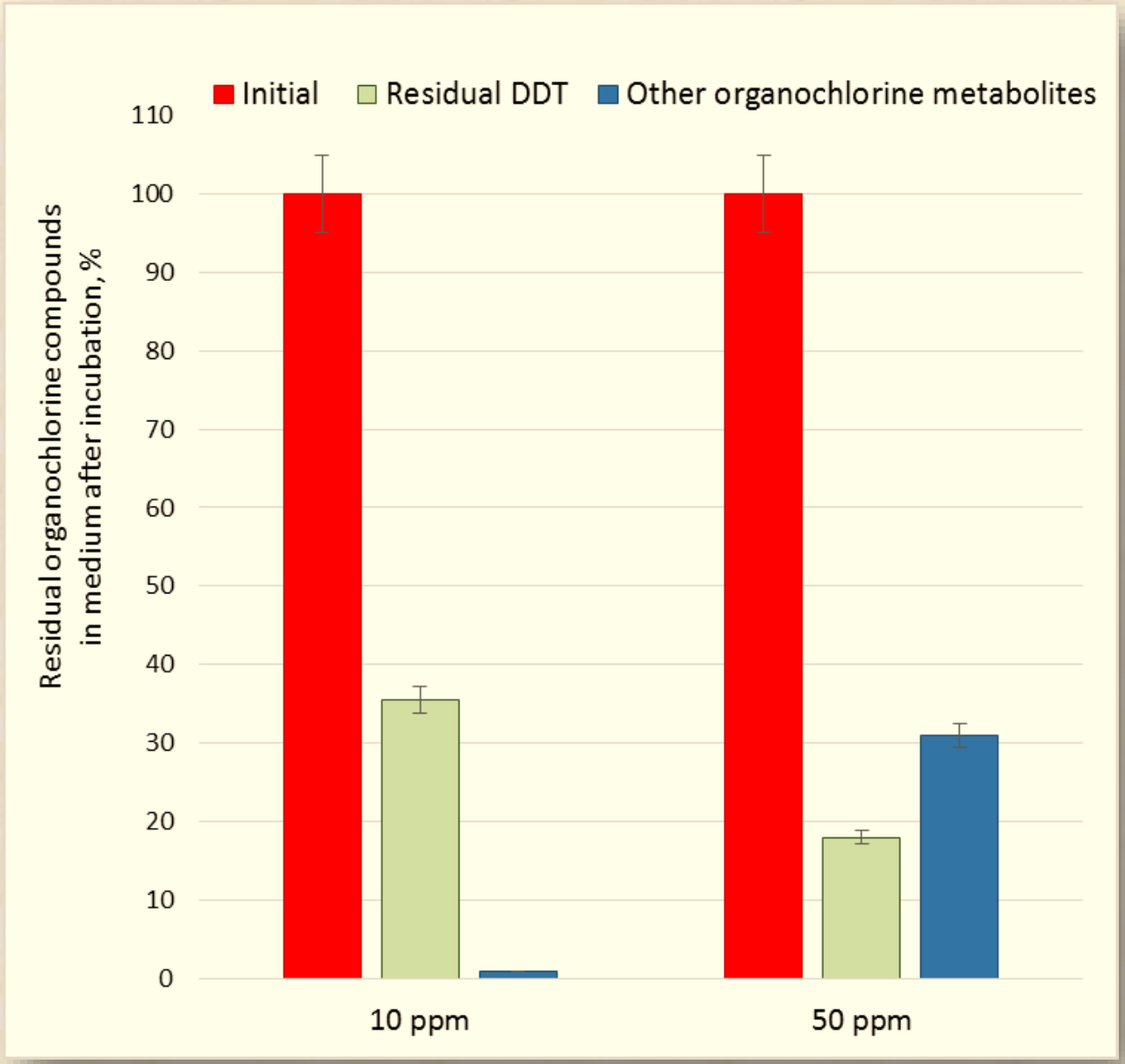


THE INFLUENCE OF DDT ON SPIRULINA CELLS

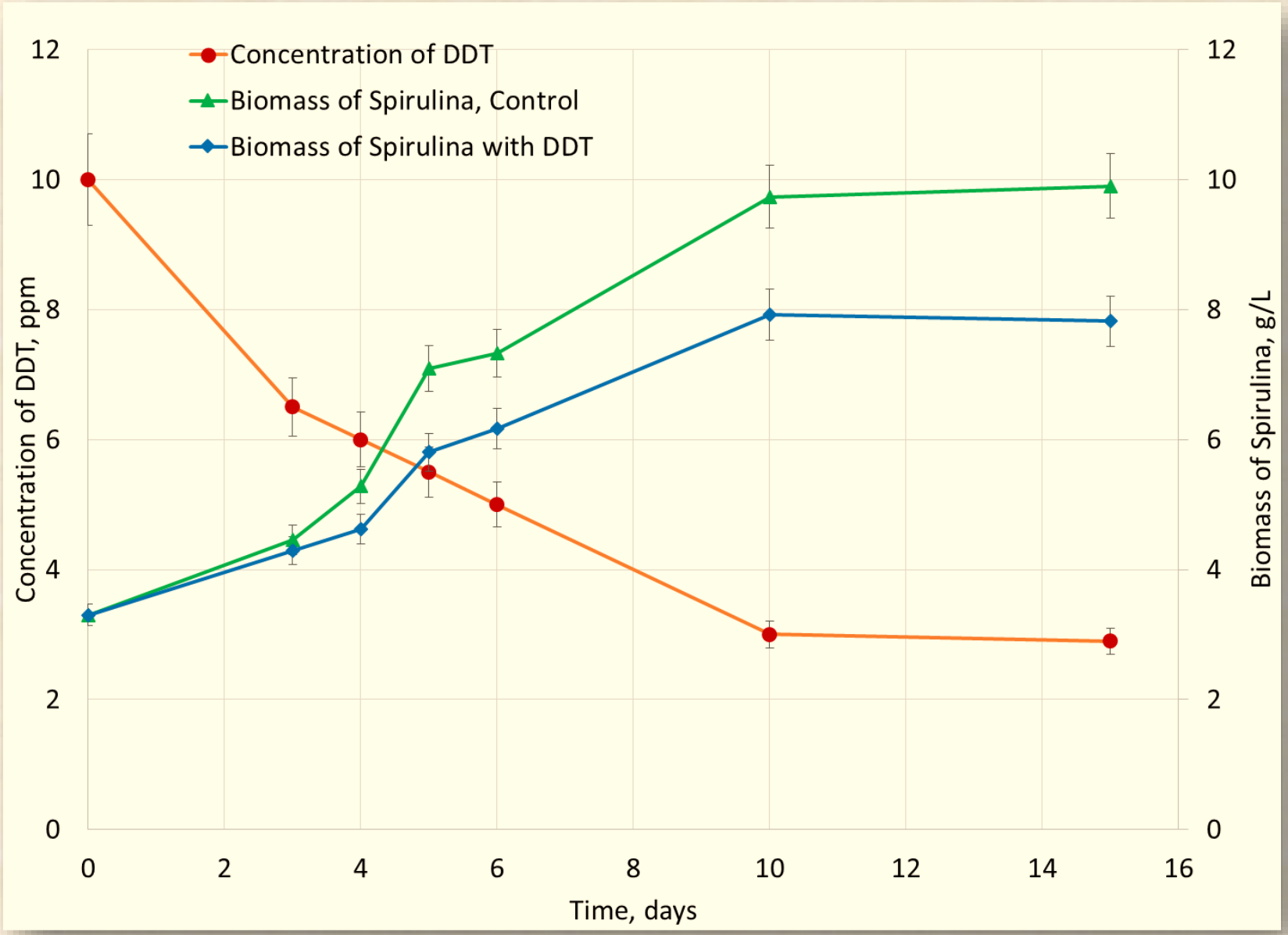




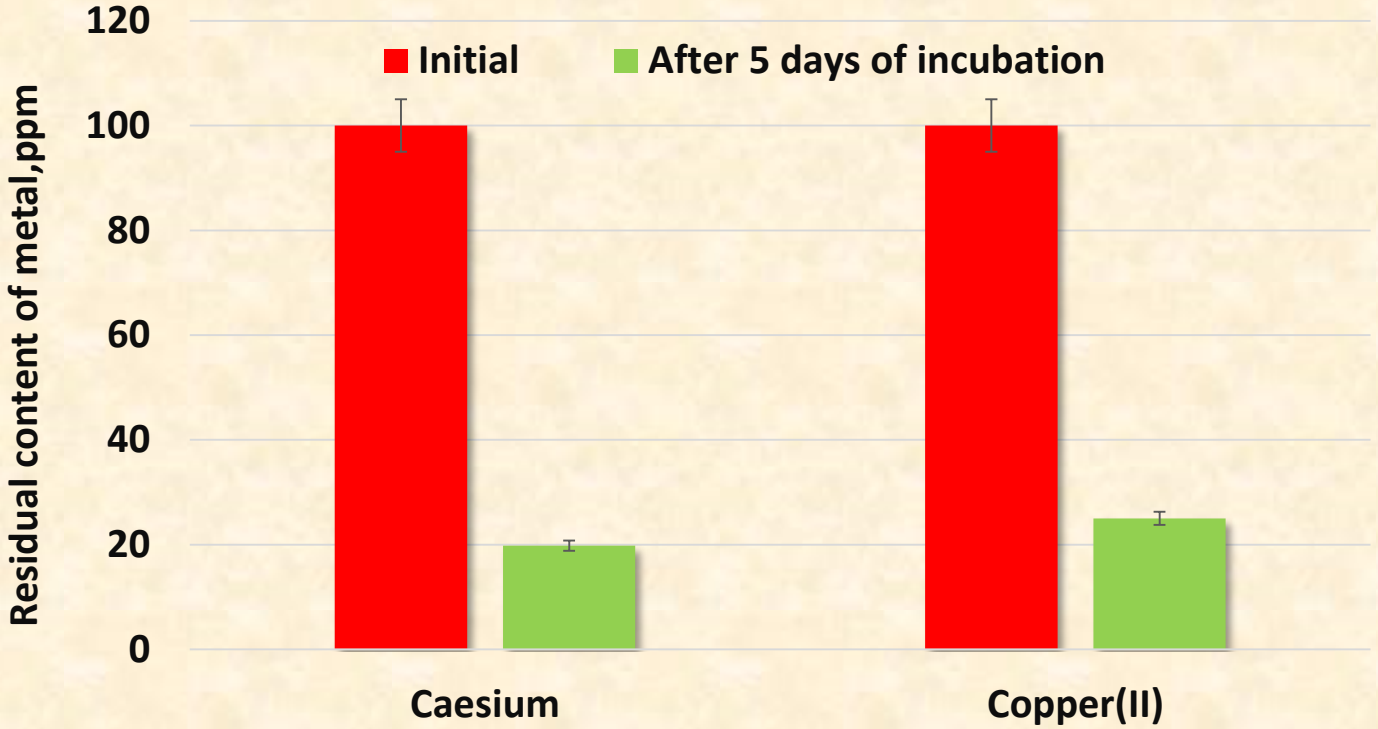
The uptake of different concentrations of DDT from cultivation area by Spirulina



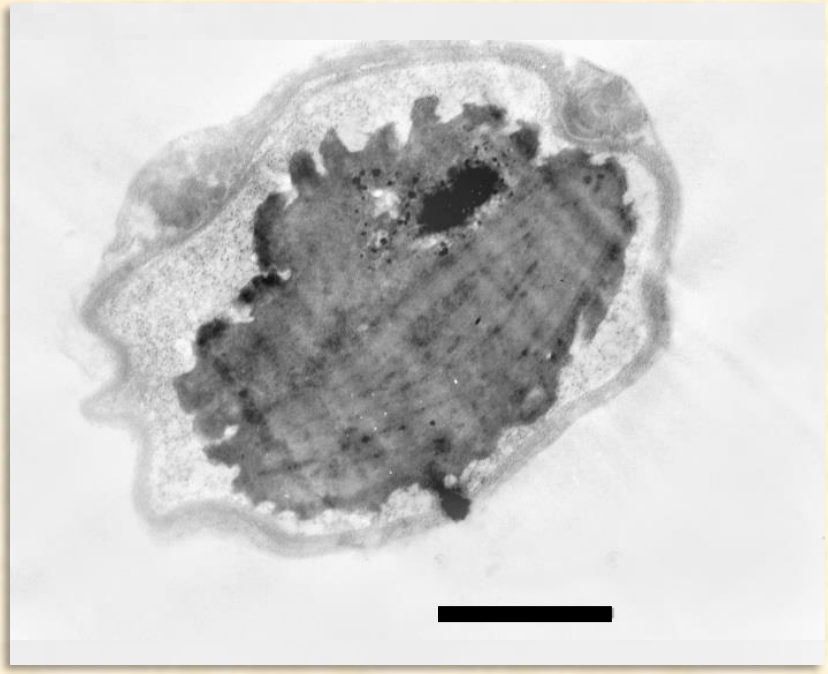
Cleaning DDT containing water by using Spirulina

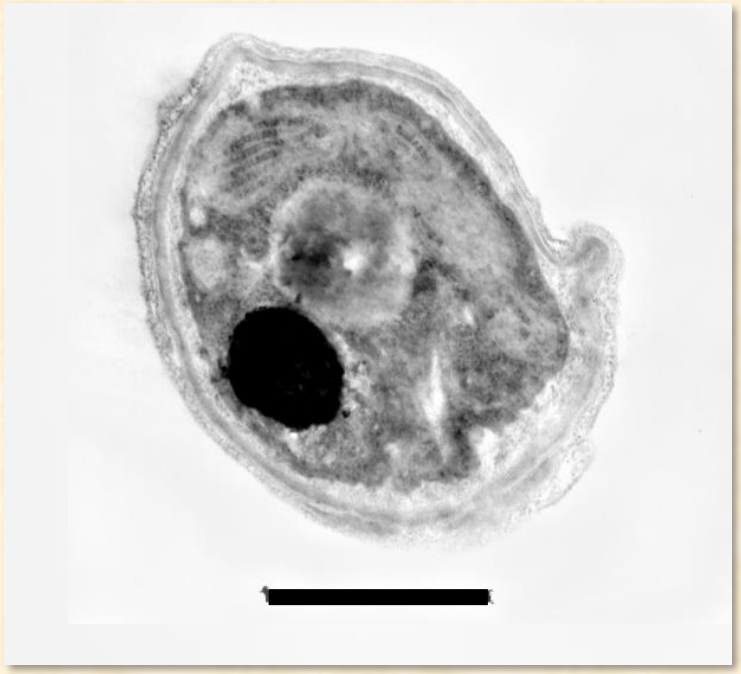


The uptake of different concentrations of Cu^{2+} and Cs^{+} from cultivation area by *Spirulina*. The control sample didn't contain algae *Spirulina*



Electron micrographs of cells of Spirulina, cultivated on Cu^{2+}-containing (100 mg/L) physiological solution for 5 days





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Thank you for attention !!!

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