ENVIRONMENT

Technological Innovation

ABSTRACT

LuminoTox, a new easy to use tool for toxicity assessment, has been tested on various types of wastewaters to validate its effectiveness and scope of use.

LuminoTox proved effective for rapid toxicity detection (15 minutes) in both treated and untreated effluents, including municipal wastewaters, leachates from landfill sites, pulp and paper mill effluents and mining industry effluents. It was also found to be an effective means of assessing the level of toxicity reduction in these types of effluents following treatment in various systems, such as those using activated sludge, aerated ponds or sequential biological reactors.

LuminoTox is a tool that can complement routine physico-chemical analyses and standardized bioassays by rapidly providing an index of the toxic potential of effluents.

INNOVATIVE TOOLS AND PROCESSES

LUMINOTOX : A TOOL FOR RAPID TOXICITY TESTING

HIGHLIGHTS

Technology
- Portable fluorescent biosensor that uses photosynthetic enzyme complexes
- *In situ* screening test
- Toxicity detection in 15 minutes

Environment
- Detection of a wide variety of toxic molecules
- Validation of the efficacy of wastewater treatment systems
- Monitoring of sewage overflows, industrial spills and water that rises to the surface on contaminated sites and sanitary landfill sites
- Rapid detection of toxic shocks associated with inflows to biological treatment systems

Cost-effectiveness
- Optimization of wastewater treatment processes
- Reduction in the amount of time that must be spent in the field
- Faster and more cost-effective than most conventional bioassays

Canada

Lab_Bell inc.

PROJECT OBJECTIVES / PHASES

The aim of this project was to demonstrate the effectiveness of a rapid, sensitive toxicity test for potable water and various effluents (municipal, agricultural, agri-food or industrial) that can also be used to assess the toxicity reduction that occurs after various treatment processes.

The main stages in the development of LuminoTox were as follows:

- **December 2002: LuminoTox test kit for isolated bioactive substances**
- **December 2003: LuminoTox test kit for toxicity (municipal and industrial effluents)**
- **April 2004: LuminoTox test kit for herbicides (triazines and urea)**
- **September 2004: LuminoTox test kit for nitrogen ammonia**
- **September 2004: Read-out for polycyclic aromatic hydrocarbons (PAH) determination**
- **December 2004: Fully automated Robot LuminoTox, for continuous on-line monitoring of water quality (surface or underground) and industrial effluents**

BACKGROUND

Conventional physico-chemical analyses cannot be used to evaluate the toxic potential of wastewater streams as they enter treatment plants or the toxicity reduction in treated effluents that are discharged into receiving waters. The bioassays that are customarily used for this purpose produce results after a variable time period (up to 96 hours). Environmental decision-makers therefore have few tools available for rapid, on-site toxicity testing.

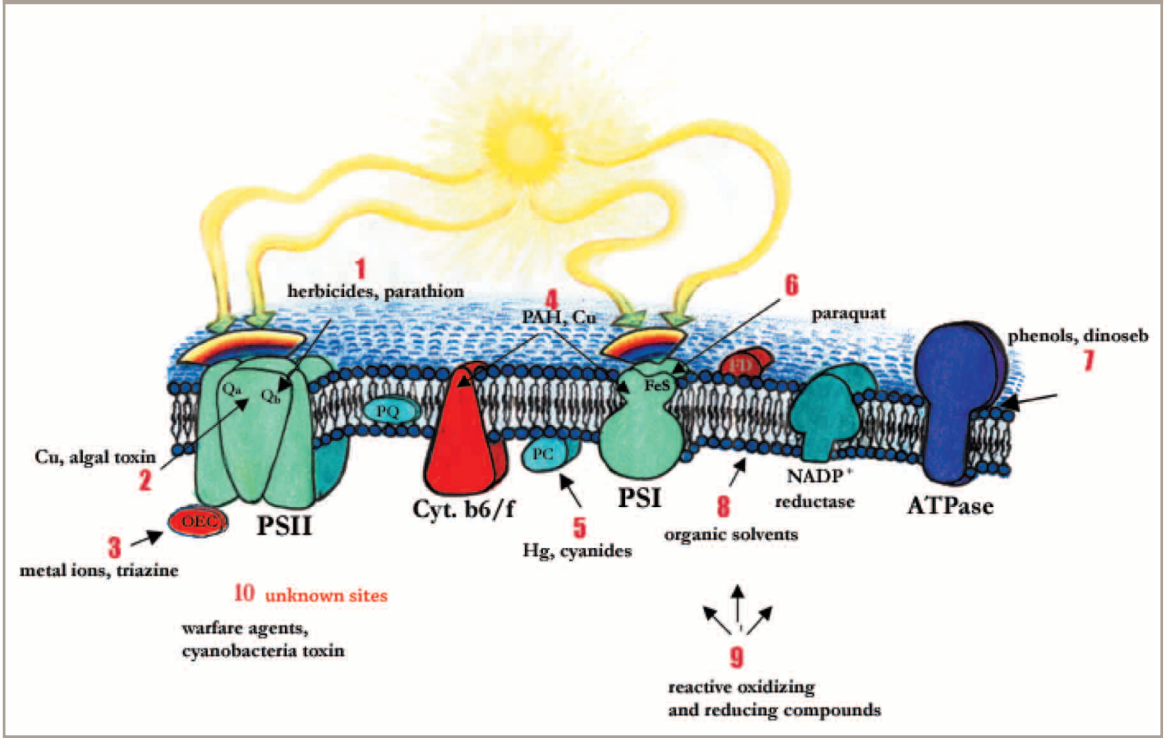
TECHNOLOGY

LuminoTox, a patented process, has two key components: stabilized photosynthetic enzyme complexes (PECs) and a specialized fluorometer for measuring photosynthetic activity based on chlorophyll fluorescence, the LuminoTox Analyzer. As PECs naturally fluoresce in response to light stimulation, this device measures the inhibition of the fluorescence reaction that occurs in the presence of toxic substances.

The conditions of fluorescence measurement and photosynthetic efficiency are pre-programmed into the apparatus. Percent inhibition is automatically calculated and displayed on screen. These data can be used directly or can be processed statistically to generate a concentration-response curve, allowing the user to derive conventional endpoints such as the IC_{50} value (the concentration that inhibits 50% of the fluorescence reaction) or toxic units.

LuminoTox uses multi-enzyme complexes that have been isolated from plant extracts, providing an easy to use and rapid technique that can be employed in the field. It is therefore a practical and cost effective tool for the environmental management of municipal, agricultural, agri-food and industrial effluents. LuminoTox is also an effective means of monitoring the quality and toxicity of drinking, surface and underground water supplies.

PECs AND INHIBITION SITES OF TOXIC SUBSTANCES



RESULTS

Effects of physico-chemical parameters

LuminoTox can be used under a wide range of physico-chemical conditions (no pre-treatment necessary) without any risk of interference with the IC_{20} and IC_{50} values for atrazine and copper, used as reference toxicants.

Assays of industrial and municipal effluents

LuminoTox was used to assess the toxicity of a number of wastewater samples and to derive an IC_{50} value for them, in just 15 minutes. Detection sensitivity was found to increase with incubation time to a maximum of 60 minutes. The toxicity results for treated effluents showed a low level of toxicity after 15 minutes of incubation (inhibition < 25% in all effluents tested).

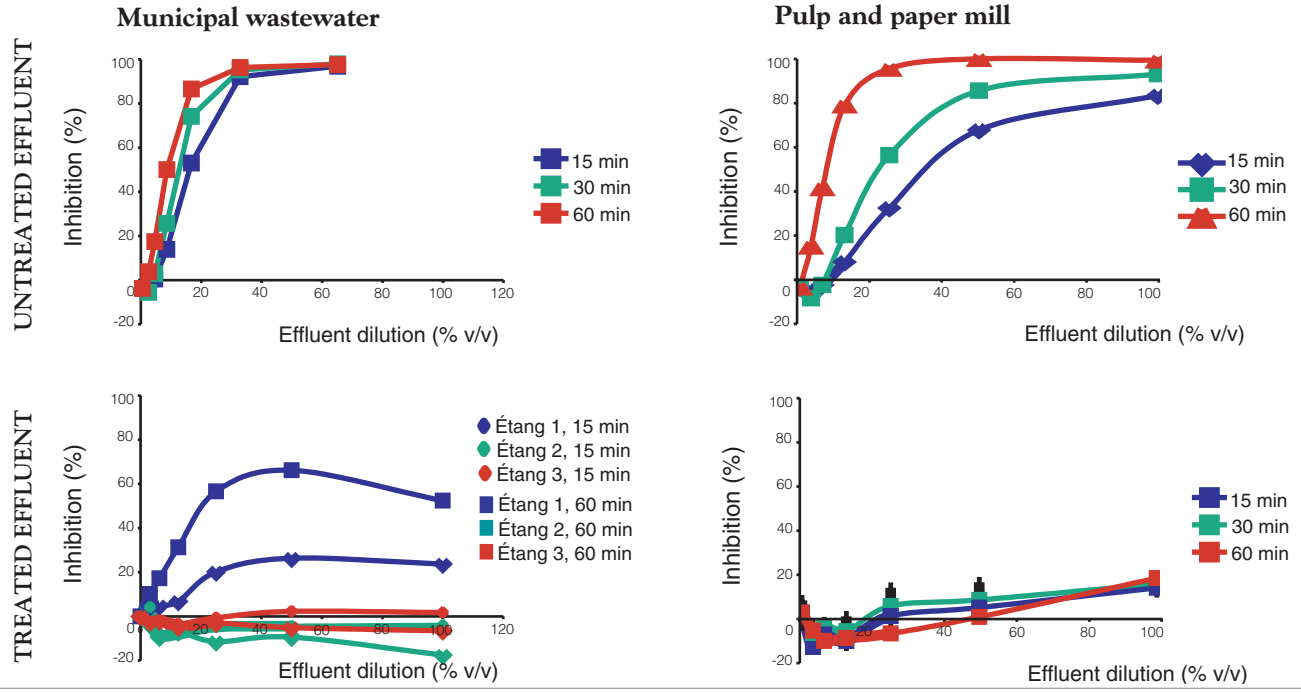
Effluents treated in a sequential biological reactor showed no toxicity even after an incubation period of 60 minutes. Wastewaters treated in activated sludge and aerated pond systems, on the other hand, showed a rise in toxicity with increasing incubation time after the effluents had gone through the first settling tank or the first aerated pond. LuminoTox is therefore sensitive to waste matter that has not been completely decomposed during the initial treatment stage. Nonetheless, these treatment processes were found to be effective after the effluents had gone through the secondary settling tank or the second or third aerated pond, since in these cases no toxicity was detected even after 60 minutes of incubation.

PHYSICO-CHEMICAL CONDITIONS FOR THE EFFECTIVE USE OF LUMINOTOX[1]

Parameters tested [2]	Stability range of IC_{20} and IC_{50}s($\pm 2\sigma$)	
	Analyses of organic compounds (reference: atrazine)	Analyses of inorganic compounds (reference: copper)
Conductivity (µS)	0-3000	0-1000
Colour (Pt. Co. CU.)	0-450	0-450
Turbidité (NTUs)	0-350	0-50[3]
Turbidity ($CaCO_3$ ppm)	0-320	0-180
Suspended solids (mg/L)	0-500	0-500

1. Statistical validation by the Centre national en électrochimie et en technologies environnementales (CNETE) and Shawinigan College.
2. Tested at 22°C and pH 7.5. Testing can be done at temperatures between 4°C and 25°C, provided the blank and the test sample are at the same temperature. The pH must be adjusted if it is not a toxicity parameter and it does not fall in the 6.5-7.8 range.
3. The turbidity effect may be due to copper chelation or adsorption in response to the standards used

RESULTS OBTAINED FOR EFFLUENTS (BEFORE AND AFTER TREATMENT)



Note :
-Sampling was carried out in summer
-The toxicity of nitrogen ammonia was not assessed in these samples as the tests were performed using PECs insensitive to Nitrogen Ammonia
-The results for other treatments and industries are available upon request.

POTENTIAL AND LIMITATIONS

Potential

- Useful to detect a wide variety of toxic molecules: phenols, sulphites, herbicides, hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), organic solvents and heavy metals
- The use of PECs and algae allows a larger number of molecules to be detected, including nitrogen ammonia
- Automation enables on-line water toxicity monitoring (Robot LuminoTox)
- Can reduce the number of samples sent to the laboratory for subsequent analysis
- Toxicity detection limits are generally lower than those required by regulatory standards and other bioassays

Limitations

- PECs can be conserved for 12 days at 20°C, 2 months at 4°C and 4 months at -20°C
- Sensitivity of PECs to light, except to green light (regeneration occurs after 30 minutes' incubation in the dark)
- Industrial plants that conduct Daphnia or trout tests will have to correlate their toxicity responses with those obtained using LuminoTox
- Approval process is ongoing
- Does not replace the tests prescribed by the regulations

INFORMATION

In developing this technology, Lab_Bell inc. received technical support from Environment Canada and financial support from the Canada Revenue Agency (tax credits), Revenue Québec (tax credits) and National Research Council of Canada (NRC).
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