St. Lawrence TECHNOLOGIES

HAZARDOUS WASTES

BIOLOGICAL TREATMENT OF GAS EMISSIONS FROM THE FLEXOGRAPHY PRINTING PROCESS

ABSTRACT

The firm Biogenie S.R.D.C. Inc. has developed and demonstrated a technology which uses a biotrickling filter for the biological treatment of gas emissions.

A pilot unit with a treatment capacity of 2100–6500 m^3 of off-gas per hour was installed at an industrial site in Montreal and operated for a period of more than ten weeks. The system removed over 95% of the volatile organic compounds (VOCs) contained in the gas emissions. The pilot unit removal rate was 350 g of VOCs per cubic metre of reactor per hour (g/m^3 per hour).

The unit cost of VOC treatment using the biotrickling filter comes to $0.32 per kilogram of VOCs degraded, or $0.20 per 1000 m^3 of off-gas treated.

MAIN FEATURES

- **Technology**
  - Aqueous-phase absorption of VOCs and treatment of process water using biotrickling filter
  - Compact modular design
  - Completely automated process
- **Environment**
  - Removes volatile organic compounds (alcohols, esters) without generating harmful by-products
  - Minimal process water to be discharged
- **Cost**
  - Treatment cost of $0.20 per 1000 m^3 of off-gas
  - Low energy demands

Saint-Laurent Vision 2000

Environment Canada — Protection — Québec Region

Environnement Canada — Protection — Région du Québec

Biogenie

Federal Office of Regional Development (Québec)

Bureau fédéral de Développement régional (Québec)

PROJECT OBJECTIVES

The aim of the project was to design, refine and demonstrate the effectiveness of a pilot unit for the treatment of gas emissions from a printing plant using the flexography process. More specifically, the project objectives were to:

- Attain a VOC removal rate of at least 90%.
- Evaluate the installation costs of the technology.

This two-phase project was further subdivided into several steps.

Phase I included project assessment based on bench-scale testing in the laboratory by:

- Isolating and refining microorganisms
- Biodegradability testing
- Refining the process in the lab

Phase II consisted of pilot unit construction and technology demonstration under real conditions. This took place in four steps, as follows:

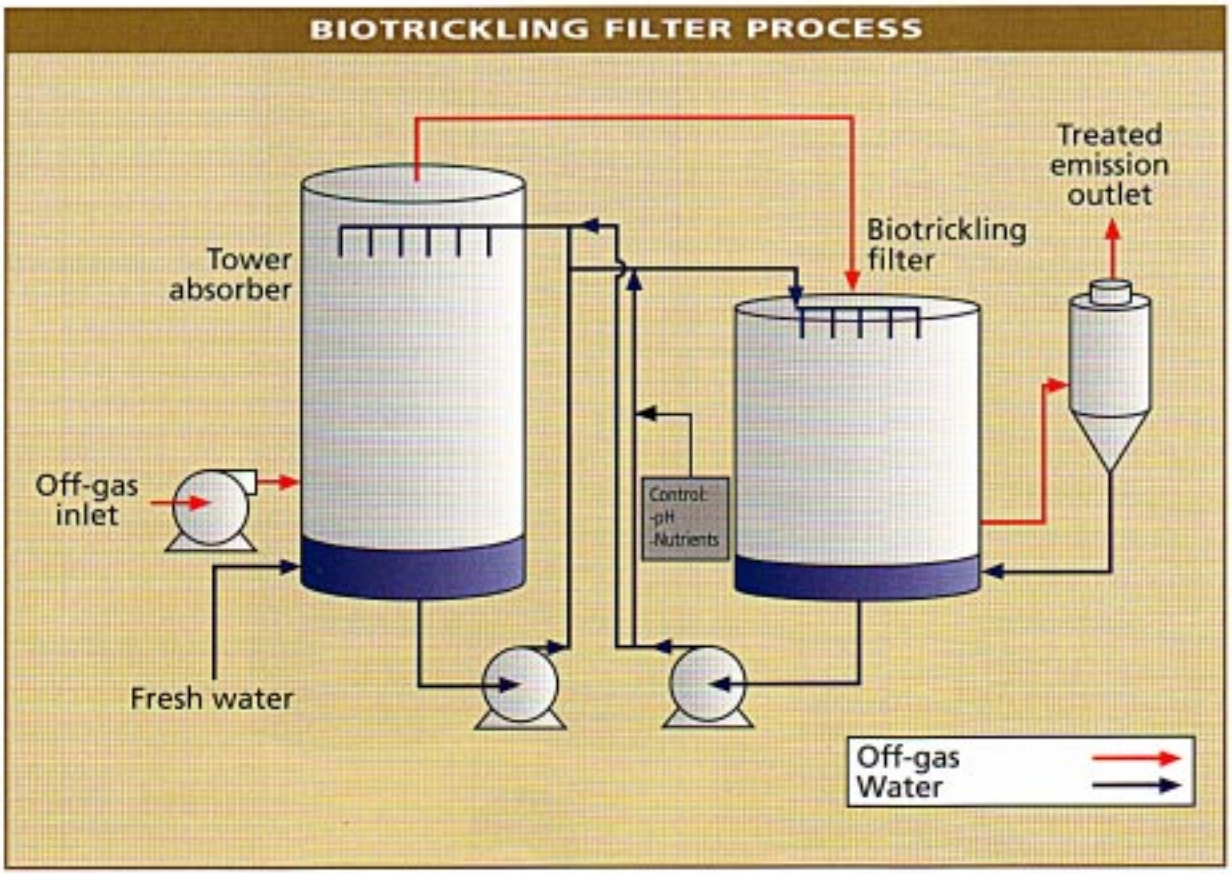
- Designing and manufacturing the pilot unit
- Refining and measuring its performance at an industrial site
- Characterizing printing-plant emissions
- Studying the technical and economic aspects of the process on an industrial scale

BACKGROUND

In 1993, close to 20 000 tonnes of volatile organic compounds (VOCs) were emitted to the atmosphere by Canadian printing plants using the flexography printing technique, thereby contributing significantly to global warming. Contaminants such as propanol, ethanol, isopropanol, propyl acetate and ethyl acetate are the main substances emitted by flexography. The treatment of atmospheric emissions, already a difficult task, is made more difficult by the need for compact equipment that can be adapted to the operations of a printing plant employing the flexography process.

TECHNOLOGY

Biogenie S.R.D.C. Inc. has developed a two-phase process which combines a tower absorber with a biotrickling filter. First, a stream of off-gas is channeled to the tower absorber and run countercurrent to a washing solution, to which it transfers most of its VOCs. The gas emissions circulate in parallel flow with the VOC-laden water, and are then diverted to the biotrickling filter, for final polishing, before being discharged to the atmosphere. The VOCs absorbed by the water are biodegraded by the microorganisms embedded in the filter. Process water may be recirculated to the absorber tower. All the instrumentation necessary for process optimization is in place. The process is entirely automated and requires a minimum of supervision and manual operation. The equipment may be installed out of doors, close to the plant, and the outlets on the roof are interconnected so as to feed the biotrickling filter. The unit is relatively compact (75 m³) and capable of treating over 700 tonnes of VOCs per year. Its modular design allows great treatment flexibility in terms of emission flow rate and contaminant level.



RESULTS

The microorganisms employed in the treatment process were isolated from the activated sludge of a biological treatment process. A chemostat continuous-feed bioreactor was used for microorganism isolation and enrichment. The microorganisms acclimated very rapidly to the nutritive solution enriched with the target VOCs. The selected microorganisms pose no risk to the environment and are non-pathogenic.

Biodegradability testing made it possible to check the VOC quantities acceptable for degradation by the microorganisms: in less than 24 hours, more than 97% of the additive compounds were accepted and degraded.

Ninety-three percent (93%) of the VOCs contained in the off-gas was removed during bench-scale testing in the laboratory. Air retention time in the system was 20 sec, with an average concentration of VOCs of 750 mg/m^3 and a removal capacity of 145 g of VOCs (m^3/h).

The pilot unit was designed for testing under real conditions and has a treatment capacity of between 2000 and 6500 m^3/h, depending on the nature of the off-gas (flow rate and VOC level). The unit was able to treat 4% of the gas emissions of the printing plant chosen as the test site. Unit performance was conclusive: more than 95% removal of VOCs in alcohol-based effluent.

These tests allowed us to optimize operating conditions and double the treatment capacity compared to the results obtained in the lab. The pilot unit has a yield of 350 g VOCs per cubic metre per hour.

A technical and economic study was done to estimate the installation costs of an industrial-sized unit, based on results obtained in the lab and at the pilot scale. The unit cost of treating off-gas was estimated at $0.32 per kilogram of VOCs removed or $0.20 per 1000 m^3 of treated emissions, for a unit with a treatment capacity of over 125 000 m^3/h of emissions containing 1000 mg/m^3 of VOCs, amortized over 15 years.

PERFORMANCE OF THE BIOTRICKLING FILTER

VOCs	Composition (%)	Removal* (kg/d)
n-Propanol	43	26.8
Ethanol	31	19.3
Isopropanol	7	3.3
Methanol	3	1.4
Propyl acetate	9	4.4
Ethyl acetate	7	2.2

*Based on the treatment of 2600 m^3/h of off-gas containing 1000 mg of VOCs/m^3.

POTENTIAL AND LIMITATIONS

Potential

This treatment process holds its own against other existing technologies, such as activated-carbon adsorption, thermal oxidation, regenerative catalytic oxidation and incineration. What's more, it needs no supplemental fuel source.

The biotrickling filter may be applicable to the treatment of other types of gas emissions, such as those of the paint, wood veneering and plastics industries.

Limitations

The performance of the biotrickling filter may be diminished in the presence of water-insoluble or extremely volatile VOCs. The process may need to be adapted in such cases.

The biotrickling filter technology may not perform optimally where the VOC concentration in off-gas is higher than 6000 mg/m^3.

INFORMATION

This technology data sheet is based on the results of a technology development and demonstration project carried out jointly by Biogenie S.R.D.C. Inc. and the Flexographic Committee, with the technical and financial assistance of Environment Canada and the Federal Office of Regional Development – Quebec.

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Canada