A TOOL FOR MANAGING TOXICS

The Potential Ecotoxic Effects Probe

PEEP

An index for comparing the potential toxicity of industrial effluents

PRINCIPES

The Potential Ecotoxic Effects Probe (PEEP) is an index that combines the results of biological tests (bioassays) representing several trophic levels in the aquatic environment and several types of toxicity (acute lethality, acute and/or chronic sublethality, and genotoxicity). It can be used to evaluate and compare the toxic potential of industrial effluents since it takes into account:

1) ***the toxicity results of the different bioassays;***

2) ***the persistence of the toxicity (the tests are repeated on an effluent sample after it has undergone biodegradation for a five-day period);***

3) ***the (multi)specificity of the toxic impact (number of aquatic species affected by the effluent);***

4) ***the flow rate of the effluent (m^3/h) which can be used to estimate the toxic load.***

All of these elements are expressed as a single value on a logarithmic scale (log_{10}) ranging from 0 to 10.

The mathematical structure of the index is flexible enough that bioassays can be added or removed as needed.

KEY POINTS

- Easy to use and interpret;
- High discrimination power;
- Cost-effective tool for evaluating the potential impact of liquid toxic discharges;
- Index that takes account of bioavailability and possible interactions among toxic substances (additive, antagonistic and synergistic effects);
- Essential complement to physico-chemical characterization for ensuring optimal management of industrial effluents.

CURRENT APPLICATIONS

- Evaluating the potential toxicity of industrial and municipal effluents;
- Managing effluent toxicity within an industrial plant;
- Assessing the effectiveness of **toxicity abatement measures for effluents**;
- Selecting standard bioanalytical levels for screening liquid toxic discharges.

FUTURE APPLICATION

Evaluating the toxic potential of solid matrices (sludges, soils or contaminated sediments).

Canada

Québec

ISSUES

1) Chemical analyses, despite their usefulness, cannot be used to assess the potential toxicity of complex mixtures such as industrial effluents.

2) Although bioassays can be employed to evaluated the bioavailability of the toxic substances present in complex mixtures, and hence their toxic potential, the lack of standardization in the way toxicity results are reported makes interpretation difficult.

3) The impact of a toxic effluent may vary according to the concentration, quantity, persistence and fate of the toxic substances it contains.

SOLUTION

PEEP is a single index that integrates the results of bioassays performed with different organisms and different toxic effect criteria. The toxic effects **cover** all potential antagonistic, additive and synergistic interactions.

All of the results are calculated based on effects thresholds and reported in toxic units. This strategy, coupled with assessment of the persistence of the toxicity and the effluent flow rate (used to compute the toxic load), represents the first attempt to group various ecotoxicological concepts in a simple, practical and useful work tool.

All of the toxic responses (10) are integrated in a mathematical formula to obtain a value on a logarithmic scale ($\log_{10}$).

Expressing the results as a single value makes it possible to quickly and accurately identify effluents that show the maximum level of toxicity. An index value of this type is also more easily disseminated to the general public, which is accustomed to receiving synthesized information. In this respect, it can be likened to the Richter scale, which measures seismic activity.

The PEEP index has a high discrimination power and a flexible structure that allows bioassays to eventually be added or removed. This flexibility permits some generalization of results (comparisons can be made between the results obtained from a different number of bioassays), while also keeping the index in the forefront of technology.

In addition, the PEEP scale provides a ready means of estimating the relative toxicity of a given effluent, that is, its percentage-wise contribution to the toxicity of a group of effluents considered as a whole.

PRINCIPLES

Measurement of toxic effects

Six toxic effect criteria, including mortality, growth inhibition and reproductive inhibition, are evaluated by means of five bioassays that use organisms (bacteria, algae, crustaceans) representing different trophic levels: decomposers, primary producers and consumers. Several levels and types of toxicity are analyzed: lethal, acute sublethal, chronic sublethal and genotoxicity.

The bioassays were selected based on various criteria: sensitivity, cost, rapid response, degree of standardization, etc.

Some of the bioassays are repeated following biodegradation of the effluent sample (stimulation of secondary treatment in an aerated lagoon over a five-day period) in order to measure any changes in toxicity resulting from microbiological activity.

Calculation of the PEEP index value

The elements considered (number of bioassays, persistence of toxicity, effluent flow rate) are integrated into the following formula:

$$\log_{10}\left[1+n\left(\sum_{i=1}^{k} Av + Ap/N\right)*D\right]$$

where
n: number of bioassays exhibiting toxic responses;
k: number of bioassays used;
N: maximum number of possible toxic responses;
Av: result of a particular bioassay before biodegradation of the sample;
Ap: result of a particular bioassay after biodegradation of the sample;
D: effluent flow rate (m^3/h).

The coefficient *n* indicates the extent of the toxicity, that is, the (multi)specificity of the toxic impact.

Responses revealing toxicity are identified by measuring the toxic threshold, that is, the geometric mean of the no observable effect concentration [NOEC] and the lowest observable effect concentration [LOEC]. They are expressed in toxic units (TU = 100/toxic threshold in % v/v [effluent volume over total volume tested]). The mean of the responses ([Σ *Av* + *Ap*] /*N*) indicates the toxic strength, that is, the expression in effect units of the concentration of bioavailable toxic substances.

The coefficient *n* multiplied by the toxic strength identifies an effluent's " toxic print, " which reflects the relative strength and extent of the toxicity.

The product of the toxic print and the flow rate yields the " toxic **load** " (TU/hour), which can be used to determine the relative contribution of a given effluent to the overall toxicity of a group of effluents.

The $\log_{10}$ of the toxic **load** + 1 yields the final PEEP value.

In theory, the PEEP scale covers a range from 0 to infinity. In practice, however, PEEP values rarely exceed 8, owing to logarithmic progression. A value of 7 and over indicates a very high toxic potential. A decrease on the PEEP scale from 6 to 5 corresponds to a 90% reduction in the potential toxic **load** of an effluent.

LIMITATIONS

The PEEP index evaluates only the toxicity of industrial effluents. It does not take account of bioaccumulation processes or the buffering capacity of the receiving environment. Furthermore, the index primarily measures the toxicity of dissolved substances in the water and not that associated with suspended solids.

The flow rate value determines the detection limit of the index. To determine this limit, it is assumed that only one of the ten toxic responses occurs at an intensity of 1 TU. Hence, the toxic print would be 0.1 TU and the toxic load 0.1 times the flow rate. For example, if a single bioassay yielded 1 TU for a sample of effluent with a flow rate of 1000 m^3/h, the toxic load would be 100 TU/h and the PEEP 2, which corresponds to the minimum detectable limit.

APPLICATIONS

St. Lawrence Action Plan (SLAP)

The main objective of SLAP (1988 to 1993) was to reduce by 90% the toxic effluents discharged by the 50 targeted priority plants. To reach this objective, it was necessary to identify the major sources of pollution and apply toxicity abatement measures to those discharges identified as being the most problematic. The PEEP index was thus used to characterize and rank all the industrial plants covered by SLAP based on their effluents toxic **load**.

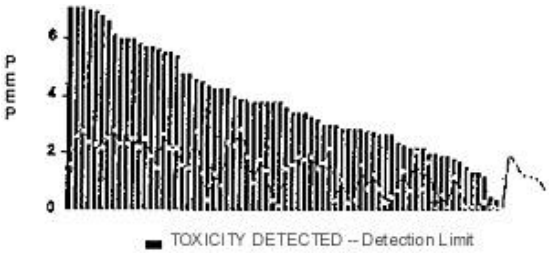
St. Lawrence Vision 2000 (SLV 2000)

The long-term objective of the Protection component of SLV 2000 (1993 to 1998) is to reduce liquid toxic discharges and virtually eliminate discharges of persistent toxic substances.

To achieve this objective, the activities of the Protection component are directed primarily at 106 priority industrial plants, and seek to reduce their discharges of toxic effluents. PEEP values are computed for these effluents in order to assess the potential toxicity of the discharges; they are used as a complement to physico-chemical characterizations in setting priorities for pollution control measures.

Figure 1 shows the toxicity levels detected to date in 77 industrial effluents. It can be seen that the PEEP index has sufficient sensitivity to evaluate and quantify the toxic **load** of most industrial effluents.

FIGURE 1 - PEEP VALUES FOR 77 INDUSTRIAL EFFLUENTS



The Environmental Choice Program

The goal of this program is to encourage manufacturers and importers of various products to exercise their right to use the EcoLogo symbol on their packaging, showing that the products have a limited environmental impact. Before EcoLogo can be used to identify a particular product or its ingredients, certain ecotoxicological criteria must be met. For all-purpose cleaning products, the PEEP index was used in defining the standard bioanalytical leevels to be applied in evaluating the whole product for *aquatic toxicity*.

INFORMATION

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