THE ROLE OF EFFLUENT MONITORING IN ENVIRONMENTAL CONTROL

PETER N. NEMETZ and HEBERT D. DRECHSLER
Division of Policy Analysis, Faculty of Commerce,
University of British Columbia, Vancouver, B.C. V6T 1W5, Canada

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Abstract. Using effluent data from a British Columbia pulp mill, the authors demonstrate certain critical deficiencies associated with currently emplaced monitoring systems. The principal ingredient in effective environmental control is information, and current monitoring regimes entail an unacceptable level of information loss. Composite sampling systems fail to provide the two key types of information required for effective environmental control: (i) a high representational accuracy of the effluent profile; and (ii) the detection of most or all pollutant releases with potentially serious environmental consequences. In light of these conclusions, the authors make several recommendations concerning current and alternative sampling regimes.

1. Introduction

In the face of increasing public concern over the issue of pollution, more elaborate and extensive monitoring programs have been instituted in North America to measure the nature of industrial discharges to both air and water.

Accurate and complete monitoring is a critical ingredient in the achievement of an effective environmental control policy. Without adequate information on the nature of effluent discharges and ambient pollutant levels, it is impossible for a government agency to assess or combat environmental degradation.

Until recently, little work has been conducted on the ability of various monitoring programs to represent the true nature of the underlying effluent profile. Such work as does exist on this subject is based on statistical inference from usually incomplete monitoring data.

This paper expands the scope of effluent analysis by using continuous monitoring data to examine the effectiveness of many current monitoring systems. This is by no means an easy task as the technology of continuous monitoring is often expensive and available for only a small number of pollutants.

We have focussed our analysis on effluent discharges from the pulp and paper industry because of the availability of information and the significant contribution to water pollution from this industry. The effluent of pulp and paper mills contains a variety of pollutants including suspended solids, five-day biochemical oxygen demand ($\text{BOD}_5$), total solids, high or low pH, phenol, P, resin acids, tannin, lignin, color, and ‘toxicity’. On the other hand regulatory monitoring and control by many national governments have tended to focus on three pollutants in particular: suspended solids, $\text{BOD}_5$, and ‘toxicity’. The last of these pollutants is a measure of...
the total toxic effect of the effluent on aquatic organisms. It is generally measured by a bioassay which has the capacity to reflect all synergistic and antagonistic effects among the effluent constituents. In this process, selected fish, such as rainbow trout, are placed in a full strength or diluted stream of effluent for up to 96 h. Observations are made on the extent of fish mortality in the test period.

While bioassays are usually conducted only once per month, most pulp mills measure BOD$_5$ and suspended solids at more frequent intervals. Two principal monitoring methods are employed for the measurement of these two pollutants. The first, grab sampling, involves taking a small and virtually instantaneous sample of the effluent stream with a bucket or jar. The second, composite sampling, involves the collection and physical pooling of a series of samples over a given time period before any measurement is taken.

An effective monitoring program must be one which has the capacity to detect most or all excessive pollutant discharges to the environment. In particular, the monitoring system must produce information on three critical variables: the frequency, intensity, and duration of elevated pollutant discharges. In light of these criteria, it is apparent that there are potential deficiencies associated with the monitoring programs most frequently employed by the pulp and paper industry. The central issue concerns the loss of information in both grab and composite sampling systems.

The key assumption in grab sampling is that the sample is representative of the effluent discharge both during and between sampling. The former assumption can often be satisfied by the proper positioning of the sampling device within the effluent stream. The latter assumption is questionable.

The two most important drawbacks to composite sampling are that: (i) the inherent averaging characteristic of this system can conceal evidence of the intensity or even existence of potentially serious discharges of short duration; and (ii) in a manner analogous to grab sampling, a system of composite sampling may not be representative of effluent levels in the periods between samples.

In each sampling system, there are several characteristics which can be varied by the pulp mill in an attempt to increase the representational accuracy of the monitoring results. In grab sampling, the critical variable is the period between samples. In composite sampling, four modifications are possible:

(a) the length of time between individual samples which are to be composited or pooled;
(b) the length of time over which one total composite sample is collected,
(c) the length of time between each total composite sample; and
(d) the number of times that an individual sample is ultimately composited.

As an example, a pulp mill might, every second week, collect individual samples once every 10 min, composite these samples every 24 h, and recomposite the daily results for a weekly average. In this case, characteristic $a = 10$ min, $b = 24$ h, $c = $ one week, and $d = $ two times.