The effluent refractory assessment concept

Authors: A.W. Busch and William G. Characklis

This is a postprint of an article that originally appeared in Water-1971 in 1972.

Busch, A.W. and W.G. Characklis, "Effluent Refractory Assessment Concept," Water-1971, A.E.Ch.E. Symposium Series 124, 68:470-472 (1972).

72-004

THE EFFLUENT REFRACTORY ASSESSMENT CONCEPT

A. W. Busch and W. G. Characklis

ACS Nat'l Meeting, May 19, 1971
Cincinnati, Ohio

THE EFFLUENT REFRACTORY ASSESSMENT CONCEPT

by

A. W. Busch and W. G. Characklis
Respectively, Professor and Assistant Professor
Environmental Science and Engineering Department
Rice University
Houston, Texas

CONCEPTS

In discussing what parameters we should measure in waste water treatment, we must first establish whether we are interested in process control or in effluent quality. Basically we must measure what is present in the wastewater and therefore what we are designing to remove. In short, what we should measure in a given wastewater system is system specific. Furthermore, the compounds which are to be removed by the process are in low concentration and, in fact, approach zero. Figure 1 shows graphically the decrease in any parameter of interest with reaction time and how its removal rate is a measure of effluent quality.

Another factor in determining what parameters we should measure is the question of specific or non-specific analyses. Such non-specific analyses as BOD and COD are not necessarily related to process function. For example, it is inconsistent to use a five day biological test to assess the performance of a process system having a total detention time of less than 5 days. Such reasoning led to the concept of the effluent refractory assessment (ERA)[1] test which simply involves holding a side stream of mixed liquor from the biological reactor under aeration for additional time (a multiple of hydraulic residence time or an arbitrary time such as 24 hours or 5 days) and comparing the dissolved organic (specific or non-specific) concentration of the reactor effluent with that from the additional aeration. Unless the dissolved organic concentration after additional aeration is significantly reduced, performance of the biological reactor is essentially complete. Figure 2 shows a schematic of the ERA concept. Quite obviously the ERA concept emphasizes that different industrial waste streams have different rates of reaction. This again points up the need for differentiating between specific and non-specific analyses and for differentiating between process control and effluent quality assessment.

INSTRUMENTATION AVAILABLE

There are two types of instruments available for measuring organic concentrations in wastewaters. Non-specific instruments measure carbon content either directly (Total Organic Carbon Analyzer, Beckman Instrument Company) or in oxygen equivalents (CO_2D, Precision Scientific Company; TOD, Ionics, Inc.). The main specific instrument is the chromatograph, which measures concentrations of specific organic compounds in a waste stream.

MUNICIPAL WASTES

Process control for municipal wastewater plants is almost impracticable because specific components are too numerous to measure. In addition, attempts to control tightly municipal wastewater processes overcomplicate operation of the plant.

Similarly, only non-specific parameters are useful for performance (effluent quality) evaluation of a municipal wastewater plant. Perhaps the most valuable information to be obtained from an ERA test on municipal waste water is that biological processes are probably unnecessary because the soluble organic content of the influent is usually very low.

The above points also should discourage combined or regional treatment of municipal and industrial wastes. Without satisfactory methods for controlling or evaluating process performance it seems unlikely that such designs would be effective, despite the illusionary "economy of scale" or "0.6 power rule".

INDUSTRIAL WASTES

Process control of industrial wastes is feasible in cases where specific waste components are known. This also presumes that the treatment process was designed to remove that component. Gas chromatography permits rapid analysis of waste component concentrations and is presently used for process control in the chemical process industry. Non-specific instruments can be used in instances where the parameter correlates directly with concentration of the specific component of interest. Experience with non-specific instruments in the petrochemical industry indicates that results are often affected by compounds containing nitrogen and sulphur of unknown oxidation state. Complications of this type preclude use of non-specific instruments for process control without several other time consuming analyses. Thus the lag time for any corrective action is increased. pH is a variable that can and has affected response of the TOC analyzer.[2] The equilibrium established by carbonates with ammonia and carbonate changes the distribution of organic carbon and inorganic carbon with varying pH.

The most effective and most direct technique for process evaluation is chromatography which measures the specific compound the process was designed to remove. Besides producing a finger print of wastewater components, it provides specific data on "bad actors" which contribute to poor effluent quality, in terms of "refractory organics."

Despite its advantages, chromatography is not a panacea. The peaks observed are often flattened, detracting from the dependability of the analysis. There are generally unknown compounds present in waste stream plus those biochemical intermediates formed in the biological process.

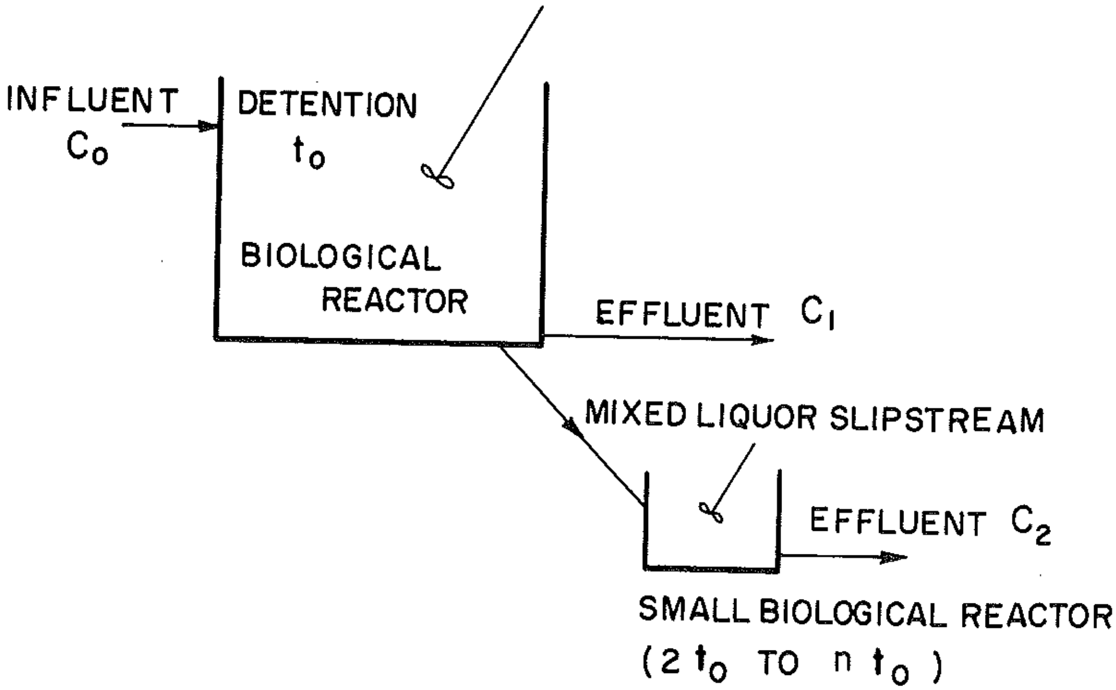
SUMMARY

The heritage of sewage treatment design still heavily influences most discussions of what parameters should be measured in waste water treatment. Quite obviously municipal wastewater is such a mixture of components that global parameters such as COD are useful. Dissolved organic carbon would be preferential to COD, however. The important point made in this paper is that in any particular wastewater treatment problem the parameters we should measure are specific to the particular influent and are determined by contaminants which we are designing the system to remove. In the use of a biological treatment system for removal of dissolved organic carbon, process performance is determined by dissolved organic carbon content measured in the effluent refractory assessment concept. The presence of suspended solids in the effluent from a clarifier, while affecting and characterizing effluent quality, is not germane to performance of the process designed and functioning only to remove dissolved organic carbon. On the other hand, the characterization of an effluent in terms of health parameters for the establishment of broad effluent quality, is not necessarily at all related to the question of process performance or control. We must turn from the traditional practice of using broad scale parameters as suitable for all waste treatment problems and look upon each waste treatment process as functioning to remove, broadly, dissolved organic carbon or in some cases specific compounds such as phenol, methanol, acetic acid or similar organics.

References

1. Busch, A. W., *Aerobic Biological Treatment of Waste Waters - Principles and Practice*, Oligodynamics Press, Houston, 1971.

2. Busch, A. W. and C. H. Ward, "Carbon Analysis in Pollution Assessment - Concepts vs Applications", *Proceedings* International Symposium on Identification and Measurement of Environmental Pollutants, Ottawa, June, 1971.



ERA VALUE $= C_1 - C_2$, mg/l.

PROCESS EFFICIENCY $= \frac{C_0 - (C_1 - C_2)}{C_0} \times 100$

FIG. 2 SCHEMATIC OF THE EFFLUENT REFRACTORY ASSESSMENT (ERA) CONCEPT

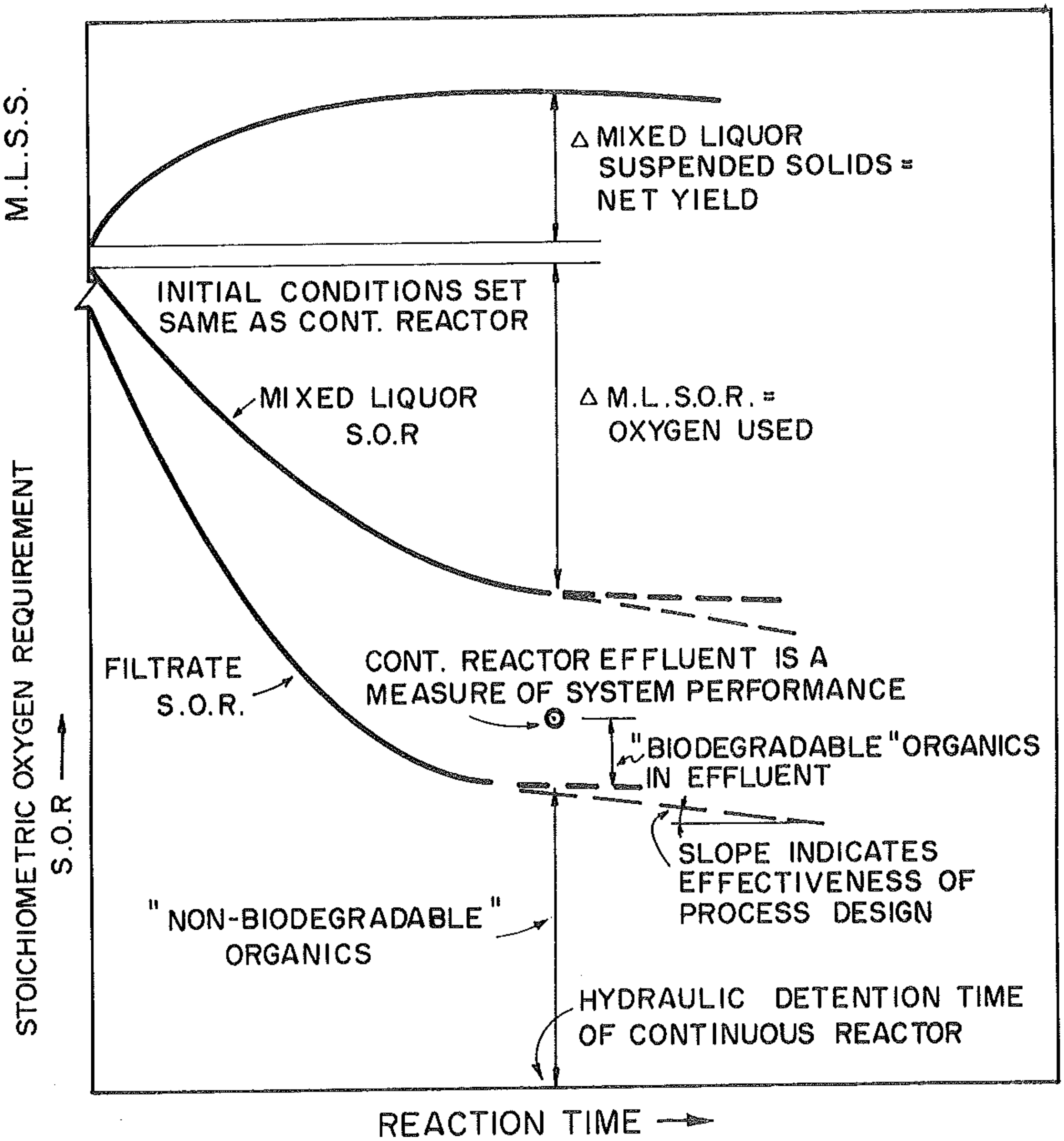


FIG. I CONCEPT OF USING MASS CULTURE $T_bO.D.$ TEST FOR THE ASSESSMENT OF PROCESS PERFORMANCE, NET YIELD, OXYGEN UTILIZATION, AND RELATIVE EFFLUENT QUALITY