Management of Man-made Eutrophication: The Swedish Concept

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ABSTRACT

The Swedish approach for the control of man-made eutrophication is described as simple, pragmatic, and effective. It was founded on a combination of an agreed definition of the problem, appropriate management instruments, adequate technology, available funds, and participation by concerned parties.

BACKGROUND

In 1971 and 1972, OECD made an extensive study of the requisites for management of man-made eutrophication. Of the reports being prepared in the course of that work, the following are of particular interest in the context of this paper:

1. Report of the Expert Group on Detergents, Paris 1973
2. Waste Water Treatment Processes for Phosphorus and Nitrogen Removal, Paris 1974
3. Report of the Water Management Sector Group on Eutrophication Control, Paris 1974

The last of these reports summarizes the conclusions. It appears to be the first official document that stresses the need to distinguish between eutrophication as a natural phenomenon and man-made eutrophication – having the character of pollution.

The report states:

> 10. Eutrophication as used in the context of this report is a form of pollution resulting from over-richment of water by nutrients from the waste products of certain human activities. The resulting increased production of algae and other aquatic plants leads to deoxygenation, deterioration of fisheries and water quality, and other objectionable responses in lakes, reservoirs, slow-flowing rivers and certain coastal waters.
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> 11. This form of eutrophication will be regarded as "man-made" so as to differentiate it from the similar natural phenomenon which, when it occurs, develops generally at a very slow pace. Man-made eutrophication in the absence of control measures proceeds frequently at an accelerated rate and must be seen as only one of the main forms of pollution. This report is focused upon man-made eutrophication, its consequences and potential remedies.

This rather marked distinction implies a warning. In the context of man-made eutrophication, conclusions drawn from studies of the natural phenomenon should be used with care – they may not apply.

Like the outcome of all international work, the OECD reports contain an element of compromise. This does not influence their status as "standard" documents that will remain valid as far as the main issues are concerned.

THE SWEDISH APPROACH

The Swedish approach to the control of man-made eutrophication was simple, pragmatic, and, as purely visual observation makes evident, effective. It was founded on experience that pollution control programs require a combination of an agreed definition of the problem, appropriate management instruments, adequate technology, available funds, and active participation by the concerned parties to be successful. Once excessive growth of planktic and rooted vegetation in lakes and archipelagos was identified as a major problem, traditional, step-wise reasoning was applied: (a) the link between, for instance, the rapid deterioration of water quality in the Stockholm archipelago and the upstream discharges of nutrient-rich sewage from approximately one million people needed no large-scale scientific work to be established – it was obvious to any experienced water manager; (b) human excreta make up a complete substrate for the nutrition of plants – illustrated by the fertilizing value formerly attributed to "night-soil"; (c) the logical remedy would be to minimize loadings, i.e., to extensively reduce the nutritive capacity of urban sewage; (d) this could be achieved only by applying adequate technical measures at the appropriate points, i.e., the sewage works; and (e) the technical measures might be supplemented but not replaced by measures of other kinds.

Lake shores being gradually overgrown by rooted vegetation, unappetizing algal blooms, and fishing nets rapidly covered by green slime were symptoms readily noticed by the general public. This justified the conclusion that any active program for control of this kind of pollution would gain broad public and, consequently, political support.

The matter of detergent phosphate as the main culprit was brought forward in the more popular part of the discussion of remedial measures. The Swedish authorities concluded, however, that there were clear disadvantages in making the detergent phosphates a major issue, the principal one being a risk that a number of communities would then feel justified to postpone expenditure on extended sewage treatment.

From late 1966 and onwards, there was consistent emphasis placed on the need to upgrade sewage treatment. Initially, this upgrading was referred to as phosphorus removal according to common terminology. The concept of phosphorus removal soon had to give way to that of chemical treatment, however, and the former is now largely abandoned. This was a result of the finding that the measures initially introduced to reduce the nutritive capacity of sewage were associated with additional, important advantages. This is particularly valid when the chemical treatment is carried out as a separate, ultimate step of a treatment system (post-precipitation in OECD terminology, Fig. 1). The levels of BOD and COD in final effluent are then lower and more stable in comparison with those characteristic of effluents from conventional biological sewage treatment, suspended organic matter virtually absent, and the number of bacteria and parasitic worm eggs reduced to low levels.

The results of the policy tentatively adopted in 1966-67 and conclusively established in 1970 are shown in Figure 2. It should be added that the authorities now consider chemical treatment of urban sewage as a standard requirement irrespective of whether eutrophication is a problem.

ECONOMIC INCENTIVES

Figure 2 shows that the situation in terms of sewage

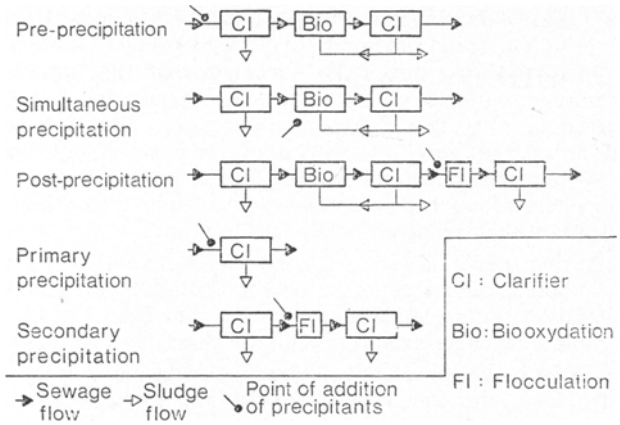
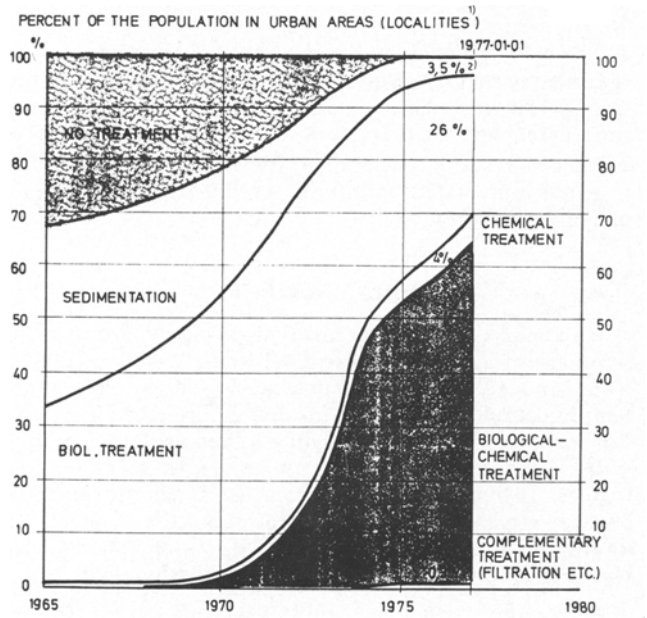


FIG. 1. Principles of chemical treatment of sewage.



NUMBER OF TREATMENT PLANTS AND PERSONS CONNECTED 1977 01 01

TYPE OF SEWAGE TREATMENT	NUMBER OF TREATMENT PLANTS	NUMBER OF PERSONS SERVED
NO TREATMENT		5000 (- 17000)
SEDIMENTATION	216 (- 57)	240 000 (- 75 000)
BIOLOGICAL TREATMENT	461 (- 63)	1 780 000 (-460 000)
CHEMICAL TREATMENT	128 (+ 11)	290 000 (+ 16 000)
BIOL-CHEMICAL TREATMENT	576 (+ 38)	4 500 000 (+600 000)
COMPLEMENTARY TREATMENT	7 (-)	21 000 (+ 3 000)

FIG. 2. Sewage treatment in Sweden – 1965-1977. The figures in parentheses refer to the change since Jan. 1, 1976. 1) Population clusters with at least 200 inhabitants are called localities if the distance between buildings as a rule does not exceed 200 meters. Localities account for ca. 83% of the total population, 2) half of which are without connection to municipal sewer system. (Reproduced by courtesy of the Swedish Environment Protection Board.)

treatment facilities was far from satisfactory when our first discussions of an upgrading program took place. Less than 40% of the population in communities exceeding 200 inhabitants were served by biological treatment facilities. Sewage from 30% of the urban population was discharged untreated. It was clear that quick action could not be expected unless economic incentives were provided. A system of governmental subsidies for construction of sewage works including facilities for chemical treatment was developed and proposed to parliament which approved the proposal by acclamation. According to that system, a maximum of 50% of the construction costs would be covered by public funds. The maximum subsidy requires in

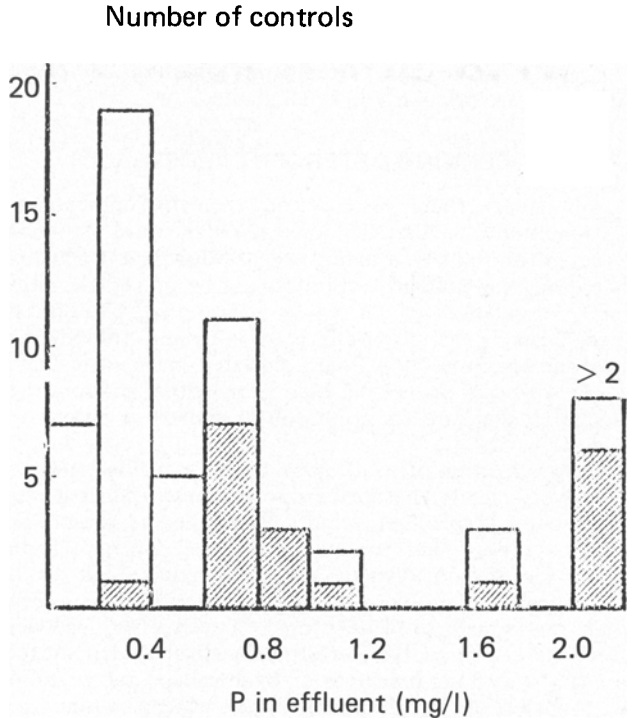


FIG. 3. Performance of sewage works with facilities for chemical treatment.

practice that the residual concentration of phosphorus does not exceed 0.5 mg/l in the final effluent under conditions of normal operation.

During the economic recession of 1971-72, the government chose construction of pollution control facilities as the main target of labor-creating economic incentives. Accordingly, projects for improving sewage treatment were for a period of time granted an additional 25% subsidy. This temporary measure is reflected in the particularly rapid change of the ratio of different forms of treatment that occurred in the years 1973 and 1974.

TECHNICAL ASPECTS

The performance of a number of sewage works was surveyed by the Swedish Environment Protection Board around 1973 (Fig. 3). The message of this figure is twofold. It says on one hand that low levels of phosphorus in treated effluent – a useful measure of overall process performance – can be achieved provided that an appropriate amount of precipitant (in the survey mostly alum or iron salts) is added, the precipitation step is optimized, and the final clarifier is of adequate design. (Incidentally, the precipitant demand was found to depend mainly on alkalinity and on sewage strength but not to any measurable extent on concentration of phosphorus.) It says, on the other hand, (the shaded parts of some piles indicate situations where performance was likely to be negatively affected by inadequate design features) that construction and engineering practices in sewage treatment technology occasionally were a bit too conservative, leaving a lot to be desired in terms of improvement.

Figure 3 reflects other lessons too. The tying of the subsidies to performance requirements made local authorities more willing to provide means for equipment maintenance and improvement. The active participation of the public in the program increased the social status of sewage operators and, hence, their interest in doing a good job. This job was facilitated in an unforeseen way. Chemical treatment increases the transparency of treated effluent in a readily noticed way, particularly when post-precipitation is applied. The use of a simple Secchi disk at the end of the

final clarifier enables the operator to check the plant performance, and his own skill, in a very convenient way. This quite primitive "monitoring" method has proved quite useful, particularly in small plants.

CONCERNING DETERGENT PHOSPHATES

Admittedly, there was a period when environmentalists, in conjunction with the media, tried hard to make detergent phosphates a major issue. Following the principle that environmental protection should be preventive rather than corrective and having in mind that, irrefutably, phosphorus is an important plant nutrient, the Swedish Environment Protection Board declared on its side that it would welcome any effort by the industry to develop an adequate substitute for triphosphate and try it out on the market.

However, in an official report issued in 1970 the Board stated very clearly that any proposed substitute must meet a number of specified requirements, i.e., it should not reduce product performance or cause damage to the laundry; it should involve no risk, toxic or allergic, to public health; it should not cause pollution problems either when discharged to waters or indirectly, by negatively affecting sewage works performance; it should not cause damage to washing machines or to sewerage; and it should be available at a reasonable price. [Translation from "Tvättmedel som miljöproblem" (Detergents as an Environmental Problem), Swedish Environment Protection Board 1970:4.]

This list of requirements is accompanied by an official recognition that there are aspects of detergent use in addition to the environmental one which deserve appropriate attention. The case against the fraction of phosphorus in untreated sewage having its origin in detergents was accordingly not considered strong enough to justify forcing consumers to use products that would make the maintaining of an achieved hygienic standard more difficult. In other words, consumer rights were not neglected.

At the initial stage, industry accepted, for reasons of good will, reduction of content of sodium triphosphate in all products to a maximum of 30% by weight. Industry claimed and the authorities accepted that this was the minimum requirement for good performance under most conditions prevailing in Sweden. Using percentage composition as the base of this nonformal agreement was convenient but not quite rational. The manufacture of high phosphate products of presoak type had to be discontinued in spite of their relatively small market shares.

During the late 1960s and early 1970s, a number of low phosphate products appeared on the market. The principal substitutes were soap, sodium citrate, and NTA. Most of the low phosphate products, with the possible exception of the NTA-based ones, did not achieve lasting consumer acceptance despite heavy advertising support. When marketing efforts lessened, sales dropped immediately. Disregarding the relatively successful NTA products, few if any of the low phosphate products succeeded in maintaining a market share exceeding 5% for any length of time.

When considered in retrospect, this period may be regarded as that of a gigantic, unique, nationwide consumer test of low phosphate products. The present structure of the detergent market provides irrevocable proof of consumer reaction. The majority of the low phosphate products were rated as inferior to the traditional ones in one or several respects.

FINAL REMARKS

This paper should be read as a highly concentrated summary of a policy that required several years and a lot of work to reach maturity and gain general acceptance. Simplification and omission of details have been inevitable. For instance, it is well recognized that a number of lakes have reacted but slowly on the remedial measures and, further, that there is much room left for improvement of sewage works performance. However, the general and locally quite fast improvement of water quality gives reassurance as to the adequacy of the chosen policy.