Progress in reducing water use and wastewater loads in the U.S. paper industry

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An NCASI survey shows that the U.S. paper industry has significantly reduced water use and wastewater loads since 1975.

An important and ongoing part of the National Council for Air and Stream Improvement's (NCASI) investigative program involves the periodic collection and organization of information characterizing wastes and emissions from the U.S. paper industry. This information not only strengthens the understanding of the capabilities of current waste and emission management practices, it also finds use in documenting the progress the industry has made in (a) making more efficient use of one of its most important raw materials, water, and (b) reducing its discharges. In an era of increasing public skepticism about the effectiveness of industry's efforts to protect and enhance the quality of the environment, such documentation takes on added importance.

This paper contains a summary of information obtained in a 1989 survey of NCASI's membership, which represents approximately 90% of U.S. production of pulp and paper. It documents the industry's progress in reducing water use, raw waste loads, and final effluent loads. In addition, the industry's sludge generation rates and increased reliance on beneficial uses for wastewater treatment sludges are documented.

General approach

In the summer of 1989, NCASI distributed to its membership a survey requesting information on the industry's 1988 solid waste and wastewater management practices. The responses returned to NCASI represented approximately two-thirds of the industry's 1988 production.

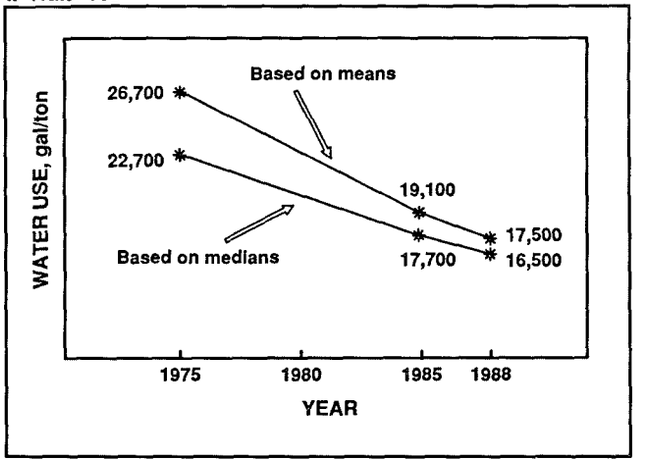
In the survey, NCASI requested information on (among other things) water usage, untreated and treated wastewater flow, BOD and total suspended solids (TSS) loads, and sludge generation rates for the years 1975, 1985, and 1988. The information was provided on a per-unit-of-production basis.

The responses were divided into eight different categories based on the principal production practices at each mill. These categories were:

1. Nonintegrated paper and board mills
2. Mills producing paper and board from non-deinked wastepaper
3. Mills producing paper and board from deinked wastepaper
4. Mills producing paper and board from mechanical (or related) pulps
5. Sulfite mills
6. Semichemical mills
7. Unbleached kraft and kraft cross-recovery mills
8. Bleached kraft and soda mills.

Only eight categories were used to ensure that there were an adequate number of mills in each category. However, while this categorization scheme is adequate for estimating overall industry statistics, it disguises some important mill-to-mill differences in waste characteristics related to differences in the types of raw materials, processes, and waste treatment methods being used, and in the products being manufactured. We caution the

1. Water use



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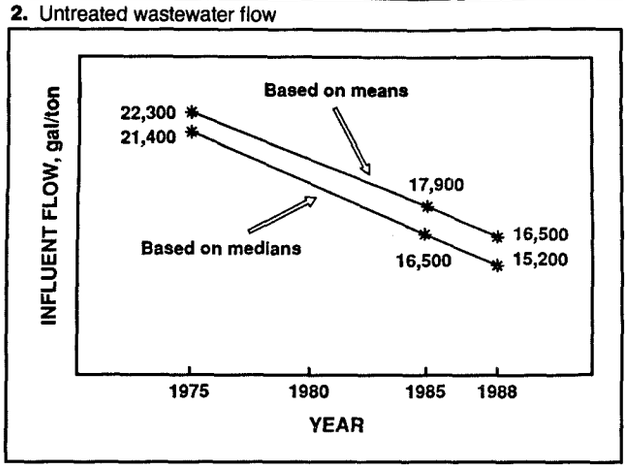
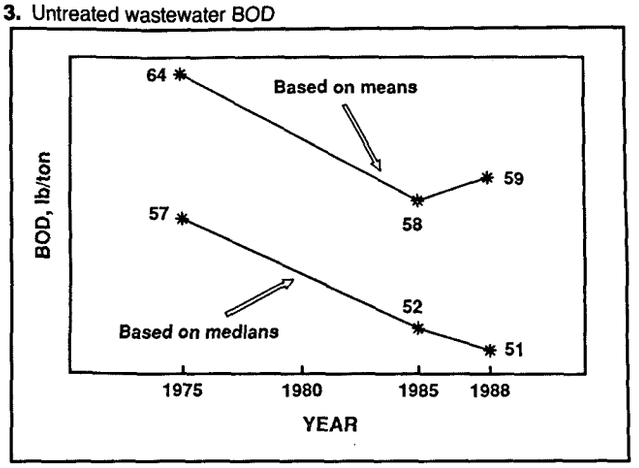
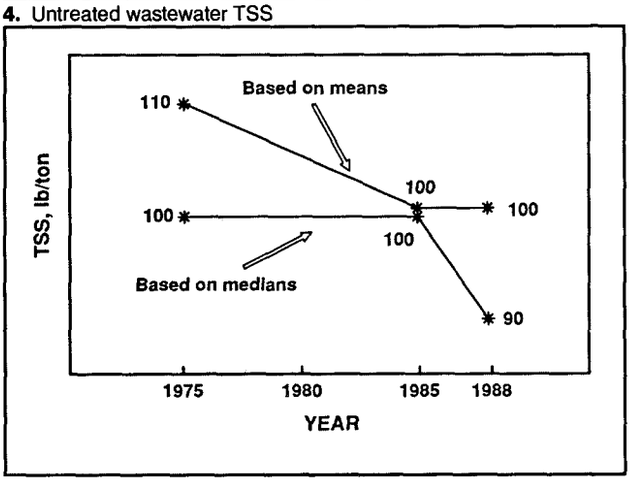
2. Untreated wastewater flow



3. Untreated wastewater BOD



4. Untreated wastewater TSS



reader not to use this categorization scheme for any purposes where such differences might be important.

After checking the data for obviously erroneous entries, the responses for each category were used to calculate median and mean values for 1988 water use, untreated wastewater flow, untreated wastewater BOD, untreated wastewater TSS, treated wastewater flow, treated wastewater BOD, treated wastewater TSS, and sludge generation. Also calculated for each category were median and mean percent reductions (or increases) in these values during the periods 1985-1988 and 1975-1988.

Overall industry figures per unit of 1988 production were derived by calculating weighted average water use and waste generation values over the industry, the weighting being based on the relative production of final product in each category. Overall industry figures for 1985 and 1975 were derived by reducing the 1988 water use or waste generation values for each category by the amounts indicated by the survey responses, and using these revised figures to calculate 1985 and 1975 weighted averages.

In the following sections, we report overall industry figures calculated two ways; the first is based on mean values for water use, waste generation, and percent reduction for each category, and the second is based on the corresponding median values.

Water use by the U.S. paper industry

The overall industry water use per ton of production in 1988, 1985, and 1975 are shown in **Fig. 1**.

The data in this figure indicate a reduction in water use from 1985 to 1988 of 7-8%, and a reduction from 1975 to 1988 of 27-34%. In 1988, it took approximately 16,000-17,000 gal of water to produce a ton of paper or board in the United States. Data presented later in this paper indicate that this is 70% less than was required to make a ton of paper in 1959.

Wastewater flow to treatment

Overall industry figures for the wastewater flow to treatment in 1988, 1985, and 1975 are shown in **Fig. 2**.

Not unexpectedly, these data indicate reductions in wastewater flow to treatment of approximately the same magnitude as documented for water use in Fig. 1. Between 1985 and 1988, untreated wastewater flows were reduced by approximately 8%, while the reductions accomplished between 1975 and 1988 were 26-29%.

Wastewater BOD to treatment

The amounts of BOD contained in the industry's wastewater before treatment are shown in **Fig. 3**.

These data suggest relatively little change in wastewater BOD going to treatment between 1985 and 1988 (the values for the two years are within approximately 2% of each other), and a reduction from 1975 to 1988 of 8-11%.

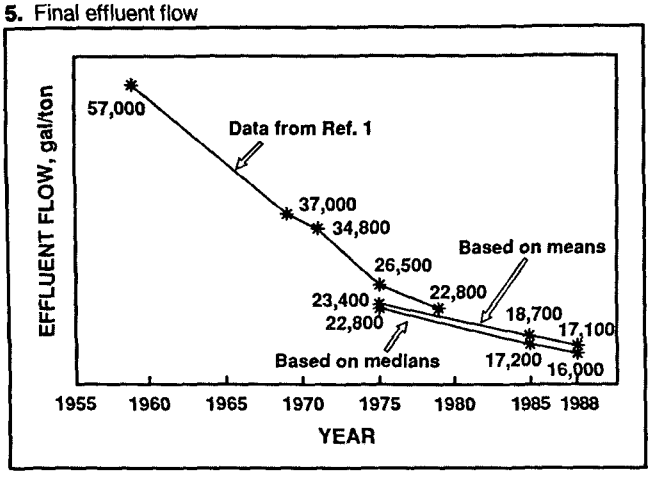
The fact that wastewater flows are dropping faster than the corresponding BOD loads suggest that raw waste concentrations are increasing. This could have important implications to wastewater treatment practices and concentration-based discharge limitations.

Wastewater TSS to treatment

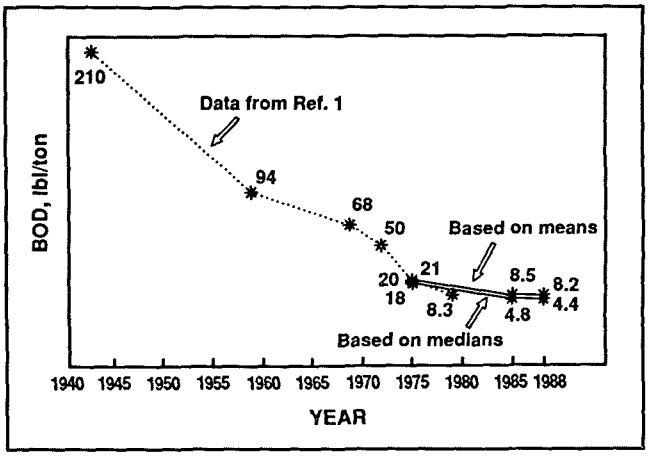
The amounts of TSS contained in the industry's wastewater before treatment are shown in **Fig. 4**.

These data suggest a modest reduction in wastewater

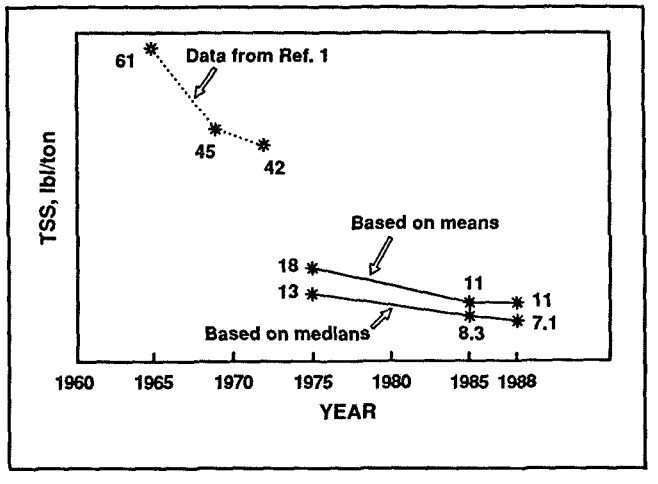
5. Final effluent flow



6. Final effluent BOD



7. Final effluent TSS



TSS going to treatment between 1985 and 1988 (there was no reduction estimated from mean values but a 10% reduction estimated from median values), and a reduction from 1975 to 1988 of 9–10%. Since before effluent quality data were generated, the paper industry has employed technologies to capture and, where feasible, reuse the solids contained in process wastewaters from papermaking. These efforts have provided steady reductions in the discharges of TSS in industry effluents. For the most part, we can assume that the reductions in raw waste suspended solids loads documented in Fig. 4 are the result of expanded efforts to (a) capture and reuse solids where possible and (b) segregate other solids from the wastewater stream, facilitating their handling and disposal.

Final effluent flow

The overall industry final effluent flow rates calculated from this survey for 1988, 1985, and 1975 are shown in **Fig. 5**. The figure also contains previously published data for 1979, 1975, 1971, 1969, and 1959 (*1*).

The data indicate that the overall industry 1988 final effluent flow per ton of production had decreased by 7–9% since 1985, 25% since 1979, 27–36% since 1975, 51% since 1971, 54% since 1969, and 70% since 1959. As expected, the reductions in water use, wastewater flow to treatment, and final effluent flow are comparable.

Final effluent BOD

The amounts of BOD estimated to be contained in the industry's final discharges in 1988, 1985, and 1975 are shown in **Fig. 6**. These figures have been calculated by applying the mean and median treated wastewater BOD loads for each category to all production in that category, whether the waste is treated on-site or by a publicly owned treatment works (POTW). This approach assumes that the amount of treatment accomplished in POTWs is comparable to that in the industry's wastewater treatment plants. This approach is consistent with that used in earlier efforts to estimate industry average discharges of BOD (and TSS) that are used as a basis for comparison to the new data discussed herein. The substantial differences between the means and medians suggest final effluent BOD loads to be very poorly described by the normal distribution, being instead highly skewed to the right. This observation conforms to findings in earlier NCASI studies of the statistical distributions useful for analyzing effluent quality data (*2*).

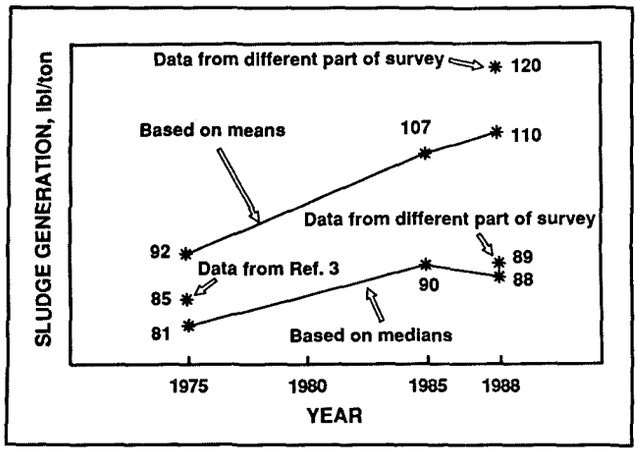
Discharges of BOD to the environment are reduced dramatically by the use of biological treatment. The paper industry began to employ biological treatment in the 1950s, with application becoming almost universal in the late 1970s. Accordingly, the reductions in BOD discharges accomplished from 1975 and earlier levels are especially impressive. The amount of BOD discharged per unit of production in 1988 was only one-third to one-quarter of that discharged in 1975, and less than 5% of that in 1943.

The data suggest effluent BOD loads were reduced by 4–8% in the relatively short period of 1985 to 1988. These improvements almost certainly reflect continued efforts to improve wastewater treatment plant performance.

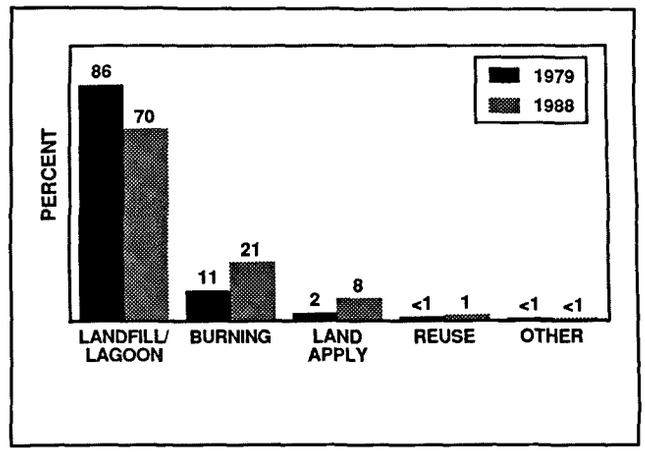
Final effluent TSS

The amounts of TSS estimated to be contained in the industry's final discharges in 1988, 1985, and 1975 are shown in **Fig. 7**. As in the case of the final BOD values, these figures have been calculated by applying the mean

8. Sludge generation



9. Sludge disposition (1979 data from Ref. 1)



and median treated wastewater TSS loads for each category to all production in that category, whether the waste is treated on-site or by a publicly owned treatment works.

As was the case for the final effluent BOD data, the substantial differences between the means and medians suggest final effluent TSS loads to be very poorly described by the normal distribution, being instead highly skewed to the right. Again, this observation conforms to findings in earlier NCASI studies of the statistical distributions useful for analyzing effluent quality data (*2*).

During the period before the widespread adoption of biological treatment (i.e., when primary treatment was the norm), reductions in discharges of solids in final effluents were more strongly related to reductions in solids losses in untreated wastes than is the case today. Solids in untreated wastes may still influence the levels of solids in biologically treated effluents, especially when solids such as coating clays are involved. Usually, however, biological treatment systems greatly diminish the dependence of final TSS levels on untreated waste TSS levels.

Biological treatment requires the growth of additional solids (biological solids). It is these solids that comprise the majority of those contained in biologically treated effluents. However, biological treatment systems also provide for efficient solids removal, usually accomplishing additional reductions in discharges of TSS compared to primary-treated wastewaters.

Available data indicate that 1988 TSS discharges per unit of production had been reduced by approximately 40% since 1975, and by over 80% since 1965. Again, the dramatic reductions from 1975 and earlier final effluent loads can be attributed in part to the use of biological treatment, which, although in widespread use in the paper industry before 1975, became almost universal in its application in the late 1970s.

The improvements in effluent quality did not cease, however, upon the widespread adoption of biological treatment by the paper industry. The continued efforts to reduce waste loads and improve treatment plant performance are demonstrated by the reductions documented during the three-year period from 1985 to 1988. Even over this short time, it appears that final discharges of BOD and TSS per unit of production were reduced by perhaps 5% or more.

Wastewater treatment sludge generation rates

Because NCASI's survey was focused on solid waste management, it was possible to generate estimates of sludge generation by several different methods. The information in **Fig. 8**, however, was generated using the same methods used in the preceding sections on water use and wastewater loads unless otherwise indicated.

These data suggest relatively little change in sludge generation rates from 1985 to 1988, and 1988 sludge generation rates that are 9–41% percent higher than those in 1975. These increases in sludge generation rates since 1975 can be explained by the corresponding reductions in final effluent BOD and TSS loads that have been accomplished over the same period.

The generation rates in Fig. 8 are presented in terms of dry sludge solids. Although not estimated, it is likely that the wet weights and volumes of sludges being managed have actually decreased dramatically since 1975 because of the installation of mechanical sludge dewatering equipment at many mills where it was not previously employed.

Beneficial uses of wastewater treatment sludges

The paper industry is expanding its efforts to apply wastewater treatment sludges to beneficial uses. The data in **Fig. 9** indicate the industry is relying less on landfill or lagoon disposal and more on burning for energy, applying to land for soil conditioning, and other recycle/reuse/by-product opportunities that represent beneficial uses of wastewater treatment sludges.

Because of the low response rates from recycled paperboard mills, the data in Fig. 9 do not sufficiently reflect the extent to which primary sludges are used as furnish at the recycled paperboard mills where they are generated. The extent to which recycled paperboard mills reuse primary sludge was documented in a 1983 survey by NCASI's Central-Lake States Regional Center of the mills in that part of the country. Thirty-three recycled

paperboard mills were contacted, of which 27 were generating sludge. The remaining six were either discharging untreated wastewaters to publicly owned treatment works or were employing treatment systems that did not allow sludges to be collected for separate disposal or reuse. Eighteen mills were reusing sludges in the production process. These 18 comprise more than half of the recycled paperboard mills contacted and two-thirds of those generating sludges in a form that would allow them to be reused. Sludges are also commonly reused at mills producing corrugating medium or linerboard from wastepaper.

Summary

The NCASI survey revealed the following:

1. Data from this survey and other sources document reductions in water use and effluent flows of approximately 30% between 1975 and 1988. In 1988, it required 70% less water to make a ton of paper than in 1959. Even in the short three-year period from 1985 to 1988, water use and effluent flow rates were reduced by 7-9%. Based on the data from this survey, the industry average water use in 1988 was approximately 16,000 to 17,000 gal/ton.
2. Raw waste BOD and TSS loads were reduced by approximately 10% between 1975 and 1988.
3. The amount of BOD discharged in final effluents per unit of production in 1988 was only one-third to one-quarter of that discharged in 1975, and less than 5% of that in 1943.
4. Available data indicate that 1988 TSS discharges in final effluents per unit of production had been reduced by approximately 40% since 1975, and by over 80% since 1965.
5. Even in the short period of 1985 to 1988, it appears that final discharges of BOD and TSS per unit of production were reduced by approximately 5%.
6. The reductions in final BOD and TSS loads have been accompanied by corresponding increases in sludge generation rates.
7. Whereas 86% of the industry's sludge was landfilled or lagooned in 1979, in 1988 this had been reduced to 70%. The recovery of energy from wastewater treatment sludges has grown in the last decade. In 1979, 11% of the paper industry's sludge was being burned, whereas 21% was being managed in this way in 1988. The use of land application has also grown, with 8% of the industry's sludge being land applied in 1988 compared to 2% in 1979. In some sectors of the industry, most notably recycled paperboard, one-half or more of the mills are reusing sludge directly in the production process.□

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