POLLUTION CONTROL IN THE TEXTILE INDUSTRY

POLLUTION CONTROL IN THE TEXTILE INDUSTRY

H. R. Jones

NOYES DATA CORPORATION
Park Ridge, New Jersey London, England
1973

Library of Congress Catalog Card Number: 72-90715
ISBN: 0-8155-0470-5
Printed in the United States

Published in the United States of America
by Noyes Data Corporation
Noyes Building, Park Ridge, New Jersey 07656

FOREWORD

This Pollution Technology Review is largely based on authoritative government reports and surveys. It attempts to clarify the ways and means open to the alert textile processor who must keep his polluting wastes down to a minimum.

Many effluent wastes from textile mills are biodegradable, but treatment costs are increasing, effluent discharge requirements are becoming more stringent, and urbanization increasingly limits the availability of land. Thus, there are many problems to be dealt with in handling the industry's waste.

In the United States, we are fortunate in receiving direct help from the numerous surveys, together with active research and development programs that are being supported by the Federal Government to help industry control its wastes and troublesome effluents.

In this book are condensed vital data from government sources of information that are scattered and difficult to pull together. Important processes are interpreted and explained by examples from recent U.S. patents. One should have to go no further than this condensed information to establish a sound background for action towards combating pollution in the textile industry.

Advanced composition and production methods developed by Noyes Data are employed to bring these durably bound books to you in a minimum of time. Specialized techniques are used to close the gap between "manuscript" and "completed book." Industrial technology is progressing so rapidly that time-honored, conventional typesetting, printing, binding and shipping methods can render a technical or scientific book quite obsolete before the potential user gets to see it.

The Table of Contents is organized in such a way as to serve as a subject index. Other indexes by company, inventor and patent number help in providing easy access to the information contained in this book.

CONTENTS AND SUBJECT INDEX

INTRODUCTION

The major pollution problems presented by the textile industry are water pollution problems. There are a few problems of air pollution by chemicals, lint, etc., but these are minor. Wastes in textile mill effluents may be divided into the following categories:

(1) Naturally occurring dirts, salts, oils and greases on cotton and wool.
(2) Chemicals added or removed during the many different process operations.
(3) Fibers removed by chemical and mechanical action during processing.

The chief sources of water pollution within the industry are as follows:

Cotton	Wool	Synthetic Fibers
Desizing	Top making	Desizing
Scouring	Scouring	Scouring
Mercerizing	Carbonizing	Dyeing
Bleaching	Fulling	
Dyeing	Dyeing	
Printing	Finishing	

Additional detail on the nature of these various processing steps and their effluent treatment will be discussed later in this volume.

A review of water use and wastes in the textile industry has been published by J.J. Porter, D.W. Lyons and W.F. Nolan of Clemson University in

Environmental Science and Technology, 1 (1), 37 to 41 (January, 1972). Considerable reliance has been placed in the preparation of this volume on the excellent publication "State of the Art of Textile Waste Treatment" by J.J. Porter of Clemson University. Prepared under government contract the report is available from the Superintendant of Documents, U.S. Government Printing Office, Washington, D.C. (1971).

Most recently, under the Industrial Waste Studies Program of the Environmental Protection Agency a report on the Textile Mill Product Industry has been prepared by Arthur D. Little, Inc., of Cambridge, Massachusetts (May 28, 1971).

There are two publications on water and the textile industry that have been prepared at Georgia Tech. Both are out of print. The first is entitled, "The State of the Art of Water Use and Waste Disposal in the Textile Industry (1950 to 1966)" by Leonard D. Jones and William L. Hyden. Call Number at the Georgia Tech Library is HD1694.G42X J6.

The second publication is entitled "Survey of the Nature and Magnitude of the Water Research Needs of the Textile Industry in Georgia" by William L. Hyden, Douglas F. Becknell, and Telford E. Elders. The Call Number is HD1694.G42X H85. These two documents can be obtained on inter-library loan from the Georgia Tech Library.

PROBLEMS AND TRENDS

Approximately 14.3 trillion gallons of water are discharged by United States industry each year according to the U.S. Department of Commerce (1970). The textile mill products (includes the SIC Industry Group Numbers 221 to 223, 225 to 229, and Industry Numbers 2823 and 2824) industry discharged about 461 billion gallons or 1% of the total. The major water users are:

	Billion Gal./Yr.	Percent
Metal and metal products	7,841	22.1
Chemical and allied products	7,820	22.0
Paper and allied products	6,599	18.6
Petroleum and coal products	7,220	20.3
Food and kindred products	1,405	4.0
Textiles mill products	1,127	3.2
Rubber and plastics	1,106	3.1
Other	2,438	6.7
Total	35,556	100.0

There are approximately 4 million employees working in textile related jobs. Of these, nearly 1 million may be considered textile employees working for 700 mills with an annual sales of 21 billion dollars. Another very important factor to consider as far as the textile industry is concerned is the rate at which this growing waste stream is changing in composition.

The use of synthetic fibers, polymers, and finishes by the textile industry is increasing at a rapid rate. Since many of these products are resistant to biological degradation, a careful study of their removal from wastewaters is essential so that effective waste treatment methods are chosen. Both state and Federal regulations will increase as the industrial community grows and the water supply is reused more often. Although mixing of domestic wastes with textile wastes has led to successful treatment in the past according to Lauria and Willis (1964), the increasing inertness of textile effluents may prevent this general approach in the future.

To get an accurate measure of the organic compounds present in a waste stream, a total carbon analysis of the waste stream is useful. A BOD test will only measure biological oxidation. It gives no indication of the presence of nondegradable materials. The BOD test is useful in designing aeration capacity for biological treatment plants, but it gives no indication of refractory organic compounds in treated effluents.

Carbon analysis is not affected by toxicity, source and acclimation of seeding organisms, dilution water, and other chemical interferences which can cause problems with the BOD determination. Automated equipment is available to measure continuously and record carbon content in wastes or process streams where continuous control becomes important as noted by Schaffer et at (1965). Even with standard equipment data from carbon analyses are available within an hour after sample collection compared to five days for BOD determination.

A research committee of the American Association of Textile Chemists and Colorists has published a list of textile chemicals which gives the 5 day BOD of each chemical (1966). Out of 300 products, almost 40% had less than a 10% 5 day BOD by weight of chemical and may be considered relatively resistant to biodegradation.

Two important considerations for the construction of a waste treatment plant are the cost and availability of land. As waste chemicals become harder to degrade biologically, longer retention times will be needed for their degradation in the treatment plant. Plant size, therefore, is dependent on the character of the waste stream. Chemicals that are resistant to biodegradation may be removed from the stream by adsorption on the sludge formed by biological degradation. In some cases this method of removal will be satisfactory, but more data is needed to substantiate the effectiveness of adsorption on sludge as a removal process.

In the future, waste streams from different processing operations will have to be isolated and treated by either physical, chemical, or biological methods, or by combinations of these methods. The choice of treatment will depend on the composition of the waste stream. Effluent through a single pipe can no longer simply be "turned over" to the pollution control engineer for him to "take care of".

New detergents and resins which are introduced onto the textile market are generally accompanied by a new or different effluent. A waste stream that may have once been homogeneous and biodegradable can become heterogeneous and inert. It is evident that waste treatment plants must be provided with built in flexibility so they can accomodate future production changes. This is hard to do when the industrial waste stream is treated by a municipal treatment plant. In some cases the mixing of industrial and municipal waste streams may very well produce a waste which is less suited for either biological or chemical treatment.

This raises the question of whether industrial waste should be treated by municipalities or by the plants themselves. No obvious answer exists, but any product or service that causes pollution should pay for its equitable share of restoring the water to a desirable condition. A better insight into some of the questions that have been raised may be obtained if we look at changes that have occurred in the textile industry over the past 20 years and see how these changes will affect waste treatment methods.

COST OF TEXTILE WASTE TREATMENT

Some of the economic aspect of various type of textile waste treatment are described in sections of this book, in joint mill-municipal waste treatment, for example. For considerable additional detail on treatment process economics, the reader is referred to "The Cost of Clean Water, Volume III: Industrial Waste Profile No. 4, Textile Mills Products", Washington, D.C., U.S. Department of the Interior, Federal Water Pollution Control Administration (June 30, 1967).

FIBERS INVOLVED

In 1950, the major fiber consumed on the American market was cotton. If man-made cellulosic fibers are not included, the quantity of man-made fibers produced at this time was hardly significant.

The lint from textile manufacturing and finishing is a noticeable part of the suspended solids in textile waste. In the case of natural fibers biological degradation will occur when the fiber is retained with the sludge in the treatment plant. This is not true for most synthetic fibers as they are comparatively inert. The buildup of synthetic fibers in a treatment plant using mechanical aeration can cause damage to pumps and aerators unless special precautions are taken to see that the fibers are removed from the waste stream before it enters the plant.

This is generally done by screening the waste stream as it enters the treatment plant. In some cases this is a difficult operation because a screen system fine enough to remove fibers 15 microns in diameter may easily clog or remove suspended solids that are suitable for biological treatment. The example just described shows in a visible way how an industrial waste stream has changed over the past 20 years.

SIZING

The principal slashing polymer used before 1960 was starch. This natural polymer of glucose is easily degraded biologically and should present no problem to the conventional waste treatment plant other than BOD loading.

The development of many synthetic fibers in the 1950's and their use in blended fabrics created the need for new sizes which were more compatible with the hydrophobic fibers. Some of those which were developed and are still in use are polyvinyl alcohol (PVA), carboxymethylcellulose (CMC), and polyacrylic acid. Of these three materials polyvinyl alcohol and carboxymethylcellulose are the most widely used. The total sizing materials entering waste streams today can be estimated.

If an average size concentration of 10% is assumed to be present on woven fabrics, which constitute 70 to 80% of the fabrics produced, approximately 400 million pounds of size per year are currently entering textile finishing waste streams. This constitutes one of the major BOD loads on waste treatment plants in the case of starch according to Souther (1969).

Since PVA and CMC are resistant to biological degradation, one would not expect conventional treatment methods to alter their chemical structure. While the polymer may be partially removed from the waste water by adsorption on the sludge, it is questionable whether this is an effective method of treatment. This brings up a point about the use of BOD analysis for industrial waste and suggests as Van Hall, Safranko and Stenger (1963) have that organic carbon analysis would be more indicative of organic contaminants.

SCOURING

The change in scouring which has possibly received the most attention since 1950 was the conversion to biodegradable detergents as noted by Allred and Huddleston (1967) and Huddleston (1966). Today most of the detergents are at least partially biodegradable so that foaming tendencies can be destroyed by microbial action.

An important factor to consider today is the impact that solvents, which are used in scouring operations as described by LeBlanc (1967), will have on pollution. Several solvents such as mineral spirits, chlorobenzenes and perchloroethylene have been used to aid in the removal of oil born stains from synthetic fibers according to White, Ross and Crowder (1959). Some of the solvents are inert to biological treatment and may not be removed from a waste stream by the conventional waste treatment plant. More research is needed to develop effective methods of removing volatile chemicals from waste streams without contributing to the problem of air pollution.

A few of the major chemical manufacturers are now offering solvent processes to the textile industry for scouring where little water is used as noted by Hofstetter (1969). In these cases nonflammable chlorinated solvents are used and the projected solvent recovery is between 90 and 97%. If a 93% recovery value is assumed and it is applied to a continuous finishing range running 70 yards a minute, it can be visualized that nearly one ton of solvent per day per range will reach the atmosphere or waste stream.

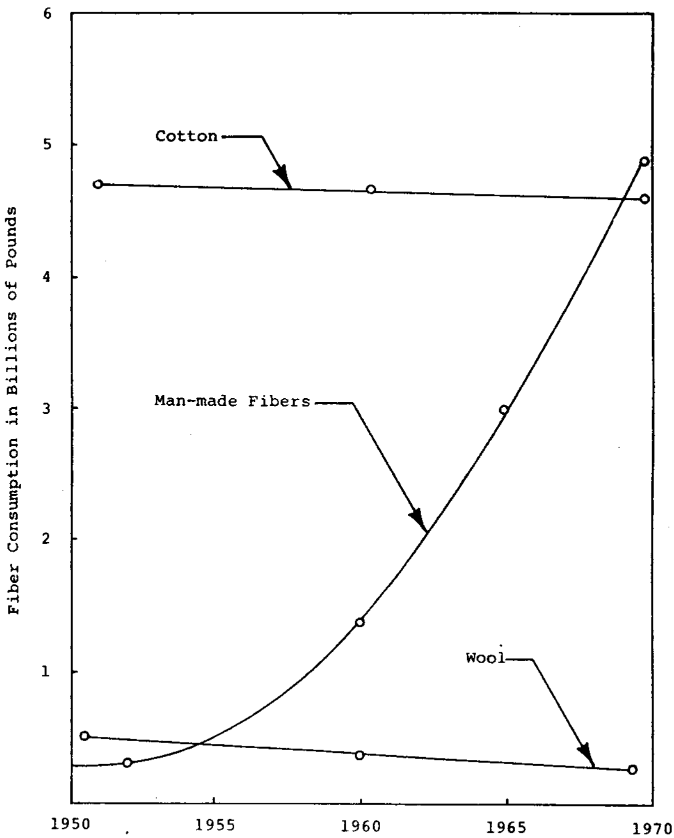
Chemical methods of treatment may be required. These could pay for part of their operation by recovering valuable solvent for reuse. When treatment methods are able to recover expensive chemicals from a waste stream, new production processes may be developed that would have been previously considered too expensive.

MERCERIZING

The original purpose of mercerization was to improve the luster of cotton fibers. Today the treatment of a cotton-containing fabric with a caustic solution is as much for improving the dyeability and absorption characteristics of the fabric as anything else. Since man-made fibers are not mercerized, the use of the process will depend on the quantity of cotton fibers reaching the finishing plant.

A significant decrease in caustic consumption is obtained when caustic recovery units are installed in the finishing plant. Several studies such as that by Carrique and Jaurequi (1966) have been made which document the improved efficiency of treatment plant operation when the caustic loading is decreased. The obvious advantages of this process accounts for its use by most finishing plants. If the fiber consumption trends shown in Figure 1 continue to change at their present rate, the percentage of fabrics receiving caustic treatments will decrease considerably in the next 10 years.

FIGURE 1: CONSUMPTION OF TEXTILE FIBERS IN THE UNITED STATES



Source: EPA Report 12060 ECS-02/71

BLEACHING

This is one textile finishing operation which has shown an improvement over the past 20 years as far as water pollution is concerned. In 1950 the major bleaching agent used was sodium hypochlorite as noted in Textile Industries (1969); today it is hydrogen peroxide. Hydrogen peroxide decomposes to water and oxygen and leaves no dissolved solids or objectionable residues behind. In fact it can raise the waste stream's dissolved oxygen concentration which is desirable in many cases.

Solvent systems for bleaching are being examined by academic institutions as well as chemical manufacturers. To be economical these processes will require efficient solvent recovery operations. With the use of suitable solvents a combined scouring and bleaching operation could be developed that would use very little water. A change in wastewater volume such as this could drastically affect the operation of a conventional biological treatment plant. Waste treatment plants must be designed with built-in flexibility where process changes are anticipated.

DYEING

This is second only to chemical finishing in the changes that occur each year. Not only have approximately 40 new fibers appeared on the market in the past 20 years, but new dyes for these fibers are developed each year. The "Textile Chemist and Colorist" (1969) lists 26 new dyes for 1969 alone, and this is by no means a complete listing. The market demands better performance each year. Dyes have to be more resistant to ozone, nitric oxides, light, hydrolysis and other degradative environments to capture a valuable portion of the commercial market.

It is not surprising that studies on the biological degradation of dyestuffs yield negative results when the dyes themselves are designed to resist this type of treatment. The high color value or absorptivity needed for a commercial dye is not an advantage when that dye ends up in a waste stream. Although some dyes are biologically degradable as noted by Pratt (1968), most that are present in wastewater are objectionable for their coloration.

To effectively remove dyes from textile waste effluents, nonbiological processes will have to be used in many instances. Dyes are just too refractory to undergo degradation in the time required for conventional waste treatment. Initial studies using chemical treatment methods such as activated carbon treatment as described in Environmental Science and Technology (1969) look good, but more research is needed to establish clearly the parameters for chemical treatment.

The auxiliary chemicals used in aqueous dyeing can also present a problem to biological processes. Carriers such as methyl naphthalene, chlorobenzenes, biphenyl, orthophenyl phenol, and benzyl alcohol are used to speed up the dyeing process. When the dyeing operation is completed, these chemicals are discharged to the sewer. Some are biodegradable; others are not. Even though the nonbiodegradable chemicals may be absorbed by the sludge in an activated sludge process, the problem is not alleviated if the sludge is not handled properly for ultimate disposal to prevent further contamination.

FINISHING

A treatment of a fabric that modifies its physical or chemical properties may be classified as finishing. Today there are finishes that are commonplace which were either nonexistent or not in significant use 20 years ago. Examples are permanent press finishes, oil repellents, soil release agents, low crock polymers, abrasion resistant polymers, fire retardants, lamination polymers, germicide and fungicide chemicals, to mention a few. A small number of these materials are biodegradable; most are not.

The polymers used for textile finishing are generally supplied to the finishing plant as emulsions. This is done because of the ease of handling and cost of manufacturing. Most polymer emulsions are sensitive to pH, salt or agitation and may coagulate when they enter waste streams. The sewer lines may then become clogged with inert materials which have to be removed by hand. Although the bulk of the polymer emulsion can be coagulated and removed in a treatment plant, some of it remains emulsified and is not removed by biological treatment. For complete removal of the polymer emulsion, chemical treatment is sometimes necessary. However, this is an additional step which in itself could replace much of the need for biological treatment.

Most of the finishes used for wash and wear and permanent press fabrics are manufactured from urea, formaldehyde, melamine and glyoxal compounds. Some of these products are readily degradable by microbial action; others are not as noted in an AATCC study (1966). The formaldehyde derivatives can react with themselves or other chemicals in the waste stream to form insoluble products that may be removed by sedimentation.

A class of finishing chemical that has come into prominence in recent years is fire retardants. These chemicals have received attention because of the growing concern over the flammability of textile fabrics. Most of the commercial fire retardant finishes are phosphorus- and nitrogen-containing compounds according to LeBlanc (1968). Two examples are *triaziridyl*