Pollution Prevention Seminar

by Brent Smith

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Source Reduction: Alternative To Costly Waste Treatment

The key is lessening wastes at their sources.

By Brent Smith

The author is professor of textile chemistry, North Carolina State University, Raleigh, N.C., and has been involved in research on source reduction of pollutants in textiles operations.

Source reduction should be every mill's first line of defense against pollution, with resulting improvements in quality and safety.

But typical mill waste treatment and disposal often represents raw material losses. There is considerable economic disadvantage in this, including the costs of waste collection, handling, treatment, disposal, as well as raw material loss, liability for harm the waste may do (actual or perceived) and resulting bad publicity.

Also, waste treatment systems usually require major capital investments with high operating costs and no economic return on investment.

High Return, Low Cost

Source reduction is an attractive alternative to waste treatment. In fact, there is a growing interest in source reduction as a major means of controlling ever-increasing waste costs.

In contrast to treatment, source reductions generally have low capital investment, high returns and low operational costs.

The optimum strategy for pollution control involves primarily reduction of all wastes at the source, treatment of only those wastes which cannot be eliminated and disposal of only the minimum amount of surviving waste materials which are not destroyed by treatment. The concept of source reduction focuses on the textile process itself to eliminate waste at its source.

Treatment systems often move an undesirable waste material from one medium to another.

For example, scrubbers on smokestacks remove air pollutants by dissolving them in water which must be treated, producing sludges and solids. These solids must then be disposed of by landfilling, with the associated risk of groundwater contamination.

Thus, in general, treatment strategies tend to create chains of waste products which lead to expense and liability, which are propagated through many layers of treatment. Source reduction, on the other hand, completely eliminates the waste once and for all.

Figure 1 - Source Reduction Cost/Benefit
Identify, Target Waste

Source reductions are usually accomplished by several different techniques including audits of processes, products, raw materials, recycling/reuse opportunities, waste segregation, design stage evaluations, chemical optimization and administrative measures. Waste comes from specific sources and any effective minimization effort begins with identification of the waste sources.

Four main types of waste which are particularly amenable to source reduction are hard-to-treat, dispersable, offensive and high volume wastes.

For each of these, there are major advantages in source reduction activities.

The first type, hard-to-treat wastes (persistent or resistant to normal treatment), includes color, metals, phosphates, phenols and certain organic materials, especially certain types of surfactants which resist biodegradation. Because of the extremely expensive and difficult procedures required to remove or destroy these via conventional wastewater treatment, source reduction is an economical and attractive alternative.

Deal With It

Several ways of dealing with hard-to-treat waste, from a source reduction point of view, are chemical substitution, chemical control and conservation, waste segregation, capture, reuse and recycle.

In doing this, the goal is to make changes which either reduce the amount of hard-to-treat waste or make the waste more treatable and less persistent.

The second category, dispersable wastes, tend to become widely dispersed when discharged. These wastes usually exist in concentrated form when they are created, and at that point they can be captured or reduced by process modifications at the source.

But once discharged they tend to become widely dispersed and hard to recapture and collect for treatment. Machinery design, chemical substitution, procedural remedies or other primary control measures can often accomplish better results at lower cost for these wastes than treatment.

In addition, reclaimed waste in concentrated form has its highest potential for recycling.

Types Of Waste

Textile examples of this type of waste include lint (from air and water filters), print paste (from drum washers), waste from coating operations (foam backcoatings), air emissions (breathing losses from tanks), waste solvents from machine cleaning (shop), still bottoms from solvent recovery (dry cleaning) and batch dumps of unused mixes (finishes).

In some cases, these dispersable materials have salvage or recycle/reuse value in their concentrated form. But even if not reused, collection, handling and disposal is usually much easier if the material is captured when least diluted or contaminated.

The third type, offensive or hazardous textile wastes, includes toxic air or water emissions, metals, various organic materials and surfactants. In many instances, chemical substitution can effectively reduce production of undesirable process by-products or reduce their offensive nature.

For these wastes, treatment often leads to undesirable waste treatment solids, like metal bearing sludges.

Hazardous or toxic wastes are generally a subgroup of offensive waste. Their impact on the environment is great, therefore they should get special attention.

Set A Goal

The goal of source reduction is to reduce either the volume or the offensiveness. For textiles, hazardous or toxic wastes include metals, chlorinated solvents, non-degradable or volatile organic materials. These often arise from non-process sources, like machine cleaning.
Table I - Chemical Prescreening Protocol

<table>
<thead>
<tr>
<th>Cost</th>
<th>Performance in intended use</th>
<th>Hazardous contents</th>
<th>Hazard potential when mixed with other chemicals</th>
<th>Storage and handling requirements</th>
<th>Potential for recycle</th>
<th>Proposed manner of use</th>
<th>Ultimate fate of the material</th>
<th>Who will handle the material</th>
<th>Potential for release to the environment</th>
<th>Spill control, decommission</th>
</tr>
</thead>
</table>

In order to achieve process optimization and product uniformity, consistent raw materials must be fed into the manufacturing process. To try to optimize processes and equipment without first controlling raw materials leads to constant adjusting of the process and equipment with little if any permanent improvements.

Raw materials coming into the textile process generally include commodities such as water, substrate (yarn, fiber, fabric), salt and size, as well as specialty process chemicals and dyes.

The first and most important step is to audit the wastes from an operation, including both the process and nonprocess items. In many cases, nonprocess sources account for over half the pollution, especially the most offensive types.

Most often found are nonprocess cooling water, solvents from machine cleaners and shop use, metals, herbicides, fungicides, boiler chemicals, insecticides and the like. Once all wastes have been listed, each should be viewed as a potential recycle/reuse product, and markets should be sought.

The next step is to identify specific reduction strategies for each identified waste.

Some broadly applicable techniques include raw material control, conservation and optimization of chemicals, chemical substitution, process modification, equipment modification, maintenance procedures, housekeeping, waste recovery (for reuse/recycle) and segregation. Using a combination of these techniques has produced documented savings in the millions of dollars.

Case histories for 39 firms reviewed in a recent report showed not only impressive pollution source reduction results but also annual savings of over $12 million for the companies. These savings will persist and even increase year after year, in contrast to waste treatment losses and costs which produce an increasing burden of cost and liability.

Control Raw Material

In any manufacturing operation, there are two fundamental sources of product variation: raw material variation and processing variations.

Making It Work

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Raw material control can be exercised both by prescreening materials before use and by testing shipments as they are received, according to the scheme indicated in Tables I and II.

These precautions provide many important benefits, not the least of which are reduction of off-quality goods, lower reworks and improved product uniformity.
Each of these increases manufacturers’ profits while reducing waste associated with inefficient processes, reworks and remakes.

These techniques also allow the mill to screen out raw materials which will ultimately produce offensive wastes. Do not overlook shop and maintenance chemicals.

**Conserve, Optimize**

It is not unusual to find dyeing and other procedures in textile wet processing which use excessive amounts of chemicals or unnecessary chemicals. Often chemicals are unnecessarily added to procedures to counteract the harmful side effects of other chemicals.

For example, defoamer is frequently added to reduce foaming caused by other chemical specialties. In many cases, it is more judicious to adjust, substitute or to remove offending chemicals from a process than to add more chemicals to offset undesired side effects.

Even better, it is often possible to accomplish the desired result by machine set up, time, temperature and other processing parameter adjustments, without using chemicals at all. Such conservative use of chemicals can significantly reduce waste loads and processing costs.

A good example of chemical specialty misuse is frequently seen with chemical specialty leveling agents and retarders. These are used with a wide variety of dye types (acid, basic, direct, disperse) to insure even and level dye exhaustion. In most cases, the same level exhaust can be obtained by proper process design. The use of chemical specialty retarders and levelers usually results in lower ultimate dyebath exhaustion.

This means more color in the wastewater and color is one of the most difficult textile related pollutants to remove from wastewat.

Thus the dyer should attempt to maximize dye exhaustion in order to reduce color in the effluent.

Higher exhaustion also pays large economic dividends by providing maximum consistency of shade repeats and minimizing dye use which results in immediate dollar savings in dye cost and reworks for off shade.

**Recycle/Reuse**

Many wastes have salvage value. This is true both for internal on-site reuse as well as external off-site use.

By reusing waste as a raw material, not only is the value of the raw material saved, but less volume of waste has to be treated. Thus the concept of recycling is fundamental to source reduction.

Each waste, especially concentrated or high volume wastes, should be thought of as a product for which a market has not yet been found. Each raw material should be thought of as an opportunity for waste reuse.

Recycling/recovery is practiced widely for heat (from air and water), size, water and caustic. Chemical mixes can also be reused.

It is good economic sense to avoid dumping unused portions of chemical mixes, but this still happens in many types of continuous textile operations such as slashing, preparation, continuous dyeing, printing, coating and finishing. Batch dumps are expensive and account for a major portion of a processor’s waste load.

To salvage unused mixes, segregation of wastes is the first step in recycle/recovery, since mixed wastes are generally not reusable. Even if wastes are not recycled, there are several reasons that segregation of wastes may be
Table III - Typical Water Conservation Measures

<table>
<thead>
<tr>
<th>Process Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low water use dyeing equipment/processes</td>
</tr>
<tr>
<td>Counter Current Washing</td>
</tr>
<tr>
<td>Reuse Final Waste Water for Next Batch</td>
</tr>
<tr>
<td>Reuse Soaper Water for Backgrey washing (printing)</td>
</tr>
<tr>
<td>Reuse Synthetic Fiber Scouring Water for Desizing</td>
</tr>
<tr>
<td>Reuse Mercerizing Wash Water Bleaching or Scouring</td>
</tr>
<tr>
<td>Reuse Water Jet Weaving Wastewater for Desizing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-Process Water Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce/optimize wash water, then reuse</td>
</tr>
<tr>
<td>Optimize cooling water flow, then separate/recover</td>
</tr>
<tr>
<td>Turn off cooling water on unused machines</td>
</tr>
<tr>
<td>Eliminate Parking Lot and Roof Drains, tied into system</td>
</tr>
<tr>
<td>Use Automatic Shutoff Valves/Interlocks on Hoses</td>
</tr>
<tr>
<td>Keep valves, plumbing in good repair and operating condition</td>
</tr>
<tr>
<td>Cut back on water use (hot water) to clean work areas</td>
</tr>
<tr>
<td>Preventative Maintenance of Water Cooler and Toilets</td>
</tr>
<tr>
<td>Avoid excessive water for equipment cleaning (never use waste streams)</td>
</tr>
<tr>
<td>Avoid washing delivery trucks (e.g. bulk chemical shipments)</td>
</tr>
</tbody>
</table>

Specific treatments, such as neutralization of acid/alkaline and oxidation/reduction wastes are more effective prior to mixing. Recovery/reuse systems generally are more effective when the waste stream is most concentrated.

Mixing hazardous and nonhazardous (or hard-to-treat and easily treatable) wastes can create unnecessarily large volumes of hazardous (or hard-to-treat) wastes.

Modify Equipment

Examples of equipment modifications include flow reducers on hoses/cooling water, countercurrent/recycle washing, physical modifications to reduce processing a solution carry-over and waste, lower liquid ratio in batch dyeing (resulting in lower chemical use and higher dye exhaustion).

It is also important to design and schedule equipment for least fouling and easiest cleanup. Some of the most offensive materials used in textile operations are highly corrosive agents or chlorinated solvent machine cleaners.

These, as well as shop, labora-

tory and maintenance chemicals are major contributors to aquatic toxicity problems. They should be selected carefully and their use should be controlled and minimized.

Almost all mills have specifications for preparation, dyeing and finishing in terms of times, temperatures and chemical types and amounts to use. But it is not unusual at all for the use of shop, laboratory and maintenance chemicals as well as times and temperatures for machine cleaning to be completely unspecified.

A related issue is maintenance, which is a critical factor in controlling waste, not to mention the quality improvements that result. Improved quality, more efficient processing and reduced reworks mean less waste.

Keep House In Order

Housekeeping is another important issue. Disorderly chemical mix areas, drug rooms and color kitchens where spilled chemicals and color are washed down the drains with water hoses are major contributors to pollution from many mills.

Often, hoses are left perpetually running in these areas, resulting in water wastes in the thousands of gallons per day.

Typically, workers and supervisors do not believe such trivial items as housekeeping make a difference but, in practice, these are very important in terms of pollution and, more importantly.
attitudes.
Of course, automatic color
and chemical
dispensing
systems reduce
working wastes
greatly, but even
simple tech-
niques related to
manual han-
dling, such as
using separate
dippers and
buckets for each
chemical (to
reduce chemical
loss through
rinsing) give
major reduc-
tions. Screen
cleaners, drum
washers, tanker
truck washing
can also be
major problem
areas.
In many
mills, the drum
washes is the main pollution
source. To control this area, the
ideal solution is to return all
containers to the vendor (without
washing).

Savings Through Change
It is often possible to change
textile production processes
themselves to greatly reduce or
eliminate waste. These changes
are usually very site-specific and
depend on which products are
being produced, quality require-
ments and waste reduction goals.
Such changes also often result in
an economic gain for the proces-
sor.

For example, cotton can be
printed or dyed with direct, fiber
reactive, vat, sulfur, naphthol
(azo), mordant or pigment dyes.
Each class produces waste of
differently different quantities
and characteristics.

As another example, pigments
use acrylic binders which, if
discharged, cause high total suspended solids (TSS) levels.

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**Table IV - Phosphate Substitutions**

| Hexaphosphates | Water Conditioner | EDTA |
| Calgon | | Silicate |
| Phosphates | Surfactants | Silicate |
| | Scouring Agents | Ethoxylates |
| | Flame Retardants | Amines |
| | | Varies |
| Phosphon- | Flame Retardants | Varies |
| amides | | |

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Pigments also frequently contain metals. Vat and sulfur dyes that require redox chemical can have major effects on the waste's metal content, especially chrome and zinc. Fiber reactive dyes require large amounts of alkali to ionize cellulose so it can react with the dye by nucleophilic substitution. Direct dyes use 90% less salt and allred: no redox chemicals and essentially no metals. But direct dyes generally are applied by exhaust methods which tend to discard large percentages (up to 30%) of the color. This choice can lead to color effluent problems.

Mordant dyes require pretreatment of the cotton with metals which can lead to metallic contamination of wastewater. Thus the choice of a dye/print system for cotton has a profound impact on the waste characteristics and quantities produced. This is even further complicated by the wide variety of processing equipment, both continuous and batch, which is available for dyeing.

Scout For Waste

Water conservation and reuse is a good illustration of a source reduction (Table III).

It is important to control water from nonprocess sources. Also wastewater should be used whenever possible for noncritical applications such as screen washing, backgrey washing, and noncritical equipment cleanup. Process and nonprocess water conservation measures (Table III) can often save up to 30% of water use in a mill.

Go To The Source

Other examples of source reductions involve oil/water or acrylic polymers from printing pastes, which may be difficult to handle and treat with automated equipment due to poor settling properties and fouling pipes, pumps and filters. These can best be captured intact and reused for the next print paste mix.

One mill assigned a fulltime employee to reuse leftover print paste. The result was an outstanding savings in color costs as well as reduction of color and suspended solids in the mill effluent.

Lint, which originates from most textile operations, particularly air filters, preparation, dyeing and washing operations, can be easily removed by primary control measures like filters in circulation lines of dyeing machines and other equipment. These filters must be maintained and cleaned out on a regular basis in order to insure proper operation. And the collected materials should be dried and then landfilled or incinerated.

Often, however, one sees machine operators dumping or washing these pastes or lint down the drains. Simply training the operator to collect these for disposal as solid waste can significantly reduce suspended solids in wastewater.

Waste solvents originate from all types of machine cleaning and shop activities and should not be mixed with other wastes but recovered and disposed of separately.

In some cases like lanolin from the wool dry cleaning, these may have commercial value.

Make Your Best Choice

Textile processing is chemical intensive. The choices are many, but in general, total chemical use can be 10% to over 100% of the weight of the goods. If a mill has specific problems, chemical substitutions may be the answer.

This is a particularly effective approach for problems with metals (from shop/lab chemicals, dyes and finishes), phosphates (sources and substitutions shown in Table IV) and aquatic toxicity (resulting from surfactants, organics, chlorinated solvents and shop/lab chemicals).

Whatever avenue is taken at your mill, start with a thorough waste audit: create the right attitude from management to the plant floor. Using the above techniques, mills have saved millions of dollars and untold pollution.