IMPROVING WATER QUALITY BY TARGETING TEXTILE INDUSTRY SUPPLY CHAIN GUIDELINES OF MULTI NATIONALS

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ABSTRACT:
This paper showcases the preliminary findings from the Bangladesh Responsible Sourcing Initiative (RSI), which is a partnership between the US based NGO Natural Resources Defense Council (NRDC), the World Bank and a group of environmentally proactive apparel retailer and brand partners. Building on NRDC's earlier work in China, the objective of RSI was to identify simple, cost-saving opportunities to reduce water, energy, and chemical use—via improvements in manufacturing efficiency; which could then be integrated into supply chain sourcing guidelines used by the apparel brands.[i] Over twenty five factories in Greater Dhaka were initially screened for potential savings. In-depth analysis was carried out in 4 factories that yielded recommended measures which are practical, low cost (or even no cost) and can save water, energy, chemicals and money. The initiative focused primarily on factory infrastructure improvements that would improve the production of steam and water heating, recycle process water, and recover heat. These infrastructure initiatives provide a particularly easy starting point for increasing manufacturing efficiency when compared to process optimization methods. The RSI identified potential 3 water saving practices and 3 energy saving practices which implemented together could generate savings of up to 20% in water and energy.

INTRODUCTION:
The ready-made garment industry contributes around 80% of Bangladesh's foreign exchange earnings.[ii] The sector value chain includes yarn making, knitting, weaving, fabric dyeing, washing, finishing, apparel cutting and making and then finally, apparel exporting. Around 1700 units are involved in the wet processing segment of the value chain (fabric dyeing, washing and finishing). The wet processing sector is yet to catch up to the gigantic apparel manufacturing sector (with over 5000 factories) for which it produces much of its raw materials, but they are on the cusp of huge growth. Many of the brand name multi nationals that source from Bangladesh see the apparel manufacturing and the textiles sector as an important strategic region for future expansion. In addition, trade provisions are encouraging growth in both textile and garment production in Bangladesh.[iii] Industry trends are also encouraging vertical and regional integration.[iv] As margins decline, the costs of importing and transporting finished textiles from other countries with stronger currencies can threaten the garment sector's profits. The government recognizes the need for what it describes as "backward linkages" and has incentives in place to encourage growth in the production of textiles.[v]

However, to date, this growth has also resulted in a large ecological footprint on Dhaka's water resources – which are already overtaxed. Dhaka, a city of 12 million people, is surrounded by extremely polluted surface waters large sections of which are biologically dead,[vi] including four rivers so polluted as to be deemed "ecologically critical."[vii] Industrial pollution accounts for around 60% of pollution in the Dhaka watershed,[viii] and the textile industry is the second largest contributor. That pollution is putting additional pressure on the groundwater resources that supply drinking water for 80% of Dhaka.[ix] The textile industry also draws groundwater for industrial use from the same aquifer that people rely on for drinking water.

The challenge is therefore to find ways of nurturing this vibrant industry while sustaining the precious water resources upon which industry, the residents of Dhaka and ecosystems depend on. There is thus a need to identify and promote measures which can simultaneously help reduce the water used and the pollution generated by these mills, save factories money in the process, and encourage more careful thought about resource use in factory decision making before significant new infrastructure is put in place.

It is within this context that the US based NGO Natural Resources Defense Council (NRDC) partnered with the World Bank to begin the Responsible Sourcing Initiative (RSI), which was generously funded by the South Asia Water Initiative (SAWI), Bank-Netherlands Partnership Program (BNPP) and the Water Partnership Program (WPP). The objective of the project was to identify cleaner production measures that would deliver the "win win" opportunities for factories (saving water, energy and chemicals to yield cash savings and ecological savings) and encourage Brand buyers to integrate greener sourcing options in their sourcing guidelines and use their buying power to drive greener growth. Of course, compliance with local environmental laws remains crucial for all textile manufacturing; even the best-run and most efficient manufacturing practices will still generate pollution that must be treated prior to discharge. Nevertheless, the RSI's suggested Best Practice Guide and Sourcing Guideline can provide an important direction for reducing the environmental impacts and costs of textile manufacturing, whilst simultaneously reducing the costs of effluent treatment.

MAIN FINDINGS:

Over 25 factories were screened and a shortlist of 4 factories were identified which had significant opportunities for improvement. The 4 factories that were assessed in detail are of various sizes but engaged in cotton knit dyeing and finishing. RSI focused only on opportunities for improvement where the largest improvements can be found. Generally, resources required for knitting or garment manufacturing was subtracted out of the total resource use of integrated mills in order to fairly compare usage per unit of product for dyeing and finishing. However, steam use and loss, water leaks, condensate loss, as well as compressed air loss were assessed across all processes.[x] All factories produce their own energy and steam onsite using natural gas generators and boilers. They also pump groundwater for the factory's use and treat their own effluent. Three factories generally fell in the "middle" range of production efficiency—they were neither state-of-the-art manufacturing operations nor the worst performers—and one of the mills was in the higher range of performance. The opportunities identified at this last mill demonstrate that many of the practices discussed here continue to be relevant even for more advanced operations. Therefore, the opportunities identified in these mills should be very widely applicable to mills across Bangladesh and the developing world.

RSI's focus was practical, low-cost (or even no cost) factory infrastructure improvements that would improve the production of steam and water heating, recycle process water, and recover heat. For each opportunity identified, the following were evaluated:

Costs—both upfront investment and ongoing operational costs (low investment < Tk 1,247,000 (~ US $15,000), medium Tk 1,247,000 – 3,076,000 (~ US $15,000 - $37,000), high > Tk 3,076,000 (~ US $37,000));

Payback period—the time required to recoup upfront investment through savings in water, materials, and energy costs (immediate < 1 month, quick 1-8 months, medium 8-15 months, long > 15 months);

Resource savings -- *Water* (for tons water/ton fabric, high > 5 tons, medium 1 to 5 tons, low < 1 ton); *Energy/Chemicals* (The savings estimates for the various energy and chemical measures were in several different units and were based variously on estimates of (a) resource savings for the specific measure or (b) cost savings for the specific measure. Therefore estimated percentages of resource or cost savings were used as a proxy to determine the significance of the environmental impact. For percentage savings in resources, High > 2% of total natural gas, electricity, or steam use *or* > 20% of costs/materials consumed for specific activity; Medium 1-2% of total natural gas, electricity, or steam use *or* 10-20% of costs/materials consumed for specific activity; Low < 1% of total natural gas, electricity, or steam use *or* < 10% of costs/materials consumed for specific activity).

These criteria were applied to 30 potential efficiency measures and clean production practices. Four of the seven non-metering best practices cost less than Tk 419,000 (US $ 5,000) each; two of these cost almost nothing (see Table 1). None requires more than fifteen months to recoup costs. From an environmental standpoint, the best practices each deliver either savings of at least 1 ton of water per ton fabric, or at least 1% of the factories' total use of steam, gas, or electricity or at least 10% of materials or costs on a particular activity. The one exception is the Insulation of Pipes, Valves, and Flanges. Because the factories had largely implemented this measure before the RSI assessment, there is no baseline pre-installation data to estimate the savings after installation; however, since the factories themselves identified this as a need on their own, this suggests that it is a best practice. In total, if implemented together at the same mill, these improvements could reduce consumption of water by as much 27 percent, and also reduce energy and chemical use significantly.

Table 1: Recommended Best Practices[xi] (An Assessment of Four Bangladeshi Factories)

Practice	% resource savings		Savings (Tk*/ton fabric)		Cost (Tk*/ton fabric)		Investment Cost (Tk)		Payback period (mths)	
	low	high	low	high	low	high	low	high	low	high
Meter resource use	N/A	N/A	N/A	N/A	N/A	N/A	20,000	500,000	N/A	N/A
Water Saving Practices										
Eliminate water leaks & reduce hose pipe use	0.3	0.7	6.8	31.3	0.7	1.1	3,000	3,000	0.4	1.4
Reuse cooling water	8.2	14.8	392	714	75	204	280,000	800,000	3.9	25.9
Reuse process water	9.0	11.9	91	426	134	196	380,000	1,000,000	10.4	15.0
Energy Saving Practices										
Steam management	1.1	5.3	81	349	-	-	-	-	Immediate	Immediate
Insulate pipes, valves, flanges	0.4		23		22		60,000.00		11.2	
Recover heat from drying operations	20.0	20.0	527	1769	267	368	1,000,000	1,500,000	2.5	8.4
Chemical Saving Practice										
Use magnetic device	almost 100%	almost 100%	44	69	37	54	150,000	150,000	8.8	11

to soften water										

THREE WATER SAVING BEST PRACTICES:
Water consumption varies among processes within a textile mill as well as by machine type and setup. Recycling and reuse of process water can yield great savings, and, since the water recovered is often hot, these improvements can save energy as well. Steam condensate and non-contact cooling water is a second valuable source of water to recover because it is high in both quality and temperature. Finally, water is used for general washing and cleaning throughout the factory, and good housekeeping practices can substantially reduce wasteful use of water in cleaning as well. In Bangladesh especially, reductions in water use also lead to savings in energy and chemicals because the factories pump and treat their own water prior to use. While these energy and chemical savings are not described in Table 2 it is worth noting that the total financial savings represent a combination of savings from avoided pumping costs (saving energy) and avoided chemical treatment costs (saving chemicals) because the factories do not pay directly for the water.[xii] RSI identified three best practices to conserve water (see Table 2). A mill that implemented all the suggested measures could save between 18 to 27 percent of its total water use (rounded to the nearest whole number).

Table 2: Water Saving Best Practices

Practice	Percentage Resources Saved (water)	Savings per ton of fabric produced (Tk/ton)
Eliminate water leaks and reduce hose pipe use	0.3-0.7%	7-31
Reuse cooling water	8-15%	392-714
Reuse process water	9-12%	91-426

Eliminate Water Leaks and Improved Hose Pipe Use

Although individual leaks may not seem important in the overall consumption picture, they can be responsible for a surprisingly significant loss of resources over the course of a year. RSI estimates conservatively that water leaks are responsible for up to 0.2-0.4 percent of water use at two of the factories, which can mean savings of water ranging between 0.35 to 1.2 tons of water per ton of fabric produced for the assessed factories. The other two factories already recognized the value of eliminating leaks to an extent that no visible leaks were detected. The savings from eliminating water leaks could be higher, judging from the relevant literature.[xiii]

Additional savings can be expected from efforts to reduce unnecessary use of water in cleaning operations. Rather than relying on workers to reduce water use, low-flow and shut-off valves or trigger guns should be installed on hoses, and thermally-controlled shut-off valves[xiv] can be installed on process units. It is estimated that the number of hose pipes in use could be reduced from current usage levels of 12-20 to 2-3, with the remaining hosepipes fitted with trigger guns. The estimated savings from improved use of hose pipes ranged from 0.2-0.7 percent of water use at the four factories. Combined savings from eliminating water leaks and reducing hose pipe use range from 0.3%-0.7% of water use at the four factories assessed, or savings of Tk 6.8-31.3/ton of production (~ US $ 0.08-0.38/ton of production).

Eliminating leaks consists of routinely investigating sources of leaks in water and implementing an effective preventive maintenance program, requiring virtually no capital investment costs and thus delivering instant payback. Likewise, using a trigger gun or shut-off valves is cheap (~ Tk 1,000 or US $ 12 per trigger gun) and pays back within two months at the most. Proper metering can be an immense help in identifying leaks and potentially excessive use of hose pipes.

Reuse cooling water from dyeing machines

Non-contact cooling water should always be recycled. It is high in quality and temperature and can thus be reused beneficially in various processes, such as in desizing, scouring, washing, or rinsing. Furthermore, the hot water discharge stresses wastewater treatment systems. One particularly promising reuse opportunity is to reduce the temperature of dyeing baths before water is drained out. In the dyeing operation there are at least three cycles inside the machine where the dyeing process is carried out at near 95°C, however the water cannot be drained out without reducing the water temperature below 80°C. Heat exchangers are used to reduce the bath water temperature. Cold water passes through the heat exchanger to reduce the temperature of the machine water via heat transfer. Currently, this clean cooling water, now warmed up by the heat exchange, is being drained out to the effluent treatment plant and the heat of the water is being wasted. Some mills were either not reusing this water at all or were using it in cold water processes that did not benefit from the heat. To use the warmed-up cooling water, factories could use an insulated hot water reservoir tank to collect and store water and then recycle this warm water into either the dyeing process or in the boiler. The collected water reduces the need to heat new cold water. This best practice requires installation of a water reuse system—pipes, valves, pumps, holding tanks, and a control system. The costs are modest, Tk 280,000-800,000 (estimated to be between US $ 3,400-9,760) and return on investment is less than 4 months.[xv] This best practice was already implemented at one of the mills assessed.

Reuse process water

After dyeing, fabric is washed with clean water to remove surplus or unabsorbed dye. While the water from the initial washes is discolored, later washes are low in both color and chemicals. In current practice, this water is discharged for effluent treatment. This water can be reused for other processes that do not require high quality water with minimal treatment such as a sand or carbon filter. Water discharged from bleaching and mercerizing machines can be collected and reused for other processes, instead of discharging it directly to wastewater treatment.[xvi] The quality of water has to be evaluated, but can often meet the quality requirements for scouring after simplefiltration. The reuse of water used to remove surplus dye requires purchasing pipes and fittings, water tanks, and electrical pumps to store and return water to the process, as well as a filter. Investment cost would range from Tk 380,000 (~ US $ 4,700) to Tk 1,000,000 (~ US $ 12,200) in upfront costs, plus operating costs of another Tk 200,000-Tk 500,000 (~ US $ 2,500-$ 6,100), depending on mill size and layout.[xvii] For two of the four factories assessed, the investment pays itself back within 8 months.[xviii] A third factory pays back within 26 months. The last factory is an outlier with a payback period of 93 months that is not representative since its payback period is more than three times the payback period of the other three factories. Some mills will not need to purchase new equipment but can adapt existing equipment and systems to this use. Since the payback period for two of the four factories was quick (under 8 months), this measure is included in the list of best practices.

THREE ENERGY SAVING BEST PRACTICES:

Global experience shows that steam generation is by far the largest energy-consuming activity in a textile mill. Usually done in an on-site industrial boiler, steam generation contributes conventional pollution as well as global warming gases (mainly from carbon dioxide emissions) to the atmosphere. With this in mind, RSI recommends increasing steam use efficiency through insulation and maintenance of the steam delivery system. Substantial additional energy is saved with some of the best practices for water efficiency as well, as discussed above. The pressure on the natural gas supply for textile mills is a particularly important incentive.[xix]

Table 3: Energy Saving Best Practices

Practice	Percentage Resources Saved (energy or energy proxy)	Savings per ton of fabric produced (Tk/ton)*
Steam Management	1-5% of total steam used	Variable (81, 123, 270, 349)
Recover heat from drying operations	20% of drying costs	Variable (527, 770, 1769)
Insulate Pipes, Valves & Flanges	0.4% of total natural gas used	23

* The Tk/ton figures represent the savings for the number of factories where the measure was applicable. Further explanations in text below.

Steam management

Ill managed steam distribution systems lead to steam energy and condensate losses through blocked or broken steam traps and loose fittings and other leaks in the steam distribution system. Poor quality fittings impact steam and introduce extra condensate into the steam system. The extra condensate must be discharged; otherwise, the condensate will result in the "water hammer" effect, which can result in inefficiencies and losses in energy equivalent to 5%.[xx]

Steam traps remove moisture from the steam lines and prevent further condensation, thereby preventing heat loss and reducing fuel consumption (and saving money). In steam systems that have not been adequately maintained, between 15 percent and 30 percent of the traps may fail.[xxi] Steam traps should be repaired or replaced as soon as they are out of order. A good rule of thumb is that leaking traps should account for less than 5 percent of the trap population.[xxii] In addition, steam traps should be installed at appropriate intervals typically one about every 27 yards (25 meters)—in the main steam headers.[xxiii]

This best practice requires routine inspection of leaks in the steam system, loose fittings, and steam traps (monthly testing is recommended) and repair or replacement of leaks, faulty fittings, and broken steam traps as soon as the problem is detected. Because no significant expenses are associated with implementing this practice, it pays for itself immediately (less than one month). Each of the factories assessed had opportunities to improve steam management.

Recover heat from drying operations
The drying and stenter operations generate heat that is vented to the atmosphere at a temperature of 120º-150º C.[xxiv] The heat could be captured and used to heat incoming process water. [xxv] In some circumstances, the hot air itself could be beneficially reused in the dryer or elsewhere; the air stream would require filtration prior to use.[xxvi] The filters would need to be cleaned daily.[xxvii] Savings are estimated to be at least 20% of drying costs based on experience.[xxviii] Textile mills also have other valuable sources of heated air, whose heat could also be captured, such as stack gases. An air to water heat exchanger would cost an estimated Tk 389,850 (US $ 4,760) per unit for main exhaust outlets.[xxix] Reusing the hot air would require the installation of pipes and filters. Investments for such reuse were estimated to be Tk 1,000,000 (~ US $ 12,200) for three of the factories and Tk 1,500,000 for the fourth (~ US $ 18,300), which was using a thermal oil dryer in addition to steam and stenter drying. Payback periods for the hot air reuse at three of the four factories assessed were estimated at less than 8.5 months. The fourth factory was an outlier in all categories, with both costs and savings at less than a third of the other three factories. It is not reflected in the table above, but its payback period was still less than 12 months.

Insulate pipes, valves, flanges
Steam losses during transportation are considerable due to widespread use of steam at locations across the factory. If all the steam pipelines are well insulated, heat loss could be reduced by up to 90 percent.[xxx] As noted earlier, the factories had largely insulated their pipes before the RSI assessment, and therefore there is no baseline pre-installation data to estimate the savings after installation; however, the widespread penetration of this practice suggests that insulating pipes is a best practice. The one factory which had not implemented the measure completely had only a short stretch of pipe exposed; materials cost were low, about Tk 60,000 (~ US $ 730), and paid back in a little over 11 months. The factories rarely insulate valves and flanges, which is another effective means of improving energy efficiency at the factories. Factories should carry out routine inspection and insulation of all pipes, valves, and flanges in the factory. Breaches in insulation (tears, etc.) should also be repaired and replaced.

ONE CHEMICAL SAVING BEST PRACTICE:
Chemical use not only incurs substantial costs for the factory, it can also increase the pollutant discharge into waters or lead to substantial treatment costs. RSI found one best practice that can make a significant dent in chemical use.

Table 5: Chemical Saving Best Practice

Practice	Percentage Resources Saved (chemicals)	Savings per ton of fabric produced (Tk/ton)
Use magnetic device to soften water	Approximately 100% of water softening chemicals in boiler	44-69

Use magnetic device to soften water
The water used by the factories often has significant mineral content. This hard water needs to be softened before use. The factories often soften the water post-pumping, but further softening may be needed to achieve greater efficiency, for instance in boiler use. To further soften the boiler's inlet water, factories can employ a magnetic device that controls the orientation of metal ions to keep them away from pipe and boiler surfaces. The device can help prevent the formation of a white calcium and magnesium carbonate scaling, increasing boiler efficiency and reducing the frequency of boiler descaling and resulting in energy savings. Use of the magnetic device will also likely eliminate the need for softening chemicals. The practice reflects an improvement over the alternative of continuous chemical dosing with caustic soda used to soften the water, eliminating the cost and use of chemicals. One high-performing factory in Bangladesh has implemented this practice and reports with very satisfactory results. The technology has also been evaluated by the U.S. Department of Energy and found to

result in savings of energy and chemicals, with a payback within a year for the case study evaluated.[xxxi] The device is estimated to cost Tk 150,000 (~ US $1,830) and result in chemical savings of approximately Tk 164,000-2190,000 (~ US $ 2,000-2,300) for three of the four factories, which have one boiler each. For the fourth factory, which has two boilers, but reported much lower water softening costs, chemical savings were estimated at Tk 205,000 (~ US $ 2,500). Energy savings are additional. One of the factories assessed had an appropriate spare magnet on site and was able to adapt it for this purpose at a cost of only Tk 25,000 (~ US $305). Results of this experiment are still pending. This best practice requires the installation of a magnetic system to reduce scaling or the adaptation of an existing magnet to achieve the desired ends. Payback periods range between 8.8-11.0 months based on use of the commercially available technology.

MEASURING FOR SUCCESS:

The issues identified in Bangladesh bear many similarities to those in China, where the RSI was originally carried out, and inadequate information on resource use is a recurring problem. As in China, the best practice that underpins all of the other opportunities recommended here and that should be adopted immediately by all dyeing and finishing textile mills is the same**:** measuring consumption with meters that track water, steam, and energy consumption in total and at the process and equipment levels.

Although many textile mills in Bangladesh *estimate* total water, energy, and chemical consumption based on capacity of pumps and machines, they do not know either total resource use or specifically how resources are used in specific areas inside the factory or in particular pieces of equipment. Meters, or better yet, measurement software, at key locations inside a mill enable a factory to closely track resource and energy consumption for specific processes, directing managers to focus their resources on improving efficiency in those processes that are the most resource intensive. Several of the mills investigated in RSI had in-machine metering in dyeing machines for process control, but had little metering otherwise to track full resource use in the process. At the minimum, factories should meter resource use at the main point of supply. Next, they should prioritize workshop level metering, and then metering at the machines which are the major consumers of a given resource.[xxxii] Installing and operating accurate meters and/or measuring software are fundamental steps to benchmarking performance and to initiating efficiency improvements. Metering allows plants to identify and respond to leaks and to detect unusual spikes in resource use, and it provides positive feedback on the effectiveness of measures that mills take to improve their processes. Meters and measurement software reinforce the benefits of efficiency measures and encourage continuous improvement. Importantly, measurement software allows process efficiency information to be sent to other locations electronically, thus enabling benchmarking of performance and identification of best-in-practice mills in an objective and straightforward manner. Meters and measurement software can be relatively inexpensive but depend on the specific needs and configuration of each mill.

Average cost of water flow meters[xxxiii]:

- Mechanical type:
    - Tk 20,000- 100,000/unit (~ US $ 260-1300/unit)
- Electromagnetic type (higher accuracy, longer life time):
    - Tk 50,000-100,000/unit (~ US $ 650-1300/unit) (Indian/Chinese origin)
    - Tk 300,000-500,000/unit (~ US $ 3900-6600/unit) (European/Japanese origin)

Investment in more sophisticated addressable or pulse type meters over basic meters allows remote data capture and more real-time analysis and is preferable for major meters (above 25mm) to automatically track usage.[xxxiv] Note that costs in China for water meters averaged approximately Tk 166,250-249,400 (US $ 2,000-3,000) per meter.[xxxv]

Estimates place the cost of steam meters in Bangladesh at Tk 300,000-400,000 (~ US $3,900-5,200).[xxxvi] Costs in China for steam meters range between approximately Tk 128,850-392,800 (US $ 1,550-4,725).[xxxvii] High accuracy integrating steam meters cost more. However, integrating meters are only called for to measure the main site supply and perhaps for use at major buildings/plants.[xxxviii] For process lines and major machines, basic steam flow or condensate meters should suffice. Basic steam flow meters will likely even suffice for major buildings and plants.

Electricity meters cost approximately Tk 83,125 (US $ 1,000) or less each in China; there is no estimate for Bangladesh.[xxxix] Measurement software is available for approximately Tk 1,246,900 (US $ 15,000), a figure that includes the price of remote collection.[xl]

CONCLUSION:
The wet process segment of the textiles and apparel supply chain is highly polluting. Dhaka's lack of clean drinking and industrial process water is reaching alarming proportions. Water treatment plants at individual factories remain an expensive option as their running costs are very high. While the continued growth of this sector is imperative to Bangladesh's foreign exchange earnings, it must be balanced with measures that reduce its ecological footprint. Preliminary results from the draft RSI Best Practices show that low-cost, easy to implement practices can, taken together, achieve significant resource savings and provide an important step in the right direction for the mills by promoting a sustainable green growth approach to water resources management.

BRIEF PROFILE OF THE AUTHORS

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