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Share the lessons learned with policymakers and regionally through the SWICTH-Asia network by 2015.

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This project is co-funded by the European Union

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Training Manual on BWMPs in Textile Sector of Pakistan

City-wide Partnership for Sustainable Water Use and Water Stewardship in SMEs in Lahore, Pakistan (WSP)

water stewardship Pakistan

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Introduction

City-wide Partnership for Sustainable Water Use and Water Stewardship in SMEs in Lahore, Pakistan (WSP)

City-wide Partnership for Sustainable Water Use and Water Stewardship in SMEs in Lahore, Pakistan (WSP) project is a three-year (2013 to 2015) capacity building project under SWITCH-Asia and funded by the European Union. SWITCH-Asia is a regional environmental programme in line with the European Commission (EC) Regional Paper for Assistance to Asia (2007-2013). The aim of this programme is to promote Sustainable Consumption and Production (SCP) among Small and Medium Enterprises (SMEs) and consumer groups in Asia.

The WSP project is being executed by a consortium of three organizations i.e. WWF-Pakistan, WWF-UK and Cleaner Production Institute (CPI). The Lahore Chamber of Commerce and Industry (LCCI) and Punjab Small Industries Corporation (PSIC) are part of the project as associates.

The project targets SMEs in Punjab in four sectors, i.e. textile processing, leather tanneries, pulp and paper and sugar. It aims to minimize the use of natural resources, toxic materials and promote a reduction in emissions, waste and pollutants over the life cycle of industrial production with a focus on effective water stewardship.

The overall objective of the project is that "by 2025 water efficient production and consumption predominates as best practice in Pakistan's major industrial cities as part of a broad engagement of business in water management, contributing to improved environmental sustainability and poverty reduction within the context of sustainable development."

The specific objectives of the project are to:

- Reduce water consumption by at least 15 per cent and pollution load by 15 per cent in 25 water intensive SMEs in Lahore by 2015.
- Increase capacity of 75 cross sectoral water intensive SMEs to adopt or support more sustainable water management practices by 2015.
- Enhance understanding and knowledge of a further 300 SMEs regarding impacts of unsustainable water use and wider community level benefits of better water stewardship.
- Develop a multi-stakeholder city-wide partnership, comprising SMEs, public authorities, River Ravi Commission, supporting institutions and Multi-national Corporations (MNCs) by 2015.
- Share the lessons learnt with policymakers and regionally through the SWICTH-Asia network by 2015.

Objective of the Training

The objective of this training is to highlight practical and easy to implement Best Water Management Practices (BWMPs) to technical professionals of the textile sector in Pakistan. The trainees will then be expected to implement these BWMPs in their productions units, monitor performance and demonstrate outcomes to others to follow the same path.

The performance data and business case of these BWMPs will also be presented in this training so that professionals can evaluate their practicability and discuss their implementation with relevant resource persons.

Mode of Training

The training will be conducted through a multimedia presentation after which there will be a detailed discussion on each BWMP with the audience. This manual will serve as reference material for the training.

The Textile Sector in Brief

Textile is the largest industrial sector of Pakistan with respect to production, export and labour force employment. Pakistan is the eighth largest exporter of textile products among Asian countries and 12th globally. At present the textile sector's established capacities is 1,550 million kilograms of yarn spinning, 4,368 million square metres of fabric weaving and 4,000 million square metres of fabric finishing. It contributes 8.5 per cent to the country's GDP and 52 per cent in terms of export. The sector employs 38 per cent of manpower in manufacturing and accounts for 31 per cent of total investment in the country.

Pakistan's major textile export products include cotton fabrics, knitwear (hosiery), cotton yarn, bed wares, readymade garments, towels, synthetic textile and raw cotton.

The textile processing sub-sector provides the greatest value addition to the textile sector. In Punjab and Sindh, the number of textile processing units is estimated to be around 1,545. Out of these units, about 840 are woven processing units and the rest are knitwear processing (hosiery) units. These units carry out various textile processes, including pretreatment, dyeing, printing and finishing.

The number of textile processing units in Punjab is estimated to be around 1,395. Out of 1,395 units, about 690 are woven textile processing units and the rest are knitwear processing (hosiery) units. The estimated total production of the textile processing sector in Punjab is 9,500 million metres/year for woven textiles and 2,200 million kg/year for knitwear textiles.

Textile Sector Issues Related with Water Management

The textile sector requires large amounts of water, steam and electricity. As a result, the main environmental stress associated with this sector is water and energy consumption as well as emissions to water.

Best Water Management Practices (BWMPs) of the textile sector are:

i)Water management

ii)Energy conservation (electrical and thermal)

iii)Wastewater pollution reduction

Water Management

Water is an important utility in the wet processing of textile units. Most production units, especially in Punjab, use groundwater whereas, in Karachi, most units buy water through tankers due to scarcity and difficulty of tapping. Therefore, water obtained is generally hard, and requires softening treatment prior to its use in processes or boilers. The most prevalent technique of water softening in the Punjab textile processing units is cat-ion exchange.

In general, groundwater quality in the Lahore-Gujranwala region is better as far as its dissolved solids contents are concerned, whereas the Faisalabad region face water quality issues due to the salty nature of groundwater. High dissolved solids in water result in higher chemical consumption and deteriorated fabric quality.

In Punjab, water is cheap and an easily accessible commodity, therefore production units do not give any serious consideration to its use and conservation. Most units, except those in Karachi, are not aware about their water consumption. Water consumption varies from unit to unit, largely depending on processes, type of machines, production capacity, and water use practices.

Unnecessary wastage of water is a regular feature of the industry. The main reason for this attitude is its abundant availability and easy accessibility. Water is considered a cheap and invaluable commodity and workers and management is not concerned about its excessive use in different processes, especially in co-current washing, where water is continuously added at the one end of the machine and discharged from the other. This attitude is also reflected on the production floor where there is no monitoring and record keeping of water consumption at different process levels. Water is continuously running and wasted even when machines have stopped. Water hoses, used for floor and equipment washing, are mostly seen lying on the floor with water continuously running. A substantial amount of water is also used in associated activities such as floor and equipment washings.

Management and production staff do not maintain any record of water consumption therefore total water consumption of the plant is not known. Clean water streams are wasted and cooling water from different machines (a clean stream), is also wasted. Reject water from reverse osmosis and softener plants is also not utilized as it is of poor quality. Process washes are not optimized and water is unnecessarily wasted from water hoses and machines. Co-current wash boxes arrangement results into water wastage.

Energy Conservation (Electrical & Thermal)

Energy Issues

Pakistan faces a severe energy crisis that is a threat to export-oriented tanneries. In recent years, textile units have had to deal with a serious power crisis, which has caused million of rupees worth of losses annually, especially during peak seasons which are normally from December to July.

Higher production costs resulting from a continuous rise in the energy costs is a major concern for the textile industry. Several in-house energy issues are increasing production costs as well. These issues, when rectified, can reduce overall energy costs between 5 to 30 per cent depending on the size of a unit and nature of energy issues in it.

Lack of Energy Monitoring

Energy monitoring is the first step in energy management. Due to a lack of awareness about energy conservation and its benefits, the management of tanneries do not take action to control energy losses. There are a number of areas where energy monitoring is not carried out and no temperature indicators or steam control valves are installed. Workers keep injecting steam in baths to heat water, even after the required temperature has been attaining. Since there is no temperature indication or automatic shut off valves in most machines, temperature is attainet on the basis of visual observations. There is no monitoring of natural gas consumption for individual machines like boiler, stenters or dryers.

Electricity Conservation

Electricity is another important utility in textile mills. Mostly large sized mills generate their own electricity as government supply is not reliable with frequent interruptions. Almost all small sized units and a few medium sized units use government electricity connections as their primary source and diesel generators as a backup facility.

Electricity consumption varies from unit to unit and largely depends on the number and size of machines in operations. Electricity consumption also depends on the age and state of the machines being used in tanneries. Major BWMPs related electrical energy issues are associated with electrical motors attached with water pumps and turbines.

Electric motors are the major consumer of electricity in any textile production unit and more than 90 per cent of total electricity is consumed by these motors. The running cost of motors is the most important factor contributing up to 95 per cent to the cost in the motor life cycle.

Motors are categorized on the basis of their efficiency i.e. Class I, Class II and Class III motors. Efficiency Class III motors, also called standard motors, consume more energy as compared to Class II or Class I motors. In older textile mills, motors with efficiency level Class-III which are mostly rewound are present, which causes considerable energy losses. There is also an issue of excessive burning in motors due to ineffective or lack of preventive maintenance and motor safeties. On the other hand in comparatively newer mills, installed motors have efficiency Class-II particularly in those machines and standard motors which are commonly used with pumps and fans.

Motors mismatched to their load (over and under-sized motors), motor burning and frequent rewinding and use of substandard rewinding material cause loss of efficiency. It is a fact that efficiency of the motor is decreased by 2-5 per cent when burned. If rewinding is not carried out properly, efficiency loss can be much more. Inefficient operation of motor driven equipments is also in practice. Throttling in circulation pumps of dyeing machines and water pumps, bypass control in therm oil pump, over speeds of circulation fans and damper control are common examples of inefficient use of machines.

Thermal

Fuels

Fuel is used in the textile industry as a direct heat source or for the generation of steam and electricity and natural gas is an important source of energy for the textile sector. However, due to current shortages of natural gas in the country, textile mills rely on alternative fuels such as coal, biomass (rice husk, wood, wheat straw, bagasse), LPG etc. Fuels are mostly utilized in generators, boilers, singeing machines, therm oil heaters, and dryers. For large and medium sized units, natural gas adequately fulfills energy demands as electricity is also generated from natural gas generators. Electricity generation through diesel-based generators is expensive and units are shifting to gas-based generators. Coal and biomass are also being evaluated for electricity generation due to gas shortages.

Steam

Steam is the main heating source in processing, which is produced through steam boilers. Boilers usually run on natural gas, coal or biomass. In some industries, waste heat recovery boilers are also installed which generate steam using the flue gases heat of power generators.

Issues with thermal energy conservation:

Boiler and Process Water Treatment

Textile processing is a water intensive industry. Daily huge quantities of water are consumed in various processes and for steam generation. The use of water depends upon its characteristic. The water in Punjab has an average total hardness value of 40-230 mg/lit as $CaCO_3$ and Total Dissolved Solids (TDS) contents of 260-560 mg/lit. However, these values largely depend on groundwater depth and regional groundwater characteristics. If hard water is used in boiler and production processes it affects the performance of the boiler and production process in the following ways:

For boiler

- Scaling of boiler heating surface
- Excessive blow down
- Reduced boiler life
- Extra fuel consumption

In production processes

- Chemical consumption is increased
- Quality of the dyed and bleached fabric is affected

Steam Leaks

Steam leaks are significant and highly visible indicators of energy wastage. Based on energy audits, almost all production units have steam leakage problems. The nature of these leaks varies from unit to unit. Steam leaks occur due to damaged fittings, damaged pipes, glands of valves and faulty steam traps. In textile units, workers generally do not pay attention to steam leaks. The magnitude of steam wastage from damaged fittings ranges from 3 to15 kg/hour.

Condensate Wastages

Steam is either directly added to water or indirectly through coils or jackets. Direct injection of steam is irrecoverable as it becomes part of hot water. On the other hand, indirect steam is condensed after heat transfer to other medium of

contact (steam condensate) and can be reused or recycled.

In textile units, the direct steam injection ratio varies from 40 to 70 per cent of total steam consumption as older machines are designed on direct steam injection while new machines have more options of indirect injection. The steam condensate recovery and reuse profile varies in textile units as well as those units with older steam system designs have poor steam condensate recovery. Poor or no steam condensate recovery occurs due to one of the following reasons:

- Condensate lines are lifted against gravity, exerting back pressure on the traps and thus operators by-pass steam traps
- Poor design of recovery system
- No provision for steam condensate recovery system in the initial designing
- Faulty condensate recovery pump

Energy Wastage in Hot Wastewater

Hot wastewater from various steps of pre-treatment and dyeing is wasted without heat recovery. This water usually ranges in temperature from 60 to 90°C and contains a significant amount of energy which can be recovered to heat other streams through heat exchangers.

Wastewater Pollution

Textile processing is a water intensive industry where water is used as to carry a variety of chemicals to fabric and for washing purposes. Consequently, textile processing units generate various types of wastewater, differing in magnitude and quality.

In general, textile wastewaters are highly coloured, have high BOD and COD values, high total dissolved solids and high temperature. The main sources of water pollution are natural impurities extracted from fabric which is being processed and use of chemicals in processing. The nature of textile wastewater largely depends on in-house operations and the degree to which water and chemicals are preserved. Table 1.0 shows wastewater sources and quality in a typical textile mill.

Table 1.0: Wastewater Sources and Quality in Textile Wet Processing

Process & Source	Wastewater	Quality
Singeing	Continuous discharge of cooling water	Temperature
Desizing		
Desizing Bath	Periodic discharge of exhausted bath	Temperature, BOD, COD, TSS, TDS,
Hot Washings	Periodic discharge of exhausted bath, wash water discharge	Acidic (Low pH)
Cold Washings	Wash water discharge	
Scouring		
Scouring Bath	Periodic discharge of exhausted bath	Temperature, BOD, COD,
Hot Washing	Wash water discharge	TSS, TDS, O&G, Surfactants,
Cold Washing	Wash water discharge	Alkaline (High pH)
Bleaching		
Bleaching Bath	Periodic discharge of exhausted bath	Temperature
Hot Washings	Wash water discharge	TDS, Surfactants,
Cold Washings	Wash water discharge	Alkaline (High pH)
Neutralization		
Neutralization Bath	Periodic discharge of exhausted bath	Temperature
Cold Washings	Wash water discharge	Acidic (Low pH)
Mercerization		
Mercerization Bath	Periodic discharge of exhausted bath	Temperature
Hot Washings	Wash water discharge	TSS, TDS
Cold Washings	Wash water discharge	Alkaline (High pH)
Dyeing		
Dye Bath	Periodic discharge of exhausted bath	Temperature, Color,
Softening Bath	Periodic discharge of exhausted bath (optional)	BOD, COD,
Oxidation Bath	Periodic discharge of bath (for sulfur and vat dyes)	TSS, TDS, Surfactants
Reduction Bath	Periodic discharge of bath (for vat dyes)	Chromium, Copper
Soaping Bath	Periodic discharge of exhausted bath (optional)	COD, TDS, TSS, Surfactants
Neutralization Bath	Periodic discharge of exhausted bath (optional)	COD, TDS, TSS, pH
Hot Washings	Wash water discharge (all dyes except pigments)	BOD, COD, TDS, TSS, pH
Cold Washings	Wash water discharge (all dyes except pigments)	BOD, COD, TDS, TSS, pH
Printing		
Screen Section	Screen development and stripping wastewater	COD, O&G, Chromium
Color Kitchen	Batch vessels and floor washing water	Color, COD, TSS, TDS, NH_3

	Continuous discharge of blanket washing water	Chromium
Fabric Washing	Wash water discharge (for fabric printed with dyes)	Color, COD, TDS, Surfactant
Finishing		
Stenter Finishing	Periodic discharge of exhausted bath	Temperature, COD, TDS
Miscellaneous		
Water Softening	Softening media regeneration wastewater	TDS, Salts
Boiler Operation	Periodic discharge of boiler blow-down water	Temperature, TDS
Laboratory	Wastewater from laboratory testing operations	Color, COD, TDS
Office Use & Miscellaneous	Wastewater from office use, floor washings and cleaning operations	BOD, COD TSS, O&G

Wastewater Quantity

The quantity of wastewater varies from unit to unit and largely depends on the extent of value addition to raw fabric. Type of technology is also a determinant, as some old and obsolete systems consume comparatively more water than their new counterparts for the same degree of finished qualities for a particular product.

Unit process wastewater generation rates, based on an analysis of flow monitoring data of local textile processing units are presented in table 2.0.

Table 2.0: Unit Process Wastewater Generation Rates

Product	Unit Process Wastewater Generation Rates (litre/kg)
Bleached Fabric	100-130
Dyed Fabric	120-320
Printed Fabric	80-170

Source: ICTP Textile Programme

Wastewater Characteristics

Characteristics of wastewater vary from unit to unit depending on the technology in use and in-house practices. Table 3.0 states estimated ranges for each environmental parameter with the help of data collected during environmental audits. These values were further refined with the help of literature survey.

Table 3.0: Characteristics of Combined Woven Textile Processing Wastewater (Composite)

Parameter	Unit	Type of Industry			NEQS
		Punjab		Karachi	[1]
		Dyeing	Dyeing-Printing	All Types	
pH		8.3-11.7	6.3-12.0	8-12	6-9
Biochemical Oxygen Demand (BOD)	(mg/l)	110-1,070	300-728	120-1100	80
Chemical Oxygen Demand (COD)	(mg/l)	365-1,200	880-1,820	500-2500	150
Total Suspended Solids (TSS)	(mg/l)	50-1335	82-450	50-800	200
Oil and Grease (O&G)	(mg/l)	17-32	11-40	10-80	10
Total Dissolved Solids-Incremental (TDS-I)	(mg/l)	1,280-1,540	1,000-1,900	3,400-8,000	3,500
Chloride-Incremental (Cl-I)	(mg/l)	400-750	90-1,100	-	1,000
Chromium (Cr)	(mg/l)	0.5-3.6	1.5-12.6	-	1.0
Copper (Cu)	(mg/l)	0.4-0.5	0.10	-	1.0

[1] NEQS for disposal to Inland Waters

Source: PISD

Unit Process Wastewater Pollution Loads

Unit wastewater pollution load is the pollution load per unit of the product. For textile processing, it is commonly reported as grams of the pollutant per kilogram of the fabric processed. Pollution loads of various process streams are mentioned in table 4.0.

Table 4.0: Unit Wastewater Pollution Loads

Parameter	Unit Pollution Loads (g/kg)		
	Bleached	Dyed	Printed
Biochemical Oxygen Demand (BOD)	35-60	50-90	40-70
Chemical Oxygen Demand (COD)	120	120-180	90-140
Total Suspended Solids (TSS)	30-60	30-85	30-50
Oil and Grease (O&G)	3-7	2-8	1-3
Incremental TDS	250-300	130-400	130-350
Incremental Cl	90-130	90-130	130
Chromium (Cr)	-	0.2-1.0	0.4-1.8

Source: ICPT-Textile Programme

Variations in the unit pollution loads are mainly due to differences in the type and quality of grey fabric, variation in chemicals used and process recipes.

Impacts Associated with Wastewater

All wastewater generated from a textile unit may have at least two disposal routes, either it is discharged into larger water bodies like water courses, canals, lakes, rivers or the sea; or to groundwater reservoirs. Following one of these

routes, wastewater may also cause some land contamination. Impacts of wastewater generated from textile processing units and are presented in table 5.0.

Table 5.0: Impacts of Wastewater Pollutants

Value of pH	Growth inhibition of bacterial species (responsible for removing organic pollution) under highly acidic and alkaline conditions
	Corrosion of water carrying systems and structures with acidic wastewaters of low pH value
	Malfunctioning and impairment of certain physico-chemical treatment processes under highly acidic and alkaline conditions
Temperature	Depletion of dissolved oxygen (DO) levels in receiving water body, resulting in growth inhibition of aquatic life
	Malfunctioning of wastewater treatment systems, under high temperatures
Color	Reduced light penetration in natural waters and consequent reduction in photosynthesis
	Aesthetic nuisance
Organic Pollutants	Depletion of dissolved oxygen (DO) levels in receiving water body, below limits necessary to maintain aquatic life (4-5 mg/l).
Suspended Solids	Sedimentation in the bottom of water bodies covers natural fauna and flora on which aquatic life depends.
	Localized depletion of dissolved oxygen in the bottom layers of waters bodies.
	Reduced light penetration in natural waters and consequent reduction in photosynthesis
	Aesthetic nuisance
Oil & Grease	Reduced re-aeration in natural surface bodies due to floating oil and grease film and consequent depletion in dissolved oxygen levels
	Reduced light penetration in natural waters and consequent reduction in photosynthesis.
	Aesthetic nuisance
Chromium	Acute renal tubular necrosis and liver necrosis in humans, at higher doses
	Gastric irritations and ulcers in humans, at lower doses

Chemical Conservation

Textile processing is a chemical intensive industry where different types of chemicals such as acids (acetic acid, formic acid), alkalis (sodium hydroxide, potassium hydroxide, sodium carbonate), bleaching agents (hydrogen peroxide, sodium hypochlorite, sodium chlorite), dyes (direct, disperse, pigment, vat), salts (sodium chloride), size (starch, PVA), stabilizers (sodium silicate, sodium nitrate, organic stabilizers), surfactants, auxiliary finishes (fire retardant, softeners) are used. The fate of these chemicals varies, ranging from 100 per cent retention in fabrics to 100 per cent discharge with effluents. Developed countries have adopted safer chemicals in their processes, whereas in developing countries such as Pakistan some mills still use harmful chemicals in their industrial processes. Impacts due to use of these chemicals are as follows:

Sodium hypochlorite is used as a bleaching agent. Its application leads to the formation of chlorinated hydrocarbons such as carcinogenic trichloromethane (chloroform).

Wastewater generated from sulfur dyeing contains sulfides which are toxic to aquatic organisms. Sulfide anions forms hydrogen sulfide gas under acidic conditions and causes problems of odour and corrosion.

Sodium hydrosulfite is used in vat dyeing and is less critical than sodium sulfide. During the dyeing process, sodium hydrosulfite is converted into sulfite, which is toxic for fish and bacteria and in some cases is further oxidized into sulfates. Sulfates also cause corrosion of concrete pipes and may be reduced under anaerobic conditions into hydrogen sulfide.

During dyeing, dichromate is used with vat and sulfur dyes as an oxidizing agent and can result in the formation of chromium VI, which is acutely toxic and is a carcinogenic agent.

Salts are employed in dyeing to facilitate exhaustion (transfer of dye from solution to fabric surface) of ionic dyes, especially anionic dyes such as direct and reactive dyes on cotton. Mostly, common salt is used which is cheap but is quite corrosive.

Many surfactants raise environmental concerns due to poor biodegradability and toxicity. These include alkylphenol ethoxylates (APEO) and nonylphenol ethoxylates (NPE) which are often contained in detergents and many other auxiliaries (e.g. dispersing agents, emulsifiers). Alkylphenol ethoxylates are themselves believed to be endocrine disruptors and known to cause feminization of male fish. More importantly, however, they produce compounds which are believed to be many times more potent than the parent compounds. The most potent of these are octyl and nonylphenol. Nonylphenol is listed as a priority hazardous substance under the EC Water Framework Directive, which means that any discharge, needs to be phased out.

Textile mills do not store chemicals safely; no containment arrangement is in place to collect leaks or spills. There is also no management practice where older chemicals are used first to avoid their spoilage. As a result, spills and leaks contribute to wastewater and soil pollution.

Workers generally add chemicals in process vessels and chemical preparation tanks without precise measurement, based on estimation. They pour chemicals solely on their judgment or use containers of different types and sizes such as plastic drums and jugs to do so. These practices result in over dozing of chemicals which increases economic loss and wastewater pollution.

Chemical Recovery

Large quantity of caustic soda is wasted in the mercerization process wash waters. These washes contain about 5 per cent caustic soda which contributes to losses of million of rupees but also contributes to wastewater pollution. Caustic soda can be recovered through a caustic recovery plant.

Specific Utility Consumption

Based on the findings of energy and environmental audits, the typical utility consumption for every kilogram of fabric processed is given in table 6.0.

Table 6.0: Specific Utilities Consumption in Textile Industries

Utilities	Consumption per kg Fabric Processed	
	Punjab	Sindh
Water (litres)	70 - 400	25-140
Natural Gas (m^3)	0.17 – 1.88	0.15-1.70
Electricity (kWh)	0.32 – 1.95	0.15-2.30
Steam (kg)	4 - 27	4-13

Source: PISD

Textile Sector BWMPs

BWMP-01	Conduct training of workers and management
Category	Water management, energy conservation, pollution reduction
Description	
Conduct training of workers and management on water conservation, energy efficiency and pollution reduction aspects. Experts, trainers and consultants can be hired to conduct these trainings.	
Investment	PKR 200,000-300,000 depending on the size of the organization and extent of trainings.
Benefits	
Trained human resource is beneficial in reducing resource waste and contribute in the profitability of the organization.	

BWMP-02	Installation of water flow meter
Category	Water management
Description	
Water management is not possible without monitoring of water consumption and setting benchmarks. Installation of water flow meters in water consuming areas is needed to determine water consumption and benchmarks (m^3/ton) for water management.	
Investment	PKR 10,000-200,000
Benefits	
PKR 11,000-220,000/year, payback in 11 months. Water management through monitoring. Water management results in reducing chemicals, energy and wastewater hydraulic load.	

BWMP-03	Leakage control, maintenance of pipelines and piping improvement
Category	Water management, energy conservation, pollution reduction
Description	
Improper maintenance or lack of preventive maintenance result in leakages which cause resource wastage, pollution generation, untidiness and safety hazard in occupational areas.	
Investment	PKR 10,000-100,000
Benefits	
PKR 20,000-200,000/year, payback in six months. Preventive maintenance results in resource management, pollution reduction and safety for workers.	

BWMP-04	Reuse of cooling water
Category	Water management
Description	
Collection and reuse of cooling water from singeing, chillers, compressors, therm oil heaters, cooling drums, caustic recovery plant etc.	
Investment	PKR 15,000-100,000
Benefits	
PKR 30,000-200,000/year, payback in six months.	

BWMP-05	Use of reduced sized diameter water hoses
Category	Water management
Description	
Water hoses with large sized diameters are used on production floors which result in large quantities of unnecessary water consumption and wastage. Management should use appropriately sized water hoses in water use points.	
Investment	PKR 20,000-100,000
Benefits	
PKR 30,000-150,000/year, payback in eight months.	

BWMP-06	Reuse of reverse osmosis (RO) reject water
Category	Water management
Description	
RO reject water is high in TDS which is generally discarded. This is poor quality water which can be used in places where high quality water is not required. Examples can be toilets, for floor and vessel washing, water showering in wet scrubbers etc.	
Investment	PKR 30,000-60,000
Benefits	
PKR 60,000-120,000/year , payback in six months.	

BWMP-07	Reuse of wastewater as showering water
Category	Water management
Description	
Water showering is carried out in wet scrubbers or cyclones attached with solid fuel boilers in production units. Wastewater, which is less polluted, can be used as an alternate for showering water in these scrubbers and cyclones.	
Investment	PKR 25,000-100,000
Benefits	
PKR 30,000-120,000/year, payback in 10 months.	

BWMP-08	Control of floor and other washings
Category	Water management
Description	
Workers generally use water liberally to wash floor. Mill management should take appropriate control measures to reduce water consumption at washing points.	
Investment	PKR 10,000-50,000
Benefits	
PKR 12,000-60,000/year, payback in 10 months.	

BWMP-09	Installation of water trigger nozzles in water hoses
Category	Water management
Description	
Workers consume large quantities of water to wash floors and other vessels and drums using water hoses. Often water hoses are kept running and thrown on floors thus wasting large quantities of water unnecessarily. These water hoses should be equipped with water trigger nozzles so that controlled water is utilized and waste avoided.	
Investment	PKR 10,000-15,000
Benefits	
PKR 15,000-25,000/year, payback in eight months.	

BWMP-10	Installation of automatic level control switches in water storage tanks
Category	Water management
Description	
In some production units, water is wasted as it overflows from water storage tanks since there is no mechanism to turn off water pumps or turbines when tanks are full. These tanks should be equipped with automatic level control switches so that water turbines switch off and restart when the water level drops.	
Investment	PKR 10,000-50,000
Benefits	
PKR 11,000-55,000/year, payback in 11 months.	

BWMP-11	Implementation of water showering on fabric in jiggers and rope washing machine
Category	Water management
Description	
In some industries, for washing of fabric in jigger and rope washing machines, water is directly applied into the solution chamber and fabric is dipped in water for washing. If water is applied in the form of showers on fabric instead of its direct application in solution chambers, it will result in improved fabric washing and reduced water consumption.	
Investment	PKR 5,000-50,000
Benefits	
PKR 6,000-60,000/year, payback in 10 months.	

BWMP-12	Dry cleaning of floors
Category	Water management, pollution reduction
Description	
Spills and leakage of chemicals on floors should not be washed with water as it increases the pollution load of wastewater. Instead floors should be dry cleaned with cloths, saw dust or any other solid material. This practice will reduce water consumption and pollution.	
Investment	PKR 5,000-10,000
Benefits	
PKR 6,000-11,000/year, payback in 11 months.	

BWMP-13	Reuse of process washes of one process into other processes
Category	Water management
Description	
In the textile industry, washing water of one process can be used for other processes to reduce water consumption. Post-bleaching and scouring washes can be reused as desizing washes.	
Investment	PKR 20,000-100,000
Benefits	
PKR 25,000-125,000/year, payback in 10 months.	

BWMP-14	Reuse of soaper machine wastewater
Category	Water management
Description	
Soaper wastewater contains some soap content and can be used for washing purposes such as washing pigments drum and cleaning the colour kitchen floor. Pigment drums and colour kitchen floor should be first washed with soaper wastewater and then with clean water.	
Investment	PKR 50,000-100,000
Benefits	
PKR 60,000-120,000/year, payback in 10 months.	

BWMP-15	Synchronizing of blanket washing
Category	Water management
Description	
It has been observed that blanket washing continues even when the printing machine is not in operation, which results in wastage of water. Blanket washing should be synchronized with the movement of the printing machine.	
Investment	PKR 15,000-50,000
Benefits	
PKR 25,000-85,000/year, payback in seven months.	

BWMP-16	Installation of temperature and pressure gauges in process vessels
Category	Energy conservation
Description	
Generally when temperature and pressure gauges are not installed in process vessels and pipelines, energy is unnecessarily used to heat water and other contents.	
Investment	PKR 5,000-50,000
Benefits	
PKR 6,000-60,000/year, payback 10 months	

BWMP-17	Conversion of machines from co-current to counter current mode
Category	Water management and energy conservation
Description	
In counter current washing, water flows in the opposite direction to the fabric. This technique is used all continuous ranges of washing and rinsing in the textile industry. Counter-current washing can be applied at de-size washers, scour washers, mercerizing washers, bleach washers, dye ranges, and print house soaper ranges.	
Investment	PKR 10,000-75,000
Benefits	
PKR 12,000-90,000/year, payback in 10 months.	

BWMP-18	Performance monitoring of electric motors
Category	Energy conservation
Description	
Generally electrical parameters of motors are not monitored and consequently their performance is not evaluated. Management should use energy analyzer, regularly monitor electrical parameters and evaluate motors' performance. In case motors don't operate as per required parameters, they should be rectified or replaced.	
Investment	PKR 50,000-300,000 (energy analyzer cost)
Benefits	
PKR 75,000-450,000/year, payback in eight months.	

BWMP-19	Use of high quality copper wire to rewind motors
Category	Energy conservation
Description	
Poor quality copper wire is generally used to rewind motors which affect motor performance. Management should use high quality copper wires for rewinding.	
Investment	PKR 50,000-200,000
Benefits	
PKR 55,000-220,000/year, payback in 11 months.	

BWMP-20	Record keeping of rewound motors
Category	Energy conservation
Description	
Motor performance records should be maintained and each motor load reading should be recorded and evaluated after rewinding. In case rewinding causes excessive current consumption, motors should be replaced.	
Investment	PKR 100,000-200,000 (motors replacement)
Benefits	
PKR 120,000-240,000/year, payback in 10 months.	

BWMP-21	Reuse of steam condensate
Category	Water management, energy conservation
Description	
Some industries waste steam condensate instead of using it as boiler feed water. This is a clean and energy intensive water stream whose wastage results in substantial monetary loss. This stream should therefore be properly collected and reused as boiler feed water.	
Investment	PKR 100,000-150,000
Benefits	
PKR 625,000-1,200,000/year, payback in two months.	

BWMP-22	Installation of heat exchangers on hot wastewater streams
Category	Energy conservation
Description	
Heat energy can be recovered from hot wastewater streams originating from machines by installing heat exchangers between wastewater and freshwater used for different washing processes. The capacity of the heat exchanger will vary with the discharge of the machine. Increase in temperature should be in the range of 30 to 40^{0}C.	
Investment	PKR 500,000-750,000
Benefits	
PKR 500,000-750,000/year, payback in 12 months.	

BWMP-23	Boiler blow down after TDS monitoring
Category	Energy conservation
Description	
Blow down occurs in a boiler to manage TDS in it. Generally boiler operators conduct blow down at fixed set intervals without measuring the TDS of boiler water. Therefore, unnecessary blow downs are conducted and energy is. Blow down should always be conducted after measuring TDS.	
Investment	PKR 10,000-20,000
Benefits	
PKR 30,000-60,000/year, payback in four months.	

BWMP-24	Monitoring of chemical consumption in processes
Category	Pollution reduction
Description	
In some production units, chemicals are added in process vessels without being properly measured. Estimated quantities of chemicals are added based on judgment which results in excessive use of chemicals. This not only increases production cost but also increases the wastewater pollution load. Workers should add chemicals after exact measurement and calibrated jugs/mugs or weighing scales can be used to do so.	
Investment	PKR 5,000-10,000
Benefits	
PKR 10,000-20,000/year, payback in six months.	

BWMP-25	Storage of chemicals with catch pans
Category	Pollution reduction
Description	
Generally chemical containers are not stored with any catch pans. In the event of a leak or spill chemicals are washed away in the wastewater drain, adding to pollution. Catch pans should be placed over chemical containers and their volume should be 110 per cent of the volume of the container placed in it.	
Investment	PKR 50,000-200,000
Benefits	
PKR 55,000-220,000/year, payback in 11 months.	

BWMP-26	Proper disposal of solid waste
Category	Pollution reduction
Description	
Solid waste is sometimes dumped in wastewater drain lines which cause pollution. Solid waste should be collected and disposed off in appropriate sites.	
Investment	PKR 10,000-50,000
Benefits	
Pollution reduction, less pollution load on wastewater treatment plant, and NEQS compliance.	

BWMP-27	Installation of automatic shut off valve in machines
Category	Water management
Description	
Water supply to machines is usually not synchronized with its operation. When machines stop, Water remains running even when machines have switched off, adding to water wastage. Machines should therefore be equipped with automatic shut off valves which allow water to be supplied only when machines are operating.	
Investment	PKR 500,000-1,000,000
Benefits	
PKR 165,000-330,000/year, payback in 36 months.	

BWMP-28	Disposal of boiler ash in dry state
Category	Water management, pollution reduction
Description	
Some production units wash fly ash from solid fuel boilers in drains with large quantities of washing water. This causes water wastage and increase in wastewater pollution. Ash should be collected from scrubbers and cyclones and disposed off in appropriate disposal sites instead of being washed with water in drains.	
Investment	PKR 300,000-3,000,000
Benefits	
PKR 100,000-1,000,000/year, payback in 36 months.	

BWMP-29	Installation of temperature controllers, steam flow meters to control energy supply
Category	Energy conservation
Description	
Energy wastage cannot be reduced unless it is monitored and control equipment is installed in machines. Temperature controllers allow energy supply to be managed and steam flow meters help in managing steam consumption in various processes.	
Investment	PKR 400,000-600,000
Benefits	
PKR 265,000-400,000/year, payback in 18 months.	

BWMP-30	Installation of energy efficient motors
Category	Energy conservation
Description	
Old, standard and inefficient motors waste a lot of energy. Inefficient motors should be replaced with energy efficient motors to reduce energy consumption.	
Investment	PKR 1,000,000-2,000,000
Benefits	
PKR 925,000-1,850,000/year, payback in 13 months.	

BWMP-31	Installation of efficient water turbine
Category	Energy conservation
Description	
Generally water turbines are inefficient and waste a lot of energy. To reduce energy consumption they should be replaced with efficient turbines.	
Investment	PKR 200,000-300,000
Benefits	
PKR 160,000-240,000/year, payback in 15 months.	

BWMP-32	Preheating of process streams with flue gases of generator/oil heaters exhausts
Category	Energy conservation
Description	
Generator exhaust gases are emitted at high temperatures of around 500°C. Process water streams can be preheated through these flue gases by installing heat exchangers in exhausts.	
Investment	PKR 1,000,000-2,000,000
Benefits	
PKR 1,000,000-2,000,000/year, payback in 12 months.	

BWMP-33	Inverters on motors
Category	Energy conservation
Description	
Inverters should be installed on motors with fluctuating loads for controlled energy consumption.	
Investment	PKR 200,000-400,000
Benefits	
PKR 200,000-400,000/year, payback in 12 months.	

BWMP-34	Use of treated water in processes
Category	Pollution reduction
Description	
Use of untreated water leads to excessive use of chemicals in processes with poor quality product quality. Water should be treated with RO and softener and then used in processes to reduce chemical consumption and wastewater pollution load.	
Investment	PKR 1,000,000-2,000,000
Benefits	
PKR 500,000-1,000,000/year, payback in 24 months.	

BWMP-35	Automatic chemical dispensing system
Category	Pollution reduction
Description	
Manual feeding of chemicals allow excessive use of chemicals which ultimately causes resource loss and increases wastewater pollution load. Automatic chemical dispensing systems allow controlled use of chemicals in process recipes.	
Investment	PKR 2,000,000-3,000,000
Benefits	
PKR 650,000-1,000,000/year, payback in 36 months.	

BWMP-36	Less bleaching of fabrics in dark shades
Category	Pollution Reduction
Description	
Fabric which is dyed in dark shades should not be bleached extensively. This will not only reduce chemical and energy consumption but also reduce pollution load generated by the process.	
Investment	
Benefits	
PKR 50,000 – 120,000/year	

BWMP-37	Installation of caustic recovery plant
Category	Pollution reduction
Description	
Mercerization wastewater with some caustic contents (5-8 Be°), is carried to the caustic recovery plant which makes the solution more concentrated and increases caustic content. This concentrated caustic soda can be reused in the mercerization process.	
Investment	PKR 3,000,000 – 4,000,000
Benefits	
PKR 3,000,000 – 4,000,000 /year, payback in 12 months.	

BWMP-38	Establishing laboratory
Category	Pollution reduction
Description	
Impure chemicals are used more regularly and increase wastewater pollution. Management should establish a laboratory to analyze incoming chemicals with respect to their purity. Only pure chemicals should be used in processes and impure chemicals should be discarded. Use of pure chemicals will reduce production cost and also wastewater pollution load.	
Investment	PKR 500,000-1,000,000
Benefits	
PKR 160,000-350,000/year, payback in 36 months.	

BWMP-39	Use of nozzles in water hoses to clean printing machine screens
Category	Water management
Description	
Water hoses used for cleaning printing machine screens do not have nozzles which results in the use of large quantities of water. It also does not effectively wash screens. Proper sized nozzles should be installed in water hoses to reduce water consumption and for effective and targeted cleaning of screens.	
Investment	PKR 10,000-15,000
Benefits	
PKR 15,000-25,000/year, payback in eight months.	

BWMP-40	Reuse of process washes containing low percentage of chemicals to make chemical solutions
Category	Water management and pollution reduction
Description	
Wastewater of certain processes like bleaching, scouring and mercerization wastewater contains low concentrations of chemicals. These water streams can be used as solvents to make chemical baths. This practice will save water as well as chemicals and reduce wastewater pollution.	
Investment	PKR 100,000-250,000
Benefits	
PKR 245,00-610,000/year, payback in five months.	

BWMP-41	Avoid disposing of pigments and dyes in drains
Category	Pollution reduction
Description	
To reduce wastewater pollution collection and residual printing paste pumps to should be reused in processes or disposed off in their dry state.	
Investment	PKR 25,000-50,000
Benefits	
PKR 35,000-65,000/year, payback in nine months.	

BWMP-42	Installation of washing machine for printing machine screens
Category	Water management
Description	
Printing machine screens are washed manually with water hoses, which consumes a lot of water and are an ineffective way of cleaning screens. Washing machines are an efficient way of washing screens with less water.	
Investment	PKR 60,000-70,000
Benefits	
PKR 30,000-35,000/year, payback in 24 months.	

Textile Sector Business Cases

Business Case Scenario-01: Frequently Implemented with Very High Payback Periods (Textile Sector)

#	Business Priority-01 Solution Options	Financial Overview		
		Investment (PKR 000)	Saving (PKR 000/yr)	Simple Payback (months)
	Water management			
1	Leakage control, maintenance of pipelines, piping improvement.	10-100	20-200	6
2	Collection and reuse of cooling water from singeing, compressors, therm oil heaters, chillers, cooling drums, caustic recovery plant etc in processes.	15-100	30-200	6
3	Reuse of RO rejected water/softener regeneration water for showering at boiler wet scrubber/cyclones or in the process where high quality water is not required.	30-60	60-120	6
4	Use of reduced sized diameter pipes for water use.	20-100	30-150	8
5	Implementing water showering of fabrics in rope and jigger machines for effective washing, with optimum water consumption.	5-50	6-60	10
6	Use of wastewater instead of freshwater in boiler wet scrubber and for cleaning of wastewater mechanical screens.	25-100	30-120	10
7	Control of floor and other washing points.	10-50	12-60	10
8	Use of nozzles in water hoses to clean printing machine screens.	10-15	15-25	8
9	Installation of water trigger nozzles in water hoses.	10-15	15-25	8
10	Reuse of process washes of one process as washing water for other processes.	20-100	25-125	10
11	Collection and reuse of blanket washing water., Synchronized blanket washing with printing machine movement to avoid water wastage during machine shut off.	15-50	25-85	7
12	Installation of automatic level control switches in water storage tanks.	10-50	11-55	11
13	Installation of water flow meters.	10-200	11-220	11
14	Collection and reuse of soaper wastewater for washing pigment drums and colour kitchen floor cleaning.	50-100	60-120	10
15	Use of dry cleaning methods to clean wet floors contaminated with chemicals.	5-10	6-11	11
	Energy Conservation			
16	Change existing machines to countercurrent mode to reduce energy and water consumption.	10-75	12-90	10

17	Installation of temperature and pressure gauges in process vessels.	5-50	6-60	10
18	Monitoring and evaluation of motor performance and improve system accordingly (loading adjustment, replacing over/under sized motors).	50-300	75-450	8
19	Use of high quality copper wires for rewinding of motors.	50-200	55-220	11
20	Keep record of motors rewinding and replace motors after three to four times of rewinding.	100-200	120-240	10
21	Collection and reuse of steam condensate as boiler feed water.	100-150	625-1,200	2
22	Conduct boiler blow down after measuring TDS levels in boiler water.	10-20	30-60	4
	Wastewater Pollution Reduction			
23	Reuse of process washes containing low content of chemicals to make chemical solutions.	100-250	245-610	5
24	Collection of residual printing paste from pigment drums and pumps to use in the process again or disposing it off in dry state.	25-50	35-65	9
25	Monitoring chemical consumption in process recipes (use of calibrated beakers for chemical dosing).	5-10	10-20	6
26	Less bleaching of fabrics which undergo black or dark shaded dyeing.	-	50-120	-
27	Chemical storage with catch pans underneath to collect leaks and spills.	50-200	55-220	11
28	Collect and dispose solid waste in appropriate dumping site instead of disposal in wastewater drains.	10-50	-	-
	Total	**760-2,655**	**1,674-4,931**	**5-6**

The textile processing sector's first priority set of BWMPs implementation makes a very good business case. An investment in the range of PKR 0.8-2.6 million, depending upon the size of a production unit, and pays back in less than a year with annual benefits of PKR 1.7-4.9 million, in terms of water conservation (5-30%), chemical savings, energy efficiency (5-10%) and pollution reduction (10-30%).

Business Case Scenario-02: Important with Moderate to High Payback Periods (Textile Sector)

#	Solution Options	Financial Overview		
		Investment (PKR 000)	Saving (PKR 000/yr)	Simple Payback
	Water management			
1	Conduct training of workers and managers on water conservation, energy efficiency and pollution reduction aspects.	200-300	-	-
2	Installation of automatic water shut off valves in machines.	500-1,000	165-330	36
3	Installation of washing machine for printing machine screens.	60-70	30-35	24
4	Disposal of boiler ash in dry state instead of washing it in the drain with water.	300-3,000	100-1,000	36
	Energy Conservation			
5	Installation of temperature controllers, steam flow meters etc.	400-600	265-400	18
6	Installation of energy efficient motors.	1,000-2,000	925-1,850	13
7	Installation of efficient water turbines.	200-300	160-240	15
8	Installation of efficient steam and condensate recovery system.	1,000-3,000	800-2,400	15
9	Installation of heat exchangers in hot wastewater streams.	500-750	500-750	12
10	Preheating of process streams with flue gases of generators/oil heater exhaust.	1,000-2,000	1,000-2,000	12
11	Inverters on motors.	200-400	200-400	12
	Wastewater Pollution Reduction			
12	Installation of caustic recovery plant.	3,000-4,000	3,000-4,000	12
13	Use of treated water with RO/softener in processes.	1,000-2,000	500-1,000	24
14	Automatic chemical dispensing system.	2,000-3,000	650-1,000	36
15	Establishing laboratory to monitor chemical purity.	500-1,000	160-350	36
16	Disposal of boiler ash in dry state instead of washing with water in drain.	-	-	-
	Total	**11,860-23,420**	**8,455-15,755**	**17-18**

The second priority set of BWMP implementation in the textile processing sector also has a very clear business case. An investment in the range of PKR 11.8-23.4 million, depending upon the size of the industry, pays back in less than two year with annual benefits of PKR 8.5-15.8 million, in terms of water conservation (5-30%), chemical savings, energy efficiency (5-10%) and pollution reduction (10-30%).

Case Study

Abdul Rehman Corporation (ARC) Pvt. Ltd implemented the following BWMPs:

Abdul Rehman Corporation (ARC) Pvt. Ltd. is a progressive textile industry. As a part of the WSP project, a production unit of ARC was audited and some recommendations were shared with the management. In addition, on-the-job and workshop trainings were offered to staff and professionals. A number of recommendations were given to ARC such as:

- Recycling of rotary blanket wash water
- Water showering in rope washing machine
- Reuse of RO rejected water for flushing and cleaning
- Reuse of singeing machine's cooling water
- Use of water trigger nozzles at washing points
- Installation of heat exchanger at soaper washing machine

After the implementation of these BWMPs the unit was able to achieve significant economic and environmental gains as below.

Water Conservation	211,000 m^3/yr
Investment	PKR 0.953 Million
Annual Saving (water & energy)	PKR 2.64 Million