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


Why we are here:

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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# Training Manual on BWMPs in Sugar 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 learned 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 sugar sector in Pakistan. The trainees will then be expected to implement these BWMPs in their industries, 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 Sugar Sector in Brief

Pakistan is one of the largest sugarcane producers in the world. It is the fifth largest in terms of area under sugarcane cultivation, 11th by production and 60th by crop yield. Sugarcane is one of the major crops in Pakistan which is cultivated over an area of approximately one million hectares. The sugar industry plays an important role in the economy of the country. Average annual production of sugarcane is in the range of 45-50 million metric tons. about a total of 83 sugar mills and 23 distilleries produce four million tons of sugar and about a quarter of a million tons of ethanol, respectively across Pakistan. An average of 41 million ton of sugarcane is crushed annually. Total contribution of the sugarcane crop to Gross Domestic Product (GDP) is in the range of 7.5-9 per cent.

After textile, the sugar industry is the second largest agro-based industry. It plays a major role in the economic development of the country and contributes more than PKR 15-20 billion per annum in the form of General Sales Tax (GST), federal, provincial, local taxes, etc. The share of the sugar industry in the GDP is 1.9 per cent. Annual per capita consumption of sugar in Pakistan is 26 kg which is the highest among developing countries. Direct employment in the sugar industry is 120,000 managerial, skilled and semi-skilled staff and indirect employment is about 4 million people. The sugar sector supports industries such as alcohol, paper, beverages, etc.

Sugar mills are mostly located in the rural areas of Punjab and Sindh. A small percentage of total production is produced in Khyber Paktunkhwa. Previously, Punjab was partly dependent on the supply of sugar from Sindh, but lately the establishment of a number of large units in Punjab has made the province self-sufficient in the commodity.

## Sugar Sector Issues Related with Water Management

The sugar sector requires a large amount of water, steam and electricity. As a result, the main environmental stress associated with the sugar sector is water and energy consumption and water pollution.

Best Water Management Practices (BWMPs) issues of sugar mills in Pakistan are:

i)Water management

ii)Energy conservation (electrical and thermal)

iii)Wastewater pollution

## Water Management

Water is an important utility for sugar mills. Sugarcane is made up of approximately 70 to 75 per cent water, which is recovered and reused in its processing. However, during the initial processing phase, some water is needed. Water is also used in boilers, imbibitions, floor washing, vessel cleaning, etc. Sugar production units use groundwater to meet their water requirement.

## The major of water consumption areas of sugar mills are:

Cooling and washing of evaporators, vacuum pans and heat exchangers;

Cooling of mills' bearings, vacuum pumps and turbines;

Makeup water at spray pond/cooling tower;

Boiler feed water to fulfill steam requirements;

Water for general purposes i.e. floor washing, sanitation, etc.

As water is a cheap and easily accessible commodity, production units don't give any serious consideration on its use or conservation. Most units do not keep a record of their water consumption which is the main reason why more water is used than needed in different processes. Water consumption varies from unit to unit, largely depending on its process, type of machines, production capacity, and water use practices.



This attitude is also reflected on the production floor where there is no monitoring and record keeping of water consumption at different process levels.

Not realizing its cost effectiveness, sugar mills waste water in various ways. On production floors, there is no record of water used in each process which means that more water is added than needed. 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. Water is also wasted through leakages in pipes and equipment due to lack of maintenance. As no records of water usage are kept, total water consumption of sugar mills is not known.

Workers and management are unaware that clean water streams can be reused, so these streams are often wasted. These clean water streams are released from mills' bearings, turbines, compressors, vacuum pumps, evaporators and pans. Water is also wasted through overflow from spray ponds. Vessels washings are not optimized.

Fly ash of boiler flue gases is removed through wet scrubbers where water is showered in the scrubber and contaminated water is discharged as wastewater, which can be used again.

Raw water is used to clean tubes of heat exchangers, evaporators and vacuum pans during mechanical cleaning (brushing). Water is discharged after one use, when it can be used in many other places where clean water is not required.

It is common practice to clean sugar leaks and spills from the floors with raw water and this water contributes to wastewater pollution.

## Energy Conservation (Electrical & Thermal)

## Thermal

## Bagasse

Fibre remaining from sugarcane after juice extraction is called bagasse and consists of hard and soft fibres. The soft fiber is called the pith. The quantity of bagasse depends upon the fibre content of sugarcane. Bagasse is about 30 per cent of crushed sugarcane and is used as fuel in boilers to produce superheated steam. The calorific value of bagasse depends on its moisture content. With an increase in moisture, its calorific value decreases and vice versa. Some sugar mills dry their bagasse through flue gases from boilers.

## Superheated Steam

In sugar mills, water tube boilers are used to generate superheated steam which is primarily used to operate steam turbines. These steam turbines, which only use a portion of the steam produced, are either used for power generation or as prime mover of processing equipment. Exhaust steam from these turbines is then used in the process house as a heating medium. Generally all exhaust steam cannot fulfill the process requirement a small quantity is used after de-superheating, called makeup steam.

## The major issues associated with thermal energy conservation:

## 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, most sugar mills management do not take actions to control energy losses. There are numbers of areas where energy monitoring is not carried out.

## Steam Leaks

Steam leaks are significant and highly visible indicators of energy wastage. Based on energy audits, almost all units have steam leakage problems. The nature of these leaks varies from unit to unit. Steam leaks are mainly due to damaged fittings, damaged pipes, glands of valves or faulty steam traps.

## Condensate Wastage

Steam is either added directly to water or indirectly through coils or jackets. Direct injection of steam is irrecoverable as it becomes a part of hot water. On the other hand, indirect steam gets condensed after heat transfer to other media of contact (steam condensate) and can be reused or recycled.

Most sugar mills recover all steam condensate and use it as boiler feed or process water. Some quantity of steam condensate is wasted due to a poor steam condensate recovery system.

## Energy Losses through Blow Down Water

When water is boiled and steam is generated, dissolved solids present in water remain in the boiler. These solids are removed from the boiler (from the mud and steam drum) by applying blow downs. Two types of blow down are applied in sugar mills i.e. intermittent and continuous. Excessive solids in boiler water encourage foaming and carryover into the steam and cause scale formation inside the boiler, resulting in localized overheating and finally causing boiler tube failure.

The temperature of blow down water is about 220°C, which is quite high and a huge amount of energy is wasted. The quantity of blow down water in sugar mills varies from 19 to 434 $m^3$/day.

## Steam Distribution Network

Steam is introduced in the main steam distributor or steam header and pipes then carry the steam to the mill house, turbo feed water pumps, cutter, shredder, power house, and the process house. Steam and feed water flow meters are installed on the boilers in most sugar mills, however pressure and temperature gauges are missing on steam distribution lines. In some sugar mills the pressure drop is higher due to an improper steam distribution network.

## Wastage of Surplus Vapour Condensate

In sugar mills, wastage of surplus vapor condensate is a serious issue. Most production units do not use vapour condensate effectively. This is energy and water loss.

## Electrical

Electricity is another important utility in sugar mills. All sugar mills in Pakistan have their own power generation facilities. Electricity is generated through steam turbine driven generators. Some sugar mills generate surplus power and sell it to the national grid to bridge the gap between supply and demand of electricity and promote alternate energy generation sources.

Electricity consumption varies from unit to unit and largely depends on the number and size of machines in operation. It also depends on the age and state of the machines being used in mills. Production units with the latest machinery are energy-efficient and produce more with less waste. On the other hand, sugar mills with old machinery consume comparatively more electricity.

Major BWMPs related to electrical energy issues are associated with electrical motors attached with water pumps and turbines.

## High Efficiency Motors

Electric motors consume most electricity in any sugar mill. More than 90 per cent of total electricity is consumed by these motors. The running cost of motors is the most important factor and contributes 95 per cent to the motor lifecycle cost.

Motors are categorized in different classes on the basis of their efficiency i.e. Class I, Class II and Class III motors. Efficiency Class III motors, also called standard motors and consume more energy as compared to Class II or Class I



motors. In older sugar mills, efficiency ClassIII motors are used, which result in more energy losses. There is also a burning issue of motors due to ineffective or lack of preventive maintenance and motor safeties. In sugar mills wastage of bagasse due to use of low efficiency motors ranges from 300 to 2,700 ton per season.

## Over and Under Sized Motors

Motors mismatched to the load (over and under sized motors) are also a cause of efficiency loss. Generally motors are at their maximum efficiency at approximately 75 per cent of their rated load. In sugar mills, most installed motors are oversize.

## Variable Speed Drive (VSD)

The application of variable speed drives by their operational torque requirements are at constant torque loads, constant horsepower loads and variable torque loads. Torque is the amount of turning force required by the load and efficiency of electrical motors and drives.

Throttling a system by using a valve or damper is an inefficient method of control as the throttling device dissipates energy which has been imparted to the fluid. A variable speed drive simply reduces total energy into the system when it is not needed. In addition to major energy saving potential, a drive also offers built-in power factor correction, better process control and motor protection.

In sugar mills, bagasse wastage due to the absence of VSD varies from 600 to 4,500 tons per season. Variable speed drives can be installed on centrifugal pumps, fans, blowers, cane carriers, inter-carriers, compressors etc.

## Rewinding of Motors

Motor efficiency and losses vary considerably after rewinding. Even if the rewound motors are restored to their original efficiency with proper stripping and rewinding, losses are typically higher in rewound motors. The efficiency of a motor is reduced by 2 per cent per rewinding, but the reduction in efficiency can be as high as 20 per cent. Core losses are usually the main reason for the decrease in efficiency (damage to stator and/or rotor from oven or physical contact). Decreasing turn from 10 to 9 increases starting current by 23 per cent. A common practice in sugar mills practices to rewind motors frequently, without analyzing the increase in operational expenses.

## Increase in Wastewater Pollution

Wastewater is a major environmental issue for sugar mills. In some units, wastewater is not discharged into water bodies but is instead used for irrigation. At present there are no guidelines in place by the Environmental Protection Agency (EPAs) or the Irrigation Department to use the discharge for irrigation purposes.

## Sources

Wastewater in sugar mills is generated from various sources. A list of these sources with possible activities are described in table 1.0.

Table 1.0: Wastewater Sources in Sugar Mills

| # | Sources | Activity | Wastewater Quality |
|---|---|---|---|
| 1 | Mill house | Floor washing, bearing cooling water and oily water from lubricating system | Turbine and mill bearing's cooling water, floor washing, product leaks and spills and oil and grease |
| 2 | Process house | Chemical cleaning and washing of evaporators and heaters, floor washings | Floor washing, washings of juice heaters, evaporators, vacuum pans and other vessels, evaporator's cooling water, sugar leakages, equipment cleaning chemicals (e.g. caustic soda, soda ash, anti-scale and sometimes HCl), scale, etc |
| 3 | Boiler house | Blow down water, fly ash (wet or dry) and clinker | Blow down wastewater containing high concentration of dissolved solids, fly ash disposed with wastewater (which increases Total Suspended Solids (TSS) of effluent), wastewater from wet scrubber |
| 4 | Spray pond | Overflow of effluent due to addition of vapour condensates and freshwater in the spray pond | Wastewater from spray pond containing sugar traces and antifoaming chemicals (comparatively less contaminated than wastewater from houses) |
| 5 | Laboratory | Laboratory testing (Pol. % etc.) | Liquid waste containing chemical solutions and lead sub-acetate |
| 6 | Sanitary waste | Effluent from wash rooms and colony of sugar mills | Sanitary waste containing fecal coliforms |

For the wet disposal of fly ash from boiler stack, freshwater is sprayed on the fly ash which becomes part of wastewater and carries it away from the boiler house. Wet disposal of fly ash increases the TSS concentration in wastewater. This method of fly ash disposal produces wastewater which does not comply with the National Environmental Quality Standards (NEQS) of Chemical Oxygen Demand (COD, Biological Oxygen Demand (BOD), and Total Suspended Solids (TSS).

Wastewater containing fly ash is either disposed off in the lagoon system (oxidation ponds) or in water bodies in surrounding areas of sugar mills. Fly ash settles down in the lagoons due to sedimentation and reduces the wastewater holding capacity of the lagoons. At the end of production season, lagoons are cleaned and settled fly ash is removed, which is finally disposed off in landfills. Wastewater containing ash disposed off in the watercourse, causes choking and increases TSS. Concentration of total suspended solids in the wastewater of sugar mills due to dry and wet disposal of ash is 40–190 mg/l and 610–3,900 mg/l respectively.

## Oil and Grease in Wastewater

Oil and grease is the priority parameter for sugar production units as per EPA standards. Oil and grease in wastewater may cause the following impacts:

Increase in pollution load

Impaired lagoon efficiency

Lubricating oils are used on the bearings of mills to reduce friction losses and smooth operations. These oils are



used in open circuits and lubricating oil may drip from bearings of the mills and mix with wastewater resulting in increased oil and grease concentration in wastewater above NEQS limit.

## Disposal

Wastewater from sugar mills is either disposed off directly into the watercourse or in oxidation ponds (which are excavated in the vicinity of mills) to provide some residence time, and then are finally used in agriculture fields (adjacent to mills) for irrigation purposes. The values of priority parameters (provided by EPA, under the Self Monitoring and Reporting (SMART) programme SMART) of combined sugar mills wastewater are given in table 2.0.

Table 2.0: Characteristics of Combined Wastewater of Sugar Mills

| Parameters | Unit | Values | % Removal Required | NEQS |
|---|---|---|---|---|
| Measured flow | $m^3$/day | 719 – 9,840 | | |
| Water consumption | $m^3$/ton of cane | 0.5 – 1.0 | | |
| pH | | 3.03 – 9.8 | - | 6.0 – 9.0 |
| $BOD_5$ | mg/l | 500 - 1500 | 84 – 95 | 80 |
| COD | mg/ l | 1500 - 3500 | 90 – 95 | 150 |
| TSS | mg/l | 80 - 2000 | 0 – 90 | 200 |
| Oil and Grease | mg/l | 6 - 9.5 | 0 – 83 | 10 |
| *Source: Programme for Industrial Sustainable Development (PISD)* | | | | |

Water consumption per ton of sugarcane crushed and concentration of pollutants vary from mill to mill. It is evident that sugar mills discharge wastewater containing high levels of pollution and all parameters are higher as compared to the NEQS. Impacts of wastewater are mentioned in table 3.0.

Table 3.0: 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 having low pH. |
| | Malfunctioning and impairment of certain physio-chemical treatment processes under highly acidic and alkaline conditions. |
| Temperature | Depletion of the Dissolved Oxygen (DO) levels of the receiving water body, resulting in growth inhibition of aquatic life. |
| | Malfunctioning of wastewater treatment systems, under high temperatures. |
| Colour | Reduced light penetration in natural water and consequent reduction in photosynthesis. |
| | Aesthetic nuisance. |
| Organic pollutants | Depletion of DO levels of the receiving water body, below limits necessary to maintain aquatic life (4-5 mg/l). |
| Suspended solids | Sedimentation in the bottom of water bodies covers the 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 and grease | Reduced re-aeration in natural surface bodies, because of floating oil and grease film and consequent depletion in DO levels. |
| | Less light penetration in natural water 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 even at lower doses |

## Chemical Management

Storage of chemicals in mills is not correct as there are no containment arrangement in place to collect leaks and spills. These spills and leaks contribute to wastewater and soil pollution. There is also no practice to issue older chemicals first to avoid spoilage.

Chemical drums and packs are kept haphazardly, without proper labeling including receiving date, expiry date and associated hazards information. Such placement of chemicals may result in their wastage during sorting and dispensing activities, and poses safety and environmental concerns.

Workers generally add chemicals to process vessels and chemical preparation tanks through estimation, without precise measurements. Chemicals are added based on judgment or with the use containers of different types and sizes. These practices result in using more chemicals than needed, which is not only an economic loss but also increases wastewater pollution.

## Evaporator Cleaning Chemicals

Evaporator tubes are cleaned with concentrated sodium hydroxide solution for de-scaling. After each cleaning cycle, the used solution is drained to a storage tank. The evaporator is then washed with water to eliminate sodium hydroxide residue and other impurities. The wash water used in this operation is discharged into the plants drainage system and



mixed with wastewater. This water contains enough sodium hydroxide to significantly raise the pH of the wastewater. Since anaerobic bacteria is very sensitive to pH variations, it is probable that this periodic discharge of sodium hydroxide affects the performance of lagoons.

## Specific Utility Consumption

Based on the findings of the energy and environmental audits, typical utility consumption for each kilogram of sugar produced is given in table 4.0.

Table 4.0: Specific Consumption of Utilities

| # | Utilities | Consumption/Ton of Cane Crushed |
|---|---|---|
| 1 | Bagasse (Ton) | 0.27-0.32 |
| 2 | Superheated steam (Ton) | 0.51-0.63 |
| 3 | Water ($m^3$) | 0.5 -1.0 |
| 4 | Electricity (kWh) | 15.17-27.40 |

*Source: PISD*

# Sugar 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.<br>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.<br>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 | Vessel cleaning and floor washing with low quality water |
|---|---|
| Category | Water management |
| Description | |
| In most sugar mills vessel cleaning and floor washings are normally carried out with freshwater. This type of cleaning and washing not only increases freshwater demand but also enhances the chances of increasing wastewater pollution load in case of product leakages and spillage. By controlling the spillage and substituting the cleaning to low quality water decreases the water requirement, and saves raw material. | |
| Investment | PKR 50,000-150,000 |
| Benefits | |
| PKR 55,000-165,000/year, payback in 11 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 vapour line heater condensate as imbibition water |
|---|---|
| Category | Water management |
| Description | |
| Condensate of vapour line heater may contain sugar content and can be reused as imbibition water to save water as well as energy. | |
| Investment | PKR 50,000-150,000 |
| Benefits | |
| PKR 55,000-165,000/year, payback in 11 months. | |

| BWMP-14 | Optimization of cooling water in evaporator |
|---|---|
| Category | Water management |
| Description | |
| The cooling of evaporator is normally carried out by continuous stream of water for about 30 minutes before the manual cleaning operation of an evaporator. Excessive water is used in general for this cooling purpose. Therefore, air force flow should be used in conjunction with a fine spray of cooling water to minimize the volume of water needed to cool evaporator. Additionally, air flow from top to bottom, with the help of a fan, can also be helpful in removing water mist and enhancing visibility inside the evaporator. | |
| Investment | PKR 50,000-100,000 |
| Benefits | |
| PKR 60,000-120,000/year, payback in 10 months. | |



| BWMP-15 | Improved efficiency of spray ponds and cooling towers |
|---|---|
| Category | Water management |
| Description | |
| In sugar mills, spray ponds and cooling towers are used to cool water from the process plant. In general, the wind drift and evaporation losses, in spray ponds and cooling towers, are compensated by the incoming process water from barometric condensers and addition of freshwater. However, in most mills this is excessive as compared to actual requirement and eventually results in overflow of water from the spray plant. In order to reduce water consumption in spry pond, a system that automatically controls the operation of its well and plant pumps engaged in refilling the pond should be installed. | |
| Investment | PKR 100,000-200,000 |
| Benefits | |
| PKR 110,000-220,000/year, payback in 11 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 | Optimization of caustic soda cleaning process of vessels |
|---|---|
| Category | Water management and pollution reduction |
| Description | |
| In vessel cleaning, sodium hydroxide cleaning is carried out first and all used chemical solution is collected and reused as many time as possible. The vessel is then rinsed with freshwater to remove caustic traces and washing water is discharged into the wastewater system. This washing water still contains enough sodium hydroxide to raise the pH of wastewater. Therefore, after the cleaning the vessel should be rinsed with spray water and spray water should be spent in sodium hydroxide solution. However, the recovery of rinse water will gradually increase the volume of recovered chemical solutions. The solution can be concentrated by evaporating excess water either in the storage tank or in the evaporators. | |
| Investment | PKR 100,000-150,000 |
| Benefits | |
| PKR 200,000-300,000/year, payback in six months. | |

| BWMP-18 | Optimize operation of evaporators and vacuum pans |
|---|---|
| Category | Water management and energy conservation |
| Description | |
| Water conservation and sugar recovery can be improved by avoiding overloading of evaporators and vacuum pans, boiling at excessive rates, or operating at incorrect liquid levels. At optimum capacity and with minimum stoppage, raw water consumption is normally reduced as compared to crushing at lower than optimum capacity and when hot water production is suspended during halts in operations (cleaning). | |
| Investment | - |
| Benefits | |
| PKR 500,000-1,000,000/year, (pay back time missing) | |

| BWMP-19 | 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-20 | 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-21 | 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-22 | 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-23 | Installation of oil skimmer |
|---|---|
| Category | Pollution reduction |
| Description | |
| Wastewater from mill house contains considerable amount of oil and grease. Oil skimmers should be installed at this wastewater stream to collect the oil content. This option not only provides financial benefits but also results in reducing organic pollution from wastewater. | |
| Investment | PKR 100,000-150,000 |
| Benefits | |
| PKR 100,000-250,000/year, payback in four months. | |

| BWMP-24 | Sugar leakage control |
|---|---|
| Category | Pollution reduction |
| Description | |
| Collect and circulate sugar leakages from pump glands. Spilled sugar should be recycled back into processes. Molasses, magma and juice pumps should be isolated by constructing a parapet around them to capture any spills. These spills should be lifted and recycled back to process. | |
| Investment | PKR 5,000-3,000,000 |
| Benefits | |
| PKR 660,000-1,000,000/year, payback in 36 months. | |

| BWMP-25 | 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-26 | 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-27 | 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-28 | 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-29 | 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-30 | 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-31 | 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-32 | 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-33 | 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-34 | Substitution of toxic lead sub acetate chemical |
|---|---|
| Category | Pollution Reduction |
| Description | |
| Lead sub-acetate is used in sugar mill laboratories to clarify product samples for sucrose analysis, and after analysis, is usually discharged into the drainage system that ultimately goes into the main wastewater channel. As lead is a toxic metal and non-biodegradable, it eventually enters the food chain. Therefore, it should be completely substituted with other chemicals or the analysis method/technique replaced to eliminate the use of this toxic chemical. The change in analysis methodology or an instrument that does not require sample clarification is an option to minimize the hazard of wastewater pollution. NIR polarimeter can be a used for this purpose. | |
| Investment | PKR 2,000,000-3,000,000 |
| Benefits | |
| PKR 660,000-1,000,000/year, payback in 36 months. | |

| BWMP-35 | 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-36 | 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-37 | 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-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 | Installation of surface condensation equipment |
|---|---|
| Category | Water management |
| Description | |
| Two types of condensation processes take place in sugar mills, namely direct condensation (DC) and surface condensation (SC) employed to condense vapours from the evaporation station. In direct condensation, incoming vapours come in direct contact with cooling media and condense due to temperatures differences and exit the condenser in the form of vapour and cooling media mixture. The mixture is then either re-circulated or disposed into the drain. In surface condenser the condensate is recycled and used in the sugar plant at higher efficiency. As there is no contact with cooling media incoming vapors do not become polluted. | |
| Investment | PKR 3,000,000 – 5,000,000 |
| Benefits | |
| PKR1,500,000 – 2,500,000/year, payback in 24 months. | |

# Sugar Sector Business Cases

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

| # | Business Priority-01 Solution Options | Financial Overview | | |
|---|---|---|---|---|
| | | Investment (RKR. 000) | Saving (RKR. 000/yr) | Simple Payback |
| | **Water management** | | | |
| 1 | Leakage control, maintenance of pipelines, piping improvement. | 10-100 | 20-200 | 6 |
| 2 | Collection and reuse of cooling water from compressors, chillers, condensers, sealing water, etc in processes. | 15-100 | 30-200 | 6 |
| 3 | Use of reduced sized diameter pipes for water use. | 20-100 | 30-150 | 8 |
| 4 | Reuse of RO rejected water/softener regeneration water for showering in boiler wet scrubber/cyclones or when high quality water is not required. | 30-60 | 60-120 | 6 |
| 5 | Use of wastewater instead of freshwater in boiler wet scrubber and for cleaning of wastewater mechanical screens. | 25-100 | 30-120 | 10 |
| 6 | Control of floor and other washing points. | 10-50 | 12-60 | 10 |
| 7 | Installation of water trigger nozzles with water hoses. | 10-15 | 15-25 | 8 |
| 8 | Installation of automatic level control switches in water storage tanks. | 10-50 | 11-55 | 11 |
| 9 | Installation of water flow meters. | 10-200 | 11-220 | 11 |
| 10 | Use of low quality sugar contaminated water for cleaning vessels and floor. | 50-150 | 55-165 | 11 |
| 11 | Collection of sugar contaminated water from vapour line heater and reuse it as imbibition water. | 50-150 | 55-165 | 11 |
| 12 | Optimization of cooling water consumption at evaporators. | 20-30 | 30-45 | 8 |
| 13 | Use of dry cleaning methods to clean the wet floor contaminated with sugar/chemicals. | 5-10 | 6-11 | 11 |
| 14 | Improved spray pond efficiency and optimized freshwater addition by installing level controller, | 100-200 | 110-220 | 11 |
| 15 | Optimize operation of evaporators and vacuum pans for water conservation, energy efficiency and sugar recovery. | - | 500-1,000 | - |
| 16 | Improve efficiency of cooling towers and reduce addition of freshwater to control water temperature. | 50-100 | 55-110 | 11 |
| 17 | Optimize caustic soda cleaning process for evaporators to utilize caustic soda as much as possible . | 100-150 | 200-300 | 6 |
| | **Energy Conservation** | | | |
| 18 | Installation of temperature and pressure gauges in process vessels. | 5-50 | 6-60 | 10 |
| 19 | Monitoring and evaluation of motors performance and improved system accordingly (loading adjustment, replacing over/under sized motors). | 50-300 | 75-450 | 8 |
| 20 | Use of high quality copper wires for rewinding of motors. | 50-200 | 55-220 | 11 |
| 21 | Record maintenance of motors rewinding and replace motors after three to four times of rewinding. | 100-200 | 120-240 | 10 |
| 22 | Collection and reuse of steam condensate as boiler feed water. | 100-150 | 625-1,200 | 2 |
| 23 | Conduct boiler blow down after measuring TDS levels in the boiler water. | 10-20 | 30-60 | 4 |
| 24 | Optimize operation of evaporators and vacuum pans for water conservation, energy efficiency and sugar recovery. | - | - | - |
| | **Wastewater Pollution Reduction** | | | |
| 25 | Use of dry cleaning methods to clean the wet floor contaminated with sugar/chemicals. | - | - | - |
| 26 | Installation of oil skimmer in oily wastewater streams. | 100-250 | 300-760 | 4 |
| 27 | Monitoring chemical consumption in process recipes (use of calibrated beakers for chemical dosing). | 5-10 | 10-20 | 6 |
| 28 | Chemical storage with catch pans under chemical containers to collect leaks and spills. | 50-200 | 55-220 | 11 |
| 29 | Reuse of sugar contaminated water as imbibition water. | - | - | - |
| 30 | Sugar leakage control. | - | - | - |
| 31 | Collect and dispose of solid waste at appropriate dumping sites instead of t wastewater drains. | 10-50 | - | - |
| 32 | Optimize caustic soda cleaning process for evaporators to utilize caustic soda as much as possible. | - | - | - |
| | **Total** | **995-2,995** | **2,506-6,396** | **5-6** |

*The sugar sector's first priority set of BWMPs implementation has a very clear business case. An investment in the range of PKR 1.0-3.0 million, depending on the size of the industry, pays back in less than a year with annual benefits of Rs. 2.5-6.4 million, in terms of water conservation (5-30 per cent), chemical savings, energy efficiency (5-10 per cent) and pollution reduction (10-30 per cent).*

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

| # | Solution Options | Financial Overview | | |
|---|---|---|---|---|
| | | Investment (RKR. 000) | Saving (RKR. 000/yr) | Simple Payback |
| | **Water management** | | | |
| 1 | Conduct trainings of workers and managers on water conservation, energy efficiency and pollution reduction aspects. | 200-300 | - | - |
| 2 | Installation of automatic water shut-off valves with machines. | 500-1,000 | 165-330 | 36 |
| 3 | Install surface condensation equipment to recover condensate and reuse in processes. | 3,000-5,000 | 1,500-2,500 | 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 efficient water turbines. | 200-300 | 160-240 | 15 |
| 7 | Installation of energy efficient motors. | 1,000-2,000 | 925-1,850 | 13 |
| 8 | Installation of efficient steam and condensate recovery system. | 1,000-3,000 | 800-2,400 | 15 |
| 9 | Inverters on motors. | 200-400 | 200-400 | 12 |
| | **Wastewater Pollution Reduction** | | | |
| 10 | Use of treated water with RO/softener in the process. | 1,000-2,000 | 500-1,000 | 24 |
| 11 | Automatic chemical dispensing system. | 2,000-3,000 | 650-1,000 | 36 |
| 12 | Establishing laboratory for chemicals purity monitoring. | 500-1,000 | 160-350 | 36 |
| 13 | Use of NIR polarimeter in the laboratory to replace toxic lead sub acetate chemical. | 2,000-3,000 | 660-1,000 | 36 |
| 14 | Install settling ponds to remove suspended solids from wastewater. | 500-1,000 | - | - |
| 15 | Disposal of boiler ash in dry state instead of washing it in the drain with water. | - | - | - |
| | **Total** | **12,800-25,600** | **6,085-12,470** | **24-25** |

*The sugar sector's second priority set of BWMPs implementation also has a very clear business case. An investment in the range of PKR 12.8-25.6 million, depending upon the size of the industry, pays back in about two year with annual benefits of Rs. 6.1-12.5 million, in terms of water conservation (5-30 per cent), chemical savings, energy efficiency (5-10 per cent) and pollution reduction (10-30 per cent).*



# Case Study

**Husein Sugar Mills is planning to implement the following BWMPs:**

- Installation of oil skimmer on the wastewater of the mill to recover oil and grease;
- Control of sugar leakages;
- Control of steam leakages;
- Disposal of sample refuse containing lead as solid waste;
- Use of nozzles for vessel cleaning and floor washing;
- Condensate recovery from secondary heat exchanger;
- Level and temperature control in imbibition tank;
- Installation of level switches on overhead water storage tanks;
- Installation of hour meters on groundwater turbines.

| | |
|---|---|
| Water Conservation | 10-15 per cent |
| Investment | PKR 0.85 Million |
| Annual Saving | PKR 0.7 Million |