T.R.
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Campaign

Water Efficiency Guidance Document Series

MANUFACTURE OF OTHER WOOD PRODUCTS; MANUFACTURE OF PRODUCTS MADE FROM CORK, WICKER, STRAW, AND SİMİLAR WOVEN MATERIALS.

NACE CODE: 16.29

ANKARA 2023

It was commisioned by the Ministry of Agriculture and Forestry, General Directorate of Water Management to the Contractor io Çevre Çözümleri Ar-Ge Ltd. Şti.

Contents

Kısaltmalar

WWTP	Wastewater Treatment Plant
EU	The European Union
SS	Suspended Solids
BREF	Best Available Techniques Reference Documents
EMS	Environmental Management System
ÇŞİDB	Ministry of Environment, Urbanization and Climate Change of Republic of Türkiyeı
NOM	Natural Organic Matter
EMAS	Directive on Eco Management and Audit Scheme
EPA	United States Environemntal Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Standards Organization
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
SYGM	General Directorate of Water Management
RO	Reverse Osmosis
TOB	Ministry of Agriculture and Forestry of Türkiye
TÜİK	National Statistical Institution of Türkiye
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
YAS	Groundwater
YÜS	Surface water

1 Introduction

Our country is located in the Mediterranean basin, where the effects of global climate change are strongly felt, and it is considered one of the regions that will be most affected by the negative impacts of climate change. Projections regarding how our water resources in the basins will be affected by climate change in the future indicate that the availability of our water resources may decrease by up to 25% over the next century.

In 2022, the per capita annual available water amount in our country is 1,313 m³, and it is expected that, due to human pressures and the impacts of climate change, the per capita available annual water amount will fall below 1,000 cubic meters after 2030. If necessary measures are not taken, it is evident that Turkey will become a water-scarce country in the near future, which will also bring many negative social and economic consequences. As the results of future projections indicate, the risk of drought and water scarcity awaiting our country necessitates the efficient and sustainable use of our current water resources.

The concept of water efficiency can be defined as "the use of the least amount of water in the production of a product or service." The water efficiency approach is based on the rational, sharing, equitable, efficient, and effective use of water across all sectors, including drinking water, agriculture, industry, and household uses, taking into account the needs of not only humans but also all living beings, considering ecosystem sensitivity and preserving water in terms of quantity and quality.

The increasing demand for water resources, changes in precipitation and temperature regimes as a result of climate change, and the rise of population, urbanization, and pollution make it increasingly important to distribute available water resources fairly and equitably among users. Therefore, it has become a necessity to create a roadmap based on efficiency and optimization for the sustainable management and conservation of limited water resources.

In the sustainable development vision established by the United Nations, the efficient, fair, and sustainable use of resources, especially water, is emphasized under Goal 7: Ensuring Environmental Sustainability of the Millennium Development Goals, and Goals 9: Industry, Innovation, and Infrastructure and 12: Responsible Production and Consumption within the Sustainable Development Goals, which also includes environmentally friendly production and consumption practices that carry the concerns of future generations.

Under the European Green Deal, which focuses on achieving carbon neutrality, implementing a clean, circular economy model, promoting efficient use of resources, and reducing environmental impacts, Turkey has prepared an action plan that highlights water and resource efficiency in production and consumption across various sectors, particularly in industry.

The "Industrial Emissions Directive (ED)," one of the most important components of EU environmental legislation from an industrial perspective, includes measures to control and prevent or reduce discharges/emissions into the receiving environment, such as air, water, and soil, arising from industrial activities. The directive introduces Best Available Techniques (BAT) to systematically establish the applicability of clean production processes and eliminate difficulties encountered in practice. BATs are the most effective application techniques for high-level environmental protection when considering costs and benefits. Reference Documents (BREF) have been prepared, detailing BATs for each sector. In BREF documents, BATs are presented within a general framework, including good management practices, technical measures of a general preventive nature, chemical use and management, technical measures for various production processes, wastewater management, emission management, and waste management.

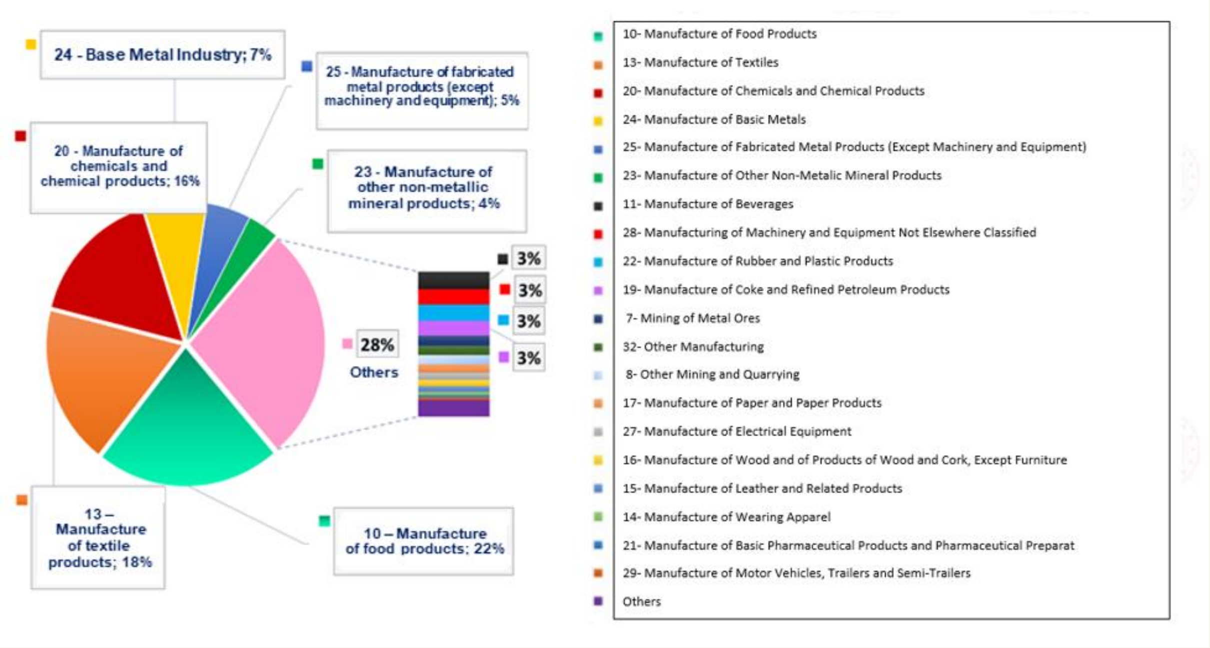
The Ministry of Agriculture and Forestry, through the General Directorate of Water Management, carries out studies aimed at popularizing efficient practices in urban, agricultural, industrial, and individual water uses and raising social awareness. Under the "Water Efficiency Strategy Document and Action Plan (2023-2033)" enacted by Presidential Circular No. 2023/9, water efficiency action plans addressing all sectors and stakeholders have been prepared. The Industrial Water Efficiency Action Plan identifies a total of 12 actions for the 2023-2033 period, with responsible and relevant institutions designated for these actions. Within the scope of this Action Plan, the General Directorate of Water Management is responsible for conducting studies to determine specific water use ranges and quality requirements by sub-sector in industry, organizing sector-specific technical training programs and workshops, and preparing water efficiency guide documents.

On the other hand, through the "Industrial Water Use Efficiency Project by NACE Codes" conducted by the General Directorate of Water Management, sector-specific best techniques for improving water efficiency in industry have been identified. As a result of the study, sectoral guide documents and action plans classified by NACE codes, containing proposed measures for improving water use efficiency in sectors with high water consumption in our country, have been prepared.

Like in the rest of the world, the sectors with the highest share of water consumption in our country are food, textiles, chemicals, and primary metals. Within the scope of the studies, field visits were conducted in businesses representing 152 sub-sectors across 35 main sectors, including food, textiles, chemicals, and primary metal industries, which have high water consumption under various capacities and diversities according to NACE Codes. Data on water supply, sectoral water use, wastewater generation, and recovery were obtained, and information was provided on existing best techniques (BAT) and sectoral reference documents (BREF) published by the European Union regarding water efficiency, clean production, water footprint, etc.

As a result of the studies, specific water consumption and potential savings rates for the processes of businesses classified under 152 different four-digit NACE codes with high water consumption have been determined, and water efficiency guide documents have been prepared considering the existing best techniques (BAT) of the EU and other clean production techniques. Within the guides, a total of 500 techniques (BAT) related to water efficiency have been examined under four main groups: (i) Good Management Practices, (ii) General Preventive Measures, (iii) Measures Related to Auxiliary Processes, and (iv) Sector-Specific Measures.

During the determination phase of BATs for each sector within the project, environmental benefits, operational data, technical specifications-requirements, and applicability criteria have been taken into account. The determination of BATs has not been limited to BREF documents but has also involved a detailed review of various data sources, such as up-to-date global literature, real case analyses, innovative practices, and reports from sector representatives to create sector-specific BAT lists. In order to evaluate the suitability of the created BAT lists for the local industrial infrastructure and capacity of our country, the specific BAT lists prepared for each NACE code were prioritized based on criteria such as water savings, economic savings, environmental benefits, applicability, and cross-media effects through scoring by the businesses. The final BAT lists were determined using the scoring results. Based on the water and wastewater data from the visited facilities and the final BAT lists established considering the local dynamics specific to our country, sectoral water efficiency guides have been created on a NACE code basis.



Distribution of sectoral water use in industry in our country

As a result of the studies, specific water consumption and potential savings rates for the processes of businesses classified under 152 different four-digit NACE codes with high water consumption have been determined, and water efficiency guide documents have been prepared considering the existing best techniques (BAT) of the EU and other clean production techniques. Within the guides, a total of 500 techniques (BAT) related to water efficiency have been examined under four main groups: (i) Good Management Practices, (ii) General Water Efficiency BATs, (iii) Measures Related to Auxiliary Processes, and (iv) Sector-Specific Measures.

In the process of determining BATs for each sector within the project, environmental benefits, operational data, technical specifications-requirements, and applicability criteria have been taken into account. The determination of BATs has not been limited to BREF documents but has also involved a detailed review of various data sources, such as up-to-date global literature, real case analyses, innovative practices, and reports from sector representatives, to create sector-specific BAT lists. To evaluate the suitability of the created BAT lists for the local industrial infrastructure and capacity of our country, the specific BAT lists prepared for each NACE code have been prioritized by businesses based on criteria such as water savings, economic savings, environmental benefits, applicability, and cross-media effects through scoring. The final BAT lists have been determined using the scoring results. Based on the water and wastewater data from the visited facilities and the final BAT lists established considering local dynamics specific to our country, sectoral water efficiency guides have been created on a NACE code basis.

2 Scope of the Study

The guidance documents prepared within the framework of water efficiency measures in the industry include the following main sectors:

- Plant and animal production, hunting, and related service activities (including 6 sub-production areas represented by four-digit NACE codes)
- Fishing and aquaculture (including 1 sub-production area represented by a four-digit NACE code)
- Coal and lignite extraction (including 2 sub-production areas represented by four-digit NACE codes)
- Support activities for mining (including 1 sub-production area represented by a four-digit NACE code)
- Mining of metal ores (including 2 sub-production areas represented by four-digit NACE codes)
- Other mining and quarrying (including 2 sub-production areas represented by four-digit NACE codes)
- Manufacture of food products (including 22 sub-production areas represented by four-digit NACE codes)
- Manufacture of beverages (including 4 sub-production areas represented by four-digit NACE codes)
- Manufacture of tobacco products (including 1 sub-production area represented by a four-digit NACE code)
- Manufacture of textiles (including 9 sub-production areas represented by four-digit NACE codes)
- Manufacture of wearing apparel (including 1 sub-production area represented by a four-digit NACE code)
- Manufacture of leather and related products (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacture of wood, wood products, and cork (excluding furniture); manufacture of wickerwork, straw, and similar materials (including 5 sub-production areas represented by four-digit NACE codes)
- Manufacture of paper and paper products (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacture of coke and refined petroleum products (including 1 sub-production area represented by a four-digit NACE code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by four-digit NACE codes)
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (including 1 sub-production area represented by a four-digit NACE code)
- Manufacture of rubber and plastic products (including 6 sub-production areas represented by four-digit NACE codes)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by four-digit NACE codes)
- Basic metal industry (including 11 sub-production areas represented by four-digit NACE codes)
- Manufacture of fabricated metal products (excluding machinery and equipment) (including 12 sub-production areas represented by four-digit NACE codes)

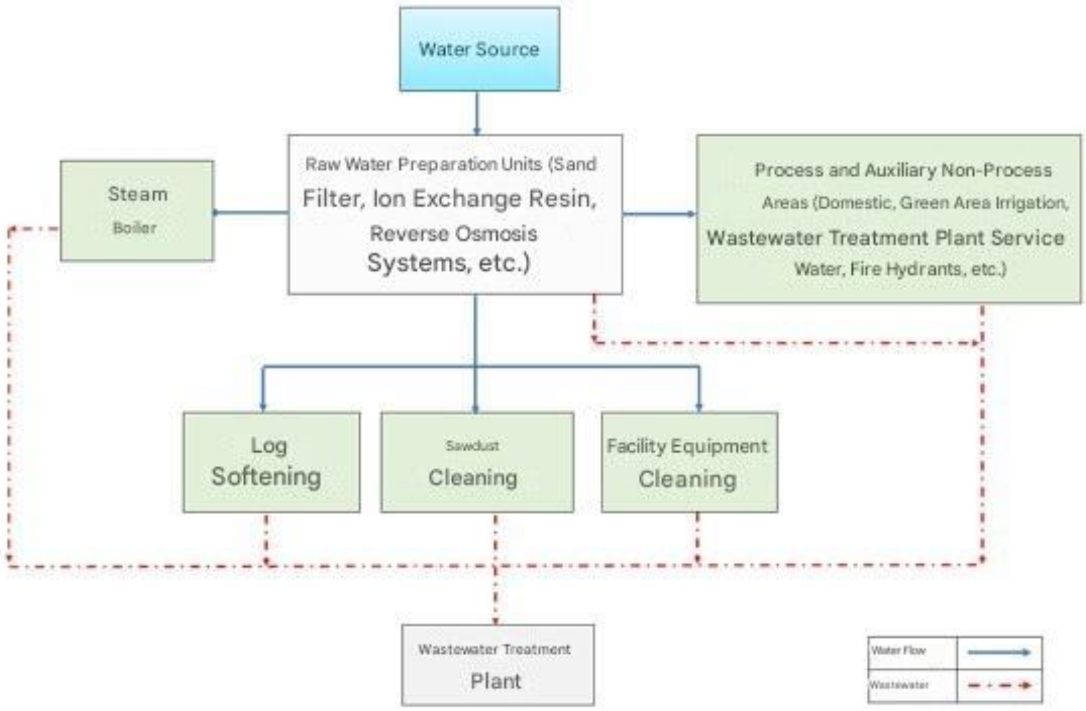
- Manufacture of computers, electronic and optical products (including 2 sub-production areas represented by four-digit NACE codes)
- Manufacture of electrical equipment (including 7 sub-production areas represented by four-digit NACE codes)
- Manufacture of other machinery and equipment n.e.c. (including 8 sub-production areas represented by four-digit NACE codes)
- Manufacture of motor vehicles, trailers, and semi-trailers (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacture of other transport equipment (including 2 sub-production areas represented by four-digit NACE codes)
- Other manufacturing (including 2 sub-production areas represented by four-digit NACE codes)
- Installation and repair of machinery and equipment (including 2 sub-production areas represented by four-digit NACE codes)
- Production and distribution of electricity, gas, steam, and air conditioning (including 2 sub-production areas represented by four-digit NACE codes)
- Waste collection, treatment, and disposal activities; materials recovery (including 1 sub-production area represented by a four-digit NACE code)
- Construction of buildings (including 1 sub-production area represented by a four-digit NACE code)
- Storage and support activities for transportation (including 1 sub-production area represented by a four-digit NACE code)
- Accommodation (including 1 sub-production area represented by a four-digit NACE code)
- Educational activities (Higher Education Campuses) (including 1 sub-production area represented by a four-digit NACE code)
- Sports activities, entertainment, and recreation activities (including 1 sub-production area represented by a four-digit NACE code)

- Manufacture of wood, wood products, and cork (excluding furniture); manufacture of wickerwork, straw, and similar materials.
-
- Under the sector of the manufacture of wood, wood products, and cork (excluding furniture); manufacture of wickerwork, straw, and similar materials, the sub-production branches for which guide documents have been prepared are as follows:

16.10	Felling and planning of trees.
16.21	Manufacture of plywood panels and wood-based panels.
16.22	Manufacture of engineered wood flooring.
16.23	Manufacture of other building carpentry and joinery products.
16.29	Manufacture of other wood products; manufacture of products made from cork, wicker, straw, and similar woven materials.

2.1 Manufacture of other wood products; manufacture of products made from cork, wicker, straw, and similar woven materials (NACE 16.29)

Other Wood Products Manufacturing; Manufacturing of Products Made of Cork, Reed, Straw, etc. Knitting Materials Sector Water Flow Diagram



	Minimum	Maximum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	4,1	
Reference Specific Water Consumption (m^3/m^3 product)	There is no reference specific water consumption.	

Percentage Distribution of Water Efficiency Practices

Wood peeling machines are used to obtain semi-finished boards, and various molds are employed to produce wood products. The pieces cut by pressing and cutting machines are dried in ovens, and their surface roughness is eliminated by various methods before the final products are packaged. Various products such as wooden tea and coffee stirrers, wooden kitchen utensils, wooden hand tools, etc., are produced in facilities operating under the relevant NACE code.

Water is consumed during the soaking process to soften the logs provided to the facility and to remove their bark. In facilities where raw materials are stored outdoors, water spraying is applied to soak the chips. Additionally, water consumption occurs in areas such as cleaning shavings from the production area and cleaning the facility and equipment.

In the sector of other wood products manufacturing, including products made from cork, reeds, straw, and similar woven materials, there is no reference specific water consumption value. The specific water consumption of the production branch analyzed in this study is 4.1 L/kg. It is estimated that by implementing good management practices and general water efficiency BATs, a water reduction of 17-24% can be achieved in the sector.

16.29 The recommended priority water efficiency application techniques under the NACE code for Other Wood Products Manufacturing; Manufacturing of Products Made from Cork, Reeds, Straw, and Similar Woven Materials are presented in the table below.

NACE Code	NACE Code Explanation		Prioritized Sectoral Water Efficiency Techniques
16.29	Manufacture of other wood products; manufacture of products made from cork, wicker, straw, and similar woven materials		**Sector Specific Measures**
		1.	Separating wood raw material storage areas from outdoor wood processing areas and other areas with additional pollution potential, and covering log storage areas with concrete or asphalt to prevent sand and soil-related substances resulting from wood (log) processing activities from mixing with wastewater.
			Good Management Practices
		1.	The use of an integrated wastewater management and treatment strategy to reduce the volume of wastewater and its pollutant load.
		2.	Environmental Management System Set up
		3.	Preparation of water flow diagrams and mass balances for water
		4.	Preparation of a water efficiency action plan to reduce water use and prevent water pollution
		5.	Provision of technical training to personnel for the reduction and optimization of water use
		6.	Proper production planning to optimize water consumption
		7.	Determination of water efficiency targets
		8.	Monitoring the quantity and quality of water used in production processes and auxiliary processes, and adapting this information into the environmental management system
			General Water Efficiency BATs
		1.	Minimization of spills and leaks
		2.	Recovery of water from rinse solutions and reuse of recovered water in appropriate processes
		3.	Use of automatic devices and equipment (sensors, smart handwashing systems, etc.) that conserve water at water usage points such as showers/toilets.
		4.	Reuse of filter wash waters in filtration processes, reuse of relatively clean cleaning waters in production processes, and reduction of water consumption through on-site cleaning systems (CIP)
		5.	Avoidance of the use of drinking water in production lines
		6.	Detection and reduction of water losses
		7.	Use of automatic control-shutoff valves to optimize water use
		8.	Documentation of production procedures to prevent waste of water and energy, and usage by employees.
		9.	Reuse of pressurized filtration backwash waters before water softening at

NACE Code	NACE Code Explanation		Prioritized Sectoral Water Efficiency Techniques
16.29	Manufacture of other wood products; manufacture of products made from cork, wicker, straw, and similar woven materials		10. Establishment of closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals to aquatic environments
		11.	Prevention of the storage, keeping, and mixing with wastewater of substances that pose risks in aquatic environments (such as oils, emulsions, binders, etc.)
		12.	Whenever technically feasible, treatment of suitable wastewaters for use as boiler feed water
		13.	Prevention of the mixing of clean water flows with dirty water flows
		14.	Characterization of wastewater volumes and qualities at all wastewater generation points to identify wastewater flows that can be reused either after treatment or without treatment
		15.	Use of computer-aided control systems in production processes
		16.	Determination of the scope for the reuse of wash and rinse waters
		17.	Collection and treatment of gray waters separately in the facility, and their use in areas that do not require high water quality (such as green area irrigation, floor cleaning, etc.)
		18.	Implementation of time optimization in production and organization of all processes to be completed in the shortest time possible
		19.	Reuse of nanofiltration (NF) or reverse osmosis (RO) concentrates based on characterization, either after treatment or without treatment **Measures Related to Auxiliary Processes**
		1.	Water savings achieved through the reuse of steam boiler condensate
		2.	Water savings provided by the insulation of steam and water lines (hot and cold), prevention of water and steam losses at pipes, valves, and connection points, and monitoring through a computer system
		3.	Prevention of flash steam losses due to boiler blowdown
		4.	Minimization of boiler blowdown water (blow-off) in steam boilers
		5.	Reuse of energy produced from the steam condenser Bu A
total of 33 techniques have been proposed in this sector.			

For the NACE Code of Other Wood Products Manufacturing; Manufacturing Products Made from Cork, Reed, Straw, and Similar Woven Materials:

(i) Sector-specific measures,
(ii) Good management practices,
(iii) General measures, and
(iv) Measures related to auxiliary processes are presented under separate headings

2.1.1 Sector Specific Measures

- • ***Separation of wood raw material storage areas from outdoor wood processing areas and other areas with additional pollution potential; covering log storage areas with concrete asphalt to prevent the mixing of sand and soil-derived materials from wood (log) processing activities into wastewater.***

It is recommended to insulate the log yard surface with pavement, concrete, or asphalt and to separate the wood raw material storage areas from outdoor wood processing areas and other areas with additional pollution potential. In cases where sand and soil contamination occurs in the raw material, more thorough cleaning is required. Additionally, the wood chip preparation process results in higher energy demand due to both additional cleaning and wear and tear of the chip mills. Asphalt paving of the log yard will facilitate the collection of water from the log yard by preventing direct contact with the soil. The surface runoff collected from the asphalted log yard will carry less sand and soil-derived materials, thereby reducing the pollution load of suspended solids (TSS) in the surface runoff. Technical measures will help prevent infiltration into groundwater, reduce the pollutant load of the collected surface runoff, and allow for more efficient collection and harvesting of surface runoff water (IPPC BREF, 2016).

2.1.2 Good Management Practices

• ***Establishment of an Environmental Management System***

Environmental Management Systems (EMS) encompass the necessary organizational structure, responsibilities, procedures, and resources for industrial organizations to develop, implement, and monitor their environmental policies. The establishment of an environmental management system improves decision-making processes between raw materials, water-wastewater infrastructure, planned production processes, and various treatment techniques. Environmental management organizes how to manage resource procurement and waste discharge demands with the highest economic efficiency, without compromising product quality, and with the least possible impact on the environment.

The most widely used Environmental Management Standard is ISO 14001. Alternatives include the Eco-Management and Audit Scheme (EMAS) (761/2001), which is designed for the assessment, improvement, and reporting of environmental performance in businesses. It is among the leading practices in the EU legislation regarding eco-efficiency (clean production) and participation is voluntary (TUBITAK MAM, 2016; TOB, 2021). The benefits of establishing and implementing an Environmental Management System include:

• Improved business performance can lead to economic benefits (Christopher, 1998).

• Adopting International Organization for Standardization (ISO) standards enhances compliance with global legal and regulatory requirements (Christopher, 1998).

• While minimizing the risks of penalties associated with environmental responsibilities, reductions in waste volume, resource consumption, and operating costs are achieved (Delmas, 2009).

• The use of internationally recognized environmental standards eliminates the need for multiple registrations and certifications for businesses operating in various locations around the world (Hutchens Jr., 2017).

• Particularly in recent years, the improvement of companies' internal control processes has become important to consumers. Implementing environmental management systems provides a competitive advantage over companies that do not adopt the standard. It also contributes to better positioning of organizations in international markets (Potoski & Prakash, 2005).

The benefits listed above depend on numerous factors such as production processes, management practices, resource use, and potential environmental impacts (TOB, 2021). Applications such as preparing annual inventory reports with similar content to the environmental management system and monitoring the quantities and qualities of inputs and outputs in production processes can achieve water savings of approximately 3-5% (Öztürk, 2014). The total duration of developing and implementing an EMS is estimated to be 8-12 months (ISO 14001 User Manual, 2015).

Industrial organizations are also working within the framework of the ISO 14046 Water Footprint Standard, which defines the requirements and guidelines for assessing and reporting water footprints. The implementation of this standard aims to reduce the consumption of freshwater required for production and its environmental impacts. Additionally, the ISO 46001 Water Efficiency Management Systems Standard, which helps industrial organizations achieve water savings and reduce operating costs, aids organizations in developing their water efficiency policies through monitoring, benchmarking, and review processes.

- ***• The use of integrated wastewater management and treatment strategies to reduce wastewater volume and pollutant load***

Wastewater management should adopt a holistic approach from the generation of wastewater to its final disposal and should encompass functional elements such as composition, collection, treatment including sludge disposal, and reuse. The selection of appropriate treatment technologies for industrial wastewater depends on integrated factors such as land availability, desired quality of treated water, and compliance with national and local regulations (Abbassi & Al Baz, 2008).

The reuse of treated wastewater not only improves the quality of water bodies but also reduces the demand for freshwater. Therefore, it is crucial to identify suitable treatment strategies for different reuse objectives.

In integrated industrial wastewater treatment, different aspects such as the wastewater collection system, treatment process, and reuse objectives are evaluated together (Naghedi et al., 2020). Methods such as the SWOT method (strengths, weaknesses, opportunities, and threats), PESTEL method (political, economic, social, technological, environmental, and legal factors), and decision trees can be combined with expert opinions to establish an integrated wastewater management framework (Naghedi et al., 2020). The integration of Analytic Hierarchy Process (AHP) and Combined Compromise Solution (CoCoSo) techniques can be used to identify priorities based on multiple criteria for industrial wastewater management processes (Adar et al., 2021).

The implementation of integrated wastewater management strategies can achieve an average reduction of up to 25% in water consumption, wastewater volume, and the pollution loads of wastewater. The potential payback period for the implementation ranges from 1 to 10 years (TOB, 2021).

Industrial Wastewater Treatment Plant

- • ***Providing technical training to staff for the reduction and optimization of water use***

  This measure can lead to water savings and water recovery by increasing the training and awareness of personnel, thereby achieving water efficiency through the reduction of water consumption and costs. In industrial facilities, problems related to high water usage and wastewater generation can arise due to the lack of necessary technical knowledge among staff. For instance, it is important for cooling tower operators, who represent a significant portion of water consumption in industrial operations, to be properly trained and possess technical knowledge. The relevant personnel must also have sufficient technical knowledge for applications such as determining water quality requirements in production processes and measuring water and wastewater volumes (TOB, 2021). Therefore, it is crucial to provide training to staff regarding water use reduction, optimization, and water conservation policies. Involving staff in water conservation initiatives, regularly generating reports on water consumption before and after water efficiency initiatives, and sharing these reports with personnel support participation and motivation in the process. The technical, economic, and environmental benefits obtained from personnel training yield results in the medium to long term (TUBİTAK MAM, 2016; TOB, 2021).

- • ***Monitoring the quantity and quality of water used in production and auxiliary processes and adapting this information to the environmental management system***

  In industrial facilities, resource usage exists, and inefficiencies and environmental problems resulting from resource use can arise from input-output flows. Therefore, it is essential to monitor the quantity and quality of water used and wastewater generated in production and auxiliary processes (TUBİTAK MAM, 2016; TOB, 2021). Process-based monitoring of quantity and quality can achieve reductions of 6-10% in energy consumption and up to 25% in water consumption and wastewater volumes when combined with other good management practices (staff training, establishment of environmental management systems, etc.) (Öztürk, 2014).

  The main steps for monitoring the quantity and quality of water and wastewater are as follows:

  - • Utilizing monitoring equipment (such as meters) for tracking water, energy, and other consumptions at the process level,
  - • Establishing monitoring procedures,
  - • Identifying all input and output points related to the production process (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste, and by-products), monitoring their quantities and qualities, documenting them, evaluating them comparatively, and reporting them,
  - • Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against raw material losses (ÇŞİDB, 2020e).

- • ***Optimizing Water Consumption Through Effective Production Planning***
  Planning the conversion of a raw material into a product with minimal process usage in industrial production processes is an effective practice for reducing labor costs, resource usage costs, environmental impacts, and achieving efficiency (TUBİTAK MAM, 2016; TOB, 2021). Conducting production planning in industrial facilities with consideration of water efficiency factors helps to reduce water consumption and wastewater volumes. Modifying production processes or combining certain processes in industrial facilities provides significant benefits in terms of water efficiency and scheduling (TOB, 2021).

- • ***Preparation of a Water Efficiency Action Plan to Reduce Water Usage and Prevent Water Pollution***
  Preparing an action plan that includes short, medium, and long-term measures to reduce water and wastewater volumes and prevent water pollution in industrial facilities is important for water efficiency. In this context, it is necessary to determine water needs throughout the facility and in production processes, establish quality requirements at water usage points, and characterize wastewater formation points (TOB, 2021). Additionally, it is crucial to identify, assess the feasibility of, and prepare action plans for measures to reduce water consumption, wastewater formation, and pollutant loads. This approach ensures water efficiency and sustainable water use in facilities (TOB, 2021).

- • ***Setting Water Efficiency Targets***
  The first step in achieving water efficiency in industrial facilities is to establish targets (TOB, 2021). To do this, a detailed water efficiency analysis should be conducted on a process basis. This will help identify unnecessary water usages, water losses, incorrect practices affecting water efficiency, process losses, and reusable water and wastewater sources, whether treated or untreated. Determining the potential for water savings and water efficiency targets for each production process and for the facility as a whole is also extremely important (TOB, 2021).

- • ***Preparation of Water Flow Diagrams and Mass Balances for Water***
  Identifying water usage and wastewater formation points in industrial facilities and establishing water-wastewater balances in production processes and auxiliary processes generally forms the basis of many good management practices. Creating process profiles on a facility-wide and production process basis facilitates the identification of unnecessary and high water usage points, evaluation of water recovery opportunities, process modifications, and the identification of water losses (TOB, 2021).

2.1.3 General Water Efficiency BATs

- ***• Detecting and Reducing Water Losses***

  In industrial production processes, water losses can occur in equipment, pumps, and pipelines. To address this, water losses should be identified first, and regular maintenance of equipment, pumps, and pipelines should be conducted to prevent leaks by keeping them in good condition (IPPC BREF, 2003). Establishing regular maintenance procedures is essential, with particular attention to the following:

  - Adding pumps, valves, level switches, pressure, and flow regulators to the maintenance checklist,
  - Conducting inspections not only in water systems but also in heat transfer and chemical distribution systems, as well as for broken and leaking pipes, barrels, pumps, and valves,
  - Regular cleaning of filters and pipelines,
  - Calibration of measurement equipment like chemical dosing devices and thermometers, and routinely checking and monitoring them at specified intervals (IPPC BREF, 2003).
  - Effective maintenance, repair, cleaning, and loss control practices can save between 1-6% of water consumption (Öztürk, 2014).

- ***• Minimizing Spills and Leaks***

  Spills and leaks in facilities can lead to losses in both raw materials and water. Additionally, when wet cleaning methods are used to clean up spilled areas, it can increase water consumption, wastewater volumes, and the pollutant load of wastewater (TOB, 2021). To minimize raw material and product losses, spill prevention devices, trays, drip pans, and screens are used to reduce spill and splash losses (IPPC BREF, 2019).

- ***• Using Suitable Treated Wastewater as Boiler Feed Water, Where Technically Feasible***

  Although challenging in industrial facilities, treating suitable wastewater to process water quality for reuse in production processes, including steam boilers, is possible. This practice can reduce total water consumption and wastewater generation by 20-50% (Öztürk, 2014; TUBİTAK MAM, 2016). The initial investment cost is primarily determined by the type of treatment system required. Payback periods vary based on factors like the amount of water reclaimed, the economic savings, unit water-wastewater costs, and operation-maintenance costs of the treatment system (TOB, 2021). Membrane systems, such as a combination of ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO), can be used for reclamation. For example, in some industrial facilities, blowdown water from cooling systems can be treated and reused as process water (TOB, 2021).

- • ***Preventing the Mixing of Clean and Dirty Water Streams***

  In industrial facilities, identifying wastewater generation points and characterizing wastewaters can enable the collection of high-pollution and relatively clean wastewaters through separate lines (TUBITAK MAM, 2016; TOB, 2021). This approach allows suitable quality wastewater streams to be reused with or without treatment. By separating wastewater streams, water pollution is reduced, treatment performance is enhanced, energy consumption associated with reduced treatment needs is lowered, and wastewater and valuable materials recovery can be achieved, reducing emissions. Additionally, heat recovery from separated hot wastewater streams is also possible (TUBITAK MAM, 2016; TOB, 2021). While separating wastewater streams generally requires high investment costs, cost reductions can be achieved in cases where substantial wastewater and energy recovery is possible (IPPC BREF, 2006).

- • ***Determining Wastewater Streams for Reuse by Characterizing the Quantities and Qualities of Wastewater at All Generation Points***

  By identifying and characterizing wastewater generation points in industrial facilities, various wastewater streams can be reused either with or without treatment (Ozturk, 2014; TUBITAK MAM, 2016; TOB, 2021). In this context, filter backwash waters, RO concentrates, blowdown waters, condensate waters, and relatively clean wash and rinse waters can be reused without treatment in the same or different processes and in areas where high water quality is not required (such as facility and equipment cleaning). Additionally, wastewater streams that cannot be directly reused can be treated with appropriate treatment technologies and then reused in production processes.

  Membrane filtration processes are an integral part of many wastewater reuse systems. Nanofiltration (NF) and Reverse Osmosis (RO) filtration systems are used for industrial wastewater recovery, while microfiltration (MF) and ultrafiltration (UF) are generally used for pre-treatment before NF or RO processing (Singh et al., 2014).

- • ***Using Automatic Control-Shutoff Valves to Optimize Water Use***

  Monitoring and controlling water consumption using flow control devices, meters, and computer-aided monitoring systems provide significant technical, environmental, and economic benefits (Ozturk, 2014). Monitoring water consumption within the facility and in various processes prevents water losses (TUBITAK MAM, 2016). The use of flow meters and counters throughout the facility and for specific production processes, automatic shut-off valves and valves on continuously operating machines, and computer-aided systems to develop monitoring-control mechanisms for water consumption and certain quality parameters are required (TUBITAK MAM, 2016). With this application, it is possible to achieve up to 20-30% savings in water consumption at the process level (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). Monitoring and controlling water consumption at the process level can achieve 3-5% savings in process water consumption (Ozturk, 2014).

- • ***Determining the Scope of Reusing Wash and Rinse Waters***

  In industrial facilities, relatively clean wastewaters, such as final rinse waters and filter backwash waters, can be reused without treatment in applications that do not require high water quality, like floor cleaning and garden irrigation (Ozturk, 2014). This can result in a raw water consumption savings of 1-5% (TOB, 2021).

- • ***Avoiding the Use of Drinking Water in Production Lines***

  Various water qualities can be used in the manufacturing industry's sub-sectors according to production requirements. Typically, raw water from groundwater sources is treated and then used in production processes in industrial facilities. However, in some cases, despite the high costs, drinking water is used directly in production, or raw water is disinfected with chlorine compounds before being used in production processes. Such chlorinated waters, containing residual chlorine, can react with organic compounds (natural organic matter, DOM) in the water during production, creating disinfectant by-products harmful to living organisms (Ozdemir & Toroz, 2010; Ogur et al.; TOB, 2021). Therefore, the use of drinking water containing residual chlorine or raw water disinfected with chlorine compounds should be avoided as much as possible. Disinfection methods with high oxidation potential, such as ultraviolet (UV), ultrasound (US), or ozone, can be used instead of chlorination for raw water disinfection. Identifying and utilizing the required water quality parameters in each production process helps to reduce unnecessary water supply and treatment costs, thereby increasing the technical, economic, and environmental benefits of the application. This approach can reduce water, energy, and chemical costs (TUBITAK MAM, 2016).

- • ***Preventing the Discharge of Substances Posing Risks to Aquatic Environments (e.g., Oils, Emulsions, Binders)***

  In industrial facilities, dry cleaning techniques and leak prevention can be used to prevent chemicals, such as oils, emulsions, and binders—risky to aquatic environments—from entering wastewater streams. This practice helps to protect water resources (TUBITAK MAM, 2016).

- • ***Establishing Closed Storage and Impermeable Waste/Scrap Yards to Prevent the Transportation of Toxic or Hazardous Chemicals to Aquatic Environments***

  To prevent the transfer of toxic or hazardous chemicals to recipient environments in industrial facilities, closed and impermeable storage sites for waste/scrap can be established. This practice is currently in place in accordance with national environmental regulations. Field studies indicate that industrial facilities can further enhance this practice by constructing separate collection channels for toxic or hazardous substance storage areas to prevent leakage water from entering natural water bodies.

- • ***Recovering Water from Rinse Solutions and Reusing it in Suitable Processes According to its Quality***

  In industrial facilities, rinse wastewater, which is relatively clean, can be reused without treatment in applications that do not require high water quality, such as floor cleaning and garden irrigation (Ozturk, 2014). Reclaiming rinse water can achieve raw water savings of approximately 1-5%.

- • ***Reuse of Backwash Waters from Pressurized Filtration Before Water Softening at Suitable Points***

Many industrial processes require softened water with low calcium and magnesium concentrations. Through water softening systems, calcium, magnesium, and other metal cations are removed from hard water to obtain soft water.

Reusing backwash waters from pressurized filtration before the water softening process at appropriate points provides savings. This measure is similar in content to applications such as "reusing relatively clean waters in production processes, reusing backwash waters from filtration processes, and using in-place cleaning systems to reduce water consumption."

- • ***Reuse of Nanofiltration (NF) or Reverse Osmosis (RO) Concentrates with or without Treatment Based on Characterization***

Depending on the characterization of wastewater and suitable reuse points, the potential reuse of other wastewaters generated from membrane processes (chemical-free or chemical-based backwashing, CIP cleaning, module cleaning, chemical tank cleaning, etc.) should be evaluated.

Nanofiltration is a membrane-based liquid separation technique suitable for treating well and surface water, characterized by low energy consumption and low operating pressures. Reverse osmosis is also a membrane-based liquid separation technique that can separate smaller particles than nanofiltration (Akgul, 2016).

Based on the characterization of nanofiltration or reverse osmosis concentrates, reuse with or without treatment provides savings. Measures should be taken in filtration processes to reuse backwash waters in production processes and to reduce water consumption by utilizing cleaning systems (TOB, 2021).

Reverse Osmosis System

- • ***Using Automatic Equipment and Devices for Water Conservation in Shower/Toilet Facilities***

  Water is essential for both production processes and for personnel to maintain necessary hygiene standards in many sectors of the manufacturing industry. While water consumption in industrial facilities may be fulfilled through various methods, savings can also be achieved by using sensor faucets and equipment like smart handwashing systems in areas where personnel use water. Smart handwashing systems not only save water but also enhance resource efficiency by correctly adjusting the mixture of water, soap, and air.

- • ***Collecting and Treating Greywater Separately for Use in Low-Quality Water Applications (Green Area Irrigation, Floor Washing, etc.)***

  The wastewater generated in industrial facilities includes not only industrial wastewater from production processes but also wastewater from showers, sinks, kitchens, and similar areas, referred to as greywater. By treating this greywater through various treatment processes and using it in areas that do not require high-quality water, water savings can be achieved.

- • ***Utilizing Computer-Assisted Control Systems in Production Processes***

  Inefficient resource use and environmental issues in industrial facilities are directly linked to input-output flows, so production processes must optimally define input and output variables (TUBITAK MAM, 2016). By doing so, measures can be developed to enhance resource efficiency, economic, and environmental performance. Maintaining input-output inventories is considered a prerequisite for continuous improvement. Such management practices require participation from technical personnel and upper management, and they quickly repay investment costs through the expertise of various specialists (IPPC BREF, 2003). The application should include the use of measurement equipment specific to processes and the regular conduct of certain analyses/measurements tailored to each process. For maximum efficiency, the use of computerized monitoring systems should be maximized to increase the technical, economic, and environmental benefits obtained (TUBITAK MAM, 2016).

Computer-Aided Control System

- ***• Reuse of filter backwash water in filtration processes, reuse of relatively clean cleaning water in production processes, and reduction of water consumption through the use of Clean-in-Place (CIP) systems***

  Wastewater generated from the backwashing of activated carbon filters and softening devices mostly contains only high concentrations of suspended solids (SS). Backwash water, which is one of the easiest types of wastewater to recover, can be filtered and recovered through ultrafiltration systems, resulting in water savings of up to 15% (URL - 1, 2021).

  Wastewater generated after the regeneration process consists of soft water with high salt content and makes up approximately 5-10% of total water consumption. Regeneration wastewater can be collected in a separate tank and used in processes requiring high salt levels, facility cleaning, and domestic purposes. This process requires a reserve tank, water pipeline, and pump. The reuse of regeneration wastewater can lead to approximately 5-10% reductions in water consumption, energy consumption, wastewater volume, and the salt content of the wastewater (Öztürk, 2014). The payback period varies depending on whether the regeneration water is used in production processes, facility cleaning, or domestic purposes. In production processes requiring high salt levels, the reuse of regeneration water is estimated to have a potential payback period of less than one year (as both water and salt are recovered). For facility and equipment cleaning and domestic use, the payback period is estimated to be over one year (TOB, 2021).

  In Turkey, reverse osmosis (RO) concentrates are typically combined with other wastewater streams and directed to the wastewater treatment facility channel. RO concentrates, generated in RO systems used for additional hardness removal, can also be used in garden irrigation, facility cleaning, and tank and equipment cleaning (TUBİTAK MAM, 2016; TOB, 2021). Moreover, with the monitoring of raw water quality, RO concentrates can potentially be fed back into raw water reservoirs, allowing for their reuse (TOB, 2021).

- • ***Documenting Production Procedures and Ensuring Use by Employees to Prevent Water and Energy Wastage***

  For efficient production in a facility, effective procedures should be implemented to identify and evaluate potential issues and sources, as well as to control production stages (Ayan, 2010). Establishing and implementing appropriate procedures in production processes enables more efficient use of resources (such as raw materials, water, energy, chemicals, personnel, and time) while ensuring reliability and quality throughout production (Ayan, 2010). Documented production procedures in production processes contribute to evaluating facility performance and developing immediate responses to problem-solving (TUBITAK MAM, 2016; TOB, 2021). Monitoring the effective implementation of these procedures for each production process is one of the most effective ways to ensure product quality, receive feedback, and develop solutions (Ayan, 2010). Documenting, implementing, and monitoring production procedures is a best practice in management and serves as an effective tool for establishing and sustaining a cleaner production approach and environmental management system. Alongside potential benefits, costs and economic returns of this application may vary depending on the sector or facility structure (TUBITAK MAM, 2016; TOB, 2021). Creating and monitoring production procedures is cost-effective and can have a short payback period when considering the savings and benefits provided (TUBITAK MAM, 2016; TOB, 2021).

- • ***Implementing Time Optimization in Production to Ensure All Processes are Completed as Quickly as Possible***

  Planning industrial production processes to convert raw materials into finished products with the minimum number of process steps is an effective approach for reducing labor costs, resource usage costs, and environmental impacts, thereby enhancing efficiency. In this regard, it may be necessary to revise production processes to minimize the number of steps (TUBITAK MAM, 2016). In cases where product quality is compromised due to inefficiencies or design flaws in primary production processes, renewal of production processes may be required. Consequently, resource usage, waste, emissions, and solid waste generation per unit of product increase. Therefore, time optimization in production processes is an effective measure (TUBITAK MAM, 2016).

2.1.4 Measures on Auxiliary Processes

METs for Steam Production

- • ***Providing Water Savings Through Isolation of Steam and Water Lines (Hot and Cold) and Preventing Water and Steam Losses at Pipe, Valve, and Connection Points, with Monitoring via Computer Systems***

In facilities, inadequate design of steam lines, lack of routine maintenance and repairs, mechanical issues in the lines, improper operation of the lines, and insufficient insulation of steam lines and hot surfaces can lead to steam losses. This situation affects both water and energy consumption in the facility. Proper insulation of steam lines and the continuous monitoring of steam consumption require the use of automated control systems with control mechanisms. By reducing steam losses, savings can be achieved in fuel consumption and additional soft water usage in boilers at similar rates. Since fuel consumption in steam boilers is expected to decrease, a corresponding reduction in waste gas emissions is also anticipated. The implementation of this practice will lead to a decrease in the amount of additional soft water used in steam boilers, thus reducing the quantities of regeneration water, the amount of salt used in regeneration, and the concentrations in reverse osmosis systems. Automated control mechanisms are utilized in many facilities where high steam consumption occurs to achieve complete steam insulation and minimize steam losses. By implementing these practices, fuel savings of 2-4% can be realized in steam boilers.

To prevent losses in production processes, it is essential to include critical components such as pumps, valves, adjustment knobs, pressure and flow regulators in the maintenance checklists. Inspections should be conducted not only for water systems but also for heating and chemical distribution systems, including drum, pump, and valve inspections. Regular cleaning of filters and pipelines, routine calibration of measurement equipment (thermometers, chemical scales, distribution/dosing systems, etc.), and regular inspections and cleaning of thermal processing units (including chimneys) at determined intervals contribute to effective maintenance, cleaning, and loss control practices, resulting in water savings of 1-6% (Hasanbeigi, 2010; Öztürk, 2014; TOB, 2021).

Industrial Steam Boilers

- • ***Water Savings Through the Reuse of Steam Boiler Condensate***

  In production processes, the recovery of condensate (the condensed steam) when indirect heating techniques using steam are employed is an effective practice for reducing water consumption (IPPC BREF, 2009). The recovery of condensate can lead to an average reduction of approximately 5% in water consumption (Greer et al., 2013). Additionally, the potential payback period varies between 4 to 18 months when considering energy savings as well (Öztürk, 2014; TUBİTAK MAM, 2016).

- • ***Prevention of Flash Steam Losses from Boiler Draining***

  Steam boiler condensate is typically discharged from equipment outlets and steam traps into the atmosphere at atmospheric pressure. In condensate systems, as the pressure decreases, some of the condensate tends to re-evaporate and cools down to the boiling point of water at atmospheric pressure. The re-evaporating condensate, referred to as flash steam, is lost to the atmosphere. In condensate return lines, which are generally quite long, cooling and consequently evaporation are inevitable. To prevent the re-evaporation of condensate, savings can be achieved by holding it under pressure in a flash tank until it returns to the boiler feed tank. As the pressure in the condensate decreases inside the tank, the steam formed accumulates at the top of the tank and feeds the low-pressure steam system. The remaining hot condensate is drawn from the bottom of the tank back to the boiler.

- • ***Minimizing Blowdown Water in Steam Boilers***

  Boiler blowdown refers to the water that is wasted from a boiler to prevent the concentration of impurities during continuous steam evaporation. With condensate recovery, blowdown can be reduced by up to 50% (IPPC BREF, 2009). In automated systems, blowdowns in the boilers are continuously monitored, and the system is re-analyzed together with the water taken after blowdown. The analysis processes data such as dissolved and undissolved particles and water density. If the density of the water exceeds the system limit for the boiler, the blowdown operation is repeated. The system should be automated, and the optimal blowdown frequency should be determined. When the blowdown frequency is reduced, the volume of wastewater decreases, saving energy used for cooling this wastewater and cooling water (IPPC BREF, 2009). Optimizing the blowdown operation of the steam boiler results in gains in boiler water consumption, waste costs, conditioning, and heating, thereby reducing operating costs.

- • ***Reuse of Energy Produced from Steam Condensers***

  A simple modification in the piping system allows for the use of the water from the outlet of the water turbine condenser unit that supplies the water for the de-aeration/carbon removal unit. This water is sufficient to achieve the desired temperature for the de-aeration/carbon removal unit. Therefore, it does not require heating via the steam produced by the heat exchanger system. This process can significantly enhance steam recovery while also reducing cooling water consumption (CPRAC, 2021).

References

- Abbassi, B., & Al Baz, İ. (2008). Integrated Wastewater Management: A Review. https://doi.org/10.1007/978-3-540-74492-4_3.
- Adar, E., Delice, E., & Adar, T. (2021). Prioritizing of industrial wastewater management processes using an integrated AHP–CoCoSo model: comparative and sensitivity analyses. International Journal of Environmental Science and Technology, 1-22.
- Akgül, D. (2016). Türkiye'de Ters Osmoz ve Nanofiltrasyon Sistemleri ile İçme ve Kullanma Suyu Üretiminin Maliyet Analizi. İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü.
- Ayan, B. (2010). Kaynaklı İmalat Yapan İşletmelerde Uluslararası Sertifikasyon Sistemleri. İzmir: Dokuz Eylül Üniversitesi, Sosyal Bilimler Enstitüsü, İşletme Anabilim Dalı, Yüksek Lisans Tezi.
- Christopher, S. (1998). ISO 14001 and Beyond Environmental Management Systems in the Real World.
- CPRAC. (2021). Med No:55. http://www.cprac.org/en/media/medclean adresinden alındı
- ÇŞİDB. (2020e). Belirli Sektörlerde Temiz Üretim Uygulamaları Projesi. T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı Çevre Yönetimi Genel Müdürlüğü.
- Delmas, M. (2009). Erratum to "Stakeholders and Competitive Advantage: The Case of ISO 14001. doi:10.1111/j.1937-5956.2004.tb00226.x.
- DEPA. (2002). Danish Environmental Protection Agency (DEPA). Danish Experience, Best Avaible Techniques-Bat in the Clothing and Textile Industry.
- Greer, L., Keane, S., Lin, C., & James, M. (2013). Natural Resources Defense Council's 10 Best Practices for Textile Mills to Save Money and Reduce Pollution. Natural Resources Defense Council.
- Hasanbeigi, A. (2010). Energy-Efficiency improvement opportunities for the textile industry. China Energy Group Energy Analysis Department Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory.
- Hutchens Jr., S. (2017). Using ISO 9001 or ISO 14001 to Gain a Competitive Advantage.
- IPPC BREF. (2003). Reference Document on Best Available Techniques for the Textiles Industry. https://eippcb.jrc.ec.europa.eu/reference adresinden alındı
- IPPC BREF. (2006). European Commission (EC) Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Surface Treatment of Metals and Plastics.
- IPPC BREF. (2009). Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Energy Efficiency. https://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf) adresinden alındı
- IPPC BREF. (2016). European Commission (EC) Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Production of Wood-based Panels.
- IPPC BREF. (2019). Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries. https://eippcb.jrc.ec.europa.eu/reference.
- ISO 14001 User Manual. (2015). Generic ISO 14001 EMS Templates User Manual.
- LCPC. (2010). Lebanese Cleaner Production Center . Cleaner Production Guide for Textile Industries.
- Naghedi, R., Moghaddam, M., & Piadeh, F. (2020). Creating functional group alternatives in integrated industrial wastewater recycling system: A case study of Toos Industrial Park (Iran). Journal of Cleaner Production. doi:https://doi.org/10.1016/j.jclepro.2020.120464.
- Oğur, R., Tekbaş, Ö. F., & Hasde, M. (2004). Klorlama Rehberi: İçme ve Kullanma Sularının Klorlanması. Ankara: Gülhane Askeri Tıp Akademisi Halk Sağlığı Anabilim Dalı.
- Özdemir, K., & Toröz, İ. (2010). İçmesuyu Kaynaklarında Klorlama Yan Ürünlerinin Deferansiyel UV Spektroskopi Yöntemi ile İzlenmesi. İtüdergisi.
- Öztürk, E. (2014). Tekstil Sektöründe Entegre Kirlilik Önleme ve Kontrolü ve Temiz Üretim Uygulamaları. Isparta.
- Potoski, M., & Prakash, A. (2005). Green Clubs and Voluntary Governance: ISO 14001 and Firms' Regulatory Compliance. American Journal of Political Science, 235-248.
- Singh, M., Liang, L., Basu, A., Belsan, M., Hallsby, G., & Morris, W. (2014). 3D TRASAR™ Technologies for Reliable Wastewater Recycling and Reuse. doi:10.1016/B978-0-08-099968-5.00011-8.
- TOB. (2021). 3 Pilot Havzada Nehir Havza Yönetim Planları Kapsamında Ekonomik Analizler ve Su

Verimliliği Çalışmaları için Teknik Yardım Projesi. T.C. Tarım ve Orman Bakanlığı.

- TUBİTAK MAM. (2016). Sanayide Temiz Üretim Olanaklarının ve Uygulanabilirliğinin Belirlenmesi (SANVER) Projesi, Final Rapor. Türkiye Bilimsel ve Teknolojik Araştırma Kurumu Marmara Araştırma Merkezi.
- URL - 1. (2021). Filtre Ters Yıkama Sularının Geri Kazanımı. https://rielli.com/portfolio/filtre-ters-yikama-sularinin-geri-kazanimi/ adresinden alındı.

çevre
çözümleri

Reşitpaşa Mah Katar Cd.
Arı Teknokent 1 2/5, D:12, 34469
Sarıyer/İstanbul

(0212) 276 65 48

www.iocevre.com