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

Water Efficiency
Campaign

Water Efficiency

Guidance Document Series

MANUFACTURE OF FINISHED TEXTILE PRODUCTS OTHER THAN CLOTHİNG

NACE KODU:13.92

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Abbreviations

AAT	Wastewater Treatment Plant
AB	European Union
AKM	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
MOEUU	Republic of Turkey Ministry of Environment, Urbanization and Climate Change
DOM	Natural Organic Matter
EMAS	Eco-Management and Audit Program Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Organization for Standardization
MET	Best Available Techniques
NACE	Statistical Classification of Economic Activities
SYGM	General Directorate of Water Management
TO	Reverse Osmosis
TOB	Republic of Turkey Ministry of Agriculture and Forestry
TUIK	Turkish Statistical Institute
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 felt intensely, and is considered to be among the regions that will be most affected by the negative effects of climate change. Projections on how our water resources in our basins will be affected in the future due to climate change show that our water resources may decrease by up to 25 percent in the next hundred years.

For the year 2022, the annual amount of water available per capita in Turkey is 1,313 m³, and it is expected that the annual amount of water available per capita will fall below 1,000 cubic meters after 2030 due to human pressures and the effects of climate change. If the necessary measures are not taken, it is obvious that Turkey will become a country suffering from water scarcity in the very near future and will bring many negative social and economic consequences. As it can be understood from the results of future projections, the risk of drought and water scarcity awaiting our country necessitates the efficient and sustainable use of our existing water resources.

The concept of water efficiency can be defined as *"using 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 in all sectors, especially in drinking water, agriculture, industry and household use, in a way that protects water in terms of quantity and quality and takes into account not only the needs of humans but also the needs of all living things with ecosystem sensitivity.

With the increasing demand for water resources, changes in precipitation and temperature regimes as a result of climate change, increasing population, urbanization and pollution, the fair and balanced distribution of usable water resources among users is becoming more and more important every day. Therefore, it has become imperative to create a road map based on efficiency and optimization in order to conserve and use limited water resources through sustainable management practices.

In the vision of sustainable development set by the United Nations, *Goal 7: Ensuring Environmental Sustainability* from the Millennium Development Goals, *Goal 9: Industry, Innovation and Infrastructure* from the Sustainable Development Goals and *Goal 12: Responsible Production and Consumption* from the Sustainable Development Goals include issues such as efficient, fair and sustainable use of resources, especially water, environmentally friendly production and consumption with concern for future generations.

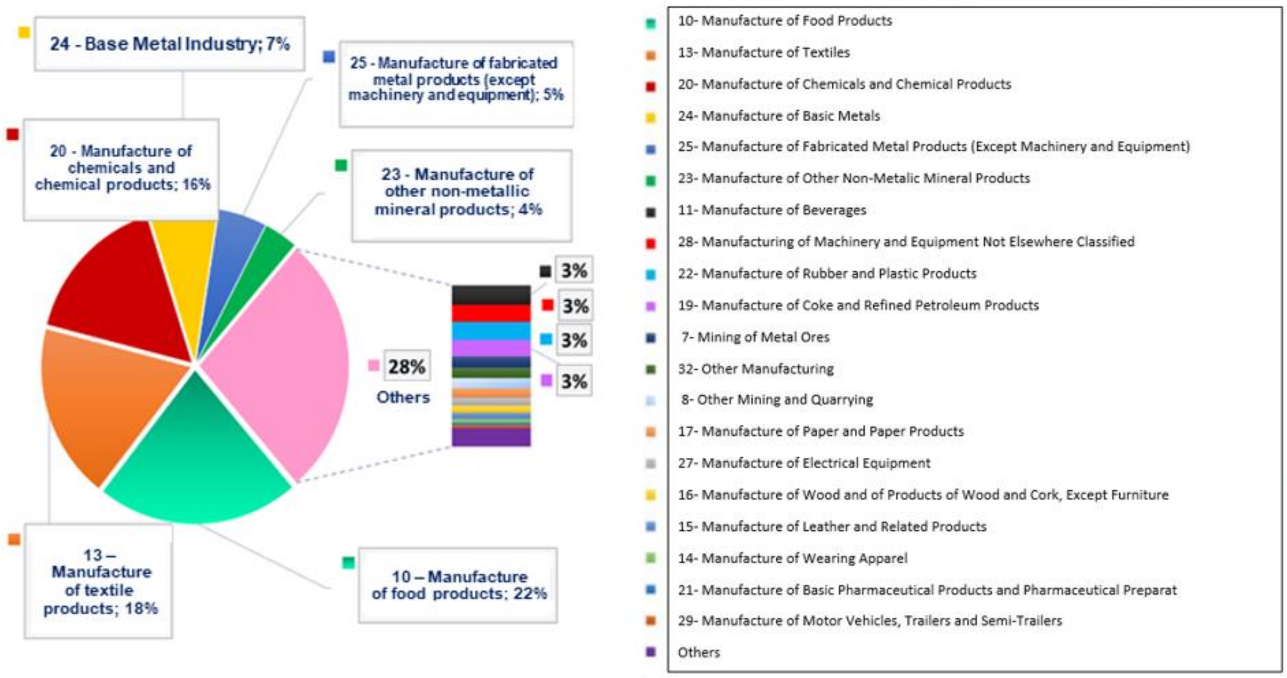
Within the scope of the European Green Deal, where member countries have agreed on goals such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing environmental impacts, actions emphasizing water and resource efficiency in production and consumption in various fields, especially in industry, have been determined in the European Green Deal Action Plan prepared by our country

The "Industrial Emissions Directive (EED)", which is one of the most important components of the European Union environmental legislation in terms of industry, includes measures to be taken for the control, prevention or reduction of discharges/emissions from industrial activities to the receiving environment, including air, water and soil, with an integrated approach. In the Directive, Best Available Techniques (BAT) are presented in order to systematize the applicability of cleaner production processes and to eliminate difficulties in implementation. BATs are the most effective implementation techniques for a high level of environmental protection, taking into account their costs and benefits. In accordance with the Directive, Reference Documents (BAT-BREF) have been prepared for each sector detailing BATs. In the BREF documents, BATs are presented in a general framework such as good management practices, techniques as general measures, chemical use and management, techniques for various production processes, wastewater management, emission management and waste management.

The Ministry of Agriculture and Forestry, General Directorate of Water Management carries out activities aimed at disseminating efficient practices in urban, agricultural, industrial and individual water use and raising social awareness. Water efficiency action plans addressing all sectors and stakeholders were prepared within the scope of ***the "Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework of Adaptation to a Changing Climate"***, which entered into force with the Presidential Circular No. 2023/9. In the Industrial Water Efficiency Action Plan, a total of 12 actions have been determined for the 2023-2033 period and responsible and relevant institutions have been assigned for these actions. Within the scope of the Action Plan, the General Directorate of Water Management has been assigned the responsibility of conducting studies to determine specific water use ranges and quality requirements on the basis of sub-sectors in industry, organizing technical training programs and workshops on sectoral basis and preparing water efficiency guidance documents.

On the other hand, with the ***"Industrial Water Use Efficiency Project by NACE Codes"*** carried out by the General Directorate of Water Management of the Ministry of Agriculture and Forestry, the best sectoral techniques specific to our country were determined within the scope of studies to improve water efficiency in industry. As a result of the study, sectoral guidance documents and action plans classified by NACE codes, which include measures recommended for improving water use efficiency in sectors with high water consumption operating in our country, were prepared.

As in the world, the sectors with the highest share in water consumption in our country are food, textile, chemical and basic metal sectors. Within the scope of the studies, field visits were carried out in enterprises representing 152 sub-sectors in 35 main sectors, especially food, textile, chemical and basic metal industries, representing production areas with different capacities and diversity within the scope of NACE Codes operating in our country and with high water consumption, and data on water supply, sectoral water use, wastewater generation, recycling were obtained and information was provided on best available techniques (BAT) and sectoral reference documents (BREF) published by the European Union, water efficiency, clean production, water footprint, etc.



Sectoral distribution of water use in industry in Turkey

As a result of the studies, specific water consumption and potential savings rates for the processes of enterprises for 152 different 4-digit NACE codes with high water consumption were determined, and water efficiency guidance documents were prepared by taking into account the EU best available techniques (BAT) and other cleaner production techniques. The guidelines include 500 techniques (BATs) for water efficiency; (i) Good Management Practices, (ii) General Measures, (iii) Measures Related to Auxiliary Processes and (iv) Sector Specific Measures.

Within the scope of the project, environmental benefits, operational data, technical specifications-requirements and applicability criteria were taken into consideration in the determination of BATs for each sector. In the identification of BATs, not only BREF documents were not limited, but also different data sources such as current literature data on a global scale, real case studies, innovative practices, reports of sector representatives were examined in detail and sectoral BAT lists were created. In order to evaluate the suitability of the BAT lists created for the local industrial infrastructure and capacity of our country, the BAT lists prepared specifically for each NACE code were prioritized by the enterprises by scoring them on the criteria of water saving, economic savings, environmental benefit, applicability, cross-media impact and the final BAT lists were determined using the scoring results. Water and wastewater data of the facilities visited within the scope of the project and the final BAT lists prioritized by sectoral stakeholders and taking into account the local dynamics specific to our country were used to create sectoral water efficiency guides based on NACE codes.

2 Scope of the Study

Guidance documents prepared within the scope of water efficiency measures in industry cover the following main sectors:

- Crop and animal production and hunting and related service activities (including sub-production area represented by 6 four-digit NACE codes)
- Fisheries and aquaculture (including sub-production area represented by 1 four-digit NACE Code)
- Coal and lignite extraction (including sub-production represented by 2 four-digit NACE codes)
- Service activities in support of mining (including sub-production area represented by 1 four-digit NACE Code)
- Metal ores mining (including the sub-production area represented by 2 four-digit NACE codes)
- Other mining and quarrying (including sub-production represented by 2 four-digit NACE codes)
- Manufacture of food products (including 22 sub-production areas represented by four-digit NACE codes)
- Manufacture of beverages (including sub-production represented by 4 four-digit NACE codes)
- Manufacture of tobacco products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of textile products (including 9 sub-production areas represented by four-digit NACE codes)
- Manufacture of apparel (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of leather and related products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of wood, wood products and cork products (except furniture); manufacture of articles made of thatch, straw and similar materials (including sub-production area represented by 5 four-digit NACE Codes)
- Manufacture of paper and paper products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of coke and refined petroleum products (including sub-production area represented by 1 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 ingredients (including sub- production area represented by 1 four-digit NACE Code)
- Manufacture of rubber and plastic products (including sub-production area represented by 6 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 sub-production area represented by 2 four-digit NACE codes)
- Electrical equipment manufacturing (including sub-production area represented by 7 four-digit NACE codes)
- Manufacture of machinery and equipment not elsewhere classified (including sub-production area represented by 8 four-digit NACE codes)
- Manufacture of motor vehicles, trailers (semi-trailers) and semi-trailers (semi-trailers) (including sub-production area represented by 3 four-digit NACE codes)

- Manufacture of other means of transportation (including the sub-production area represented by 2 four-digit NACE codes)
- Other manufacturing (including sub-production represented by 2 four-digit NACE codes)
- Installation and repair of machinery and equipment (including sub-production represented by 2 four-digit NACE codes)
- Electricity, gas, steam and ventilation system production and distribution (including sub-production area represented by 2 four-digit NACE codes)
- Waste collection, reclamation and disposal activities; recovery of materials (including sub-production represented by 1 four-digit NACE Code)
- Construction of non-building structures (including sub-production area represented by 1 four-digit NACE Code)
- Warehousing and supporting activities for transportation (including sub-production area represented by 1 four-digit NACE Code)
- Accommodation (including sub-production area represented by 1 four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including sub-production area represented by 1 four-digit NACE Code)
- Sports, leisure and recreation activities (including sub-production area represented by 1 four-digit NACE Code)

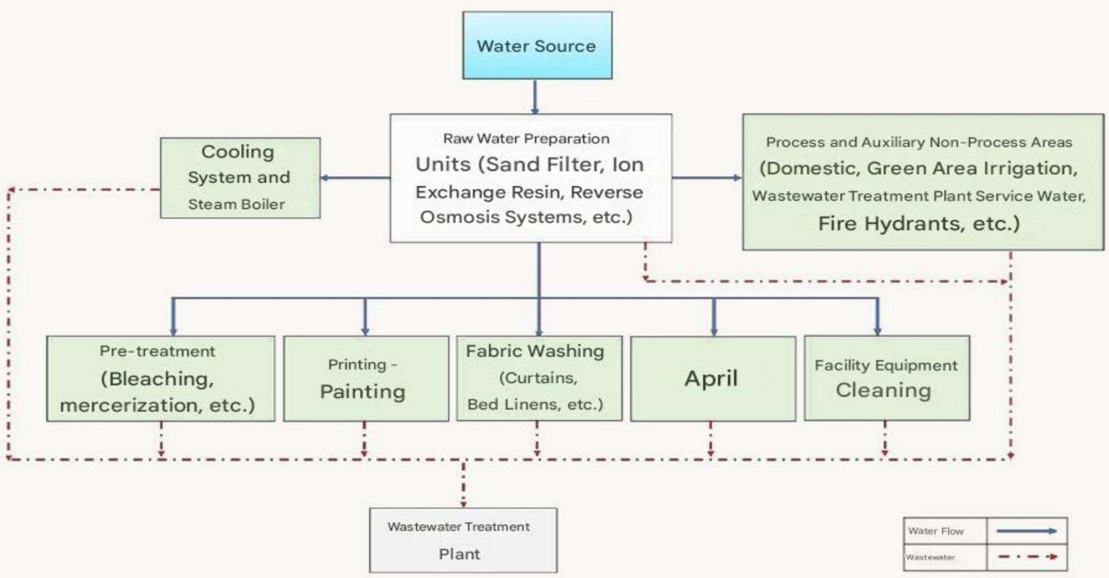
"Manufacture of Textile Products" and "Manufacture of Clothing"

Under the "Manufacture of Textile Products" and "Manufacture of Clothing" sectors, the sub-production branches for which guidance documents were prepared are as follows

13.10	Preparation and twisting of textile fibers
13.20	Weaving
13.30	Finishing of textile products
13.91	Manufacture of knitted (knitwear) or crocheted (crochet) fabrics
13.92	Manufacture of finished textile products other than apparel
13.93	Carpet and rug manufacturing
13.95	Manufacture of nonwovens and products made of nonwovens, except apparel
13.96	Manufacture of other technical and industrial textiles
13.99	Manufacture of other textiles not elsewhere classified
14.13	Manufacture of other outerwear

2.1 Manufacture of finished textile products other than clothing (NACE13.92)

Water Flow Diagram for Manufacturing of Finished Textile Products Other Than Apparel



	Minimum	Maximum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	90,9	
Reference Specific Water Consumption (L/kg product)	50	250

Percentage Distribution of Water Efficiency Practices

Water Efficiency Mobilization

13.92 NACE code covers the manufacture of home textile products such as bedspreads, sheets and curtains. These products include pre-finishing, dyeing - printing and stapling processes of the fabrics to be produced. Depending on the raw materials used in the facilities, the techniques/technologies applied and the properties expected from the product, one or more of these processes may be used in the production processes. Textile materials are prepared for the dyeing/printing process in pre-finishing processes such as bleaching, desizing, bleaching, hydrophilisation, mercerisation. In addition, technical properties such as strength, dyestuff affinity, brightness are also provided to the raw material to be used. Dyeing-printing processes aim to colour textile materials with various dyeing-printing methods and recipes. In the final finishing processes, technical properties such as flame retardancy, water-oil repellency, wrinkle resistance are provided in accordance with the use of the final product.

In the manufacturing of finished textile products other than apparel, water consumption is generally realized in fabric washing, printing/dyeing and finishing processes. Significant water consumption is also realized for filter washing, resin regeneration and membrane cleaning processes in raw water preparation units such as activated carbon filter, ion exchange resin, reverse osmosis, which are used to produce soft water for use in production processes in the sector. Water is also consumed in auxiliary units such as cooling towers and steam boilers.

The reference specific water consumption in the textile finishing sector is in the range of 50 - 250 L/kg. The specific water consumption of the production line analyzed within the scope of the study remains in the range of 90.9 L/kg. With the implementation of sector-specific techniques, good management practices, measures in the form of general measures and measures related to auxiliary processes, it is possible to reduce water consumption in the sector by 5- 41% recovery is possible.

13.92 Manufacture of Finished Textile Products Other than Clothing The priority water efficiency implementation techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Descr pt on	Sectoral Prioritization Best Available Techniques
		Sector Specific Measures
		1. Improving washing efficiency in textile processes
		2. Reuse of dyeing baths
		3. Reducing the use of sizing agent by pre-wetting the warp yarns
		4. Reuse of the rinse water in the next dyeing
		5. Reuse of washing/rinsing wastewater for cleaning Reuse
		6. of washing water from printing dyeing belt cleaning
		7. Collecting cooling water that does not come into contact with the fabric/yarn and reusing it in processes that require hot water
		8. Use of water flow control devices and automatic shut-off valves in continuously operating machines
		9. Reuse of cooling water that does not come into contact with the product in the process
		Good Management Practices
		1. Use integrated wastewater management and treatment strategy to reduce wastewater quantity and pollutant load
		2. Establishment of an environmental management system
		3. Preparation of water flow diagrams and mass balances for water
		4. Preparing a water efficiency action plan to reduce water use and prevent water pollution
		5. Providing technical trainings to staff for the reduction and optimization of water use
		6. Good production planning to optimize water consumption
		7. Setting water efficiency targets
		8. Water used in production processes and auxiliary processes and the resulting monitoring the quantity and quality of wastewater and adapting this information to the environmental management system
		Measures in the nature of General Measures
		1. Minimizing spills and leaks
		2. Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality
		3. It will save water at water usage points such as shower/toilet etc. use of automated hardware and equipment (sensors, smart hand washing systems, etc.)
		4. Pressure washing for equipment cleaning, general cleaning, etc. use of systems

Sectoral Prioritized Best Available

Descr pt on

NACE Code

NACE Code

5. Reuse of filter wash water in filtration processes, production reuse relatively clean cleaning water in their processes and reduce water consumption by using clean-in-place systems (CIP)
6. Avoiding the use of drinking water in production lines
7. Use of cooling water as process water in other processes
8. Identification and reduction of water losses
9. Use of automatic control-close valves to optimize water use
10. Production procedures are documented and used by employees to prevent water and energy waste
11. Reuse of pressurized filtration backwash water prior to water softening at appropriate points
12. Optimizing the frequency and duration of regeneration (including rinses) in water softening systems
13. Transportation of toxic or hazardous chemicals for the aquatic environment construction of closed storage and impermeable waste/scrap yard for prevention

Storage of substances that pose a risk to the aquatic environment (such as oils, emulsions, binders 14.), storage and mixing into wastewater after use prevention

15. Preventing the mixing of clean water streams with dirty water streams Preventing the quantity and quality of wastewater at all wastewater generation points
16. characterization of wastewater streams that can be reused with or without treatment
17. Use of closed-loop water cycles in appropriate processes Use
18. of computer-aided control systems in production processes
19. Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes Scope of reuse of washing and rinsing water
20. Determination of

Separate collection and treatment of gray water and high water quality Techniques21. in areas that do not require (green area irrigation, floor washing, etc.) use of

13.92 Manufacture of Finished Textile Products Other than Clothing The priority water efficiency implementation techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Description		Sectoral Prioritization Best Available Techniques
13.92	Finished Textile Products Other Than Clothing Manufacturing	22.	Implementing time optimization in production and organizing all processes to be completed as soon as possible
		23.	Collecting rainwater and utilizing it as an alternative water source for facility cleaning or in suitable areas
		24.	Avoiding the need to rinse between activities by using compatible chemicals in sequential processes
			Precautions for Auxiliary Processes
		1.	Use of closed loop cooling system to reduce water usage

For the NACE Code for Manufacture of Finished Textile Products Other than Clothing;

(i) Sector Specific Measures,
(ii) Good Management Practices,
(iii) General Precautions and
(iv) Measures for auxiliary processes are given under separate headings.

2.1.1 Sector Specific Measures

- ***Reuse of cooling water that does not come into contact with the product in the process***

Water is used as the most favorable heat transfer fluid in the cooling process. In industrial applications, cooling water is used in single pass cooling systems, closed circuit cooling systems and open type cooling circuits. Cooling water that does not come into contact with any product can be reused in the process by rotating it in a closed circuit or by storing it properly (IPPC BREF, 2003).

- ***Reuse of wash water from printing dyeing belt cleaning***

High quality process water is not required for printing blanket washing. Wastewater with appropriate characterization can be reused in printing blanket washing. In addition, printing blanket washing wastewater can be reused 2-3 times for the same purpose (Öztürk, 2022). Light colored printing dyeing belt wastewater, which may contain fibers, can be collected in a tank after mechanical filtration and reused in the same process. With this application, 70% water savings can be achieved in cases where clean water addition is insufficient (IPPC BREF, 2003).

- ***Use of washing/rinsing wastewater for cleaning purposes***

In the textile industry, process wastewaters with different characteristics are generated in main production processes such as finishing, dyeing and auxiliary production processes such as raw water softening systems. The high pH, electrical conductivity, COD, ECM and color content of some process wastewaters prevent their reuse without treatment. However, these wastewaters can be used in plant washing processes that do not require high water quality (Öztürk, 2014). Water used in plant and equipment cleaning does not need to be of process water quality. Water consumption and wastewater generation in plant and equipment cleaning can be reduced by using not highly contaminated washing and rinsing water in cleaning processes.

Textile Printing Machine

https://ctnbee.com/blog/pl/wp-content/uploads/sites/3/2019/05/Drukowanie-materialy-na-zam%C3%B3wienie.jpg

- ***Reuse of dyeing baths***

Turbidity in the dyeing bath is removed with toluene and similar extractions to replenish the dye and chemicals missing from previous use for reuse. Different recovery methods may need to be developed for different bath solutions. With the application of this technique, more efficient dyeing can be achieved by reducing the frequency of dyeing bath emptying.

- ***Reducing the use of sizing agent by pre-wetting the warp yarns***

Reducing the amount of sizing applied to the warp yarn during preparation for weaving is one of the most effective pollution prevention methods to reduce the organic load caused by sizing agents. Pre-soaking is based on passing the warp yarn through hot water before sizing. The warp yarn is immersed in hot water (an additional spray of hot water may be possible) and then a pair of squeezing rollers removes excess water before the sizing step. Systems with double dipping and squeezing steps are also used. In addition to more homogeneous sizing, pre-wetting also improves sizing adhesion and reduces yarn hairiness. With this method, a smaller amount of sizing agent can be applied to the fibers without affecting the weaving efficiency. Reducing the use of sizing agent reduces the pollutant load in the wastewater and increases the wastewater recovery potential.

Sizing agents are applied to the warp yarns to prevent yarn breakage during weaving. Before the application of sizing agents to the warp yarn, pre-wetting can be applied to the warp yarn. Pre-wetting is based on passing the warp yarn through hot water before sizing. The warp yarn is immersed in hot water (an additional spray of hot water may be possible) and then a pair of squeezing rollers removes excess water before the sizing step. Pre-wetting ensures more uniform sizing and minimizes the amount of sizing agent used (IPPC textile BREF, 2003). By pre-wetting the warp yarn, reductions of 20-50% in the amount of sizing agent used can be achieved (IPPC textile BREF, 2003). Reducing the use of sizing agent reduces the pollutant load in the wastewater and increases the wastewater recovery potential.

Textile Dyehouses
https://www.hursan.com.tr/up/galeri/baslik-1454924924-boyahane-2.jpg

- ***Collecting cooling water that does not come into contact with the fabric/yarn and reusing it in processes that require hot water***

  Cooling water that does not come into contact with the fabric or yarn can be collected in a tank and reused in processes that require hot water such as dyeing, bleaching and washing. With this method, condenser-cooling water, heat exchanger water, water from compressors can be recovered (IPPC BREF, 2003).

- ***Use of water flow control devices and automatic shut-off valves in continuously operating machines***

  In industrial enterprises, monitoring and control equipment is widely used in production processes where water consumption is high. Thus, inefficiencies in processes and water consumption can be minimized. In this context, continuously operating machines can be equipped with flow meters, meters and automatic shut-off valves. This practice facilitates the implementation of managerial BATs such as preparing annual inventory reports based on mass balances, monitoring production inputs and outputs in terms of quantities, and loss control. In the implementation of this BAT recommendation, the main investments are flow meters, automatic shut-off valves and installation costs (Öztürk, 2014).

- ***Reuse of the rinse water in the next dyeing***

  By using techniques to minimize the effect of regurgitation in the rinsing process, the rinse bath can be used for the next dye bath. Thus, all residues of the rinsing flotate are removed and total water consumption is reduced by 50% (IPPC BREF, 2003).

http://cronytrade.com/images/product/12/What-Types-of-Machinery-Used-in-Garment-Washing-Plant.jpg

Washing Machines

- ***Improving washing efficiency in textile processes***

  Significant water and energy savings can be achieved by optimizing washing efficiency in washing and rinsing processes, which are among the most widely used processes in the textile sector (IPPC BREF, 2003). In order to increase washing efficiency, the following techniques are recommended to be applied.

  - Using one of the "fill and drain" or "smart rinsing" systems instead of overflow rinsing systems that cause inefficient water consumption in machines operating at high liquor ratios
  - Saving water and energy by reducing the dirty water/flotten in the fabric with the reverse flow principle in continuous washing and rinsing systems
  - The use of fully closed-circuit systems in fabric washing systems with organic solvents, both caustic recovery and reuse of the filtrate water in the process if it meets the process water criteria
  - Enzymatic post-soaping in reactive dyeing is the application of enzymatic treatment to remove unfixed dyestuff molecules not only from the fibers but also from the shrinkage bath. With the application of enzymatic post-treatment, there is no need for a hot washing step. With this application, water and energy savings are achieved and the process time is shortened.

2.1.2 Good Management Practices

Establishment of an environmental management system

Environmental Management Systems (EMS) include the organizational structure, responsibilities, procedures and resources necessary to develop, implement and monitor the environmental policies of industrial organizations. The establishment of an environmental management system improves the decision-making processes of organizations between raw materials, water and wastewater infrastructure, planned production process and different treatment techniques. Environmental management organizes how resource supply and waste discharge demands can be managed 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 Directive (EMAS) (761/2001). It was developed to assess, improve and report on the environmental performance of businesses. It is one of the leading practices within the scope of eco-efficiency (cleaner production) in EU legislation and voluntary participation is provided (TUBITAK MAM, 2016; TOB, 2021). The benefits of establishing and implementing an Environmental Management System are as follows:

- Economic benefits can be achieved by improving business performance (Christopher,1998).
- International Organization for Standardization (ISO) standards are adopted, ensuring greater compliance with global legal and regulatory requirements (Christopher, 1998).
- While minimizing the risks of penalties associated with environmental responsibilities, the amount of waste, resource consumption and operating costs are reduced (Delmas, 2009).
- The use of internationally recognized environmental standards eliminates the need for multiple registrations and certifications for businesses operating in different locations around the world (Hutchens Jr., 2017).
- Especially in recent years, the improvement of companies' internal control processes has also been emphasized by consumers. The implementation of environmental management systems provides a competitive advantage against companies that do not adopt the standard. It also contributes to the better position of organizations in international areas / markets (Potoski & Prakash, 2005).

The above-mentioned benefits depend on many factors such as the production process, management practices, resource utilization and potential environmental impacts (TOB, 2021). Practices such as preparing annual inventory reports with similar content to an environmental management system and monitoring the quantity and quality of inputs and outputs in production processes can save 3-5% of water consumption (Öztürk, 2014). The total duration of the development and implementation phases of an EMS takes an estimated 8-12 months (ISO 14001 User Manual, 2015).

Industrial organizations also carry out studies within the scope of ISO 14046 Water Footprint Standard, an international standard that defines the requirements and guidelines for assessing and reporting water footprint. With the implementation of the relevant standard, it is aimed to reduce the use of fresh water required for production and environmental impact

Use integrated waste water management and treatment strategy to reduce wastewater quantity and pollutant load

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

On-site reuse of treated wastewater not only improves the quality of water bodies, but also reduces the demand for freshwater. It is therefore crucial to identify appropriate treatment strategies for different reuse objectives.

In integrated industrial wastewater treatment, different aspects such as wastewater collection system, treatment process and reuse target are considered together (Naghedi et al., 2020). For industrial wastewater recovery, methods such as SWOT method (strengths, weaknesses, opportunities and threats), PESTEL method (political, economic, social, technological, environmental and legal factors), decision tree can be combined with expert opinions to determine the integrated wastewater management framework (Naghedi et al., 2020). The integration of Analytic Hierarchy Process (AHP) and CoCoSo techniques can be used to set priorities for industrial wastewater management processes based on multiple criteria (Adar et al., 2021).

The implementation of integrated wastewater management strategies can reduce water consumption, wastewater quantity and pollution loads of wastewater by up to 25% on average. The potential payback period of implementation varies between 1-10 years (MoAF, 2021).

- ***Preparation of a water efficiency action plan to reduce water use and prevent water pollution***

Preparation of a short, medium and long term action plan to reduce water-wastewater quantities and prevent water pollution in industrial facilities is important in terms of water efficiency.

It may be necessary to determine water quality requirements at water quality points, wastewater generation points and wastewater characterization (MoAF, 2021). At the same time, it is necessary to determine the techniques to be applied to reduce water consumption, wastewater generation and pollution loads, to make their feasibility and to make action plans for the short-medium-long term. In this way, sustainability of water efficiency in facilities can be ensured (TOB, 2021)

Providing technical trainings to staff for the reduction and optimization of water use

With this measure, water saving and water recovery can be achieved by increasing the training and awareness of the personnel, and water efficiency can be achieved by reducing water consumption and costs. In industrial facilities, problems related to high water use and wastewater generation may arise due to the lack of necessary technical knowledge of the personnel. For example, it is important that cooling tower operators, who represent a significant proportion of water consumption in industrial operations, are properly trained and have technical knowledge. It is also necessary for the relevant personnel to have sufficient technical knowledge in applications such as determining water quality requirements in production processes, measuring water and wastewater quantities, etc. (TOB, 2021). Therefore, it is important to train staff on water use reduction, optimization and water saving policies. Practices such as involving staff in water conservation efforts, creating regular reports on water use before and after water efficiency initiatives, and sharing these reports with staff support participation and motivation in the process. The technical, economic and environmental benefits of staff training are realized in the medium or long term (TUBITAK MAM, 2016; TOB, 2021).

- ***Preparation of water flow diagrams and mass balances for water***

Determining the points of water use and wastewater generation in industrial plants, establishing water-wastewater balances in production processes and auxiliary processes other than production processes constitute the basis of many good management practices in general. Establishing process profiles on a plant-wide and production process basis facilitates the identification of unnecessary water use points and high water use points, evaluation of water recovery opportunities, process modifications and determination of water losses (TOB, 2021).

- ***Good production planning to optimize water consumption***

In industrial production processes, planning by using the least amount of process from raw material to product is an effective practice to reduce labor costs, resource utilization costs and environmental impacts and to ensure efficiency (TUBITAK MAM, 2016; TOB, 2021). Production planning in industrial plants, taking into account the water efficiency factor, reduces water consumption and wastewater amount. Modifying production processes or combining some processes in industrial plants provides significant benefits in terms of water efficiency and time planning (TOB, 2021).

- ***Setting water efficiency targets***

The first step in achieving water efficiency in industrial facilities is to set targets (TOB, 2021). For this, first of all, a detailed water efficiency analysis should be carried out on the basis of processes. In this way, unnecessary water use, water losses, wrong practices affecting water efficiency, process losses, reusable water-wastewater sources with or without treatment, etc. can be determined. It is also extremely important to determine the water saving potential and water efficiency targets for each production process and the plant as a whole (TOB, 2021).

Monitoring the quantity and quality of water used in production processes and auxiliary processes and the wastewater generated and adapting this information to the environmental management system There is resource utilization in industrial facilities, and inefficiency and environmental problems resulting from resource utilization may arise from input-output flows. For this reason water and wastewater used in production processes and auxiliary processes should be monitored in terms of quantity and quality (TUBITAK MAM, 2016; TOB, 2021). Process-based quantity and quality monitoring together with other good management practices (personnel training, establishment of an environmental management system, etc.) can reduce energy consumption by 6-10%, water consumption and wastewater quantities by
It can provide up to 25% reduction (Öztürk, 2014).

The main stages for monitoring water and wastewater in terms of quantity and quality are as follows:

- Use of monitoring equipment (such as meters) to monitor water, energy, etc. consumption on a process-by-process basis,
- Establish monitoring procedures,
- Identifying the use/exit points of all inputs and outputs (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste and by-products) related to the production process, monitoring, documenting, comparative evaluation and reporting in terms of quantity and quality,
- Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against raw material losses (MoEU, 2020e).

2.1.3 General Measures

- ***Identification and reduction of water losses***

  Water losses occur in equipment, pumps and pipelines in industrial production processes. First of all, water losses should be identified and equipment, pumps and pipelines should be regularly maintained and kept in good condition to prevent leaks (IPPC BREF, 2003). Regular maintenance procedures should be established, paying particular attention to

  - Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist,
  - Inspections not only of the water system, but also, in particular, of heat transfer and chemical distribution systems, broken and leaking pipes, drums, pumps and valves,
  - Regular cleaning of filters and pipelines,
  - Calibrate, routinely check and monitor measurement equipment such as chemical measuring and dispensing devices, thermometers, etc. (IPPC BREF, 2003).

  With effective maintenance-repair, cleaning and loss control practices, savings ranging from 1-6% in water consumption can be achieved (Öztürk, 2014).

- ***Minimizing spills and leaks***

  Both raw material and water losses can occur due to spills and leaks in enterprises. In addition, if wet cleaning methods are used to clean the areas where spills occur, water consumption, wastewater amounts and pollution loads of wastewater may also increase (TOB, 2021). In order to reduce raw material and product losses, spill and splash losses are reduced by using splash guards, flaps, drip trays, screens (IPPC BREF, 2019).

- ***Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes***

  In industrial plants, relatively clean wastewaters such as washing-final rinse wastewaters and filter backwash wastewaters can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality, saving between 1-5% in raw water consumption. The initial investment costs required for the application are the installation of new pipelines and reserve tanks (Öztürk, 2014).

- ***Determining the scope of reuse of washing and rinsing water***

  In industrial facilities, relatively clean wastewaters such as washing-final rinse wastewaters and filter backwash wastewaters can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Thus, it is possible to save between 1-5% in raw water consumption (TOB, 2021).

- ***Determination of wastewater streams that can be reused with or without treatment by characterizing wastewater quantities and qualities at all wastewater generation points***

Determination and characterization of wastewater generation points in industrial facilities make it possible to reuse various wastewater streams with or without treatment (Öztürk, 2014; TUBıTAK MAM, 2016; TOB, 2021). In this context, filter backwash waters, TO concentrates, blowdown waters, condensate waters, relatively clean washing and rinsing waters can be reused without treatment in the same/different processes and in areas that do not require high water quality (such as facility and equipment cleaning). In addition, wastewater streams that cannot be directly reused can be reused in production processes after treatment using appropriate treatment technologies.

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. Microfiltration (MF) and ultrafiltration (UF) are generally used for pre-treatment of water before it goes to NF or TO (Singh et al., 2014).

In the textile industry, 30-70% water savings can be achieved by reusing washing and rinsing water without treatment (USEPA, 2008; LCPC, 2010; TOB, 2021). In addition, in a cleaner production study carried out in the textile industry, it was reported that 29-55% reduction in total water consumption and 42-53% reduction in pollution loads of composite wastewater would be achieved with the recovery of appropriate wastewater streams with or without treatment (Öztürk, 2014). In another textile company engaged in textile finishing and dyeing, it was reported that by reusing wastewater with or without treatment, water consumption would be reduced by 46-50% and wastewater amounts would be reduced by 42-53% (Öztürk, 2014).48-56% and 16-20% reduction in COD load of wastewater (Öztürk, 2014).

- ***Use of cooling water as process water in other processes***

Water cooling systems are widely used in processes where thermal energy is intensively used and cooling is required. By using heat exchangers in cooling water return, it is possible to recover heat, prevent contamination of cooling water and save water and energy by increasing cooling water return rates (TUBITAK MAM, 2016; TOB, 2021). In addition, if cooling water is collected separately, it is often possible to use the collected water for cooling purposes or to reuse it in appropriate processes (EC, 2009). Cooling water reuse can save 2-9% of total water consumption (Greer et al., 2013). Energy consumption can be saved by up to 10% (Öztürk, 2014; TOB, 2021).

- ***Use of pressure washing systems for equipment cleaning, general cleaning, etc.***

Water nozzles are widely used in equipment plant cleaning. Effective results can be achieved by using correctly placed, appropriate nozzles to reduce water consumption and wastewater pollution loads. The use of active sensors and nozzles where possible and where high water consumption occurs is very important for the efficient use of water. It is possible to achieve significant water savings by replacing mechanical equipment with pressurized nozzles (TUBITAK MAM, 2016). Reducing water consumption, wastewater generation and wastewater pollution load through the use of water pressure optimized nozzles in technically appropriate processes are the main environmental benefits of the application.

- ***Use of automatic control-close valves to optimize water use***

Monitoring and controlling water consumption using flow control devices, meters and computer-aided monitoring systems provides significant technical, environmental and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed in the plant and in various processes prevents water losses (TUBITAK MAM, 2016). It is necessary to use flow meters and meters in the plant in general and in production processes in particular, to use automatic shut-off valves and valves in continuously operating machines, and to develop monitoring-control mechanisms according to water consumption and some determined quality parameters by using computer-aided systems (TUBITAK MAM, 2016). With this practice, it is possible to save up to 20-30% of water consumption on a process basis (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). By monitoring and controlling water consumption on a process basis, 3-5% savings in process water consumption can be achieved (Öztürk, 2014).

- ***Avoiding the use of drinking water in production lines***

In different sub-sectors of the manufacturing industry, waters with different water quality can be used for production purposes. In industrial plants, raw water from groundwater sources is generally used in production processes after treatment. However, in some cases, although it is costly, drinking water can be used directly in production processes or raw water is disinfected with chlorinated compounds and then used in production processes. These waters containing residual chlorine can react with organic compounds (natural organic matter (DOM)) in water in production processes and form disinfectant by-products harmful to living metabolisms (Özdemir & Toröz, 2010; Oğur et al.) The use of drinking water containing residual chlorine compounds or raw water disinfected with chlorinated compounds should be avoided as much as possible. Highly oxidizing disinfection methods such as ultraviolet (UV), ultrasound (US) or ozone can be used instead of chlorine disinfection for disinfection of raw water. In order to increase the technical, economic and environmental benefits of the application, it helps to reduce unnecessary water supply and treatment costs by determining and using the water quality parameters required in each production process. With this application, it is possible to reduce water, energy and chemical costs (TUBITAK MAM, 2016).

- ***Prevention of mixing of clean water flows with polluted water flows***

By identifying wastewater generation points in industrial facilities and characterizing wastewater, wastewater with high pollution load and relatively clean wastewater can be collected in separate lines (TUBITAK MAM, 2016; TOB, 2021). In this way, wastewater streams with appropriate quality can be reused with or without treatment. By separating wastewater streams, water pollution is reduced, treatment performances are improved, energy consumption can be reduced in relation to the reduction of treatment needs, and emissions are reduced through wastewater recovery and recovery of valuable materials. It is also possible to recover heat from separated hot wastewater streams (TUBITAK MAM, 2016; TOB, 2021). Separation of wastewater streams generally requires high investment costs, which can be reduced where it is possible to recover large amounts of wastewater and energy (IPPC BREF, 2006).

- ***Collecting rainwater and utilizing it as an alternative water source for facility cleaning or in suitable areas***

  Nowadays, when water resources are decreasing, rainwater harvesting is frequently preferred especially in regions with low rainfall. There are different technologies and systems for rainwater collection and distribution systems. Cistern systems, ground infiltration, surface collection and filter systems are used. Rainwater collected with special drainage systems can be used for production processes, garden irrigation, tank and equipment cleaning, surface cleaning, etc. if it meets the required quality requirements (Tanık et al., 2015).

  In various examples, roof rainwater collected in industrial facilities was stored and then used inside the building and in landscape areas, resulting in 50% water savings in landscape irrigation (Yaman, 2009). Perforated stones and green areas can be preferred to increase the permeability of the ground and allow rainwater to pass through and be absorbed into the soil on site (Yaman, 2009). Rainwater collected on building roofs can be used for car washing and garden irrigation. It is possible to recover and reuse 95% of the collected water after use through biological treatment (Şahin, 2010).

- ***Optimizing the frequency and duration of regeneration (including rinses) in water softening systems***

  Cationic ion exchange resins, one of the most commonly used methods for softening raw water in industrial plants, are routinely regenerated. In regeneration, pre-washing of the resin using raw water, regeneration with salt water and final rinsing processes are carried out respectively. Regeneration periods are determined depending on the hardness of the water. If the hardness is high, regeneration should be performed more frequently in water softening systems.

  In regeneration processes, washing, regeneration and rinsing wastewaters are usually removed directly. However, if the washing and final rinse water is of raw water quality, it can be sent to raw water storage or reused in processes that do not require high water quality such as facility cleaning and green area irrigation (TOB, 2021).

  It is very important to determine the optimum regeneration frequency in regeneration systems. Although regeneration in water softening systems is adjusted according to the frequencies recommended by the supplier or depending on the flow rate and duration entering the softening system, this frequency also varies depending on the calcium concentration in the raw water. For this reason, online hardness measurement is applied when determining the regeneration frequency. Thus, regeneration frequencies can be optimized and excessive washing rinsing or backwashing with brine can be prevented by using online hardness sensors.

- ***Reuse of pressurized filtration backwash water prior to water softening at appropriate points***

  Many industrial processes require softened water with low calcium and magnesium concentrations. With water softening systems, calcium, magnesium and some other metal cations in hard water are removed from the water and soft water is obtained.

  Savings are achieved by reusing pressurized filtration backwash water at appropriate points before water softening. This measure is similar in content to practices such as "Reuse of filter backwash water in filtration processes, reuse of relatively clean water in production processes, reduction of water consumption by using on-site cleaning systems".

- ***Storage, storage and post-use of substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) and preventing their mixing with wastewater as much as possible*** Dry cleaning techniques in industrial plants to prevent the mixing of chemicals that pose a risk to the aquatic environment such as oils, emulsions and binders into wastewater streams can be used and leaks can be prevented. In this way, water resources can be protected (TUBITAK MAM, 2016).

- ***Construction of closed storage and impermeable waste/scrap sites to prevent the transportation of toxic or hazardous chemicals for the aquatic environment***

  Closed and impermeable waste/scrap storage sites can be constructed in industrial facilities to prevent the transportation of toxic or hazardous chemicals for the aquatic environment to receiving environments. This practice is already being implemented in our country within the scope of existing environmental regulations. Within the scope of the field studies carried out, a separate collection channel can be built in the storage areas of toxic or hazardous substances in industrial facilities to collect the leachate separately and prevent it from mixing into natural water environments.

Water Softening Systems

- ***Use of closed loop water cycles in appropriate processes***

In general terms, refrigerants are chemical compounds with certain thermodynamic properties that take heat from the substances to be cooled and cool them, affecting the performance of the cooling process (Kuprasertwong et al., 2021).

Water is used as a refrigerant in many processes in the manufacturing industry, led by product cooling. During this cooling process, water can be reused through cooling towers or central cooling systems. If unwanted microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MAM, 2016).

By reusing cooling water in processes such as cleaning, water consumption and the amount of wastewater generated is reduced. However, the need for energy for cooling and recirculation of cooling water is a side interaction.

Heat recovery is also provided by the use of heat exchangers in cooling water. Generally, closed loop systems are used in plants using water cooling systems. However, cooling system blowdowns are discharged directly to the wastewater treatment plant channel. This blowdown water can be reused in appropriate production processes.

- ***Avoiding the need to rinse between activities by using compatible chemicals in sequential processes***

Chemical compatibility is a measure of how stable a substance is when mixed with another substance. If two substances mix together and undergo a chemical reaction, they are considered incompatible.

Various chemicals are used in industrial plants to increase washing and rinsing efficiency. The fact that these chemicals are compatible and act as solvents shows a positive trend in increasing the efficiency. Therefore, the dirt on the material can be removed in a shorter time and more effectively and the amount of water used in washing processes can be significantly reduced. In this case, even if the amount of wastewater can be reduced, there may be an increase in the chemical loads carried by the wastewater. These negative effects can be minimized by reusing the washing water containing solvents used in washing rinsing processes.

Water savings of 25-50% are possible by reusing wash water. The application may require reserve tanks and new pipelines. Alternatively, the wash solution can be kept directly in the system and used repeatedly until it loses its properties.

- ***Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality***

Rinsing wastewater in industrial plants is relatively clean wastewater that can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Raw water consumption can be reduced with the recovery of rinse water.
Savings between 1-5% can be achieved.

- ***Production procedures are documented and used by employees to prevent water and energy waste***

  In order to ensure efficient production in an enterprise, effective procedures should be implemented to identify and evaluate potential problems and resources and to control production stages (Ayan, 2010). Determining and implementing appropriate procedures in production processes ensures more efficient use of resources (such as raw materials, water, energy, chemicals, personnel and time) and ensures reliability and quality in production processes (Ayan, 2010). The existence of documented production procedures in production processes contributes to the development of the ability to evaluate business performance and develop immediate reflexes to solve problems (TUBITAK MAM, 2016; TOB, 2021). Effective implementation and monitoring of procedures created specifically for production processes is one of the most effective ways to ensure product quality, receive feedback and develop solutions (Ayan, 2010). Documenting, effectively implementing and monitoring production procedures is a good management practice and an effective tool in structuring and ensuring the continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, the cost and economic gains of the application may vary from sector to sector or depending on the facility structure (TUBITAK MAM, 2016; TOB, 2021). Although establishing and monitoring production procedures is not costly, the payback period may be short considering the savings and benefits (TUBITAK MAM, 2016; TOB, 2021).

- ***Implementing time optimization in production and organizing all processes to be completed as soon as possible***

  In industrial production processes, planning the process from raw material to product by using the minimum number of processes is an effective practice to reduce labor costs, resource utilization costs and environmental impacts and to ensure efficiency. In this context, it may be necessary to revise the production processes to use the minimum number of process steps (TUBITAK MAM, 2016). In cases where the desired product quality cannot be achieved due to some inadequacies, inefficiencies and design errors in basic production processes, production processes may need to be renewed. Therefore, in this case, the resource utilization and the amount of waste, emissions and solid waste generated in the production of a unit amount of product increases. Time optimization in production processes is an effective practice (TUBITAK MAM, 2016).

- ***Separate collection and treatment of gray water in the facility and its use in areas that do not require high water quality (green area irrigation, floor washing, etc.)***

  Wastewater generated in industrial facilities is not only industrial wastewater from production processes, but also includes wastewater from showers, sinks, kitchens, etc. Wastewater from showers, sinks, kitchens, etc. is called gray water. Water savings can be achieved by treating this gray water with various treatment processes and using it in areas that do not require high water quality.

- ***Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) to save water at water usage points such as showers/toilets etc.***

  Water is very important in many sectors of the manufacturing industry, both for production processes and for personnel to maintain the necessary hygiene standards. Water consumption in the production processes of industrial facilities can be achieved in various ways, and water consumption can be saved by using equipment such as sensor faucets and smart hand washing systems in the water usage areas of personnel. Smart hand washing systems provide resource efficiency in addition to water savings while adjusting the water, soap and air mixture at the right ratio.

- ***Use of computer-aided control systems in production processes***

Since inefficient resource utilization and environmental problems in industrial facilities are directly linked to input-output flows, it is necessary to define the process inputs and outputs in the best way for production processes (TUBITAK MAM, 2016). Thus, it becomes possible to develop measures to improve resource efficiency, economic and environmental performance. The organization of input-output inventories is considered a prerequisite for continuous improvement. While such management practices require the participation of technical staff and senior management, they pay for themselves in a short time with the work of various experts (IPPC BREF, 2003). On the basis of the implementation processes, the use of measurement equipment and some routine analyzes/measurements specific to the processes are required. Utilizing computerized monitoring systems as much as possible in order to maximize the efficiency of the application increases the technical, economic and environmental benefits (TUBITAK MAM, 2016).

- ***Reducing water consumption by reusing filter wash water in filtration processes, reusing relatively clean cleaning water in production processes and using clean-in-place systems (CIP)***

Wastewater from backwashing of activated carbon filters and softeners often contains only high levels of suspended solids (TSS). Backwash water, which is one of the easiest types of wastewater to recover, can be recovered by filtration with ultrafiltration plants. In this way, water savings of up to 15% can be achieved (URL - 1, 2021).

Regeneration wastewater generated after the regeneration process is soft water with high salt content and accounts for approximately 5-10% of total water consumption. Regeneration wastewater is collected in a separate tank and utilized in processes with high salt requirements, plant cleaning and domestic use. This requires a reserve tank, plumbing and a pump. By reusing regeneration wastewater, water consumption, energy consumption, wastewater quantities and salt content of wastewater are reduced by approximately 5-10% (Öztürk, 2014). The payback period varies depending on whether the regeneration wastewater is consumed in production processes, plant cleaning or domestic use. The potential payback period is estimatedto be less than one year if regeneration water is reused in production processes that require high salt content (since both water and salt will be recovered). For facility and equipment cleaning and domestic uses, the payback period is estimated to be over one year (MoAF, 2021).

In Turkey, reverse osmosis (RO) concentrates are combined with other wastewater streams and discharged to the wastewater treatment plant channel. The concentrates formed in TO systems used for additional hardness removal can be used in garden irrigation, in-plant and tank-equipment cleaning (TUBITAK MAM, 2016; TOB, 2021). In addition, with the structuring of raw water quality monitoring, it is possible to feed TO concentrates back into the raw water reservoirs and reuse them by mixing (MoAF, 2021).

2.1.4 Precautions for Auxiliary Processes

BATs for cooling systems

- ***Use of closed loop cooling system to reduce water usage***

  Closed loop cooling systems significantly reduce water consumption compared to open loop systems, which are more water intensive. In closed loop systems, the same amount of water is recirculated within the system, usually requiring the addition of cooling water equal to the amount of water evaporated. By optimizing cooling systems, evaporation losses can also be reduced.

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Cooling Systems (Chiller)

https://www.chiller.com.tr/wp-content/uploads/2018/04/chiller-sogutma-kapasitesi-he

Bibliography

- Abbassi, B., & Al Baz, I. (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.
- Ayan, B. (2010). International Certification Systems in Welded Manufacturing Enterprises. Izmir: Dokuz Eylül University, Institute of Social Sciences, Department of Business Administration, Master's Thesis.
- Christopher, S. (1998). ISO 14001 and Beyond Environmental Management Systems in the Real World.
- MoEU. (2020e). Cleaner Production Practices in Certain Sectors Project. Republic of Turkey Ministry of Environment, Urbanization and Climate Change General Directorate of Environmental Management.
- 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.
- EC. (2009). Source Document on Optimal Techniques for Energy Efficiency. European Commission.
- 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.
- 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. Retrieved from https://eippcb.jrc.ec.europa.eu/reference
- 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. (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.
- Kuprasertwong, N., Padungwatanaroj, O., Robin, A., Udomwong, K., Tula, A., Zhu, L., . . . Gani, R. (2021). Computer-Aided Refrigerant Design: New Developments.
- 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). Chlorination Guide: Chlorination of Drinking and Potable Water. Ankara: Gülhane Military Medical Academy, Department of Public Health.
- Ozturk, E. (2022). Improving Water-Use Efficiency and Environmental Performances in an Integrated Woven-Knitted Fabric Printing-Dyeing Textile Mill. Journal of Cleaner Production. doi:https://doi.org/10.1016/j.jclepro.2022.134805
- Özdemir, K., & Toröz, İ. (2010). Monitoring of Chlorination By-Products in Drinking Water Sources with Differential UV Spectroscopy Method. ITU Journal.
- Öztürk, E. (2014). Integrated Pollution Prevention and Control and Cleaner Production Practices in Textile Sector. 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.
- Sahin, N. I. (2010). Water Conservation in Buildings. Istanbul Technical University, Institute of Science and Technology, Master's Thesis.
- Tanık, A., Öztürk, İ., & Cüceloğlu, G. (2015). Reuse of Treated Wastewater and Rainwater Harvesting Systems (Handbook). Ankara: Union of Municipalities of Turkey.

- TOB. (2021). Technical Assistance Project for Economic Analyses and Water Efficiency Studies within the Scope of River Basin Management Plans in 3 Pilot Basins. Republic of Turkey Ministry of Agriculture and Forestry.
- TUBİTAK MAM. (2016). Determination of Cleaner Production Opportunities and Applicability in Industry (SANVER) Project, Final Report. Scientific and Technological Research Council of Turkey Marmara Research Center.
- URL - 1. (2021). Recovery of Filter Backwash Water. Retrieved from https://rielli.com/portfolio/filtre-ters- yikama-sularinin-geri-kazanimi/
- Yaman, C. (2009). Siemens Gebze Facilities Green Building. IX. National Installation Engineering Congress.

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