REPUBLIC OF Türkiye
MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency
Campaign

Water Efficiency Guidance Documents Series

ALUMINIUM PRODUCTION

NACE KODU: 24.42

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Contents

Abbreviations

AAT	Wastewater Treatment Plant
EU	Europe Union
AKM	Suspended Solids
BREF	Best Available Techniques Reference Document
EMS	Environment Management System
CSIDB	Ministry of Environment, Urbanization and Climate Change of the Republic of Türkiye
DOM	Natural Organic Matter
EMAS	Eco Management and Control Program Directive
EPA	United States Environmental Protection Agency
IPC	Industrial Pollution Prevention and Control
ISO	International Standards Organization
MET	Best Available Techniques
NACE	Statistical Classification of Economic Activities
SYGM	General Directorate of Water Management
TO	Reverse Osmosis
TOB	Ministry of Agriculture and Forestry of the Republic of Türkiye
TUIK	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
WHEW	Ultrafiltration
AGE	Groundwater
YUS	Surface Water

1 Introduction

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

The usable annual water amount per capita in our country for 2022 is 1,313 m^3, and with human pressures and the effects of climate change, the usable annual water amount per capita is expected to fall below 1,000 cubic meters after 2030. It is obvious that if the necessary measures are not taken, Turkey will become a country suffering from water scarcity in the very near future, bringing with it many negative social and economic consequences. As can be understood from the results of the projections for the future, 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 "the use of the least amount of water in the production of a product or service". The water efficiency approach; It is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, especially drinking water, agriculture, industry and households, by protecting the amount and quality of water and taking into account the needs of not only people but also all living things with ecosystem sensitivity.

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

In the sustainable development vision determined by the United Nations, within the scope of Goal 7 of the Millennium Development Goals: Ensuring Environmental Sustainability, Goal 9 of the Sustainable Development Goals: Industry, Innovation and Infrastructure and Goal 12 of the Responsible Production and Consumption, issues such as efficient, equitable and sustainable use of resources, especially water, environmentally friendly production and consumption that are concerned about future generations are included.

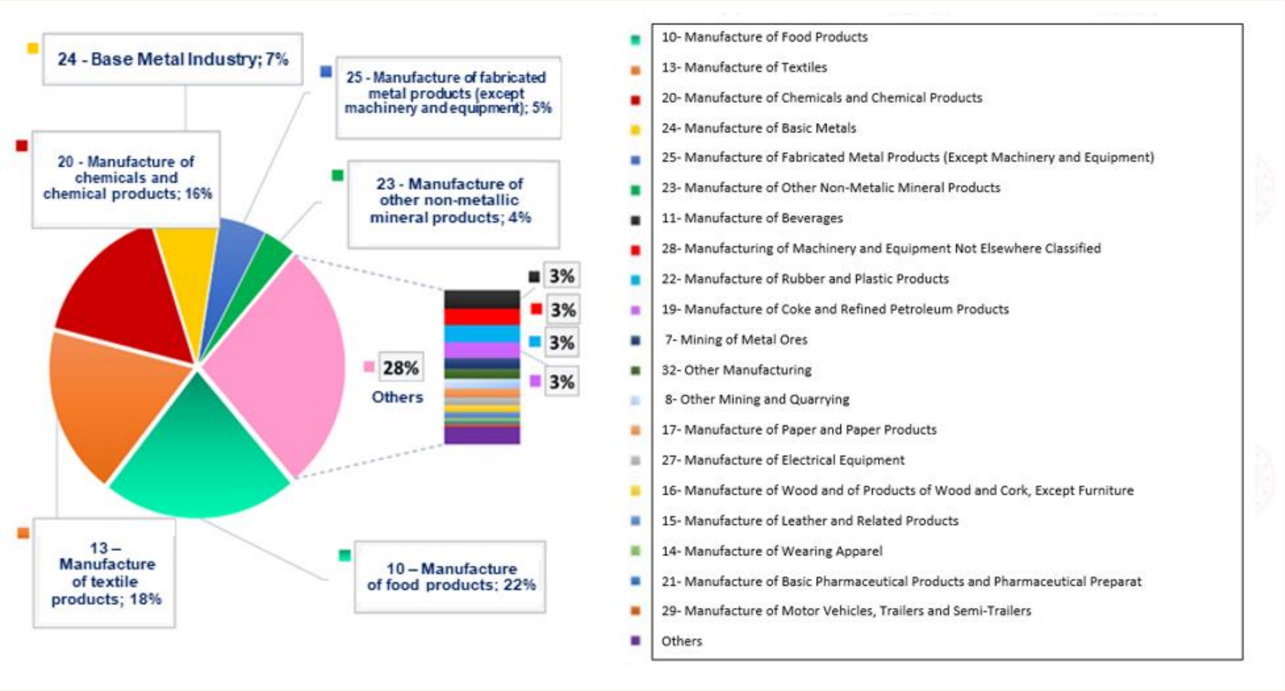
Within the scope of the European Green Deal, in which member countries have agreed on targets such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing environmental impacts, actions emphasizing water and resource efficiency 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 (IED), one of the most important components of the European Union environmental legislation in terms of industry, includes measures to be taken to control, prevent or reduce discharges/emissions originating from industrial activities and made to the receiving environment, including air, water and soil, with an integrated approach. In the Directive, Best Available Techniques (BAT) have been presented in order to systematize the applicability of cleaner production processes and to eliminate the difficulties experienced in implementation. BATs are the most effective application techniques for high-level protection of the environment when their costs and benefits are taken into account. In accordance with the Directive, Reference Documents (BAT-BREF) have been prepared in which BATs are explained in detail for each sector. In BREF documents, BATs are presented within a general framework such as good management practices, techniques of general precautions, 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 is carrying out studies aimed at spreading efficient practices in urban, agricultural, industrial and individual water use and increasing social awareness. Within the scope of the "Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework of Adaptation to the Changing Climate", which entered into force with the Presidential Circular No. 2023/9, water efficiency action plans addressing all sectors and stakeholders have been prepared. A total of 12 actions have been determined for the 2023-2033 period in the Industrial Water Efficiency Action Plan, and responsible and relevant institutions have been assigned for the said actions. Within the scope of the said Action Plan; conducting studies on determining specific water use intervals and quality requirements on a sub-sector basis in the industry, organizing technical training programs and workshops on a sectoral basis and preparing water efficiency guide documents have been defined as the responsibility of the General Directorate of Water Management.

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

As in the world, the sectors with the highest share in water consumption in our country are the 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, primarily food, textile, chemical and basic metal industries, representing different capacity and variety of production areas 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 and recovery were obtained and the best available techniques (MET) and sectoral reference documents (BREF) published by the European Union, water efficiency, clean production, water footprint, etc. information was provided on the issues.



Distribution of water usage in industry on a sectoral basis in our country

As a result of the studies, specific water consumption levels and potential savings rates were determined for businesses across 152 distinct 4-digit NACE codes with high water consumption. Water efficiency guidance documents were prepared by taking into account the EU's Best Available Techniques (BAT) and other clean production techniques. These guides analyze a total of 500 BATs (Best Available Techniques) for water efficiency, categorized under four main groups: (i) Good Management Practices, (ii) General Preventive Measures, (iii) Auxiliary Process Measures, and (iv) Sector-Specific Measures.

During the project, environmental benefits, operational data, technical specifications-requirements, and applicability criteria were considered in identifying BATs for each sector. The determination of BATs was not limited to BREF documents; updated global literature data, real case analyses, innovative applications, and reports from sector representatives were also examined in detail to compile sector-specific BAT lists. For evaluating the compatibility of these BAT lists with the local industrial infrastructure and capacity in Turkey, specific BAT lists were prepared for each NACE code. These lists were prioritized based on water savings, economic savings, environmental benefits, applicability, and cross-media impact criteria, and final BAT lists were determined using these prioritization scores. Sectoral water efficiency guides were created based on NACE codes, using the final BAT lists identified by incorporating data from the water and wastewater records of the visited facilities and local dynamics highlighted by sectoral stakeholders.

2 Scope of the Study

The guidance documents prepared within the scope of industrial water efficiency measures include the following main sectors:

- Crop and animal production, hunting, and related service activities (including 6 sub-production areas represented by 4-digit NACE codes)
- Fishing and aquaculture (including 1 sub-production area represented by a 4-digit NACE code)
- Mining of coal and lignite (including 2 sub-production areas represented by 4-digit NACE codes)
- Support services for mining (including 1 sub-production area represented by a 4-digit NACE code)
- Metal ore mining (including 2 sub-production areas represented by 4-digit NACE codes)
- Other mining and quarrying (including 2 sub-production areas represented by 4-digit NACE codes)
- Manufacture of food products (including 22 sub-production areas represented by 4-digit NACE codes)
- Manufacture of beverages (including 4 sub-production areas represented by 4-digit NACE codes)
- Manufacture of tobacco products (including 1 sub-production area represented by a 4-digit NACE code)
- Manufacture of textiles (including 9 sub-production areas represented by 4-digit NACE codes)
- Manufacture of clothing (including 1 sub-production area represented by a 4-digit NACE code)
- Manufacture of leather and related products (including 3 sub-production areas represented by 4-digit NACE codes)
- Manufacture of wood, wood products, and cork products (excluding furniture); manufacture of woven products from reed, straw, and similar materials (including 5 sub-production areas represented by 4-digit NACE codes)
- Manufacture of paper and paper products (including 3 sub-production areas represented by 4-digit NACE codes)
- Manufacture of coke and refined petroleum products (including 1 sub-production area represented by a 4-digit NACE code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by 4-digit NACE codes)
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (including 1 sub-production area represented by a 4-digit NACE code)
- Manufacture of rubber and plastic products (including 6 sub-production areas represented by 4-digit NACE codes)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by 4-digit NACE codes)
- Basic metal industry (including 11 sub-production areas represented by 4-digit NACE codes)
- Manufacture of fabricated metal products (excluding machinery and equipment) (including 12 sub-production areas represented by 4-digit NACE codes)
- Manufacture of computers, electronic, and optical products (including 2 sub-production areas represented by 4-digit NACE codes)
- Manufacture of electrical equipment (including 7 sub-production areas represented by 4-digit NACE codes)
- Manufacture of machinery and equipment not elsewhere classified (including 8 sub-production areas represented by 4-digit NACE codes)
- Manufacture of motor vehicles, trailers, and semi-trailers (including 3 sub-production areas represented by 4-digit NACE codes)
- Manufacture of other transportation equipment (including 2 sub-production areas represented by 4-digit NACE codes)

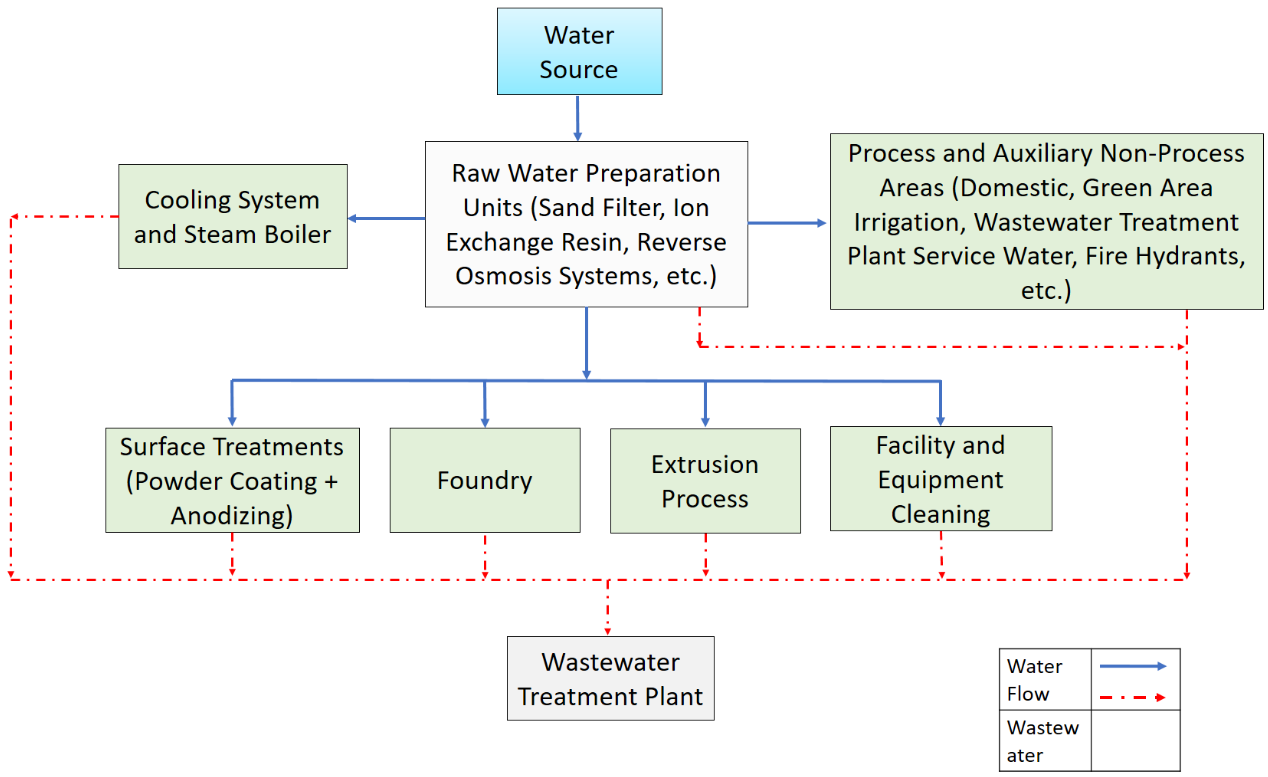
- Other manufacturing (including 2 sub-production areas represented by 4-digit NACE codes)
- Installation and repair of machinery and equipment (including 2 sub-production areas represented by 4-digit NACE codes)
- Production and distribution of electricity, gas, steam, and ventilation systems (including 2 sub-production areas represented by 4-digit NACE codes)
- Waste collection, treatment, and disposal activities; materials recovery (including 1 sub-production area represented by a 4-digit NACE code)
- Construction of non-residential buildings (including 1 sub-production area represented by a 4-digit NACE code)
- Storage and support activities for transportation (including 1 sub-production area represented by a 4-digit NACE code)
- Accommodation (including 1 sub-production area represented by a 4-digit NACE code)
- Educational activities (Higher Education Campuses) (including 1 sub-production area represented by a 4-digit NACE code)
- Sports, entertainment, and recreational activities (including 1 sub-production area represented by a 4-digit NACE code)

"Basic Metal Industry" and "Manufacture of Fabricated Metal Products (excluding machinery and equipment) "

"The sub-production branches for which guidance documents have been prepared under the sectors of "Basic Metal Industry" and "Manufacture of Fabricated Metal Products (excluding machinery and equipment)" are as follows:"
24.10 Manufacture of basic iron and steel products and ferroalloys
24.20 Manufacture of tubes, pipes, hollow profiles, and related fittings of steel
24.31 Cold drawing of bars
24.32 Cold rolling of narrow strips
24.34 Cold drawing of wire
24.41 Precious metal production
24.42 Aluminium production
24.51 Casting of iron
24.52 Casting of steel
24.53 Casting of light metals
24.54 Casting of other non-ferrous metals
25.12 Manufacture of metal doors and windows
25.21 Manufacture of central heating radiators (excluding electric radiators) and boilers for hot water
25.30 Manufacture of steam generators, except central heating hot water boilers
25.50 Forging, pressing, stamping, and roll-forming of metal; powder metallurgy
25.61 Treatment and coating of metals
25.62 Machining and shaping of metals
25.71 Manufacture of cutlery and other cutting tools
25.73 Manufacture of hand tools, tool parts, saw blades, etc.
25.92 Manufacture of light metal packaging materials
25.93 Manufacture of wire products, chains, and springs
25.94 Manufacture of fasteners and screw machine products
25.99 Manufacture of other fabricated metal products not elsewhere classified

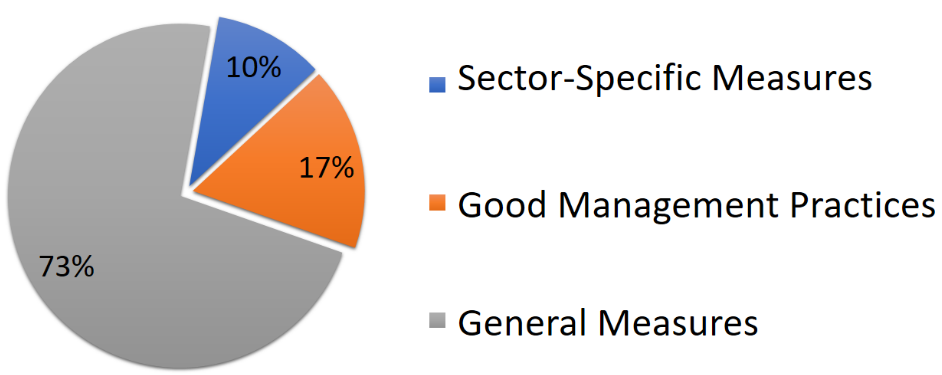
2.1 Aluminum Production (NACE 24.42)

Aluminum Production Sector Water Flow Diagram



	Minimum	Maximum
Facilities Visited Within the Scope of the Project Specific Water Consumption (L/kg product)	3.8	6.3
Reference Specific Water Consumption (L/kg product)	2.3	9.2

Percentage Distribution of Water Efficiency Practices



Aluminum material is processed through extrusion, rolling, and casting techniques to be transformed into various products. Using the extrusion method, products such as aluminum profiles, rods, pipes, strips, and wire rods are produced in various dimensions and shapes. Additionally, aluminum is shaped into parts of different sizes and forms through methods like permanent mold casting, pressure casting, or sand casting. Due to its lightweight nature, aluminum is ideal for the distribution of electrical energy; therefore, energy lines today are constructed from aluminum materials. Aluminum conductors are produced by continuously casting wire rods, drawing the wire rods into wires at the rolling mill, and then braiding the wires.

In aluminum production, water is used in surface treatments, foundries, and extrusion processes. To produce soft water for manufacturing processes, substantial water consumption occurs in raw water preparation units such as sand filters, ion exchange resins, and reverse osmosis units for filter washing, resin regeneration, and membrane cleaning. Additionally, water is consumed in auxiliary processes like cooling systems and steam boilers.

The reference specific water consumption in aluminum production ranges from 2.3 to 9.2 L/kg. The specific water consumption for the production branch analyzed in this study is between 3.8 and 6.3 L/kg. By implementing sector-specific measures, good management practices, and general preventive measures, water savings of 26–66% are achievable in the sector.

24.42 Aluminum Production Priority water efficiency application techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Explanation	Prioritized Sectoral Water Efficiency Techniques
24.42	Aluminum production	**Industry Specific Measures**
		1. To save water in cooling systems; reducing the amount of water by combining the evaporation step with gradual (cascade type) and/or eco-rinse systems.
		2. Reducing water consumption in rinsing processes by using spray rinsing systems
		3. Use of washing-rinsing wastewater in a closed loop, recovery or reuse including chemical recovery.
		Good Management Practices
		1. Using an integrated wastewater management and treatment strategy to reduce wastewater volume and pollutant load
		2. Establishment of environmental management system
		3. Preparation of a water efficiency action plan to reduce water use and prevent water pollution
		4. Providing technical training to personnel for the reduction and optimization of water usage
		5. Determining water efficiency targets
		General Precautions
		1. Minimizing spills and leaks
		2. Recovering water from rinse solutions and reusing the recovered water in processes appropriate to its quality
		3. Use of automatic equipment and hardware (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets etc.
		4. Use of pressure washing systems in equipment cleaning, general cleaning, etc.
		5. Reusing filter wash water in filtration processes, reusing relatively clean cleaning water in production processes, and reducing water consumption by using cleaning-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. Detection and reduction of water losses
		9. Use of automatic control-shutoff valves to optimize water usage
		10. Reuse of pressurized filtration backwash waters before water softening at appropriate points
		11. Optimizing the frequency and duration of regeneration (including rinses) in water softening systems
		12. Establishing closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals to the aquatic environment.
		13. substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) from being stored, stored, and mixed with wastewater after use.
		14. Preventing clean water streams from mixing with dirty water streams

NACE Code	NACE Code Explanation	Prioritized Sectoral Water Efficiency Techniques
		15. Determination of wastewater streams that can be reused with or without treatment by characterizing the quantities and qualities of wastewater at all wastewater generation points.
		16. Use of closed loop water cycles in suitable processes
		17. Reuse of relatively clean wastewater resulting from washing, rinsing and equipment cleaning in production processes without treatment.
		18. Determining the scope of reuse of washing and rinsing waters
		19. Grey water is collected and purified separately in the facility and used in areas that do not require high water quality (green area irrigation, ground washing, etc.)
		20. Implementing time optimization in production and arranging all processes to be completed in the shortest time possible.
		21. Collecting rainwater and using it as an alternative water source for facility cleaning or in suitable areas.
A total of 29 techniques were proposed in this sector.		

Aluminum Production
NACE To your code
Oriented;

(i) To the sector Unique Measures,
(ii) Good Management Applications,
(iii) General Measures
separate Titles in is given.

2.1.1 Industry Specific Measures

- ***Reducing Water Consumption in Rinsing Processes by Using Spray Rinsing Systems***

In industrial processes, rinsing is performed to clean residues from the product and/or prepare it for the next process. Rinsing processes generally consume large amounts of process water, and the rinse wastewater is usually of a quality suitable for reuse. In many cases, more water than necessary is used in rinsing processes. Where technically feasible, spray rinsing systems can be employed to reduce water consumption in rinsing processes. This can provide water savings of up to 30%, allowing the same amount of rinsing with less water. Although the initial investment costs can vary depending on the characteristics of the process, they are generally not high, resulting in a short payback period.

- ***Reusing Wash-Rinse Wastewater in a Closed Loop System or Including Chemical Recovery***

In industrial production processes, wash and rinse wastewater are relatively clean wastewater sources. Therefore, wash-rinse wastewater can be reused in production processes without treatment. In some processes, however, wash-rinse water may contain washing chemicals, such as solvents, to ensure effective cleaning. These wastewaters can be reused in the same processes after replenishing any missing chemicals. This approach can lead to significant savings in both chemicals and water in wash-rinse processes. Additionally, reductions can be achieved in wastewater volume and chemical loads. The initial investment cost for implementation is low (mainly requiring only piping and a reserve tank), with a potentially short payback period.

- ***Reducing Water Consumption in Cooling Systems through Cascaded Evaporation and Eco-Rinsing Systems***

To save water in cooling systems, combining the evaporation step with cascaded (cascade type) and/or eco-rinsing systems can yield variable savings/benefits in different industrial facilities. This approach is similar to "water savings achieved by reusing boiler condensate," offering comparable benefits.

2.1.2 Good Management Applications

- ***E stablishment of environmental management system***

Environmental Management Systems (EMS) include the organizational structure, responsibilities, procedures and resources required to develop, implement and monitor the environmental policies of industrial organizations. Establishing an environmental management system improves the decision-making processes of institutions regarding raw materials, water-wastewater infrastructure, planned production processes and different treatment techniques. Environmental management organizes how to manage resource supply 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. Among its alternatives is the Eco-Management and Audit Program Directive (EMAS) (761/2001). It was developed for the assessment, improvement and reporting of the environmental performance of enterprises. It is one of the leading applications within the scope of eco-efficiency (cleaner production) in EU legislation and participation is provided voluntarily (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).

• By adopting International Standards Organization (ISO) standards, greater compliance with global legal and regulatory requirements is achieved (Christopher, 1998).

• While the risks of penalties related to environmental liabilities are minimized, a decrease in the amount of waste, resource consumption and operating costs is achieved (Delmas, 2009).

• The use of internationally accepted environmental standards eliminates the need for multiple registrations and certificates 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 considered important 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 institutions' better position in international areas/markets (Potoski & Prakash, 2005).

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

Industrial organizations are also conducting studies within the scope of the ISO 14046 Water Footprint Standard, which is an international standard that defines the requirements and guidelines for assessing and reporting water footprints. The implementation of the relevant standard aims to reduce the use of fresh water required for production and environmental impacts. In addition, the ISO 46001 Water Efficiency Management Systems Standard, which helps industrial organizations save water and reduce operating costs, helps organizations develop their water efficiency policies by conducting monitoring, benchmarking and review studies.

- ***Use of integrated wastewater management and treatment strategy to reduce wastewater volume and pollutant load***

A 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 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) .

The reuse of treated wastewater in the facility not only improves the quality of water bodies but also reduces the demand for fresh water. Therefore, it is very important to determine appropriate treatment strategies for different reuse targets.

In integrated industrial wastewater treatment, different aspects such as wastewater collection system, treatment process and reuse target are evaluated together. (Naghedi, Moghaddam, & Piadeh, 2020) . For industrial wastewater recovery, an integrated wastewater management framework can be determined by combining methods such as the SWOT method (strengths, weaknesses, opportunities and threats), the PESTEL method (political, economic, social, technological, environmental and legal factors) , and the decision tree with expert opinions (Naghedi, Moghaddam, & Piadeh, 2020) . Integrating the Analytical Hierarchy Process (AHP) and the Combined Consensus Solution (CoCoSo) techniques, can be used to set priorities for industrial wastewater management processes based on a number of criteria (Adar, Delice, & Adar, 2021) .

25% in water consumption, wastewater amount and wastewater pollution loads can be achieved. The potential payback period of the application varies between 1 and 10 years (TOB, 2021) .

Industrial Wastewater Treatment Plant

- ***Providing technical training to personnel for the reduction and optimization of water usage***

  With this measure, water saving and water recovery can be achieved by increasing the training and awareness of personnel, and water efficiency can be achieved by reducing water consumption and costs. In industrial facilities, problems related to high amounts of water consumption and wastewater formation can occur due to the lack of necessary technical knowledge of personnel. For example, it is important for cooling tower operators, who represent a significant proportion of water consumption in industrial operations, to be properly trained and have technical knowledge. The relevant personnel must also 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 provide training to personnel on water use reduction, optimization and water saving policies. Practices such as including personnel in water saving studies, creating regular reports on water usage amounts before and after water efficiency initiatives and sharing these reports with personnel support participation and motivation in the process. Technical, economic and environmental benefits to be obtained through personnel training yield results in the medium or long term (TUBITAK MAM, 2016; TOB, 2021) .

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

  In order to reduce the amount of water and wastewater in industrial facilities and to prevent water pollution, it is important to prepare an action plan that includes short, medium and long-term actions in terms of water efficiency. At this point, water needs should be determined throughout the facility and in production processes, quality requirements should be determined at water usage points, wastewater generation points and wastewater characterization should be carried out (TOB, 2021) . At the same time, it is necessary to determine the measures to be implemented to reduce water consumption, wastewater generation and pollution loads, to conduct feasibility studies and to prepare action plans for the short-medium-long term. In this way, water efficiency and sustainable water use are ensured in the facilities (TOB, 2021) .

- ***Determining water efficiency targets***

  The first step in ensuring water efficiency in industrial facilities is to determine targets (TOB, 2021) . For this purpose, a detailed water efficiency analysis must be carried out on a process basis. In this way, unnecessary water usage, water losses, incorrect applications affecting water efficiency, process losses, water that can be reused with or without treatment, etc. can be determined. It is also extremely important to determine water saving potential and water efficiency targets for each production process and the facility in general (TOB, 2021)

2.1.3 General Measures In the nature of Measures

- ***Detection and reduction of water losses***

In industrial production processes, water losses occur in equipment, pumps and pipelines. First of all, water losses should be determined and leaks should be prevented by regularly maintaining equipment, pumps and pipelines and keeping them in good condition (IPPC BREF, 2003) . Regular maintenance procedures should be established and attention should be paid to the following issues in particular:

Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist,

Conducting inspections not only on the water system, but also specifically on heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps and valves.

Regular cleaning of filters and pipelines,

Calibrating, routinely checking and monitoring measuring 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% to 6% in water consumption can be achieved (Öztürk, 2014) .

- ***Minimizing spills and leaks***

Spills and leaks in businesses can cause both raw material and water losses. In addition, if wet cleaning methods are used to clean spilled areas, water consumption, wastewater amounts and pollution loads of wastewater may increase (TOB, 2021) . In order to reduce raw material and product losses, spillage and splash losses are reduced by using splash guards, wings, drip trays and sieves (IPPC BREF, 2019) .

- ***Reuse of relatively clean wastewater resulting from washing, rinsing and equipment cleaning in production processes without treatment.***

In industrial facilities, wastewater with relatively clean characteristics, especially washing-final rinse wastewater and filter backwash wastewater, can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality, thus providing savings of 1-5% in raw water consumption. The initial investment costs required for the application consist of the establishment of new pipelines and reserve tanks (Öztürk, 2014) .

- ***Preventing clean water streams from mixing with dirty water streams***

By determining the wastewater generation points in industrial facilities and characterizing the 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 increased, energy consumption can be reduced in relation to the reduction of treatment needs, and emissions are reduced by ensuring wastewater recovery and recovery of valuable materials. In addition, heat recovery from separated hot wastewater streams is also possible (TUBITAK MAM, 2016; TOB, 2021). Separation of wastewater streams generally requires high investment costs, and costs can be reduced in cases where it is possible to recover high amounts of wastewater and energy (IPPC BREF, 2006) .

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

  By determining and characterizing wastewater generation points in industrial facilities, it is possible to reuse various wastewater streams with or without treatment (Öztürk, 2014; TUBİTAK MAM, 2016; TOB, 2021) . In this context, filter backwash water, RO concentrates, blowdown water, condensate water, relatively clean washing and rinsing water 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). Apart from this, it is possible to reuse wastewater streams that cannot be directly reused in production processes after being treated 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 often used for pretreatment of water before it goes to the NF or RO process. (Singh, et al., 2014) .

- ***Cooling water as process water in other processes***

  Water cooling systems are widely used in processes where thermal energy is used intensively and cooling is required. It is possible to save water and energy by using heat exchangers in cooling water return, preventing the pollution of cooling water and increasing cooling water return rates (TUBITAK MAM, 2016; TOB, 2021) . In addition, if cooling waters are collected separately, it is generally possible to use the collected water for cooling purposes or to re-evaluate it in appropriate processes (EC, 2009) . Reusing cooling water can save 2–9% of total water consumption (Greer, Keane, Lin, & James, 2013) . Savings of up to 10% can be achieved in energy consumption (Öztürk, 2014; TOB, 2021) .

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

  In industrial facilities, relatively clean wastewater, especially washing-final rinse wastewater and filter backwash wastewater, 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 1–5% in raw water consumption (TOB, 2021) .

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

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

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

  Today, 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 (Tanik, Ozturk, & Cuceoglu, 2015) .

  In various examples, 50% water savings were achieved in landscape irrigation by storing roof rainwater collected in industrial facilities and using it inside the building and in landscape areas (Yaman, 2009) . In order to increase the permeability of the ground and to ensure that rainwater passes into the soil and is absorbed in the field, perforated stones and green areas can be preferred (Yaman, 2009) . Rainwater collected on building roofs can be used for car washing and garden watering. After use, 95% of the collected water can be recovered and reused through biological treatment (Şahin, 2010).

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

  Water is very important for both production processes and for personnel to provide the necessary hygiene standards in many sectors of the manufacturing industry. Water consumption in the production processes of industrial facilities can be provided in various ways, as well as savings in water consumption can be achieved by using equipment such as sensor taps and smart hand washing systems in areas where personnel use water. Smart hand washing systems adjust the mixture of water, soap and air in the right proportions, while also providing resource efficiency in addition to water savings.

- ***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 facilities, are routinely regenerated. In regeneration, the resin is pre-washed using raw water, regenerated with salt water and final rinsed . Regeneration periods are determined depending on the hardness of the water. If the hardness is high, regeneration should be done more frequently in water softening systems.

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

  Determining the optimum regeneration frequency in regeneration systems is very important. Although regeneration in water softening systems is adjusted according to the frequency recommended by the supplier or depending on the flow rate and time 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. In this way, regeneration frequencies can be optimized and excessive washing and rinsing or backwashing with salt water can be prevented by using online hardness sensors.

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

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


https://www.youtube.com/watch?v=Deazp2Ukgio

Water Softening Systems

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

Refrigerants are generally chemical compounds with certain thermodynamic properties that cool the substances to be cooled by taking heat from them and affecting the performance of the cooling process (Kuprasertwong, ve diğerleri, 2021).

In manufacturing industry processes and many processes, primarily product cooling, water is used as a coolant. 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 are reduced. However, the need for energy for cooling and recirculation of cooling waters emerges as a side effect.

Heat recovery is also achieved by using heat exchangers in cooling water. Closed loop systems are generally used in facilities where water cooling systems are used. However, cooling system blowdowns are removed by being given directly to the wastewater treatment plant channel. These removed blowdown waters can be reused in suitable production processes.

- ***Recovering water from rinse solutions and reusing the recovered water in processes appropriate to its quality***

In industrial facilities, rinsing wastewater is relatively clean and can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014) . By recycling rinsing water, savings of 1-5% can be achieved in raw water consumption.

- ***Using automatic control-shutoff valves to optimize water usage***

Monitoring and controlling water consumption using flow control devices, meters and computer-aided monitoring systems provides significant advantages in technical, environmental and economic terms (Öztürk, 2014). Monitoring the amount of water consumed within the facility and in various processes prevents water losses (TUBİTAK MAM, 2016). It is necessary to use flow meters and meters in the facility in general and in production processes, to use automatic shut-off valves and valves in continuously operating machines, and to develop monitoring-control mechanisms according to water consumption and certain quality parameters determined by using computer-aided systems (TUBİTAK MAM, 2016). With this application, it is possible to achieve savings of up to 20-30% in 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 can be achieved in process water consumption (Öztürk, 2014).

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

  Wastewater resulting from backwashing of activated carbon filters and softening devices mostly contains only high levels of suspended solids (SS). Backwash water, which is one of the easiest wastewater types to recover, can be recycled by filtering with ultrafiltration facilities. In this way, water savings of up to 15% are achieved (URL - 1, 2021) .

  The regeneration wastewater formed after the regeneration process is soft water with high salt content and constitutes approximately 5-10% of the total water consumption. Regeneration wastewater is collected in a separate tank and used in processes requiring high salt, facility cleaning and domestic use. A reserve tank, water installation and pump are needed for this. By reusing regeneration wastewater, a reduction of approximately 5-10% is achieved in water consumption, energy consumption, wastewater amounts and salt content of wastewater (Öztürk, 2014) . The payback period varies depending on whether regeneration water is consumed in production processes, facility cleaning, and domestic purposes. In case of reuse of regeneration water in production processes requiring high salt (since both water and salt will be recovered), the potential payback period is estimated to be less than one year. In facility and equipment cleaning and domestic uses, the payback period is estimated to be over one year (TOB, 2021) .

  In our country, reverse osmosis (RO) concentrates are combined with other wastewater streams and given to the wastewater treatment plant channel. The concentrates formed in RO 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 monitoring for raw water quality, it is possible to re-evaluate RO concentrates by feeding them back into raw water tanks and mixing them (TOB, 2021) .

- ***Reuse of pressurized filtration backwash waters at appropriate points before water softening***

  Today, there is a need for softened process waters 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.

  Various savings can be achieved by reusing pressurized filtration backwash waters at appropriate points before water softening. This measure is similar in content to applications such as "Reuse of filter backwash waters in filtration processes and relatively cleaning waters in production processes, and reduction of water consumption by using on-site cleaning systems".

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

  In different sub-sectors of the manufacturing industry, water with different water quality can be used in accordance with production purposes. In industrial facilities, raw water, usually obtained from underground water sources, is used in production processes after being purified. However, in some cases, drinking water can be used directly, despite being costly in production processes, or raw water is disinfected with chlorinated compounds and then evaluated in production processes. These waters containing residual chlorine can react with organic compounds (natural organic substances (DOM)) in water during production processes and form harmful disinfectant by-products in terms of living metabolisms. (Özdemir & Toröz, 2010; Oğur, Tekbaş, & Hasde, 2004; TOB, 2021) . The use of drinking water containing residual chlorine compounds or raw water disinfected with chlorinated compounds should be avoided as much as possible. Instead of chlorine disinfection in the disinfection of raw water, disinfection methods with high oxidation capacity such as ultraviolet (UV), ultrasound (US) or ozone can be used. In order to increase the technical, economic and environmental benefits to be provided by the application, determining and using the water quality parameters required in each production process helps to reduce unnecessary water supply and treatment costs. It is possible to reduce water, energy and chemical costs with this application (TUBITAK MAM, 2016) .

- ***Substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) from being stored, stored, and mixed with wastewater after use.***

  In industrial facilities, water recovery is achieved by using dry cleaning techniques and preventing leaks in order to prevent chemicals that pose a risk to the aquatic environment, such as oils, emulsions and binders, from mixing into wastewater streams (TUBITAK MAM, 2016)

- ***Establishing closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals to the aquatic environment.***

  In industrial facilities, closed and impermeable waste/scrap storage areas can be built to prevent the transfer of toxic or hazardous chemicals to the recipient environment for the aquatic environment. This practice is currently implemented within the scope of current environmental regulations in our country. Within the scope of the field studies carried out, a separate collection channel can be built for toxic or hazardous substance storage areas in industrial facilities, and the leakage water in question can be collected separately and prevented from mixing with natural water environments.

- ***Production and organization of all processes to be completed in the shortest time possible.***

  In industrial production processes, planning the process from raw material to product by using the least amount of processes is an effective practice to reduce labor costs, resource usage costs and environmental impacts and to ensure efficiency. In this context, it may be necessary to review production processes and revise them to use the least 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 usage required for the production of a unit amount of product and the amount of waste, emissions and solid waste generated increase. Time optimization in production processes is an effective application (TUBITAK MAM, 2016) .

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