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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Guidance Documents Series

MANUFACTURE OF CUTLERY AND OTHER CUTTING TOOLS

NACE code: 25.71

ANKARA/January 2023

Tarı Ministry of Agriculture and Forestry, General Directorate of Water Management Contractor io Environmental Solutions R&D Ltd. Sti. has been prepared.

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Abbreviations

WTP	Wastewater Treatment Plant
EU	European Union
SSM	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
MoEUCC	Republic of Turkey Ministry of Environment, Urbanization and Climate Change
NOM	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
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GSWM	General Directorate of Water Management
RO	Reverse Osmosis
MAF	Republic of Turkey Ministry of Agriculture and Forestry
TurkStat	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
SW	Surface Water

1 Entrance

Our country is located in the Mediterranean basin, where the effects of global climate change are felt intensely, and is considered 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 2022, the annual amount of usable water per capita in our country is 1,313 m^3, and it is expected that the annual amount of usable water per capita will fall below 1,000 cubic meters after 2030 due to human pressures and the effects of climate change. 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 and will bring many negative social and economic consequences. As 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.

With the increasing demand for water resources, the change in precipitation and temperature regimes as a result of climate change, the increase in population, urbanization and pollution, it is becoming more and more important to share the usable water resources among the users in a fair and balanced way. For this reason, it has become a necessity to create a roadmap 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, issues such as efficient, fair and sustainable use of resources, especially water, environmentally friendly production and consumption that are of concern to future generations are included within the scope of Goal 7: Ensuring Environmental Sustainability from the Millennium Development Goals and Goal 9: Industry, Innovation and Infrastructure from the Sustainable Development Goals and Goal 12: Responsible Production and Consumption.

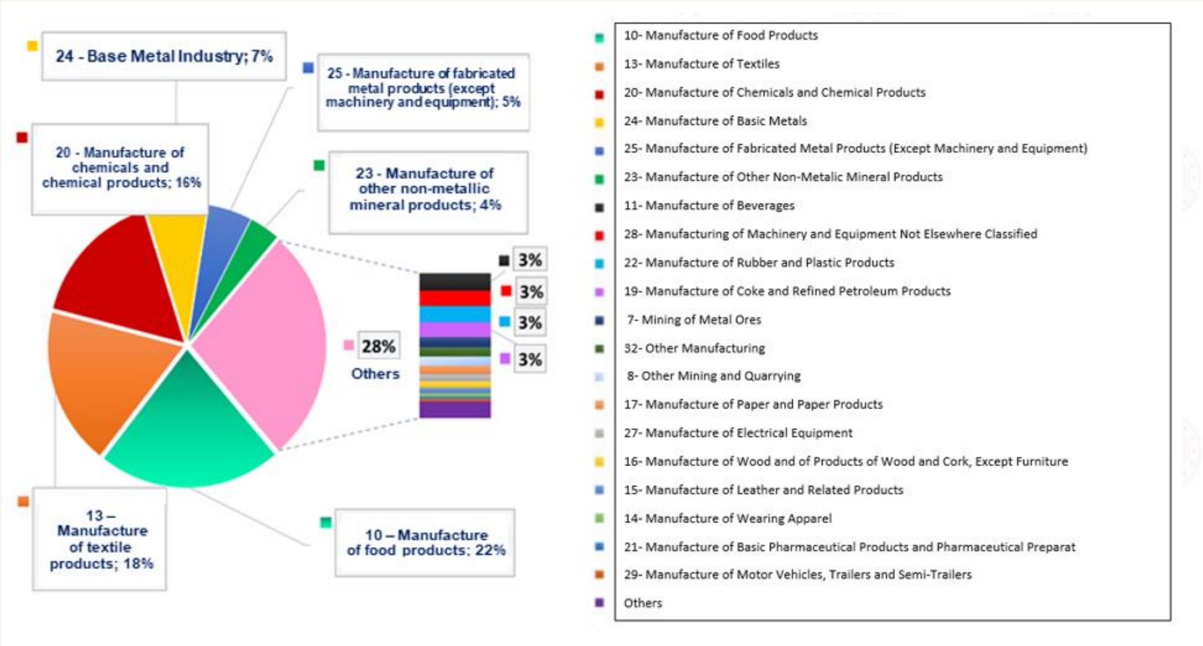
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal, where member countries agree on goals such as implementing a clean, circular economy model with the goal of carbon neutrality, expanding the efficient use of resources and reducing environmental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

The "Industrial Emissions Directive (EED)", which is one of the most important components of the European Union environmental legislation in terms of industry, includes the measures to be taken to control, prevent or reduce the 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/ MET) are presented in order to systematize the applicability of cleaner production processes and to eliminate the difficulties experienced in practice. Considering the costs and benefits, METs are the most effective implementation techniques for a high level of environmental protection. In accordance with the Directive, Reference Documents (BAT-BREF) have been prepared for each sector, in which the METs are explained in detail. In BREF documents, METs are presented in a general framework such as good management practices, general precautionary techniques, 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 studies aimed at disseminating 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 within the Framework of Adaptation to the Changing Climate (2023-2033)", which entered into force with the Presidential Circular No. 2023/9, water efficiency action plans addressing all sectors and stakeholders have been prepared. In the Industrial Water Efficiency Action Plan, a total of 12 actions have been determined for the period 2023-2033 and responsible and relevant institutions have been appointed for these actions. Within the scope of the said Action Plan; Carrying out studies to determine specific water usage ranges and quality requirements on the basis of sub-sectors in the industry, organizing technical training programs and workshops on a sectoral basis, and preparing water efficiency guidance documents are defined as the responsibility of the General Directorate of Water Management.

On the other hand, with the "Industrial Water Use Efficiency Project According to NACE Codes" carried out by the Ministry of Agriculture and Forestry, General Directorate of Water Management, the best sectoral techniques specific to our country have been determined within the scope of studies to improve water efficiency in the industry. As a result of the study, sectoral guidance documents and action plans classified with NACE codes, which include the measures recommended to improve 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 food, textile, chemistry 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, chemistry, basic metal industry, which will represent production areas of different capacities and diversity within the scope of NACE Codes, which operate in our country and have high water consumption, and data on water supply, sectoral water use, wastewater generation, recycling were obtained and the best available techniques (MET) published by the European Union and sectoral reference documents (BREF), water efficiency, clean production, water footprint, etc.



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

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

Within the scope of the project carried out, at the stage of determining the METs for each sector; environmental benefits, operational data, technical specifications-requirements and applicability criteria were taken into account. In the determination of METs, BREF documents were not limited to the METs, but also different data sources such as current literature data, real case studies, innovative practices, and reports of sector representatives on a global scale were examined in detail and sectoral MET lists were created. In order to evaluate the suitability of the created MET lists for the local industrial infrastructure and capacity of our country, the MET lists prepared specifically for each NACE code are prepared by the enterprises; water saving, economic savings, environmental benefits, applicability, cross-media impact were scored and prioritized on the criteria, and the final MET lists were determined using the scoring results. Sectoral water efficiency guidelines have been created on the basis of the NACE code based on the water and wastewater data of the facilities visited within the scope of the project and the final MET lists highlighted by the sectoral stakeholders and determined by taking into account the local dynamics specific to our country.

2 Scope of the Study

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

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

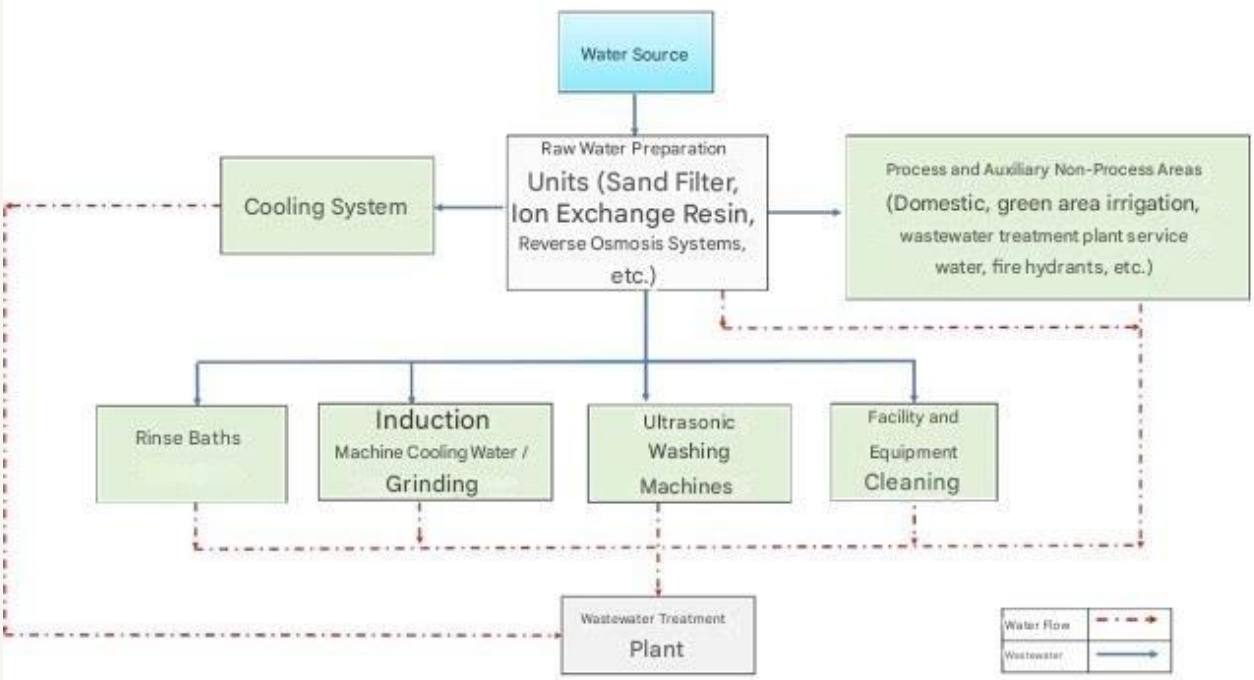
- Manufacture of other transport equipment (including 2 sub-production areas represented by four-digit NACE Codes)
- Other manufacturing (including 2 sub-production areas represented by four-digit NACE Codes)
- Installation and repair of machinery and equipment (including 2 sub-production areas represented by four-digit NACE Codes)
- Production and distribution of electricity, gas, steam, and ventilation systems (including 2 sub-production areas represented by four-digit NACE Codes)
- Waste collection, treatment, and disposal activities; materials recovery (including 1 sub-production area represented by a four-digit NACE Code)
- Construction of buildings and civil engineering works (including 1 sub-production area represented by a four-digit NACE Code)
- Warehousing and support activities for transportation (including 1 sub-production area represented by a four-digit NACE Code)
- Accommodation (including 1 sub-production area represented by a four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including 1 sub-production area represented by a four-digit NACE Code)

- Sports activities, entertainment, and recreation (including 1 sub-production area represented by a four-digit NACE Code)
  “Basic metal industry" and "Manufacture of fabricated metal products (except machinery and equipment)”The sub-production branches for which guide documents are 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 ferro-alloys
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	• Manufacture of precious metals
24.42	• Manufacture of aluminum
24.51	• Iron casting
24.52	• Steel casting
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 hot water boilers
25.30	• Manufacture of steam generators, except central heating hot water boilers
25.50	• Forging, pressing, stamping, and rolling of metals; 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 heads for machine tools, saw blades, etc.
25.92	• Manufacture of basic iron and steel products and ferro-alloys
25.93	• Manufacture of tubes, pipes, hollow profiles, and related fittings of steel
25.94	• Cold drawing of bars
25.99	• Cold rolling of narrow strips

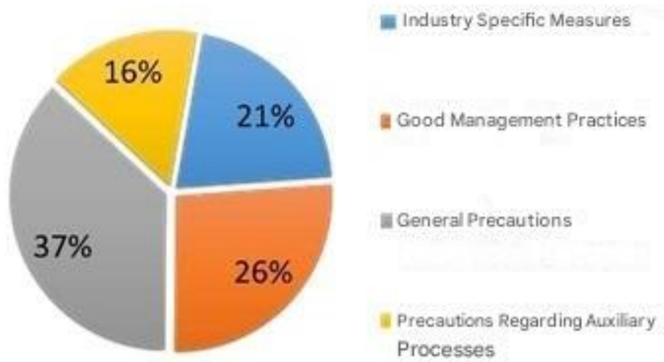
2.1 Cutlery and Manufacture of Other Cutting Tools (NACE 25.71)

Cutlery and Other Cutting Tools Manufacturing Industry Water Flow Diagram



	Minimum	Maximum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	18.2	
Reference Specific Water Consumption (L/kg product)	6	42

Percentage Distribution of Water Efficiency Practices



Cutlery and knives are produced by cutting stainless steel materials with press machines. The cut parts are shaped by the "stenciling" process. The surface of the product is smoothed by sanding. They are subjected to washing by the ultrasonic cleaning process. After the blades are heated up to 1000 ° C, they are hardened by shock cooling. The products are polished for the final polishing process and washed again in the ultrasonic cleaning machine.

In the sector, water consumption is realized in the induction machine for cooling water purposes and rinsing/washing processes. Raw water preparation units such as activated carbon filters, ion exchange resins, reverse osmosis, which are used to produce soft water for use in production processes in the sector, also consume significant amounts of water for filter washing, resin regeneration and membrane cleaning. In addition, water consumption is also realized in auxiliary processes such as cooling system, facility and equipment cleaning.

In the sector of cutlery and other cutting tools, the reference specific water consumption is in the range of 6 – 42 L/kg. The specific water consumption of the production branch analyzed within the scope of the study is 18.2 L/kg. It is possible to achieve 33-41% water recovery in the sector with the application of sector-specific techniques, good management practices, general measures and measures related to auxiliary processes.

Ultrasonic Cleaning Bath

25.71 Manufacture of Cutlery and Other Cutting Tools The priority water efficiency implementation techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Explanation		Prioritized Sectoral Water Efficiency Techniques
25.71	Manufacture of cutlery and other cutting tools		**Industry-Specific Measures**
		1.	In order to make the rinsing process more efficient, immersion more than one piece in the rinse tank at a time, using the smallest possible size rinse tanks, placing the water inlets and outlets oppositely, placing curtains, dispensers or diffusers at the water inlets, rinsing with the reverse current principle
		2.	Use of surfactants to reduce the amount of percolation water carried in baths
		3.	Operation of baths with the lowest possible concentration to reduce the filtrate water carried in the baths, and reducing the convection on the material by lowering the viscosity of the solutions by raising the bath temperatures
		4.	In order to minimize the filtrate water carried in the baths, it is ensured that the solutions are transferred back to the tank with inclined drainage boards placed between the tanks
			Good Management Practices
		1.	Using an integrated wastewater management and treatment strategy to reduce the amount of wastewater and the pollutant load
		2.	Establishment of an 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 use
			General Precautionary Measures
		1.	Minimizing spills and leaks
		2.	Use of automatic devices and equipment (such as sensors, smart hand-washing systems, etc.) to save water at usage points like showers/toilets
		3.	Use of pressure washing systems for equipment cleaning, general cleaning, etc.
		4.	Detection and reduction of water losses

NACE Code	NACE Code Explanation		Prioritized Sectoral Water Efficiency Techniques
25.71	Manufacture of cutlery and other cutting tools	5.	Storage and containment of substances that pose risks in aquatic environments (such as oils, emulsions, binders) to prevent them from entering wastewater after use
		6.	Use of closed-loop water cycles in appropriate processes
		7.	Reuse of relatively clean wastewater generated from washing, rinsing, and equipment cleaning in production processes without treatment
		8.	Separate collection and treatment of greywater in the facility for use in areas that do not require high water quality (e.g., irrigation of green spaces, floor cleaning, etc.)
		9.	Implementation of time optimization in production to ensure that all processes are completed as quickly as possible
			Precautions for Ancillary Processes
		1.	Reducing water consumption by increasing the number of cycles in closed-loop cooling systems and improving the quality of makeup water
		2.	Installing water softening systems to ensure efficient operation of cooling water recovery systems
		3.	Using closed-loop cooling systems to reduce water usage
			A total of 20 techniques have been proposed in this sector.

Manufacture of Cutlery and Other Cutting Tools for NACE Code;

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

2.1.1 Industry-Specific Measures

- Ensuring that solutions are returned to the tank by placing sloped drainage plates between tanks to minimize transfer of rinse water in baths

Solutions and rinse waters can be returned to the tank using sloped drainage plates between non-sequential tanks (ÇŞİDB, 2013).

- Operating baths at the lowest possible concentration and increasing bath temperatures to reduce the viscosity of solutions, thereby reducing transport of solutions on materials to minimize transfer of rinse water in baths

To reduce the viscosity of solutions, keeping the concentration of fresh solutions at the lowest possible level and gradually increasing concentrations over time can help minimize transport of solutions on materials (ÇŞİDB, 2013).

- Using surfactants to reduce transfer of rinse water in baths

Surfactants reduce surface tension, thereby decreasing the transport of chemicals and rinse water (ÇŞİDB, 2013).

- Making the rinsing process more efficient by submerging multiple parts simultaneously in the rinse tank, using the smallest possible rinse tanks, placing water inlets and outlets in opposite directions, adding baffles, distributors, or diffusers at water inlets, and using counter-current rinsing techniques to reduce water usage

Submerging parts in the rinse tank multiple times is a more effective method for reducing rinse water volume than simply immersing and agitating the tank. Double immersion of coated materials in the rinse tank is six times more effective in preventing rinse water transfer compared to single immersion (ÇŞİDB, 2013). In counter-current rinsing, the rinsing water flows in the opposite direction to the coated part. The material first encounters the most contaminated rinse water and then gradually moves to cleaner baths. This method can achieve water savings of over 90% compared to parallel flow, as clean water in the first tank does not contact the most contaminated material (ÇŞİDB, 2013).

2.1.2 Good Management Practices

 Establishing an Environmental Management System (EMS):

Environmental Management Systems (EMS) provide the organizational structure, responsibilities, procedures, and resources necessary for industrial organizations to develop, implement, and monitor environmental policies. Establishing an EMS helps institutions improve decision-making processes related to raw materials, water-wastewater infrastructure, planned production processes, and different treatment techniques. Environmental management organizes how to handle resource procurement and waste discharge requirements with maximum economic efficiency, maintaining product quality, and minimizing environmental impact.

The most widely used Environmental Management Standard is ISO 14001, with alternatives such as the Eco-Management and Audit Scheme (EMAS) Directive (761/2001), which has been developed for evaluating, improving, and reporting the environmental performance of enterprises. It is a prominent application within EU legislation under eco-efficiency (clean production) and is voluntary (TUBITAK MAM, 2016; TOB, 2021). The benefits of establishing and implementing an Environmental Management System include:

- *Improved business performance, resulting in economic benefits (Christopher, 1998).*
- *Greater alignment with global legal and regulatory requirements through the adoption of International Organization for Standardization (ISO) standards (Christopher, 1998).*
- *Reduced risks of penalties related to environmental responsibilities and decreased waste, resource consumption, and operating costs (Delmas, 2009).*
- *Use of internationally recognized environmental standards eliminates the need for multiple registrations and certifications for businesses operating in different locations worldwide (Hutchens Jr., 2017).*
- *In recent years, the improvement of internal control processes within companies has become a priority for consumers. Implementing environmental management systems provides a competitive advantage over companies that do not adopt these standards and also contributes to better positioning in international markets (Potoski & Prakash, 2005).*

These benefits depend on various factors, such as production processes, management practices, resource use, and potential environmental impacts (TOB, 2021). Practices like preparing annual inventory reports similar to EMS content and monitoring the quantity and quality of inputs and outputs in production processes can achieve 3-5% water savings (Öztürk, 2014). The total duration for developing and implementing an EMS is estimated to take 8-12 months (ISO 14001 User Manual, 2015).

 Water Footprint and Efficiency Standards: Industrial organizations also work within the ISO 14046 Water Footprint Standard, an international standard that defines requirements and guidelines for assessing and reporting water footprint. The application of this standard aims to reduce freshwater use and environmental impacts associated with production. Furthermore, the ISO 46001 Water Efficiency Management Systems Standard, which helps industrial organizations achieve water savings and reduce operational costs, assists organizations in developing water efficiency policies through monitoring, benchmarking, and review studies.

Using an Integrated Wastewater Management and Treatment Strategy to Reduce Wastewater Volume and Pollutant Load:

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

Reusing treated wastewater in the facility not only improves the quality of water bodies but also reduces the demand for freshwater. Therefore, determining suitable treatment strategies for various reuse purposes is essential.

Integrated industrial wastewater treatment involves jointly evaluating aspects like the wastewater collection system, treatment process, and reuse targets (Naghedi et al., 2020). For industrial wastewater recovery, methods such as SWOT analysis (strengths, weaknesses, opportunities, and threats), PESTEL analysis (political, economic, social, technological, environmental, and legal factors), and decision trees can be combined with expert opinions to establish an integrated wastewater management framework (Naghedi et al., 2020). Techniques such as the Analytical Hierarchy Process (AHP) and the Combined Compromise Solution (CoCoSo) can also be integrated to prioritize various criteria in industrial wastewater management processes (Adar et al., 2021).

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

Industrial Wastewater Treatment Plant

- ***Providing technical training to personnel 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. Due to the fact that the personnel do not have the necessary technical knowledge in industrial facilities, problems may arise with the use of high amounts of water and wastewater formation. 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. In applications such as determining water quality requirements in production processes, measuring water and wastewater amounts, etc., it is necessary for the relevant personnel to have sufficient technical knowledge (TOB, 2021). For this reason, it is important to provide training to staff on water use reduction, optimization and water saving policies. The involvement of staff in water-saving work is important before and after water efficiency initiatives.

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

  In terms of water efficiency, it is important to prepare an action plan that includes what to do in the short, medium and long term in order to reduce the amount of water-wastewater in industrial facilities and to prevent water pollution. 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 formation points and wastewater characterization should be done (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 make feasibility and to prepare action plans for the short-medium-long term. In this way, water efficiency and sustainable water use are ensured in facilities (TOB, 2021).

2.1.3 General Precautionary 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 detected and leaks should be prevented by keeping equipment, pumps and pipelines in good condition by performing regular maintenance (IPPC BREF, 2003). Regular maintenance procedures should be established and particular attention should be paid to the following: Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist, Carrying out inspections not only in the water system, but especially for heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps and valves, Regular cleaning of filters and pipelines, Chemical measuring and dispensing devices, calibrating, routinely checking and monitoring measuring equipment such as thermometers, etc., at designated periods (IPPC BREF, 2003). With effective maintenance-repair, cleaning and loss control practices, water consumption is between 1-6%.

- ***Minimization of spills and leaks***

  Both raw material and water losses can be experienced due to spills and leaks in enterprises. In addition, if wet cleaning methods are used to clean the spilled areas, there may be increases in water consumption, wastewater amounts and pollution loads of wastewater (TOB, 2021). In order to reduce raw material and product losses, spillage and splash losses are reduced by using anti-splashes, fins, drip trays, sieves (IPPC BREF, 2019).

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

  In industrial facilities, relatively clean wastewater, especially washing-final rinsing wastewater and filter backwash wastewater, can be recycled 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 consist of the establishment of new pipelines and reserved tanks (Öztürk, 2014).

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

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

- ***Storage, storage and prevention of substances that pose a risk in the aquatic environment (such as oils, emulsions, binders) and mixing with wastewater after use as much as possible***

  In industrial facilities, dry cleaning techniques can be used to prevent chemicals that pose a risk to the aquatic environment, such as oils, emulsions and binders, from mixing with wastewater streams and leaks can be prevented. In this way, the protection of water resources can be ensured (TUBITAK MAM, 2016).

Using Closed-Loop Water Cycles in Suitable Processes:

Refrigerants are chemical compounds with specific thermodynamic properties that absorb heat from materials to be cooled, impacting the performance of the cooling process (Kuprasertwong et al., 2021). In various processes, especially those in manufacturing and product cooling, water is commonly used as a cooling fluid. This cooling water can be recirculated through cooling towers or central cooling systems, reducing both water consumption and wastewater generation. If unwanted microbial growth occurs in the cooling water, chemicals can be added to the recirculating water to control it (TÜBİTAK MAM, 2016).

Reusing cooling water for cleaning reduces water consumption and wastewater volume, though it requires energy for cooling and recirculation. Additionally, heat recovery can be achieved by using heat exchangers in cooling systems. Facilities using water-cooled systems generally employ closed-loop systems, with cooling system blowdowns being directly diverted to the wastewater treatment facility. These blowdowns can be reused in suitable production processes.

Optimizing Production Time and Streamlining Operations for Efficiency:

Minimizing the steps required in industrial production processes from raw materials to the final product enhances productivity, reduces labor and resource costs, and mitigates environmental impacts. This approach may require reviewing and streamlining production processes to utilize fewer steps (TÜBİTAK MAM, 2016). If certain production process deficiencies or design issues prevent desired product quality, the production steps may need redesigning to avoid excessive resource usage and increased waste, emissions, and solid waste. Time optimization in production processes is an effective approach (TÜBİTAK MAM, 2016).

Implementing Water-Saving Equipment at Water Use Points (Showers, Toilets, etc.):

Water plays a crucial role in both production processes and hygiene maintenance for staff in many industrial sectors. In addition to the varied ways water is used in production, equipping personnel water use areas with sensor-activated faucets and smart handwashing systems helps achieve water savings. Smart handwashing systems not only save water but also enhance resource efficiency by precisely adjusting water, soap, and air ratios.

Collecting and Treating Gray Water for Non-Potable Use (Irrigation, Floor Cleaning, etc.):

Industrial facilities generate wastewater not only from production processes but also from showers, sinks, and kitchens, known as gray water. By treating this gray water through various processes and reusing it in non-potable areas requiring lower water quality—such as irrigation and cleaning—water savings can be achieved***.***

2.1.4 Precautions for Ancillary Processes

METs for refrigeration systems

- ***Use of a closed-loop refrigeration system to reduce water use***

Closed-loop cooling systems significantly reduce water consumption compared to open-loop systems with more water-intensive use. In closed-loop systems, when the same water is recirculated in the system, cooling water is usually required to be added as much as the amount of evaporated water. Evaporation losses can also be reduced by optimizing cooling systems.

- ***Reducing water consumption by increasing the number of cycles in closed-loop cooling systems and improving the quality of the make-up water***

Water is used as a refrigerant in many processes such as the production processes of the manufacturing industry and the cooling of products. Water is recirculated through a cooling tower or central cooling systems and the cooling process is carried out. If an undesirable microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MAM, 2016). In the recirculation process, the number of cycles can be increased by good chemical conditioning. In this way, water can be saved by reducing the amount of fresh water fed into the system. In addition, good conditioning of the cooling completion water can also increase the number of cycles (TOB, 2021).

- ***Installation of water softening systems for the healthy operation of cooling water recovery systems***

Cooling water is collected separately and used for cooling purposes or reused in appropriate processes (EC, 2009). In order for this system to work properly, a water softening system is required. It has suitable water quality in terms of cooling water, cleaning and reuse as irrigation water. However, due to the fact that it contains some hardness in its use as cooling water, an additional softening is required in order to prevent corrosion problems that will occur over time. Cooling water or before it can be reused in the process, these waters must be properly disinfected. In addition, it is possible to reuse the water in question not only in cooling processes but also in all production processes by treating it with appropriate treatment techniques (membrane filtration, advanced oxidation, chemical precipitation, granular activated carbon adsorption, etc.) (TUBITAK MAM, 2016). As the hardness of the cooling water increases, limestone and debris formation occurs on the walls. A couple of ...

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