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

Water Efficiency
Campaign

Water Efficiency
Guidance Documents Series

PRECIOUS METAL PRODUCTION

NACE CODE: 24.41

ANKARA 2023

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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 m³, 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.

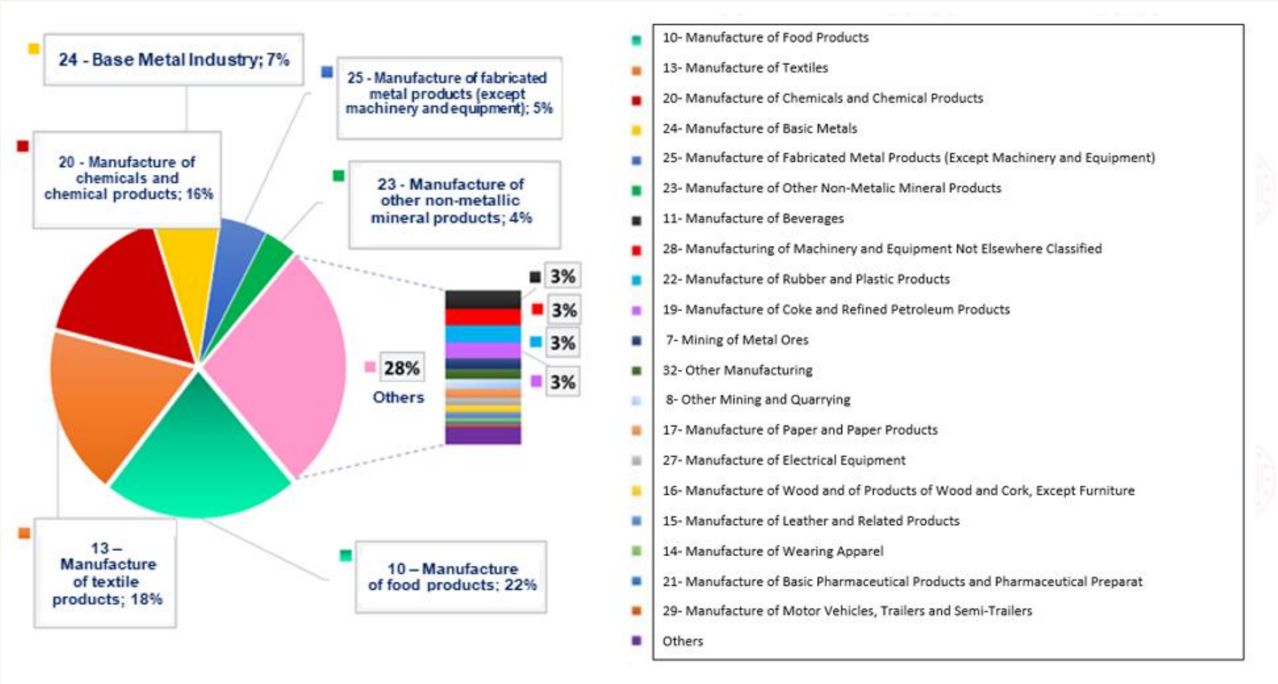
Within the scope of the European Green Deal, in which member countries have agreed on targets such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing environmental impacts, actions emphasizing water and resource efficiency 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)
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- Crop and animal production, hunting, and related service activities (including 6 sub-production areas represented by 4-digit NACE codes)
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- 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)
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- 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)

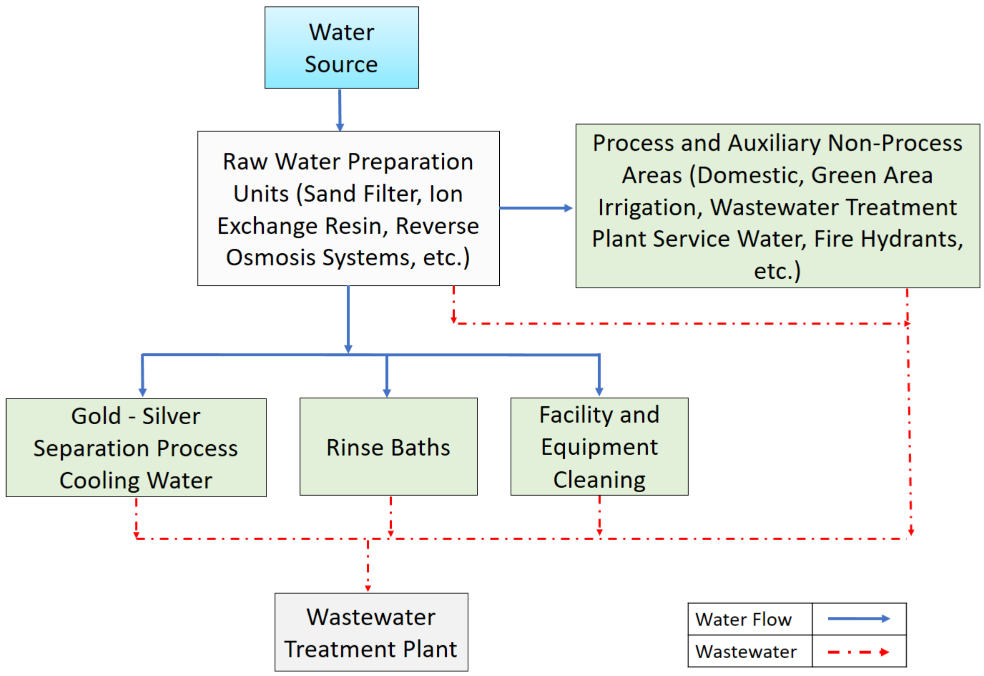
"Basic Metal Industry" and "Manufacture of Fabricated Metal Products (excluding machinery and equipment) "

"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

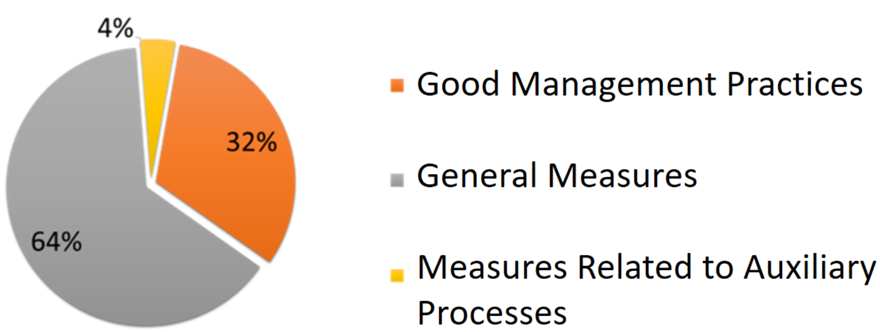
2.1 Precious Metal Production (NACE 24.41)

Precious Metal Production Sector Water Flow Diagram



	Minimum	Maximum
Facilities Visited Within the Scope of the Project Specific Water Consumption (L/kg product)	1.45	
Reference Specific Water Consumption	There is no reference specific water consumption value.	

Percentage Distribution of Water Efficiency Practices



"In facilities that produce precious metals, various purities, grades, and weights of scrap gold ingots are melted in induction furnaces. They are then pulverized, forming small particles called granules, which are suitable for chemical dissolution. The granules are introduced into chemical processing reactors and dissolved with aqua regia (a chemical solution that reacts with gold but is minimally affected by other acids). During this reaction, alloy elements in the raw material such as gold, copper, and zinc dissolve in the acid, while silver chloride precipitates due to its chemical properties. The solution is filtered, and the silver chloride is purified. The purified silver is melted in furnaces and cast into ingot or granule form for market use. Gold remaining in the solution separated from silver is precipitated in a settling tank. Other metals remain dissolved in the solution. The pure, precipitated gold is washed, freed of chemical residues, and dried. The obtained pure gold is melted in induction furnaces and cast into ingots of various weights. The standard-purity ingot is re-melted to achieve standard weights, and some are produced as certified standard ingots of various weights. Logos, serial numbers, purity, and weight specifications are stamped onto them by pressing before they are marketed.

In precious metal production facilities, water is used for cooling systems and rinse baths in gold purification and gold-silver separation processes. Significant water consumption can also occur in the raw water preparation units (such as activated carbon filters, ion exchange resin, and reverse osmosis) used for producing soft water, specifically for filter washing, resin regeneration, and membrane cleaning processes.

In the jewelry and related products manufacturing sector, there is no reference specific water consumption value. However, the specific water consumption for the production branch analyzed in this study is 1.45 L/kg. By applying good management practices, general preventive measures, and auxiliary process measures, water savings of 72–90% in the sector are achievable."

24.41 Precious Metal Production The 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
24.41	Precious metal production	**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 water flow diagrams and mass balances for water
		4.Preparation of a water efficiency action plan to reduce water use and prevent water pollution
		5.Providing technical training to personnel for the reduction and optimization of water usage
		6.Good production planning to optimize water consumption
		7.Determining water efficiency targets
		8.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.
		General Precautions
		1. Minimizing spills and leaks
		2. 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.
		3. Use of pressure washing systems in equipment cleaning, general cleaning, etc.
		4. Avoiding the use of drinking water in production lines
		5. Detection and reduction of water losses
		6. Use of automatic control-shutoff valves to optimize water usage
		7. To prevent water and energy waste, production procedures must be documented and used by employees.
		8. Establishing closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals to the aquatic environment.
		9. substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) from being stored, stored, and mixed with wastewater after use.
		10. Preventing clean water streams from mixing with dirty water streams
		11. 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.
		12. Use of closed loop water cycles in suitable processes
		13. Use of computer-aided control systems in production processes
		14. Reuse of relatively clean wastewater resulting from washing, rinsing and equipment cleaning in production processes without treatment.
		15. Determining the scope of reuse of washing and rinsing waters
		16. 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.)
		17. Implementing time optimization in production and arranging all processes to be completed in the shortest time possible.

NACE Code	NACE Code Explanation	Prioritized Sectoral Water Efficiency Techniques
		18. Collecting rainwater and using it as an alternative water source for facility cleaning or in suitable areas.
		Precautions Regarding Auxiliary Processes
		1. Reuse of condensate from the ventilation system
A total of 27 techniques were proposed in this sector.		

Precious Metal
Production NACE To
your code Oriented;

(i) Good Management Applications,
(ii) General Measures And
(iii) Helper to processes related measures separate
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2.1.1 Good Management Applications

- ***Establishment 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) .


http://www.asw-eg.com/en/images/products/116567Water-Sewage-Treatment-System-With-Plant-And-Facility.jpg

Industrial Wastewater Purification The facility

- ***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) .

- ***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 are resource uses in industrial facilities, and inefficiency and environmental problems resulting from resource use can arise from input-output flows. For this reason, the amount and quality of water and wastewater used in production processes and auxiliary processes must be monitored (TUBİTAK 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 provide reductions of up to 6% -10% in energy consumption and 25% in water consumption and wastewater amounts (Öztürk, 2014) .

The main stages for monitoring water and wastewater in terms of quantity and quality are:
• Using monitoring equipment (such as meters) to monitor water, energy, etc. consumption on a process basis,
• Establishing monitoring procedures,
• Determining the usage/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, comparatively evaluating and reporting in terms of quantity and quality,
• Monitoring raw material losses in production processes where raw materials are transformed into products and taking precautions against raw material losses (ÇŞİDB, 2020e).

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

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

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

  Determining water usage and wastewater generation points in industrial facilities, creating water-wastewater equivalences in production processes and auxiliary processes outside of production processes generally form the basis of many good management practices. Creating process profiles throughout the facility and on the basis of production processes facilitates the determination of unnecessary water usage points and high water usage points, the evaluation of water recovery opportunities, process modifications and water losses (TOB, 2021).

2.1.2 General Precautions

- ***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, such as 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 saving 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).

- ***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 achieve savings of 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.

- ***Use of 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 technical, environmental and economic advantages (Öztürk, 2014) . Monitoring the amount of water consumed within the facility and in various processes prevents water losses (TUBITAK MAM, 2016) . It is necessary to use flow meters and counters throughout the facility and specifically for production processes, to use automatic shut-off valves and shut-off valves in continuously operating machines, and to develop monitoring-control mechanisms according to water consumption and certain quality parameters using computer-aided systems (TUBITAK 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) .

- ***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, although it is costly in production processes, or raw water is evaluated in production processes after being disinfected with chlorinated compounds. These waters containing residual chlorine can react with organic compounds (natural organic substances (DOM)) in water during production processes and form disinfectant by-products that are harmful to 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) .

- ***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) .

  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 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.

- ***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.

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

  Since inefficient resource use and environmental problems in industrial facilities are directly related to input-output flows, it is necessary to define the process inputs and outputs in the best way possible, especially in production processes. (TUBITAK MAM, 2016) . Thus, it becomes possible to develop measures to increase 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 personnel and senior management, they quickly pay for themselves with the work of various experts. (IPPC BREF, 2003) . The use of measurement equipment and some routine analyses/measurements specific to the processes are required based on the application processes. In order to obtain the highest level of efficiency from the application, the use of computerized monitoring systems as much as possible increases the technical, economic and environmental benefits to be obtained. (TUBITAK MAM, 2016) .

- ***To prevent water and energy waste, production procedures must be documented and used by employees.***

  In order to ensure efficient production in a business, effective procedures should be implemented to identify and evaluate potential problems and their sources, 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) . Having documented production procedures in production processes contributes to the evaluation of business performance and the development of the ability to develop immediate reflexes to solve problems (TUBITAK MAM, 2016; TOB, 2021) . Effectively implementing and monitoring procedures created specifically for production processes is one of the most effective ways to ensure product quality, receive feedback and develop solution suggestions (Ayan, 2010) . Documenting and effectively implementing and monitoring production procedures is a good management practice and is an effective tool in structuring and ensuring continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, there may be differences in the cost and economic gains of the application depending on the sector or facility structure (TUBITAK MAM, 2016; TOB, 2021) . Although creating and monitoring production procedures is not costly, the payback period can be short considering the savings and benefits it will provide (TUBITAK MAM, 2016; TOB, 2021) .

- ***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) .

Computer Supported Control System

- ***To prevent water and energy waste, production procedures must be documented and used by employees.***

  In order to ensure efficient production in a business, effective procedures should be implemented to identify, evaluate potential problems and their sources, and 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). Having documented production procedures in production processes contributes to the evaluation of business performance and the development of the ability to 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 solution suggestions (Ayan, 2010). Documenting, implementing, and monitoring production procedures effectively is a good management practice and is an effective tool in structuring and ensuring the continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, there may be differences in the cost and economic gains of the application depending on the sector or facility structure (TUBITAK MAM, 2016; TOB, 2021). Although the creation and monitoring of production procedures is not costly, the payback period may be short when the savings and benefits it will provide are taken into account (TUBITAK MAM, 2016; TOB, 2021).

- ***Implementation of time optimization in 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 the production processes and revise them so that the minimum number of process steps are used (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 practice (TUBITAK MAM, 2016).

2.1.3 Precautions Regarding Auxiliary Processes

BAT for ventilation and air conditioning systems

- ***Reuse of condensate from the ventilation system***

  During the ventilation cycle, condensate with good water quality can be produced in the system. For example, in a plant in Spain, condensate with a conductivity of approximately 200 µS from the ventilation system is collected in a tank and used to wash the automatic galvanizing line (MedClean, nd).

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