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Water Efficiency Campaign

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Abbreviations

WWTP	Wastewater Treatment Plant
EU	European Union
SS	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
MoEUCC	Republic of Türkiye Ministry of Environment, Urbanisation and Climate Change
NOM	Natural Organic Matter
EMAS	Eco-Management and Audit Programme Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Standards Organisation
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GDWM	General Directorate of Water Management
RO	Reverse Osmosis
MoAF	Republic of Türkiye Ministry of Agriculture and Forestry
TSI	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
SW	Surface Water

1 Introduction

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

For the year 2022, the annual amount of water available per capita in Türkiye is 1,313 m³, and it is expected that the annual amount of water available per capita will fall below 1,000 cubic metres after 2030 due to human pressures and the effects of climate change. If the necessary measures are not taken, it is obvious that Türkiye 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.

The concept of water efficiency can be defined as *"using the least amount of water in the production of a product or service"*. The water efficiency approach is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, especially in drinking water, agriculture, industry and household use, in a way that protects water in terms of quantity and quality and takes into account not only the needs of humans but also the needs of all living things with ecosystem sensitivity.

With the increasing demand for water resources, the change in precipitation and temperature regimes as a result of climate change, the increase in population, urbanisation 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 a necessity to create a road map based on efficiency and optimisation in order to protect and use the limited water resources with sustainable management practices.

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

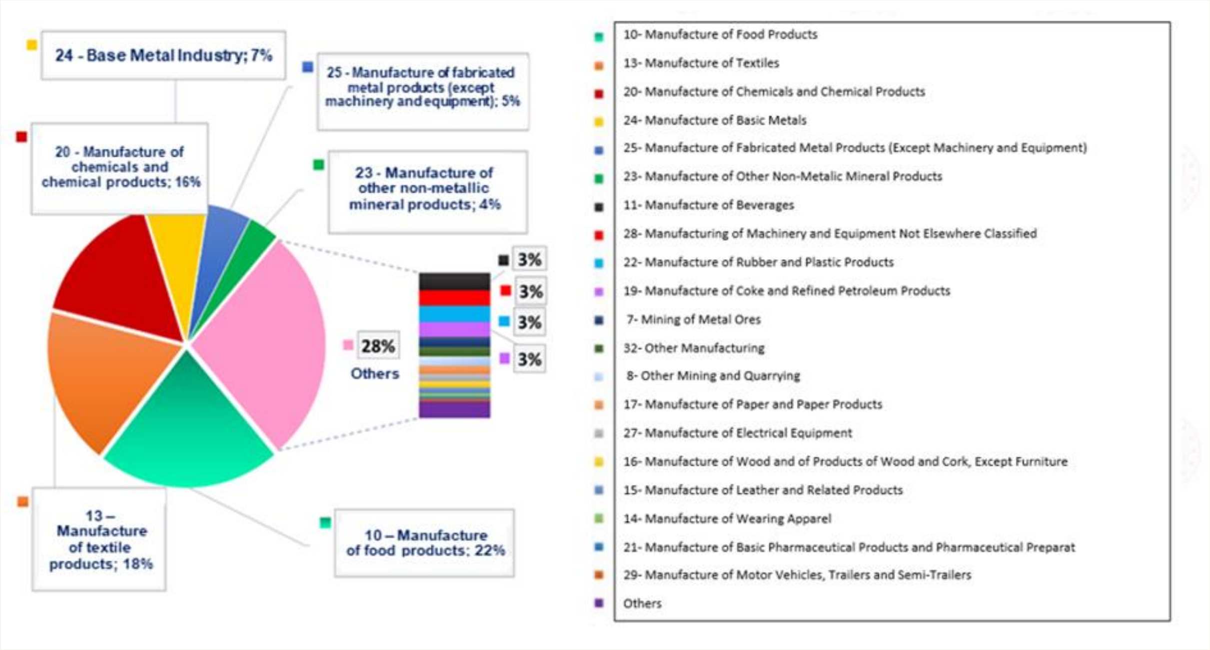
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal Action Plan, in which member countries agreed on the objectives such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing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

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

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

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

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



Sectoral distribution of water use in industry in Türkiye

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

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

2 Scope of the Study

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

- Crop and animal production and hunting and related service activities (including sub-production area represented by 6 four-digit NACE codes)
- Fisheries and aquaculture (including sub-production area represented by 1 four-digit NACE Code)
- Coal and lignite extraction (including sub-production area represented by 2 four-digit NACE codes)
- Service activities in support of mining (including sub-production area represented by 1 four-digit NACE Code)
- Metal ores mining (including the sub-production area represented by 2 four-digit NACE codes)
- Other mining and quarrying (including the sub-production area represented by 2 four-digit NACE codes)
- Manufacture of food products (including 22 sub-production areas represented by four-digit NACE codes)
- Manufacture of beverages (including the sub-production area represented by 4 four-digit NACE codes)
- Manufacture of tobacco products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of textile products (including 9 sub-production areas represented by four-digit NACE codes)
- Manufacture of articles of clothing (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of leather and related products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of wood, wood products and cork products (except furniture); manufacture of articles made of thatch, straw and similar materials (including sub-production area represented by 5 four-digit NACE Codes)
- Manufacture of paper and paper products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of coke and refined petroleum products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by four-digit NACE codes)
- Manufacture of basic pharmaceutical products and pharmaceutical ingredients (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of rubber and plastic products (including sub-production area represented by 6 four-digit NACE codes)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by four-digit NACE codes)
- Basic metal industry (including 11 sub-production areas represented by four-digit NACE codes)
- Manufacture of fabricated metal products (except machinery and equipment) (including 12 sub-production areas represented by four-digit NACE codes)
- Manufacture of computers, electronic and optical products (including sub-production area represented by 2 four-digit NACE codes)
- Manufacture of electrical equipment (including sub-production area represented by 7 four-digit NACE codes)

- Manufacture of machinery and equipment not elsewhere classified (including sub-production area represented by 8 four-digit NACE codes)
- Manufacture of motor vehicles, trailers (semi-trailers) and semi-trailers (semi-trailers) (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of other transport equipment (including sub-production area represented by 2 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 sub-production area represented by 2 four-digit NACE codes)
- Electricity, gas, steam and ventilation system production and distribution (including sub-production area represented by 2 four-digit NACE codes)
- Waste collection, reclamation and disposal activities; recovery of materials (including sub-production area represented by 1 four-digit NACE Code)
- Construction of non-building structures (including sub-production area represented by 1 four-digit NACE Code)
- Warehousing and supporting activities for transport (including sub-production area represented by 1 four-digit NACE Code)
- Tourism Activities (Accommodation) (including sub-production area represented by 1 four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including sub-production area represented by 1 four-digit NACE Code)
- Sporting activities, leisure and recreation activities (including sub-production area represented by 1 four-digit NACE Code)

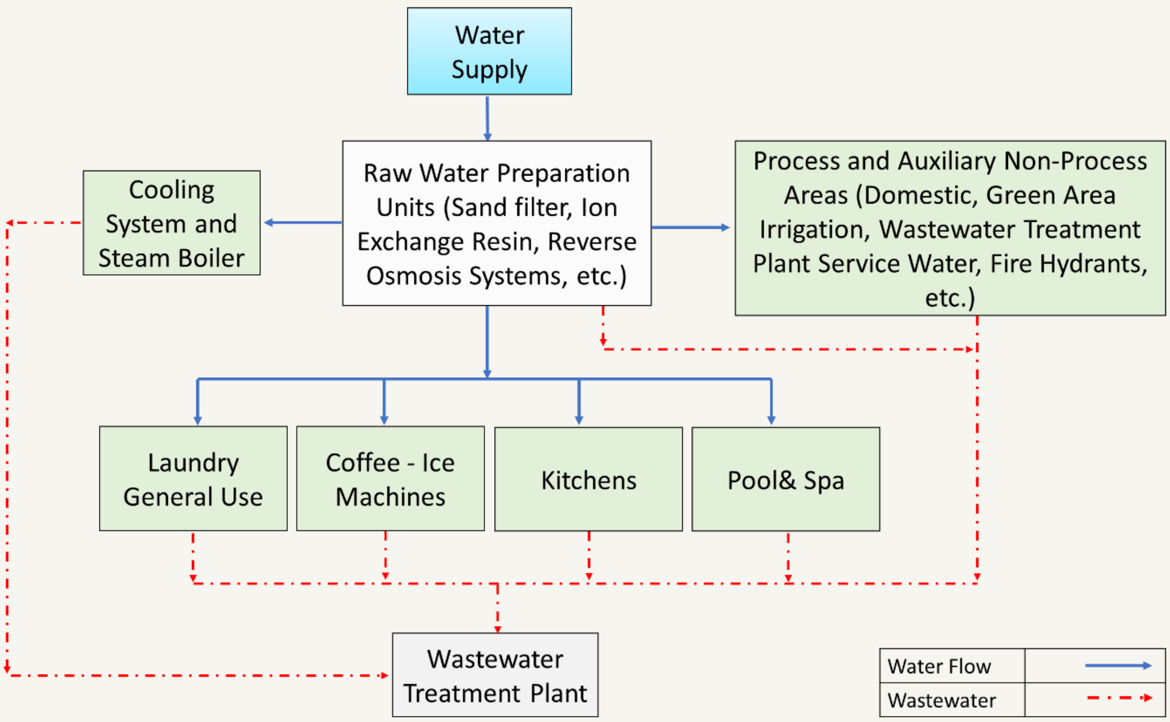
Tourism Activities (Accommodation)

The sub-production branches for which guidance documents have been prepared under the accommodation sector are as follows:

55.10 Hotels and similar accommodation

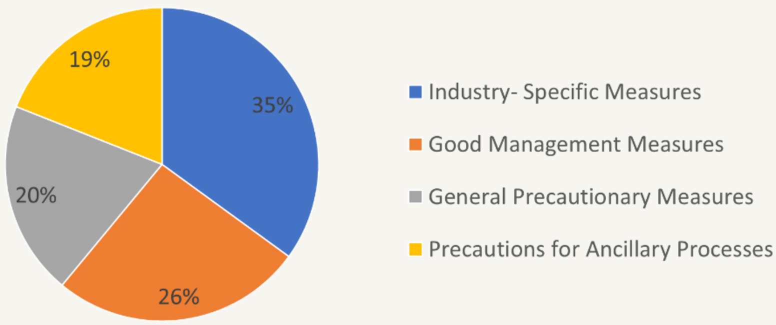
2.1 Hotels and Similar Places of Accommodation (NACE 55.10)

Hotels and Similar Accommodation Sector Water Flow Chart



	Minimum	Maximum
Specific Water Consumption of the Facilities Visited within the Scope of the Project (L/overnight)	385,41	
Reference Specific Water Consumption (L/overnight)	188	507

Percentage Distribution of Water Efficiency Applications



A significant portion of the water consumed in hotels and similar accommodation places is used in toilets, sinks and room cleaning processes in hotel rooms. In addition, water is consumed in laundries, kitchens, coffee ice machines, pools and spas. Water consumption also occurs in raw water preparation units such as ion exchange resin, reverse osmosis, resin regeneration and membrane cleaning processes used to produce soft water. Water consumption also occurs in auxiliary processes such as closed cooling systems and steam boilers in hotels.

The reference specific water consumption in the hotels and similar accommodation sector is in the range of 188 - 507 L/night. The specific water consumption of the production line analysed in the study is 385.4 L/night. With the implementation of sector-specific techniques, good management practices, general measures and measures related to auxiliary processes
It is possible to provide 36 - 50% water recovery.

55.10 Hotels and Similar Accommodation Places Priority water efficiency implementation techniques recommended within the scope of NACE code are presented in the table below.

NACE Code	NACE Code Description		Sectoral Prioritisation Best Available Techniques
55.10	Hotels and similar accommodation		**Sector Specific Measures**
		1.	To minimise evaporation, green areas should be irrigated during the hours when evaporation is lowest
		2.	Control of irrigation processes through the use of timers and rain gauges
		3.	Weighing the laundry before washing for maximum capacity operation of washing machines
		4.	Use of machines that can be adjusted according to the laundry load in the laundry
		5.	Using front-loading machines that use less water instead of top-loading machines in laundries
		6.	Sorting the laundry according to the pollution status and washing in programmes suitable for the pollution levels
		7.	Backwashing of filters according to filter pressure instead of a fixed programme
		8.	Organising foot baths to reduce the amount of sand and soil carried into the pool
		9.	Routine inspection of pools and spa areas for leaks and necessary repairs
		10.	Achieving and maintaining the appropriate chemical balance to avoid the need to drain the pool
		11.	Keeping the pool temperature low or using a pool cover to reduce evaporation when the pool is not in use
		12.	Application of dry powder cleaning methods instead of wet or steam carpet cleaning methods
		13.	Development of a standardised cleaning process to increase efficiency in cleaning guest rooms
		14.	Providing flow with a mixture of water and air using tap aerators, and installing flow restriction devices on taps that cannot be equipped with aerators
		15.	Use of combination ovens instead of steam cookers
		16.	Replacement of old and inefficient pre-rinse spray valves used in dishwashers with efficient ones
		17.	Use of pedal taps or sensor taps in kitchens
		18.	Checking ice machines for leaks and repairing them
		19.	Replacement of inefficient ice machines with water and energy efficient units
		20.	Cleaning the walkways by sweeping instead of washing them with a hose
		21.	Use of an efficient, high-pressure system if wet cleaning is required to wash walkways
			Use of water obtained by rainwater harvesting in garden irrigation

NACE Code	NACE Code Description		Sectoral Prioritisation Best Available Techniques
55.10	Hotels and similar accommodation	23.	Reducing the frequency of laundry rinsing, using only the required amount of soap/detergent to reduce the need for rinsing
		24.	Selection of service providers applying water efficiency techniques for laundry
		25.	Installation of counters to monitor the amount of water consumed in laundries
		26.	Using a cistern set with a dual-stage flushing mechanism or using toilet dams that take up space in the cistern to ensure less water use per flush in toilet flushes
		27.	Determination of water recovery potential in grey water and domestic wastewater systems and recovery of water by subjecting to appropriate treatment processes
		28.	Identification of water that can be reused in equipment such as air conditioners, steam systems, cooling towers, pools and reverse osmosis systems
		29.	Pre-heating of domestic hot water by steam condensation, thus reducing water wastage during the waiting time for water heating
		30.	Use of grey water from sinks, showers and laundries for garden irrigation after appropriate treatment processes
		31.	Elimination of leaks in taps and sinks, periodic cleaning and descaling
			Good Management Practices
		1.	Establishment of environmental management system
		2.	Preparation of water flow diagrams and mass balances for water
		3.	Preparing a water efficiency action plan to reduce water use and prevent water pollution
		4.	Providing technical trainings to personnel for the reduction and optimisation of water use
		5.	Good production planning to optimise water consumption
		6.	Determination of water efficiency targets
			Measures in the nature of General Measures
		1.	Minimising spillages and leakages
		2.	Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) to save water at water usage points such as showers/toilets etc.
		3.	Use of pressure washing systems for equipment cleaning, general cleaning, etc.
		4.	Reducing water consumption by reusing filter wash water in filtration processes, reusing relatively clean cleaning water in production processes and using clean-in-place systems (CIP)
		5.	Identification and minimisation of water losses
		6.	Automatic control-close valves to optimise water use

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
55.10	Hotels and similar accommodation	1.	Documented production procedures are kept and used by employees to prevent water and energy wastage
		2.	Reuse of pressurised filtration backwash water prior to water softening at appropriate points
		3.	Optimising the frequency and duration of regeneration (including rinses) in water softening systems
		4.	Construction of closed storage and impermeable waste/scrap sites to prevent the transport of toxic or hazardous chemicals for the aquatic environment
		5.	Storage and storage of substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) and prevention of their mixing with wastewater after use
		6.	Where technically feasible, treatment of suitable wastewater and use as steam boiler feed water
		7.	Prevention of mixing of clean water flows with polluted water flows
		8.	Determination of wastewater flows that can be reused with or without treatment by characterising the wastewater quantities and qualities at all wastewater generation points
		9.	Use of closed loop water cycles in appropriate processes
		10.	Use of computer aided control systems in production processes
		11.	Implementation of time optimisation in production and arrangement of all processes to be completed as soon as possible
		12.	Collecting rainwater and utilising it as an alternative water source in facility cleaning or in suitable areas
			Precautions for Auxiliary Processes
		1.	Saving water by reusing steam boiler condensate
		2.	Ensuring water saving by insulating steam and water lines (hot and cold) and preventing water and steam losses in pipes, valves and connection points in the lines and monitoring them with a computer system
		3.	Replacement of old equipment in the aeration system with ion exchange resins based on the principle of reverse osmosis (systems producing demineralised water) and water reuse
		4.	Re-use of the liquid formed by condensation from the ventilation system
		5.	Avoiding unnecessary cooling processes by identifying processes that need wet cooling
		6.	By increasing the number of cycles in closed loop cooling systems and reducing water consumption by improving the quality of make-up water

NACE Code	NACE Code Description	Prioritised Sectoral Water Efficiency Techniques
55.10	Hotels and similar accommodation	7. Reducing evaporation losses in closed loop cooling water
		8. Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle
		9. Prevention of flash steam losses caused by boiler unloading
		10. Use of air cooling systems instead of water cooling in cooling systems
		11. Installation of water softening systems for the healthy operation of cooling water recovery systems
		12. Use of a closed-loop cooling system to minimise water use
		13. Local dry air cooling in some periods of the year when the cooling requirement is low
		14. Collecting the water generated by surface runoff with a separate collection system and using it for purposes such as cooling water, process water, etc.
		15. Reducing the amount of blowdown by using degassers in steam boilers
		16. Minimisation of boiler discharge water (blowdown) in steam boilers
		17. Re-use of energy produced from steam condenser
A total of 72 techniques were proposed in this sector.		

For Hotels and Similar Accommodation Places NACE Code;

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

2.1.1 Sector Specific Measures

- ***Using a cistern set with a dual-stage flushing mechanism or using a toilet dam that occupies space in the cistern to ensure less water use per flush in toilet flushes***

  Toilet dams, water displacement devices, short flush valves, and flow diverters that reduce the amount of water used per flush can reduce water use by up to 30 per cent compared to conventional toilets. While conventional toilets use 5-7 gallons of water per flush, new water-saving toilets use as little as 1.6 gallons per flush (Meade & Morel, 1999).

- ***Elimination of leaks in taps and sinks, periodic cleaning and descaling***

  Preventing faucet and sink leaks and ensuring that they are descaled, partially closing valves to reduce the water flow of taps with excessively high flow, and ensuring that sink plugs are properly sealed prevent water waste (Meade & Morel, 1999).

- ***Providing flow with a mixture of water and air using tap aerators, and installing flow restriction devices on taps that cannot be equipped with aerators***

  Tap aerators and flow restriction devices can be used to control water flow and reduce unnecessary water consumption (Meade & Morel, 1999). Thanks to the holes in the tap aerators, the water flow is slowed down without a decrease in water pressure. Depending on the characterisation of the water, tap aerators become clogged over time and their efficiency decreases. For this reason, the existing aerators should be maintained periodically.

- ***Development of a standardised cleaning process to increase efficiency in cleaning guest rooms***

  Guest rooms are usually the areas with the highest water usage. The use of dry cleaning practices under appropriate conditions in the cleaning of rooms reduces water consumption. If wet cleaning is required, water-efficient materials and equipment can be used (NYCEP, n.d.).

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- ***Using front-loading machines that use less water instead of top-loading machines in laundries***

  The amount of water used for washing laundry accounts for about 20 per cent of the water consumption of the facilities. Front-loading washing machines are more efficient than top-loading washing machines consumes 40% less water (Meade & Morel, 1999).

- ***Use of machines that can be adjusted according to the laundry load in the laundry***

  Machines that can be adjusted according to the laundry load adjust the amount of water to be used for washing according to the amount of laundry. Thus, water consumption can be reduced and water waste can be prevented by using water in accordance with the amount of laundry in the machine (Meade & Morel, 1999).

- ***Application of dry powder cleaning methods instead of wet or steam carpet cleaning methods***

  Water consumption can be reduced by preferring dry cleaning methods using special sprays or special powders instead of steam carpet cleaning (NYCEP, n.d.).

- ***Pre-heating of domestic hot water by steam condensation, thus reducing water wastage during the waiting time for water heating***

  A vapour condenser can be used to prevent water wastage during the waiting time for the water to heat up. In this way, water consumption can be reduced by preheating the water and water saving is achieved (NYCEP, n.d.).

- ***Installation of counters to monitor the amount of water consumed in laundries***

  In laundries, measuring the amount of water consumed by washing machines helps to monitor high usage levels. Installing meters on the water distribution pipelines serving the laundry also facilitates monitoring of water consumption (NYCEP, n.d.).

- ***Weighing the laundry before washing for maximum capacity operation of washing machines***

  Considering how many kilos the washing machine can take according to its capacity, it can be ensured that the machine is loaded according to its capacity by weighing the weight of the laundry to be loaded into the machine and measuring how much their weight is. Thus, the machine is not operated more or less than its capacity and water and energy saving is ensured (Meade & Morel, 1999).

- ***Sorting the laundry according to the pollution status and washing in programmes suitable for the pollution levels***

  Both energy and water savings can be achieved in terms of water temperature and quantity by washing the laundry in programmes selected according to the level of contamination (Meade & Morel, 1999).

- ***Backwashing of filters according to filter pressure instead of a fixed programme***

  Inappropriate sand filter backwashing by the pool operator causes water waste. Instead, determining the backwashing frequency according to the filter pressure can save water (Meade & Morel, 1999).

- ***Achieving and maintaining the appropriate chemical balance to avoid the need to drain the pool***

  The chemical balance in the pool can be maintained by adding the chemicals used for disinfection of the pool to the water in appropriate proportions and periods. Thus, it can be ensured that the periods of draining the pool water and filling it with fresh water are longer (NYCEP, n.d.).

- ***Keeping the pool temperature low or using a pool cover to reduce evaporation when the pool is not in use***

  The amount of evaporation of pool water can be reduced by keeping the pool at low temperatures when not in use. The use of pool covers can also help prevent water losses due to evaporation (NYCEP, n.d.).

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- ***Organisation of foot baths to reduce the amount of sand and soil carried into the pool***

  The use of foot baths before entering the pool can prevent substances such as sand and soil that may come with the feet from mixing into the pool water and contaminating the pool (NYCEP, n.d.). With the application of this technique, it is predicted that the pool water will remain clean for a longer period of time and water change periods can be improved.

- ***Routine inspection of pools and spa areas for leaks and necessary repairs***

  Pools and spas are areas with high water saving potential. Leaks occur at plumbing connections, separations and liners along the pool deck, side walls, and the pool itself. Regular maintenance reduces water losses due to evaporation and leaks and reduces the water required to compensate for these losses (NYCEP, n.d.).

- ***Reducing the frequency of laundry rinsing, using only the required amount of soap/detergent to reduce the need for rinsing***

  Water waste can be prevented by preventing the need for excessive rinsing by using as much detergent as necessary in accordance with the dirtiness of the laundry.

- ***Selection of service providers applying water efficiency techniques for laundry***

  If laundry activities are performed at a source other than the school, service providers that implement water efficiency methods should be selected (NYCEP, n.d.).

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- ***Replacement of inefficient ice machines with water and energy efficient units***

  Ice machines are common in the hospitality industry. In the ice making process, significant amounts of heat are released. This heat is cooled by means of a water or air cooling system. Water cooling units can consume more water than is required to make ice. Air-cooled machines are more water efficient than water-cooled ones (NYCEP, n.d.).

- ***Use of an efficient, high-pressure system if wet cleaning is required for walkways***

  Cleaning walkways by pressurised water spraying can prevent excess water use (Meade & Morel, 1999).

- ***Cleaning the walkways by sweeping instead of washing them with a hose***

  Using brooms instead of water to clean walkways can prevent water waste (Meade & Morel, 1999).

- ***To minimise evaporation, green areas should be irrigated during the hours when evaporation is lowest***

  Water losses due to evaporation during irrigation can be prevented by irrigating plants in the morning or in the evening after sunset (Meade & Morel, 1999).

- ***Control of irrigation processes through the use of timers and rain gauges***

  The use of timers and rain gauges in irrigation processes and the use of intelligent automation systems using real-time weather and climate data make it easier to optimise irrigation processes. With optimum irrigation, unnecessary and excessive water consumption can be prevented. In addition, by monitoring weather and rainfall conditions, unnecessary irrigation can be avoided and water savings can be achieved (Meade & Morel, 1999).

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- ***Checking ice machines for leaks and repairing them***

  It is important to check and eliminate leaks in ice machines to prevent water losses (NYCEP, n.d.).

- ***Replacement of old and inefficient pre-rinse spray valves used in dishwashers with efficient ones***

  Before the dishes are loaded into the machine, they are usually cleaned with a pre-rinse spray valve. Replacing outdated spray valves with a new and improved model reduces water consumption.

- ***Use of combination ovens instead of steam cookers***

  Cooking is usually done with steam cookers using a central boiler. These cookers usually consume large amounts of water. Combination ovens, on the other hand, cook food in less time by distributing the heat evenly. Water and energy savings can be achieved by using combined ovens.

- ***Use of pedal taps or sensor taps in kitchens***

  Replacing conventional taps with pedal taps or sensor taps is important to prevent water wastage (Meade & Morel, 1999).

- ***Use of water obtained by rainwater harvesting in garden irrigation***

  Collected rainwater can be used for irrigation of green areas. Significant water savings can be achieved by using this water instead of municipal water (NYCEP, n.d.).

- ***Use of grey water from sinks, showers and laundries for garden irrigation after appropriate treatment processes***

  Used water from sinks, showers and laundries can be reused for irrigation after appropriate treatment. Using grey water from sinks, showers and laundry for irrigation can reduce water consumption by up to 20 percent (Meade & Morel, 1999).

- ***Identification of water that can be reused in equipment such as air conditioners, steam systems, cooling towers, pools and reverse osmosis systems***

  Recycling and reuse of reusable water from water-using machines or units saves water (NYCEP, n.d.).

- ***Determination of water recovery potential in grey water and domestic wastewater systems and recovery of water by subjecting to appropriate treatment processes***

  Water from showers, bathrooms, washbasins, washing machines and dishwashers is defined as grey water. Grey water and domestic wastewater have a high water recovery potential. Significant water savings can be achieved by recovering and reusing these waters (NYCEP, n.d.).

2.1.2 Good Management Practices

- ***Establishment of environmental management system***

Environmental Management Systems (EMS) include the organisational structure, responsibilities, procedures and resources required to develop, implement and monitor the environmental policies of industrial organisations. The establishment of an environmental management system improves the decision-making processes between raw materials, water and wastewater infrastructure, planned production process and different treatment techniques. Environmental management organises how resource supply and waste discharge demands can be managed with the highest economic efficiency, without compromising product quality and with the least possible impact on the environment.

The most widely used Environmental Management Standard is ISO 14001. Alternatives include the Eco Management and Audit Scheme Directive (EMAS) (761/2001). It has been developed for the assessment, improvement and reporting of the environmental performance of enterprises. It is one of the leading practices within the scope of eco-efficiency (cleaner production) in EU legislation and voluntary participation is provided (TUBITAK MAM, 2016; MoAF, 2021). The benefits of establishing and implementing an Environmental Management System are as follows:

- Economic benefits can be obtained by improving business performance (Christopher, 1998).
- International Standards Organisation (ISO) standards are adopted to ensure greater compliance with global legal and regulatory requirements (Christopher, 1998).
- While the risks of penalties related to environmental responsibilities are minimised, the amount of waste, resource consumption and operating costs are reduced (Delmas, 2009).
- The use of internationally recognised 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 the internal control processes of companies is also 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 better position of organisations in international areas / markets (Potoski & Prakash, 2005).

The above-mentioned benefits depend on many factors such as the production process, management practices, resource utilisation and potential environmental impacts (MoAF, 2021). Practices such as preparing annual inventory reports with similar content to the environmental management system and monitoring 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 development and implementation phases of the EMS takes an estimated 8-12 months (ISO 14001 User Manual, 2015).

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

- ***Providing technical trainings to the staff for the reduction and optimisation of water use***

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

- ***Effective planning to optimise water consumption***

  Carrying out the production processes of products, goods and services using the minimum number of processes and work steps is an effective practice for reducing labour and resource use, environmental impacts and associated costs and ensuring efficiency (TUBITAK MAM, 2016; MoAF, 2021). On the other hand, making the necessary planning by considering water efficiency at every stage of industrial products and services reduces water consumption and wastewater amount in production processes. Modifying production and business processes or combining some processes and work steps provides significant benefits in terms of water efficiency and time planning (MoAF, 2021).

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

  It is important for water efficiency to prepare an action plan that includes short, medium and long term actions to be taken in order to reduce water-wastewater quantities and prevent water pollution in industrial facilities. At this point, determination of water needs throughout the facility and in production processes, determination of quality requirements at water use points, wastewater generation points and wastewater characterisation should be carried out (MoAF, 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 their feasibility 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 (MoAF, 2021).

- ***Determination of water efficiency targets***

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

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

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

2.1.3 General Measures

- ***Identification and minimisation of water losses***

  Water losses occur in equipment, pumps and pipelines in industrial production processes. Firstly, water losses should be identified and leakages should be prevented by regular maintenance of equipment, pumps and pipelines to keep them in good condition (IPPC BREF, 2003). Regular maintenance procedures should be established, paying particular attention to the following points:

  - Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist,
  - Carrying out inspections not only in the water system, but also in particular in the heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps and valves,
  - Regular cleaning of filters and pipework,
  - Calibrate, routinely check and monitor 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 1-6% in water consumption can be achieved (Öztürk, 2014).

- ***Minimising spillages and leakages***

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

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

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

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

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

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

  It is possible to reuse various wastewater streams with or without treatment by determining and characterising the wastewater generation points in industrial facilities (Öztürk, 2014; TUBİTAK MAM, 2016; MoAF, 2021). In this context, filter backwash waters, RO concentrates, blowdown waters, condensate waters, relatively clean washing and rinsing waters can be reused without treatment in the same/different processes and in areas that do not require high water quality (such as plant and equipment cleaning). In addition, wastewater streams that cannot be directly reused can be reused in production processes after treatment using appropriate treatment technologies.

  Membrane filtration processes are an integral part of many wastewater reuse systems. Nanofiltration (NF) and reverse osmosis (RO) filtration systems are used for industrial wastewater recovery. Microfiltration (MF) and ultrafiltration (UF) are generally used for pre-treatment of water before it goes to NF or RO (Singh et al., 2014).

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

  Monitoring and controlling water consumption using flow control devices, meters and computer-aided monitoring systems provide significant technical, environmental and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed in the plant and in various processes prevents water losses (TUBITAK MAM, 2016). It is necessary to use flow meters and counters in the plant in general and in production processes in particular, to use automatic shut-off valves and valves in continuously operating machines, and to develop monitoring-control mechanisms according to water consumption and some determined quality parameters by using computer-aided systems (TUBITAK MAM, 2016). With this application, it is possible to save up to 20-30% of water consumption on 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).

- ***Where technically feasible, treatment of suitable wastewater and use as steam boiler feed water***

  Although it is difficult to apply in industrial plants, it is possible to treat suitable wastewater to process water quality and reuse it in production processes, including steam boilers. In this way, savings ranging from 20-50% in total water consumption and wastewater generation can be achieved (Öztürk, 2014; TUBİTAK MAM, 2016). The initial investment cost required for the application is the treatment system to be used. Considering the amount of water to be recovered, the amount of economic savings, unit water-wastewater costs applied, treatment system operation-maintenance costs, payback periods vary (MoAF, 2021). A combination of membrane systems (ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) systems can be used for recovery. For example, in some industrial plants, cooling system blowdown water can be treated and reused as process water (MoAF, 2021).

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

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

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

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

Since inefficient resource utilisation 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 for production processes (TUBITAK MAM, 2016). Thus, it becomes possible to develop measures to improve resource efficiency, economic and environmental performance. The organisation of input-output inventories is considered as a prerequisite for continuous improvement. While such management practices require the participation of technical staff and senior management, they pay for themselves in a short time with the work of various experts (IPPC BREF, 2003). It is necessary to use measurement equipment on the basis of application processes and to carry out some routine analyses/measurements specific to the processes. In order to maximise the efficiency of the application, computerised monitoring systems should be used as much as possible to increase the technical, economic and environmental benefits (TUBITAK MAM, 2016).


https://sayachizmet.com/wp-content/uploads/2020/01/SCADA-nedir-1280x720-1.jpg.webp

Computer Aided Control System

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

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

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

  It is very important to determine the optimum regeneration frequency in regeneration systems. Although regeneration in water softening systems is adjusted according to the frequencies recommended by the supplier or depending on the flow rate and 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 while determining the regeneration frequency. Thus, regeneration frequencies can be optimised and excessive washing rinsing or backwashing with salt water can be prevented by using online hardness sensors.

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

  Softened water with low calcium and magnesium concentrations is required for many industrial processes. With water softening systems, calcium, magnesium and some other metal cations in hard water are removed from the water and soft water is obtained.

  Savings are achieved by reusing pressurised filtration backwash water at appropriate points before water softening. Practices such as reuse of filter backwash water in filtration processes, reuse of relatively cleaning water in production processes, reduction of water consumption by using on-site cleaning systems can be given as examples for this measure.

Water Softening Systems

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

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

Water is used as a refrigerant in many processes in the manufacturing industry and in many processes led by the product cooling process. During this cooling process, water can be recovered through cooling tower 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 water is a side interaction.

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

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

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

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

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

- ***Implementation of time optimisation in production and arrangement of all processes to be completed as soon as possible***

In industrial production processes, planning the process from raw material to product by using the minimum number of processes is an effective practice for reducing labour costs, resource use costs and environmental impacts and ensuring efficiency. In this context, it may be necessary to revise the production processes so that the minimum number of process steps is used (TUBITAK MAM, 2016). In cases where the desired product quality cannot be achieved due to some inefficiencies, inefficiency and design errors in basic production processes, production processes may need to be renewed. Therefore, in this case, the resource utilisation and the amount of waste, emission and solid waste generated in the production of unit amount of product increases. Time optimisation in production processes is an effective application in terms of resource use and waste management (TUBITAK MAM, 2016).

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

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

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

In our country, reverse osmosis (RO) concentrates are combined with other wastewater streams and discharged to the wastewater treatment plant channel. The concentrates formed in RO systems used for additional hardness removal can be used in green area irrigation or in plant and tank-equipment cleaning after being brought to the desired quality standard (TUBITAK MAM, 2016; MoAF, 2021). In addition, with the structuring of monitoring for raw water quality, it is possible to re-evaluate the RO concentrates by feeding them back to the raw water reservoirs and mixing them (MoAF, 2021).

https://genesiswatertech.com/wp-content/uploads/2019/08/RO-waste-water-recycling-1.jpg

Reverse Osmosis System

- ***Documented production procedures are kept and used by employees to prevent water and energy wastage***

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

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

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

2.1.4 Precautions for Auxiliary Processes

BATs for steam generation

- ***Ensuring water saving by insulating steam and water lines (hot and cold) and preventing water and steam losses in pipes, valves and connection points in the lines and monitoring them with a computer system***

  Steam losses may occur if the steam lines are not designed properly, routine maintenance and repairs of the steam lines are not carried out, mechanical problems occurring in the lines and the lines are not operated properly, steam lines and hot surfaces are not fully insulated. This situation affects both water consumption and energy consumption of the plant. It is necessary to use control systems with automatic control mechanisms in order to make steam isolation and continuous monitoring of steam consumption. Depending on the reduction of steam losses, similar savings can be achieved in fuel consumption and additional soft water consumption in boilers. Since fuel consumption in steam boilers will decrease, waste gas emissions are expected to decrease at the same rate. Since the use of additional soft water used in steam boilers will decrease with the application, the amount of regeneration water, the amount of salt used in regeneration and reverse osmosis concentrates are also reduced. Full steam isolation application and automatic control mechanisms to minimise steam losses are used in many plants with intensive steam consumption. With the configuration of the application, fuel savings of 2-4% are achieved in steam boilers.

In order to prevent losses in production processes; adding the most important parts of the equipment such as pumps, valves, control knobs, pressure, flow regulators to the maintenance check list, inspecting not only water systems but also heating and chemical dispensing systems, drums, pumps and valves, regular cleaning of filters and pipelines, regular calibration of measuring equipment (thermometers, chemical scales, dispensing/dosing systems, etc.) and inspection and cleaning of heat treatment units (including chimneys) at routinely determined periods, effective maintenance-repair, cleaning and loss control practices can reduce water consumption by %.Regular calibration of measuring equipment (thermometers, chemical scales, distribution/dosing systems, etc.) and routine inspection and cleaning of heat treatment units (including chimneys) at specified periods, effective maintenance-repair, cleaning and loss control practices can save 1-6% in water consumption (Hasanbeigi, 2010; Öztürk, 2014; MoAF, 2021).

Industrial Steam Boiler

- ***Saving water by reusing steam boiler condensate***

When steam indirect heating techniques are used to transfer thermal energy in production processes, recovery of condensed steam (condensate) is an effective application in terms of reducing water consumption (IPPC BREF, 2009). An average of 5% reduction in water consumption can be achieved by recovering condensate (Greer et al., 2013). In addition, the potential payback period varies between 4-18 months (considering energy savings) (Öztürk, 2014; TUBİTAK MAM, 2016).

- ***Prevention of ffaş steam losses due to boiler unloading***

Steam boiler condensate is generally discharged from the system at atmospheric pressure from equipment outlets and steam traps. As the pressure decreases in condensate systems, some of the condensate re-evaporates and cools to the boiling point of water at atmospheric pressure. The re-evaporated condensate, called flash steam, is lost by being thrown into the atmosphere. In condensate return lines, which are usually quite long, cooling and therefore evaporation is inevitable. In order to prevent re-evaporation of condensate, savings can be achieved by keeping it in a flash tank under pressure until it returns to the boiler feed tank. As the pressure decreases in the condensate taken into the tank, the vapour formed is collected on the tank and feeds the low pressure steam system from here. The remaining hot condensate is taken from the bottom of the tank to the boiler.

Minimisation of boiler discharge water (blowdown) in steam boilers

Boiler blowdown refers to the water wasted from a boiler to prevent the condensation of pollutants during the continuous evaporation of steam. Boiler blowdown can be reduced by 50% with condensate recovery (IPPC BREF, 2009).

In automatic systems, blowdowns in the boilers are continuously monitored and the system is re-analysed with the water taken after the blowdown. In the analysis, data such as dissolved and undissolved particles in the water and water density are processed. If the density for the boiler is above the system limits, the blowdown process is repeated. The system should be automated and the optimum blowdown frequency should be determined. When the blowdown frequency is reduced, the amount of wastewater decreases. Energy and cooling water used for cooling this wastewater is saved (IPPC BREF, 2009). By optimising the steam boiler blowdown process, operating costs are reduced by saving on boiler water consumption, waste costs, treatment and heating.

- ***Re-use of the energy generated from the steam condenser***

With a simple modification to the pipework system, the water supplying the water resting/decarbonising unit can be obtained from the outlet of the turbine condenser unit. This water has a sufficient temperature for the resting/decarbonising unit. Therefore, it is not necessary to heat this water by means of the steam produced by the heat exchanger system. Significant vapour recovery can be achieved through this operation. Cooling water consumption can also be reduced (CPRAC, 2021).

- ***Reducing the amount of blowdown by using degassers in steam boilers***

  Free oxygen dissolved in the feed water of steam boilers and hot water boilers and carbon dioxide formed by the decomposition of carbonates in boilers can cause corrosion in the form of pores, rusting and melting in steam boilers, steam appliances and especially in installations. The effects of these gases increase as the fresh feed water ratio and system operating pressure increase. If these dissolved gases are not removed from the boiler feed water, the useful life of these systems is shortened, corrosion and various deformations may occur. These gases also cause excessive corrosion in carbon dioxide coils, steam devices and condensate pipes. Boiler feed water must be purified from dissolved gases such as oxygen and carbon dioxide by passing through degasser. Deaerator systems are mechanical systems that provide the evaporation of dissolved gases from the water by supplying air to the water with a fan. Dissolved gas removal can be increased by increasing the water and air contact surface in the degasser system. In this way, while corrosion formation is reduced, boiler efficiency is increased (TUBITAK MAM, 2016; MoAF, 2021).

BATs for cooling systems

- ***Use of a closed-loop cooling system to minimise water use***

  Closed loop cooling systems significantly reduce water consumption compared to open loop systems with more intensive water use. In closed loop systems, while the same water is recirculated within the system, it is usually necessary to add cooling water equal to the amount of water evaporated. By optimising cooling systems, evaporation losses can also be reduced.

- ***Collecting the water generated by surface runoff with a separate collection system and using it for purposes such as cooling water, process water, etc.***

  In most industrial plants, wastewater is generated from process or non-process areas. The wastewater generated can be treated and reused in appropriate places. Savings can be achieved at varying rates in various industrial plants by reusing the wastewater generated in the plant after treatment. Water generated by surface runoff can be collected with a separate collection system and used as cooling water (MoAF, 2021).

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

Cooling Systems (Chiller)

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

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

- ***Local dry air cooling in some periods of the year when the cooling requirement is low***

  In cases where the cooling requirement is low, it is possible to save water by cooling with dry air.

- ***Use of air cooling systems instead of water cooling in cooling systems***

  Industrial cooling systems are used for cooling heated products, processes and equipment. For this purpose, closed and open circuit cooling systems can be used, as well as industrial cooling systems using a fluid (gas or liquid) or dry air (IPPC BREF, 2001b; MoAF, 2021). Air cooling systems consist of finned pipe elements, condenser and air fans (IPPC BREF, 2001b; MoAF, 2021). Air cooling systems can have different operating principles. In industrial air cooling systems, the heated water is cooled by air in closed circuit cooling condensers and heat exchangers (IPPC BREF, 2001b; MoAF, 2021). In water cooling systems, the heated water is taken into a cooling tower and the water is cooled in drip systems. However, although water-cooled systems operate in closed circuit, a significant amount of evaporation occurs. In addition, since some water is discharged as blowdown in cooling systems, water loss also occurs in this way (IPPC BREF, 2001b; MoAF, 2021). The use of air cooling systems instead of water in cooling systems is effective in reducing evaporation losses and also the risk of contamination of cooling water (IPPC BREF, 2001b; MoAF, 2021).

- ***Avoiding unnecessary cooling processes by identifying processes that need wet cooling***

  The boundaries of the plant site affect design parameters such as cooling tower height. In cases where it is necessary to reduce the tower height, a hybrid cooling system can be applied. Hybrid cooling systems are a combination of evaporative and non-evaporative (wet and dry) cooling systems. Depending on the ambient temperature, the hybrid cooling tower can be operated as a fully wet cooling tower or as a combined wet/dry cooling tower (TUBITAK MAM, 2016). In regions where there is not enough cooling water or where water costs are high, the evaluation of dry cooling systems or hybrid cooling systems can be an effective solution to reduce the amount of cooling booster water (TUBITAK MAM, 2016).

- ***Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle***

  Cooling towers and evaporative condensers are efficient and low-cost systems that remove heat from air conditioning and industrial process cooling systems (IPPC BREF, 2001b; MoAF, 2021). In these systems, more than 95% of the circulating water can be recovered (TUBITAK MAM, 2016). In cooling systems, impurities remain in the recirculated water due to the evaporation of a portion of the recirculated water and the impurity concentrations gradually increase in each cycle. Impurities that can be included in the cooling system together with air can cause contamination in recirculation water (TUBITAK MAM, 2016). If impurities and contaminants are not effectively controlled, they can cause scaling and corrosion, unwanted biological growth and sludge accumulation. This can become a chronic problem leading to reduced efficiency of heat transfer surfaces and increased operating costs. In this case, it is necessary to implement a water treatment programme specifically designed for the quality of the feed water supplied to the cooling system, the cooling water system construction material and operating conditions. In this context; blowdown control, control of biological growth, corrosion control, avoidance of hard water, use of sludge control chemicals, filtration and screening systems may be appropriate (TUBITAK MAM, 2016). The establishment and periodic implementation of an effective cleaning procedure and programme is also a good management practice for the protection of cooling systems. Corrosion is one of the most important problems in cooling systems. In tower recirculation water, dissolved solids (sulphate, chloride, carbonate, etc.) that cause corrosion as a result of the formation of limestone and deposits on the walls as the degree of hardness increases will cause corrosion on the surface over time. In addition, the formation of deposits reduces energy efficiency by negatively affecting heat transfer. In order to prevent these problems, chemical treatment programme should be applied to prevent scale and corrosion, disinfection with biological activation inhibitor biocide, cooling towers in use should be subjected to chemical and mechanical cleaning at least twice a year to remove deposits, hardness and conductivity values of the make-up water should be as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). In order to improve the quality of the makeup water, it may be necessary to treat (condition) it using an appropriate treatment system. In addition, unwanted microbial growth should be kept under control (IPPC BREF, 2001b; MoAF, 2021). Blowdown occurs in cooling systems as well as in steam boilers due to micro-residues and deposits in the cooling water. The deliberate draining of the cooling system to stabilise the increasing concentration of solids in the cooling system is called cooling blowdown. By pre-treatment of cooling water with appropriate methods and continuous monitoring of cooling water quality, biocide usage and blowdown amounts can be reduced (TUBITAK MAM, 2016). Although the investment cost depends on the scale of the application, the payback period for the expected investment costs varies between 3 and 4 years (IPPC BREF, 2001).

- ***Reduction of evaporation losses in closed loop cooling water***

  Some water evaporates during the cooling of heated water in cooling systems. Therefore, in closed cycle cooling systems, cooling water is added as much as the amount of evaporated water. Evaporation losses can be prevented by optimising cooling systems. In addition, the amount of blowdown can be reduced by applications such as treatment of make-up water added to cooling systems and prevention of biological growth in cooling systems. Within the scope of the field studies carried out, the blowdown water formed in the cooling system is generally discharged directly to the wastewater channel. By reusing the cooling system blowdown water, water consumption of cooling systems can be saved up to 50%. Implementation of this measure may require the installation of new pipelines and reserve tanks (MoAF, 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 recycled in appropriate processes (EC, 2009). A water softening system is required for this system to work properly. Cooling water has suitable water quality for reuse as cleaning and irrigation water. However, since it contains some hardness in its use as cooling water, additional softening is required to prevent corrosion problems that will occur over time. These waters should be subjected to an appropriate disinfection process before being reused as cooling water or in the process. In addition, these waters can be treated with appropriate treatment techniques (membrane filtration, advanced oxidation, chemical precipitation, granular activated carbon adsorption, etc. processes) and reused not only in cooling processes but also in all production processes (TUBITAK MAM, 2016). As the hardness of the cooling water increases, limestone and deposit formation occurs on the walls. The formation of deposits adversely affects heat transfer, reducing energy efficiency and increasing energy costs. With the increase in evaporation in the system, the ion concentration and conductivity value in the water increases. In order to prevent these negativities, chemical treatment of the cooling water to prevent scale and corrosion, disinfection with a biocide that prevents biological activation, chemical and mechanical cleaning of cooling towers at least twice a year and cleaning of deposits, hardness and conductivity values should be kept as low as possible (TUBITAK MAM, 2016).

BATs for ventilation and air conditioning systems

- ***Re-use of the liquid formed by condensation from the ventilation system***

  Condensate with good water quality can be produced in the system during the aeration cycle. For example, in a plant in Spain, condensate from the aeration system with a conductivity of about 200 µS is collected in a tank and used to wash the automatic galvanising line (MedClean, n.d.).

- ***Replacement of old equipment in the aeration system with ion exchange resins based on the principle of reverse osmosis (systems producing demineralised water) and reuse of water***

  Conductivity of the final effluent using ion exchange resins in the aeration system is brought to a conductivity level suitable for use in cleaning equipment. Example in a facility in Spain, by replacing the equipment in the aeration system with ion exchange resins, effluent with a conductivity value of approximately 1000 µS is obtained and reused in the system (MedClean, n.d.).

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