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

Water Efficiency
Campaign

Water Efficiency
Guidance Documents Series

HIGHER EDUCATION CAMPUSES

NACE CODE: 85.42

ANKARA 2023

It was commissioned by the Ministry of Agriculture and Forestry, General Directorate of Water Management to the Contractor io Çevre Çözümleri R&D Ltd. Şti.

Contents

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
TUIK	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, changes in precipitation and temperature regimes as a result of climate change, increase in population, urbanisation and pollution, fair and balanced allocation 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 limited water resources through sustainable management practices.

In the vision of sustainable development set by the United Nations, *Goal 7: Ensuring Environmental Sustainability* from the Millennium Development Goals 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.

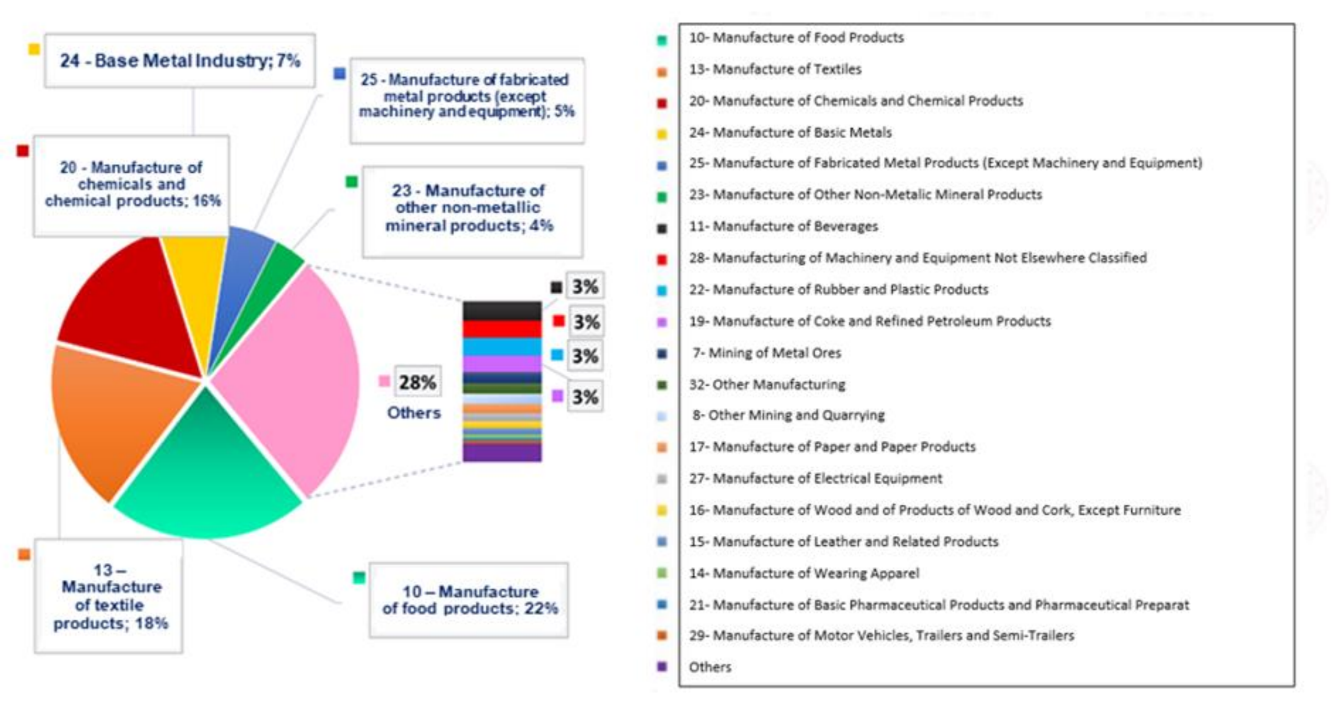
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal Action Plan, in which member countries agreed on the objectives such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing 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 the 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, mainly food, textile, chemical and basic metal industries, representing production areas with different capacities and diversity within the scope of NACE Codes operating in our country and with high water consumption, and data on water supply, sectoral water use, wastewater generation, recycling were obtained and information was provided on the best available techniques (BAT) and sectoral reference documents (BREF) published by the European Union, water efficiency, clean production, water footprint, etc.



Sectoral distribution of water use in industry in 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)
- Electrical equipment manufacturing (including sub-production area represented by 7 four-digit NACE codes)

- Manufacture of machinery and equipment not elsewhere classified (including sub-production area represented by 8 four-digit NACE codes)
- Manufacture of motor vehicles, trailers (semi-trailers) and semi-trailers (semi-trailers) (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of other 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)

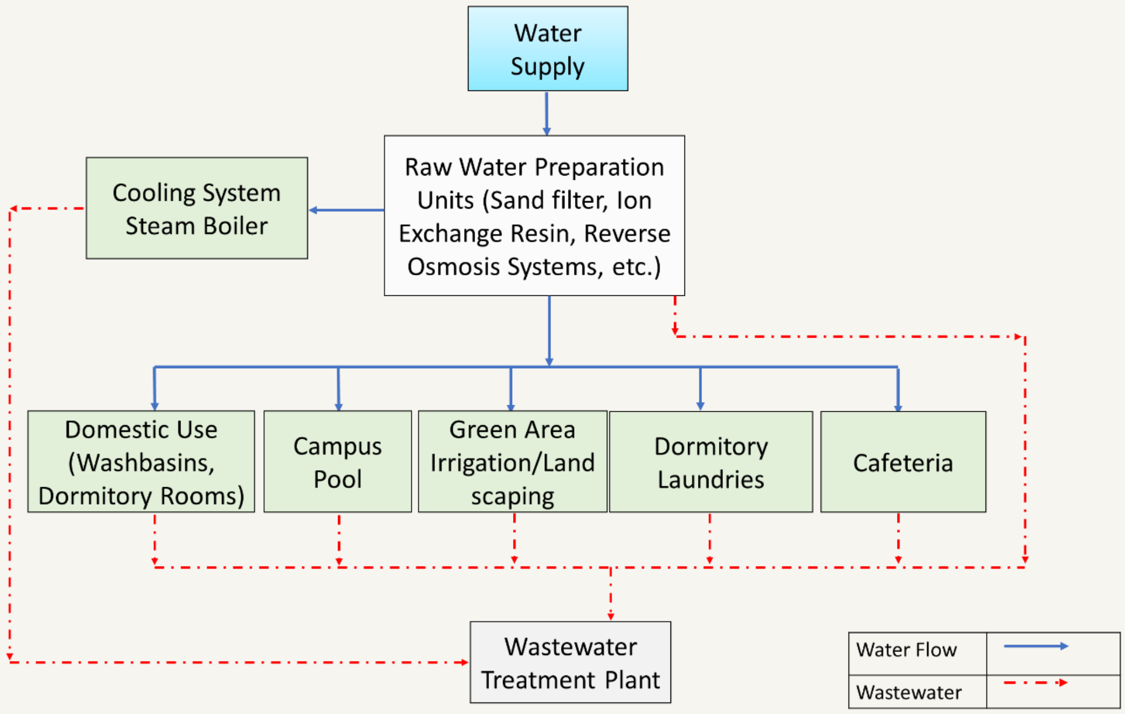
Education

The NACE Code information prepared under the education sector is given below:

85.42	Higher Education Campuses

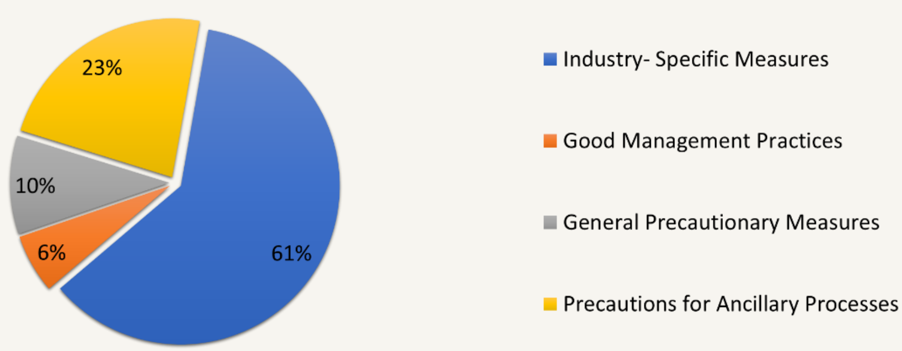
2.1 Higher Education Campuses (NACE 85.42)

Higher Education Activities Sector Water Flow Chart



	Minimum	Maximum
Specific Water Consumption of the Facilities Visited within the Scope of the Project (l/person.day)	125,67	
Reference Specific Water Consumption	There is no reference specific water consumption value.	

Percentage Distribution of Water Efficiency Applications



Within the scope of educational activities, water consumption is realised in green area irrigation, pools, dormitory laundries, dining halls and dormitory rooms in school campuses. Especially in university campuses, water consumption can reach high levels as there is domestic water consumption in dormitories where students are accommodated.

The specific water consumption of the sector analysed within the scope of the study is 125.67 L/person.day. With the implementation of sector-specific measures, auxiliary process measures, good management practices and general measures, it is possible to achieve water savings of 38-60%.

85.42 Priority water efficiency implementation techniques recommended under the Higher Education Campuses NACE code are presented in the table below.

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
85.42	Higher Education Campuses		**Sector Specific Measures**
		1.	Weighing the laundry before washing for maximum capacity operation of washing machines
		2.	Use of machines that can be adjusted according to the laundry load in the laundry
		3.	Installation of counters to monitor the amount of water consumed in laundries
		4.	Using front-loading machines that use less water instead of top-loading machines in laundries
		5.	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
		6.	Green roof application on the roofs of faculty buildings
		7.	Backwashing of filters according to filter pressure instead of a fixed programme
		8.	Checking the pools routinely for leaks and making necessary repairs
		9.	Achieving and maintaining the appropriate chemical balance to avoid the need to drain the pool
		10.	Using compost and mulch to improve the water retention properties of the soil and reduce evaporation in green areas on campus
		11.	Establishment of rainwater cisterns in the campus
		12.	Selecting plants that are suitable for local climatic characteristics and require little or no irrigation in campus landscape areas
		13.	In order to minimise evaporation in green areas on the campus, irrigation of green areas during the hours when evaporation is at a minimum
		14.	Elimination of leaks in taps and sinks, periodic cleaning and removal of limescale
		15.	Use of pedal taps or sensor taps in kitchens
		16.	Keeping the pool temperature low or using a pool cover to reduce evaporation when the pool is not in use
		17.	Using smart automation systems that utilise real-time weather and climate data in landscaping areas on campus and controlling irrigation processes with the use of timers and rain gauges
		18.	Recovery of grey water and domestic wastewater in higher education campuses
		19.	Replacement of old and inefficient pre-rinse spray valves used in higher education campus dishwashers with efficient ones
		20.	Use of combined ovens instead of steam cookers in higher education campus cafeterias
		21.	Providing flow with a mixture of water and air by using tap aerators, and installing flow restriction devices on taps that cannot be equipped with aerators
		22.	Developing a standardised cleaning process to increase efficiency in cleaning dormitory rooms

NACE Code	NACE Code Descriptio	Prioritised Sectoral Water Efficiency Techniques
85.42	Higher Education	24. Sorting the laundry according to the pollution status and washing in programmes suitable for the pollution levels
		25. Reducing the frequency of laundry rinsing, using only the required amount of soap/detergent to reduce the need for rinsing
		26. Selection of service providers applying water efficiency techniques for laundry
		27. Manual cleaning of filters where possible instead of backwashing with water
		Good Management Practices
		1. Establishment of environmental management system
		2. Providing technical trainings to personnel for the reduction and optimisation of water use
		3. Determination of water efficiency targets
		Measures in the nature of General Measures
		1. Minimising spillages and leakages
		2. Identification and minimisation of water losses
		3. Documented production procedures are kept and used by employees to prevent water and energy wastage
		4. Optimising the frequency and duration of regeneration (including rinses) in water softening systems
		5. Storage and storage of substances (such as oils, emulsions, binders) that pose a risk in the aquatic environment and prevention of their mixing with wastewater after use
		6. Use of closed loop water cycles in appropriate processes
		7. Collecting rainwater and utilising it as an alternative water source in facility cleaning or in suitable areas
		8. Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) to save water at water usage points such as showers/toilets etc.
		Precautions for Auxiliary Processes
		1. Use of a closed-loop cooling system to minimise water use
		2. Re-use of the liquid formed by condensation from the ventilation system
		3. Reducing water consumption by increasing the number of cycles in closed loop cooling systems and improving the quality of make-up water
		4. Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle
		5. Avoiding unnecessary cooling processes by identifying processes that need wet cooling
		6. Reduction of evaporation losses in closed loop cooling water
		7. Use of air cooling systems instead of water cooling in cooling systems
		8. Establishment of water softening systems for the healthy operation of cooling water recovery systems
		9. Saving water by cooling with local dry air in some periods of the year when the cooling requirement is low

A total of 47 techniques have been proposed in this sector.

2.1.1 Sector Specific Measures

- ***Establishment of rainwater cisterns in the campus***

  Collected rainwater can be used for flushing toilets or watering green areas. Significant water savings can be achieved by using this water for irrigation instead of municipal water.

- ***Green roof application on the roofs of faculty buildings***

  In the green roof application, gravel, soil and sand under the plants can be used to filter the pollutants in the rainwater, so that rainwater can be collected and reused. Harvested rainwater can be used in laundry processes. The use of rainwater in laundries eliminates the need for the use of water softening devices. It reduces or completely eliminates the amount of chemicals consumed in the washing process (Meade & Morel, 1999).

  In order to purify and collect rainwater, roofs can be planted with green roof technique. Plants absorb the minerals in the rainwater and allow the water to be filtered in components such as soil, gravel and sand under the plants. Thus, rainwater can be utilised more (Meade & Morel, 1999).

Green Roof and Stormwater Harvesting

- ***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).

- ***Using compost and mulch to improve the water retention properties of the soil and reduce evaporation in green areas on campus***

  Green areas are very important in terms of water consumption in campuses, accommodation facilities and similar facilities. Mulching is also an environmentally friendly agricultural practice. The materials used to cover the soil are called "mulch". By covering the soil with compost or mulch materials, water losses can be prevented by reducing evaporation (Meade & Morel, 1999).

- ***In order to minimise evaporation in green areas on the campus, irrigation of green areas during the hours when evaporation is at a minimum***

  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).

- ***Selecting plants that are suitable for local climatic characteristics and require little or no irrigation in campus landscape areas***

  In garden landscaping, landscaping using plants that do not need irrigation or plants that need little irrigation reduces the amount of water used for garden irrigation and water savings can be achieved (NYCEP, n.d.).

- ***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).

https://earthworksinc.net/wp-content/uploads/sites/330/2018/03/lawn-sprinker.jpg

Water Spray Apparatus with Automatic Timer

- ***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***

  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 removal of limescale***

  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).

- ***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 consume 40 per cent less water than top-loading washing machines (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).

- ***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).

- ***Checking the pools routinely for leaks and making necessary repairs***

  Pools 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 can reduce water losses due to evaporation and leaks and reduce the water required to compensate for these losses (NYCEP, n.d.).

- ***Recovery of grey water and domestic wastewater in higher education campuses***

  Water from showers, bathrooms, washbasins, washing machines and dishwashers are defined as grey water. Grey water and domestic wastewater have the potential to be recovered after being treated under appropriate conditions. Significant water savings can be achieved by recovering and reusing these waters.

  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).

- ***Developing a standardised cleaning process to increase efficiency in cleaning dormitory rooms***

  Dormitory rooms are generally the areas with the highest water use. The use of dry cleaning applications under appropriate conditions in the cleaning of the rooms reduces water consumption. If wet cleaning is required, water-efficient materials and equipment can be used.

- ***Select service providers that apply water efficiency techniques for laundry*** If laundry activities are carried out at a source other than the school, service providers that apply water efficiency methods should be selected**.**
- ***Manual cleaning of filters where possible, rather than water backwashing*** Cleaning filters manually where possible, rather than water backwashing, can provide a more thorough cleaning and save water (NYCEP, n.d.).
- ***Backwashing of filters according to filter pressure instead of a fixed programme***
  Inappropriate backwashing of sand filters 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 at appropriate rates and periods. Thus, it is envisaged that the periods of draining the pool water and filling it with fresh water can be improved (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.).

- ***Replacement of old and inefficient pre-rinse spray valves used in higher education campus 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 combined ovens instead of steam cookers in higher education campus cafeterias***
  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.
- ***Providing flow with a mixture of water and air by 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 periodically maintained.

- ***Applying dry powder cleaning methods instead of wet or steam carpet cleaning methods*** Water consumption can be reduced by choosing dry cleaning methods using special sprays or special powders instead of steam carpet cleaning.
- ***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).
- ***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.

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 enterprises. The establishment of an environmental management system improves organisations' decision-making processes between raw materials, water-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 personnel 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 plants, problems related to high water use and wastewater generation may arise due to the lack of necessary technical knowledge of the personnel. For example, it is important that cooling tower operators, who represent a significant proportion of water consumption in industrial operations, are properly trained and have technical knowledge. 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 the staff on water use reduction, optimisation and water saving policies. Practices such as involving the staff in water saving studies, creating regular reports on water use amounts 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).

- ***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 very important to determine the water saving potential and water efficiency targets for each production process and the plant as a whole (MoAF, 2021).

2.1.3 Measures in the Nature of Gener

- ***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,
  - Calibrating, 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).

- ***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.

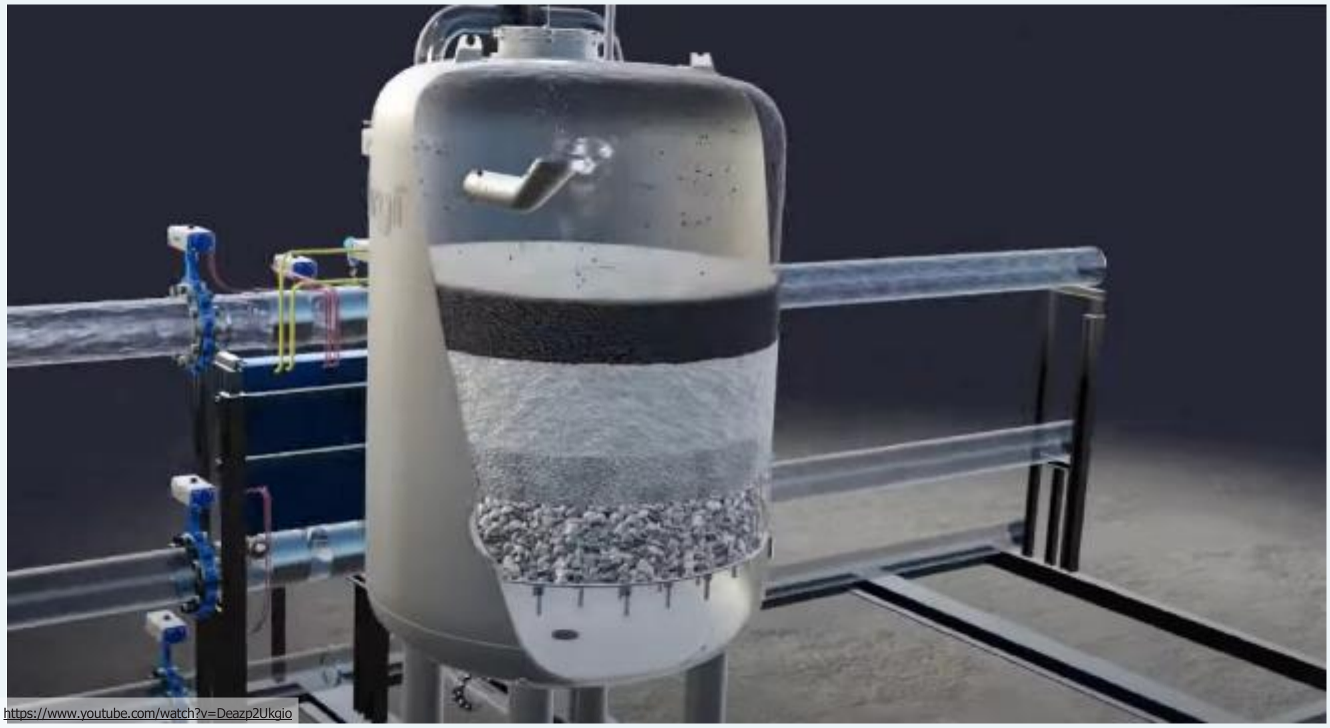
  Heat recovery is also provided by the use of heat exchangers in cooling water. Generally, closed loop systems are used in plants where aqueous cooling systems are used. However, cooling system blowdowns are discharged directly to the wastewater treatment plant channel. These blowdown waters can be reused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

- ***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.



Water Softening Systems

- ***To prevent water and energy wastage, production procedures should be documented and used by employees***

  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).

- ***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 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.

- ***Storage and storage of substances (such as oils, emulsions, binders) that pose a risk in the aquatic environment 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).

2.1.4 Precautions for Auxiliary Processes

BATs for cooling systems

- ***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).

- ***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).

- ***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).

- ***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.

- ***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).

- ***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).

- ***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).

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, 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.).

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Reşitpaşa Mah Katar Cd.
Arı Teknokent 1 2/5, D:12, 34469
Sarıyer/Istanbul

(0212) 276 65 48

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