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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Campaign

Water Efficiency
Guide Documents Series

MANUFACTURE OF OTHER INORGANIC BASIC CHEMICAL SUBSTANCES

NACE CODE: 20.13

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Abbreviations

WTP	Wastewater Treatment Plant
EU	European Union
SSM	Suspended Solid Matter
BATRD	Best Available Techniques Reference Document
EMS	Environmental Management System
MEUCC	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
MAF	Republic of Türkiye Ministry of Agriculture and Forestry
TurkSTAT	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
SW	Surface Water

1Introduction

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

For 2022, the annual amount of usable water per capita in our country is 1,313 m^3, and it is expected that the annual amount of usable water per capita will fall below 1,000 cubic meters after 2030 due to human pressures and the effects of climate change. It is obvious that if the necessary measures are not taken, Turkey will become a country suffering from water scarcity in the very near future and will bring many negative social and economic consequences. As can be understood from the results of future projections, the risk of drought and water scarcity awaiting our country necessitates the efficient and sustainable use of our existing water resources.

The concept of water efficiency *can be defined as* "the use of the least amount of water in the production of a product or service". Water efficiency approach; It is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, especially drinking water, agriculture, industry and household uses, taking into account the needs of not only people but also ecosystem sensitivity and all living things by protecting it in terms of quantity and quality.

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

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

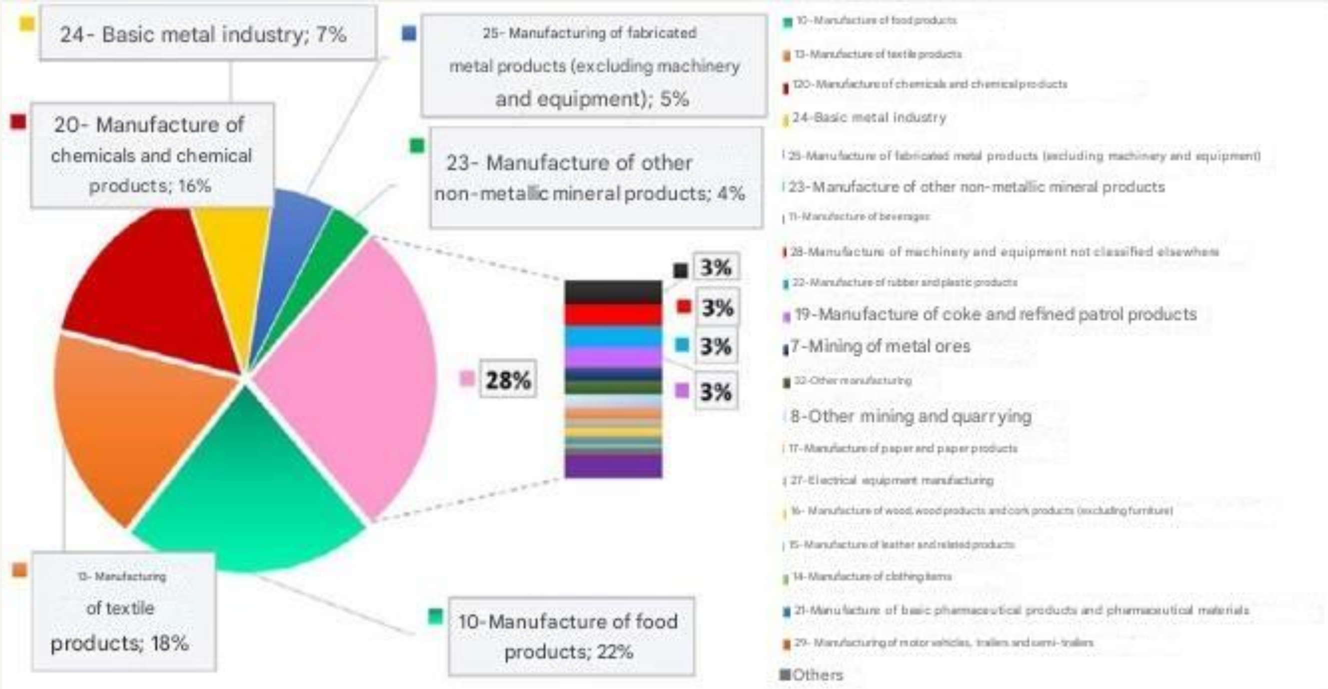
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal, where member countries agree on goals such as implementing a clean, circular economy model with the goal of carbon neutrality, expanding the efficient use of resources and reducing environmental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

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

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

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

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



Distribution of water uses in industry on a sectoral basis in Türkiye

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

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

2 Scope of the Study

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

- Crop and animal production, hunting and related service activities (including sub-production areas represented by 6 four-digit NACE Codes)
- Fisheries and aquaculture (including 1 sub-production area represented by a four-digit NACE Code)
- Extraction of coal and lignite (including 2 sub-production areas represented by a four-digit NACE Code)
- Service activities in support of mining (including 1 sub-production area represented by a four-digit NACE Code)
- Metal ore mining (including 2 sub-production areas represented by a four-digit NACE Code)
- Other mining and quarrying (including 2 sub-production areas represented by a four-digit NACE Code)
- Manufacture of food products (including 22 sub-production areas represented by a four-digit NACE Code)
- Manufacture of beverages (including 4 sub-production areas represented by a four-digit NACE Code)
- Manufacture of tobacco products (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of textiles (including 9 sub-production areas represented by a four-digit NACE Code)
- Manufacture of apparel (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of leather and related products (including 3 sub-production areas represented by a four-digit NACE Code)
- Manufacture of wood, wood products and cork products (except furniture); manufacture of articles made by knitting from reeds, straw and similar materials (including 5 sub-production areas represented by a four-digit NACE Code)
- Manufacture of paper and paper products (including 3 sub-production areas represented by a four-digit NACE Code)
- Manufacture of coke and refined petroleum products (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by a four-digit NACE Code)
- Manufacture of basic pharmaceutical products and pharmaceutical materials (including 1 sub-production area represented by a four-digit NACE Code)
- Manufacture of rubber and plastic products (including 6 sub-production areas represented by a four-digit NACE Code)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by a four-digit NACE Code)
- Base metal industry (including 11 sub-production areas represented by a four-digit NACE Code)
- Manufacture of fabricated metal products (excluding machinery and equipment) (including 12 sub-production areas represented by a four-digit NACE Code)
- Manufacture of computers, electronic and optical products (including sub-production area represented by 2 four-digit NACE Codes)
- Manufacture of electrical equipment (including 7 sub-production areas represented by a four-digit NACE Code)
- Manufacture of machinery and equipment, n.e.c. (including 8 sub-production areas represented by a four-digit NACE Code)
- Manufacture of motor vehicles, trailers and semi-trailers (including 3 sub-production areas represented by a four-digit NACE Code)
- Manufacture of other means of transport (including 2 sub-production areas represented by a four-digit NACE Code)
- Other productions (including 2 sub-production areas represented by a four-digit NACE Code)

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- Installation and repair of machinery and equipment (including 2 sub-production areas represented by a four-digit NACE Code)
- Electricity, gas, steam and ventilation system production and distribution (including 2 sub-production areas represented by a four-digit NACE Code)
- Waste collection, remediation and disposal activities; recovery of materials (including 1 sub-production area represented by a four-digit NACE Code)
- Construction of non-building structures (including 1 sub-production area represented by a four-digit NACE Code)
- Storage and supporting activities for transportation (including 1 sub-production area represented by a four-digit NACE Code)
- Accommodation (including 1 sub-production area represented by a four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including 1 sub-production area represented by a four-digit NACE Code)
- Sports, entertainment and recreational activities (including 1 sub-production area represented by a four-digit NACE Code)

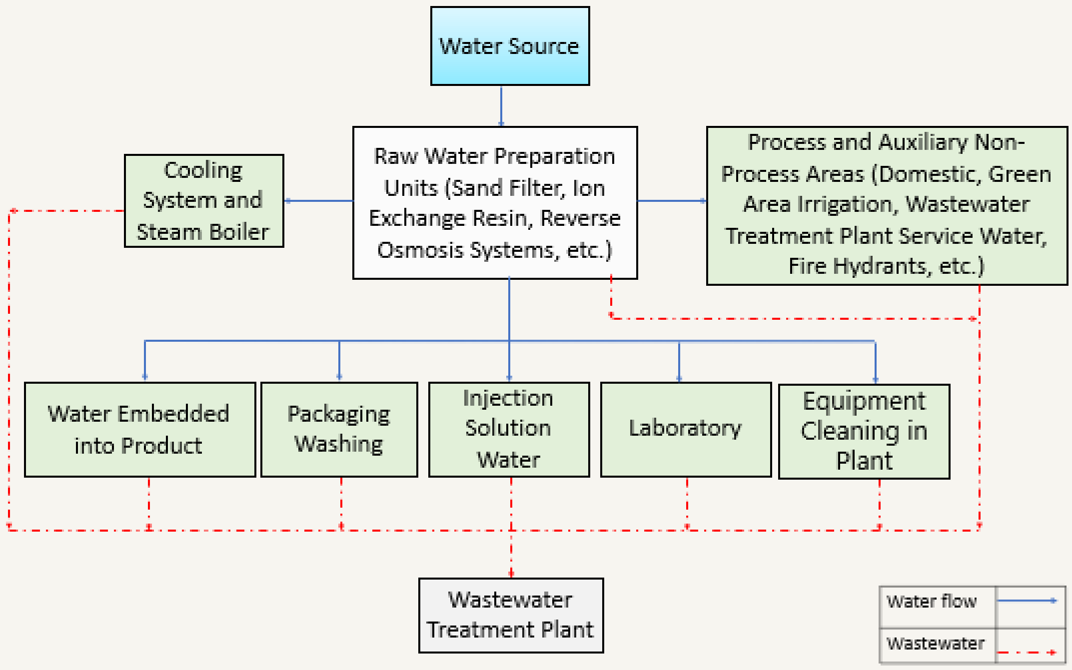
Manufacture of chemicals and chemical products

Under the manufacturing of chemicals and chemical products sector, the sub-production branches for which guide documents have been prepared are as follows:

20.11	Manufacture of industrial gases
20.12	Manufacture of dyestuffs and pigments
20.13	Manufacture of other inorganic basic chemicals
20.14	Manufacture of other organic basic chemicals
20.15	Manufacture of chemical fertilizers and nitrogen compounds
20.16	Manufacture of plastic raw materials in primary form
20.17	Manufacture of synthetic rubber in primary form
20.20	Manufacture of pesticides and other agro-chemical products
20.30	Manufacture of paints, varnishes and similar coating agents, printing ink and putty
20.41	Manufacture of soaps and detergents, cleaning and polishing agents
20.42	Manufacture of perfumes, cosmetics and personal care products
20.59	Manufacture of other chemical products n.e.c.
20.60	Manufacture of man-made or man-made fibers

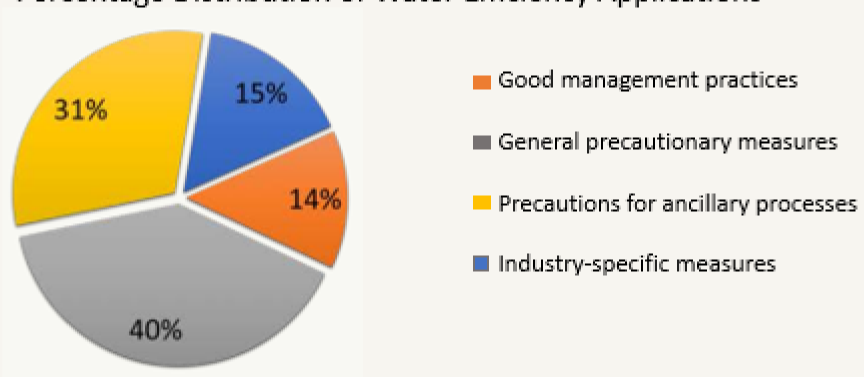
2.1Manufacture of Other Inorganic Basic Chemicals (NACE 20.13)

Manufacture of Other Inorganic Chemical Products Sector
Water Flow Chart



	Minimum	Maximum
Specific Water Consumption of the Facilities Visited within the Scope of the Project (L/kg product)	0,9	27,3
Reference Specific Water Consumption (L/kg product)	4	125

Percentage Distribution of Water Efficiency Applications



Production processes used in the manufacture of other inorganic basic chemicals can generally be listed as ore crushing and grinding, reaction, filtration, crystallization-centrifugation, drying and packaging unit. However, production processes may vary depending on the preferred raw material, the technique/technology used and the desired final product. The raw materials used in production can be prepared with the ore crushing and grinding unit, or they can be accepted as ready for the facility from outside. The ore crushing and grinding unit is used to ensure that the raw material is reduced to the desired dimensions. The raw materials that pass through the ore crushing and grinding unit and/or are supplied from outside are taken to the reaction unit and mixed in the reaction tanks is carried out. Depending on the desired final product, mixing can also be done by heating the tanks if needed. When necessary, the heated boilers are subjected to the cooling process. The solution obtained as a result of the reaction is sent to the filtration unit to separate the impurities in it. After filtration, the prepared solutions are taken from the tanks where they are stored and transferred to the crystallization tank according to the desired final product, and then the moisture content is reduced in the centrifuge unit. In the drying unit, the moisture content of the final product is reduced to the required level. Finally, the product coming to the packaging unit is packaged and made ready for shipment.

In the manufacture of other inorganic basic chemicals, water consumption is realized in crushing-screening-washing, dusting prevention, injection solution water preparation, laboratory and packaging washing processes. In addition, there are also waters that are added directly to the content of the product according to the final product produced. Significant water consumption is also realized for filter washing, resin regeneration and membrane cleaning processes in raw water preparation units such as activated carbon filter, ion exchange resin, reverse osmosis, which are used to produce soft water needed in production processes in the sector. In addition, water consumption occurs in auxiliary units such as cooling towers and steam boilers.

In the manufacture of other inorganic basic chemicals, the reference specific water consumption is in the range of 4 - 125 L/kg. The specific water consumption of the production branch analyzed within the scope of the study is 0.9 – 27.3 L/kg. With the implementation of sector-specific techniques, good management practices, measures in the nature of general measures and measures related to auxiliary processes, in the sector
It is possible to achieve 22-33% water recovery.

20.13 Manufacture of Other Inorganic Basic Chemicals The priority water efficiency implementation techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Description		Prioritized Sectoral Water Efficiency Techniques
20.13	Manufacture of other inorganic basic chemicals		**Industry-Specific Measures**
		1.	Use of low-pressure steam in the ammonium nitrate process to heat boiler feed water
		2.	The use of condensate from ammonium nitrate plant in the absorption column of nitric acid plant
		3.	Recovery of spilled materials from acid conditioning
		4.	Reuse of process water by treatment
		5.	Treatment of wastewater resulting from wet cleaning, washing of metallurgical waste gases and cleaning of gases from acid regeneration by sedimentation, filtration/decantation and neutralization processes
		6.	Using a common ammonia evaporator for nitric acid (HNO3) and ammonium nitrate (AN) processes
		7.	Condensation and reuse of steam obtained as a result of nitric acid and ammonia reactions
		8.	Purification or condensation of the process steam from the neutralizer and subsequent purification, use of the steam in the evaporator or pre-heating the ammonia and reusing it in different processes
		9.	Recovery of process vapors by condensation in a single column
			Good Management Practices
		1.	Using an integrated wastewater management and treatment strategy to reduce the amount of wastewater and the pollutant load
		2.	Establishment of an environmental management system
		3.	Preparation of water flow diagrams and mass balances for water
		4.	Preparation of a water efficiency action plan to reduce water use and prevent water pollution
		5.	Providing technical training to personnel for the reduction and optimization of water use
		6.	Good production planning to optimize water consumption
		7.	Setting water efficiency targets
		8.	Monitoring the amount and quality of the water used in production processes and auxiliary processes and the wastewater generated and adapting this information to the environmental management system

NACE Code	NACE Code Description		Prioritized Sectoral Water Efficiency Techniques
20.13	Manufacture of other inorganic basic chemicals	1.	Minimization of spills and leaks
		2.	Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality
		3.	Use of automatic equipment and equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets, etc.
		4.	Use of pressure washers for equipment cleaning, general cleaning, etc.
		5.	Reuse of filter wash water in filtration processes, reuse of relatively clean cleaning water in production processes, and reduction of water consumption by using clean-in-place systems (CIP)
		6.	Avoiding the use of drinking water in production lines
		7.	Use of cooling water as process water in other processes
		8.	Detection and reduction of water losses
		9.	Use of automatic check-off valves to optimise water use
		10.	Documentation of production procedures and use by employees to prevent waste of water and energy
		11.	Optimising the frequency and duration of regeneration (including rinses) in water softening systems
		12.	Construction of closed storage and impermeable waste/scrap yard to prevent the transportation of toxic or hazardous chemicals for the aquatic environment
		13.	Storage, storage and prevention of substances that pose a risk in the aquatic environment (such as oils, emulsions, binders) and mixing with wastewater after use
		14.	Where technically feasible, suitable wastewater is treated and used as steam boiler feed water
		15.	Prevention of mixing of clean water streams with dirty water streams
		16.	Characterizing the amount and quality of wastewater at all wastewater formation points and determining the wastewater flows that can be reused with or without treatment
		17.	Use of closed-loop water cycles in appropriate processes

NACE Code	NACE Code Description		Prioritized Sectoral Water Efficiency Techniques
20.13	Manufacture of other inorganic basic chemicals	18.	Use of computer-aided control systems in production processes
		19.	Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes
		20.	Determination of the scope of reuse of washing and rinsing waters
		21.	Separate collection and treatment of gray water in the facility and in areas that do not require high water quality (green area irrigation, floor, floor washing, etc.) Use
		22.	Implementation of time optimization in production and arrangement of all processes to be completed as soon as possible
		23.	Collecting rainwater and evaluating it as an alternative water source in facility cleaning or in appropriate areas
		24.	Avoiding the need for rinsing between activities by using compatible chemicals in successive processes
		25.	Reuse of nanofiltration (NF) or reverse osmosis (CTR) concentrates with or without purification depending on characterization
			Precautions for Ancillary Processes
		1.	Saving water by reusing steam boiler condensate
		2.	Replacement of old equipment in the ventilation system with ion exchange resins (systems that produce demineralized water) based on the principle of reverse osmosis and reuse of water
		3.	Reuse of the liquid formed by condensation from the ventilation system
		4.	Avoiding unnecessary cooling processes by identifying processes that need wet cooling
		5.	Reduction of water consumption in closed-loop cooling systems by increasing the number of cycles and improving the quality of the catch-up water
		6.	Reduction of evaporation losses in closed-loop cooling water
		7.	With tower cooling application in systems that do not have a closed loop Water recovery

NACE Code	NACE Code Description	Prioritized Sectoral Water Efficiency Techniques
20.13	Manufacture of other inorganic basic chemicals	8. Increasing the number of cycles by using anti-corros ion and anti-scale inhibitors in systems with a closed water loop
		9. Prevention of flash steam losses due to boiler draining
		10. Installation of water softening systems for the healthy operation of cooling water recovery systems
		11. Use of a closed-loop refrigeration system to reduce water use
		12. In some periods of the year, when the need for cooling is low, cooling with local dry air
		13. Collecting the water generated by surface runoff with a separate collection system and using it for cooling water, process water, etc.
		14. Reducing the amount of blowdown by using deaerators in steam boilers
		15. Minimizing boiler discharge water (blowdown) in steam boilers
		16. Reuse of energy generated from the steam condenser
		17. Making the most effective use of cooling water by reducing cooling water discharges
		18. Water saving through isolation of steam and water lines (hot and cold) providing, preventing water and steam losses at pipes, valves and connection points in the lines and monitoring them with a computer system

A total of 60 techniques have been proposed in this sector.

Manufacture of other inorganic basic chemicals
Towards NACE Code;

(i) Sector-Specific Methods,
(ii) Good Management Practices,
(iii) General Water Efficiency BATs and
(iv) Measures related to auxiliary processes are given under separate headings.

2.1.1 Industry-Specific Methods

- ***Use of low-pressure steam in the ammonium nitrate process to heat boiler feed water***

  Ammonia is used in the production of acids and fertilizers. By using low-pressure steam from the ammonium nitrate process to heat boiler feed water, environmental benefits can be achieved, such as improving energy efficiency, reducing water pollution, and reducing demineralized water consumption. In addition, it is a feasible method that provides economic benefits as it reduces energy and demineralized water consumption, has a low investment cost and is applicable (IPPC BREF, 2007d).

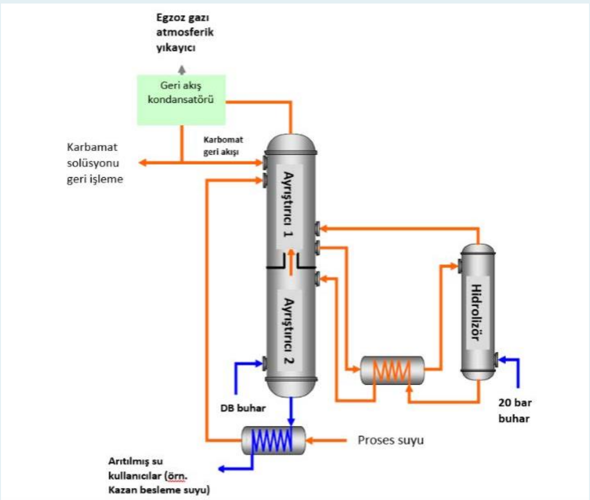
- ***The use of condensate from ammonium nitrate plant in the absorption column of nitric acid plant***

  The use of condensate from the ammonium nitrate plant in the absorption column of the nitric acid plant is a method to increase process integration (IPPC BREF, 2007d). With the application of this technique, the need for demineralized water will decrease and the amount of emissions released into the water will also decrease.

- ***Reuse of process water by treatment***

  In the urea plant with a capacity of 1,000 tons/day, approximately 500 m³ of process water is generated per day. The main source of the water formed is the synthesis reaction, in which 0.3 tons of water are formed for each ton of urea produced. Other water sources are ejector steam, washing and sealing water, and steam used in wastewater treatment plant.

  Heated process water can be reused by purification by techniques such as distillation and hydrolysis, stripping and hydrolysis, CO2/NH3 removal, and then biological treatment. The process water is fed through the separator 1, which is shown in the process flow diagram below. Here, ammonia (NH3) and carbon dioxide (CO2) are removed by the gas flow from the hydrolyzer to the decomposer 2. The liquid coming out of the base of the separator 1 is preheated and fed (IPPC BREF, 2007d). With the application of this technique, CO2 and NH3 are returned to the process. In addition, if the treated process water is of suitable character, it can be reused in the process and the emissions released into the water are also important advantages.



Process Water Treatment

- ***Recovery of spilled materials from acid conditioning***

  All phosphoric acid conditioning procedures should be carried out in a confined space where spills can be recovered . The recovered drainage water can be used to dilute the acid. Gases, water vapor and powders from the reactor can be washed in a scrubber or sent to the dryer, which uses water to dilute the acid. In the various production facilities that use this process, wastewater can be generated with little or no wastewater. When a gas scrubber is not used as dedusting equipment, there is no need to add water to the system and no wastewater is generated. When a scrubber is used, the water can be kept in a closed loop, allowing this water to be reused (IPPC BREF, 2007e).

- ***Using an integrated wastewater management and treatment strategy to reduce the amount of wastewater and its pollutant load***

  Wastewater management should be based on a holistic approach from the production of wastewater to the final disposal stage and should include functional elements such as its composition, collection, treatment including sludge treatment, and reuse. Selection of appropriate treatment technology for industrial wastewater should be based on integrated factors such as land availability, desired treated water quality, and compliance with national and local regulations (Abbassi & Al Baz, 2008).

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

  In integrated industrial wastewater treatment, different aspects such as the wastewater collection system, the treatment process, and the reuse target are evaluated together (Naghedi et al., 2020). Facilities can determine the integrated wastewater treatment framework by combining methods such as SWOT method (strengths, weaknesses, opportunities and threats), PESTEL method (political, economic, social, technological, environmental and legal factors), decision tree with expert opinions in order to create the most appropriate functional group for industrial wastewater recycling (Naghedi et al., 2020). Integrating the Analytical Hierarchy Process (AHP) and Unified Consensus Solution (CoCoSo) techniques can be used to set priorities for industrial wastewater management processes based on a multitude of criteria (Adar et al., 2021).

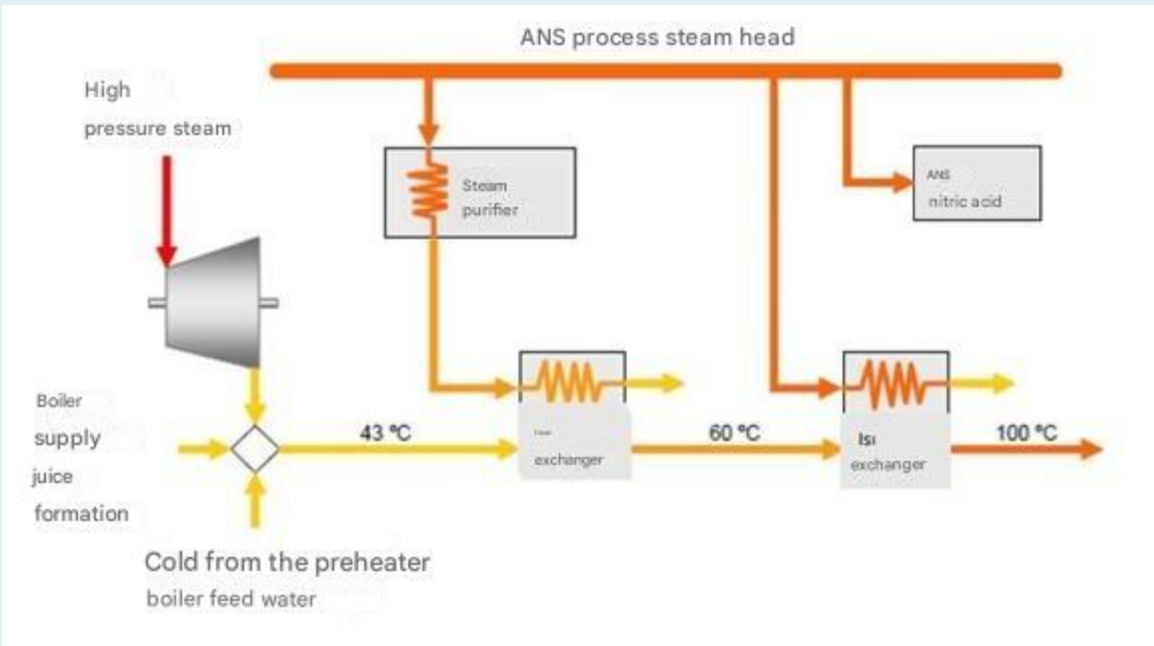
  With the implementation of integrated wastewater management strategies, reductions of up to 25% in water consumption, wastewater quantities and pollution loads of wastewater can be achieved on average. The potential payback period of the application can range from 1-10 years (MAF, 2021).

- ***Treatment of wastewater resulting from wet cleaning, washing of metallurgical waste gases and cleaning of gases from acid regeneration by sedimentation, filtration/decantation and neutralization processes***

  The main environmental benefit of treating wastewater resulting from wet cleaning, leaching of metallurgical waste gases and cleaning of gases from acid regeneration by sedimentation, filtration/decantation and neutralization processes is the reduction of pollution elements in wastewater (IPPC BREF, 2007d).

- ***Using a common ammonia evaporator for nitric acid (HNO3) and ammonium nitrate (AN) processes***

  In this system, which increases process integration, it is recommended to use a common evaporator operated with ammonium nitrate process steam for heated and gaseous ammonia, which is used as raw material for both processes. The main environmental benefits of the method are increasing energy efficiency, reducing the amount of pollution in the water, and reducing the consumption of demineralized water. In addition, it provides economic benefits due to the reduction of energy and demineralized water consumption, and it is a low investment cost and feasible method (IPPC BREF, 2007d). The process of heating the boiler feed water with steam in the Ammonium Nitrate plant is shown below (IPPC BREF, 2007d).



Steam Heating Process of Boiler Feed Water in AN Plant

- ***Condensation and reuse of steam obtained as a result of nitric acid and ammonia reactions***

  The ammonium nitrate synthesis process involves the reaction of nitric acid and ammonia. The condensates formed as a result of the vapor condensations produced during the reaction of nitric acid and ammonia in the two existing reactors can be purified and reused. This method is based on re-evaporation of condensates in two double-acting evaporators. The operating cost is very low. It takes place in two different stages. Due to the quality of the condensate produced, it can be used as desalinated water for a variety of uses. It has environmental benefits such as reducing wastewater generation and air pollution (MedClean(c), n.d.).

- ***Saffinating or condensing the process steam from the neutralizer and then saffinating it, using the steam in the evaporator or preheating the ammonia and reusing it in different processes***

  It is possible to saffle or condense and then saffle the process steam from the neutralizer, use the steam in the evaporator, or preheat and evaporate the ammonia or use it to preheat nitric acid. Some water is fed into the process along with nitric acid (HNO3) and only a portion of this water is used in the ammonium nitrate system (ANS). A significant amount of process steam is generated during the process. The condensed process vapor contains ammonium nitrate (AN), nitric acid (HNO3) or ammonia (NH3) in varying proportions depending on the process conditions and the degree of purification. Contaminated condensate can be reused or purified using a variety of techniques, including:

  - Air or steam stripping with the addition of alkali to release ionized ammonia when necessary,
  - Distillation
  - Use of membrane separation techniques such as Reverse Osmosis.

  Another option is ion exchange. However, the recycling of organic resins to ammonium nitrate and nitration of the exchange resin should be prevented. The options for the discharge/disposal of condensate from the steam from the neutralizer are:

  - Sending it to biological treatment (on-site or joint treatment with municipal wastewater),
  - Sending to nitric acid plant to be used as absorption water,
  - Evaluation in the production of fertilizer solution,
  - To be used as boiler feed water by applying advanced treatment,
  - Submission to the granulation scrubbing department (IPPC BREF, 2007d).

- ***Recovery of process vapors by condensation in a single column***

  The method is used for the production of ammonia, acid and fertilizer and is based on condensing and recovering the steam generated in the process in a single column by reverse osmosis. For the application, a column in which the steam from the production of the nitrate solution is washed, an ammonia evaporator, a preheater, an air condenser, a reverse osmosis unit are required. It is a process that increases energy efficiency. Water, natural gas and electricity consumption is reduced by ensuring that boiler feed water is reused (MedClean(d), n.d.).

2.1.2 Good Management Practices

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

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

The most widely used Environmental Management Standard is ISO 14001. Alternatives include the Eco Management and Audit Programme Directive (EMAS) (761/2001). It has been developed for the evaluation, 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 participation is provided voluntarily (TUBITAK MAM, 2016; MAF, 2021). The benefits of establishing and implementing an Environmental Management System are as follows:

- Economic benefits can be achieved by improving business performance (Christopher, 1998).
- International Organization for Standardization (ISO) standards are adopted, resulting in greater compliance with global legal and regulatory requirements (Christopher, 1998).
- While the penalty risks related to environmental responsibilities are minimized, the amount of waste, resource consumption and operating costs are reduced (Delmas, 2009).
- The use of internationally accepted environmental standards eliminates the need for multiple registrations and certifications 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 important to consumers. The implementation of environmental management systems provides a competitive advantage over companies that do not adopt the standard. It also contributes to the better position of institutions in international areas/markets (Potoski & Prakash, 2005).

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

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

- ***Using an integrated wastewater management and treatment strategy to reduce the amount of wastewater and the pollutant load***

  Wastewater management should be based on a holistic approach from wastewater production to final disposal and includes functional elements such as composition, collection, treatment including sludge disposal and reuse. The selection of appropriate treatment technology for industrial wastewater depends on integrated factors such as land availability, desired treated water quality, and compliance with national and local regulations (Abbassi & Al Baz, 2008).

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

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

  With the implementation of integrated wastewater management strategies, an average reduction of up to 25% in water consumption, wastewater quantity and pollution loads of wastewater can be achieved. The potential payback period of the application ranges from 1-10 years (MAF, 2021).

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

  With this measure, water saving and water recovery can be achieved by increasing the training and awareness of the personnel, and water efficiency can be achieved by reducing water consumption and costs. Due to the fact that the personnel do not have the necessary technical knowledge in industrial facilities, problems may arise with the use of high amounts of water and wastewater formation. For example, it is important that cooling tower operators, who represent a significant proportion of water consumption in industrial operations, are properly trained and have technical knowledge. In applications such as determining water quality requirements in production processes, measuring water and wastewater amounts, etc., it is necessary for the relevant personnel to have sufficient technical knowledge (MAF, 2021). For this reason, it is important to provide training to staff on water use reduction, optimization and water saving policies.

Practices such as involving personnel in water conservation studies, creating regular reports on water usage amounts before and after water efficiency initiatives, and sharing these reports with personnel support participation and motivation in the process. The technical, economic and environmental benefits to be obtained through personnel training give results in the medium or long term (TUBITAK MAM, 2016; MAF, 2021).

- ***Monitoring the water used in production processes and auxiliary processes and the wastewater generated in terms of quantity and quality and adapting this information to the environmental management system,*** There are resource uses in industrial facilities, and as a result of resource use,
  Inefficiency and environmental problems can be caused by input-output flows. Therefore
  It is necessary to monitor the water and wastewater used in production processes and auxiliary processes in terms of their quantity and quality (TUBITAK MAM, 2016; MAF, 2021). Process-based quantity and quality monitoring, together with other good management practices (personnel training, establishment of an environmental management system, etc.), can be used to reduce energy consumption by 6-10%, water consumption and wastewater amounts. It can provide a reduction of up to 25% (Öztürk, 2014).

The main stages for monitoring water and wastewater in terms of quantity and quality are:

- Use of monitoring equipment (such as meters) to monitor consumption of water, energy, etc. on the basis of processes,
- Establishment of monitoring procedures,
- Determining the use/exit points of all inputs and outputs (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste and by-products) related to the production process, monitoring, documenting, comparatively evaluating and reporting in terms of their quantity and quality,
- Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against raw material losses (MoEUB, 2020e).

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

  In industrial production processes, planning a raw material until it turns into a product by using the least process is an effective practice to reduce labor costs, resource use costs and environmental impacts and to ensure efficiency (TUBITAK MAM, 2016; MAF, 2021). Production planning in industrial facilities by considering the water efficiency factor reduces water consumption and wastewater. Modifying production processes or combining some processes in industrial facilities provides significant benefits in terms of water efficiency and time planning (MAF, 2021).

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

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

- ***Setting water efficiency targets***

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

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

  Determination of water use and wastewater generation points in industrial facilities, creation of water-wastewater balances in production processes and auxiliary processes other than production processes are the basis of many good management practices in general. Creation of process profiles throughout the plant and on the basis of production processes; It facilitates the identification of unnecessary water usage points and high water use points, the evaluation of water recovery opportunities, process modifications and the determination of water losses (MAF, 2021).

2.1.3 General Water Efficiency BATs

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

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

  - Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist ,
  - Carrying out inspections not only in the water system, but also especially for heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps and valves,
  - regular cleaning of filters and pipelines,
  - Calibrating, routinely checking and monitoring measuring equipment such as chemical measuring and dispensing instruments, 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).

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

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

- ***Where technically feasible, suitable wastewater is treated and used as steam boiler feed water***

  Although it is difficult to apply in industrial facilities, 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; TUBITAK MAM, 2016). The initial investment cost required for the application is the treatment system to be used. Considering the amount of water to be recycled, the amount of economic savings, the applied unit water-wastewater costs, and the operation and maintenance costs of the treatment system, the payback periods vary (MAF, 2021). Membrane systems (a combination of ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (CTR) systems can be used for recovery. For example, in some industrial facilities, it is possible to treat the cooling system blowdown water and reuse it as process water (MAF, 2021).

- ***Prevention of mixing of clean water streams with dirty water streams***

  By determining the wastewater formation points and characterizing the wastewater in industrial facilities, wastewater with high pollution load and relatively clean wastewater can be collected in separate lines (TUBITAK MAM, 2016; MAF, 2021). In this way, wastewater streams of appropriate quality can be reused with or without treatment. By separating wastewater streams, water pollution is reduced, treatment performances are increased, energy consumption can be reduced in relation to reducing treatment needs, and emissions are reduced by ensuring wastewater recovery and recovery of valuable materials. In addition, heat recovery from separated hot wastewater streams is also possible (TUBITAK MAM, 2016; MAF, 2021) Separation of wastewater streams often requires high investment costs, and costs can be reduced when it is possible to recover large amounts of wastewater and energy (IPPC BREF, 2006).

- ***Determination of wastewater flows that can be reused with or without treatment by characterizing the amount and quality of wastewater at all wastewater formation points***

  By determining and characterizing wastewater formation points in industrial facilities, it is possible to reuse various wastewater streams with or without treatment (Öztürk, 2014; TUBITAK MAM, 2016; MAF, 2021). In this context, filter backwash water, CTR concentrates, blowdown water, condensate water, relatively clean washing and rinsing water can be reused without treatment in the same/different processes and in areas that do not require high water quality (such as plant and equipment cleaning). Apart from this, it is possible to reuse wastewater streams that cannot be reused directly in production processes after they are treated using appropriate treatment technologies.

  Membrane filtration processes are an integral part of many wastewater reuse systems. Nanofiltration (NF) and Reverse osmosis (CTR) filtration systems are used for industrial wastewater recovery. Microfiltration (MF) and ultrafiltration (UF) are often used for the pretreatment of water before it goes to the NF or CTR process (Singh et al., 2014).

- ***Use of cooling water as process water in other processes***

  Water cooling systems are widely used in processes where thermal energy is used intensively and cooling is required . It is possible to save water and energy by using heat exchangers in cooling water return, preventing contamination of cooling water and increasing cooling water return rates (TUBITAK MAM, 2016; MAF, 2021). In addition, if the cooling water is collected separately, it is often possible to use the collected water for cooling purposes or to reuse it in appropriate processes (EC, 2009). With the reuse of cooling water , 2-9% of total water consumption can be saved (Greer et al., 2013). Savings of up to 10% can be achieved in energy consumption (Öztürk, 2014; MAF, 2021).

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

  In industrial facilities, relatively clean wastewater such as washing-final rinsing wastewater and filter backwash wastewater can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Thus, it is possible to save between 1-5% in raw water consumption (MAF, 2021).

- ***Use of automatic check-off valves to optimise water use***

  Monitoring and controlling water consumption using flow control devices, meters and computer-aided monitoring systems provides significant technical, environmental and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed within the facility and in various processes prevents water losses (TUBITAK MAM, 2016). It is necessary to use flow meters and meters in the facility and production processes, to use automatic shut-off valves and valves in continuously operating machines, to develop monitoring-control mechanisms according to water consumption and some determined quality parameters using computer-aided systems (TUBITAK MAM, 2016). With this application, it is possible to save up to 20-30% in water consumption on a process basis (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). By monitoring and controlling water consumption on a process basis , 3-5% savings can be achieved in process water consumption (Öztürk, 2014).

- ***Avoiding the need for rinsing between activities by using compatible chemicals in successive processes***

  Chemical compatibility is a measure of how stable a substance is when mixed with another substance. If two substances mix with each other and undergo a chemical reaction, they are considered incompatible.

  Various chemicals are used in industrial facilities to increase washing and rinsing efficiency. The fact that these chemicals are compatible and act as solvents shows a positive course in increasing efficiency. Therefore, dirt on the material can be removed in a shorter time and more effectively, and the amount of water used in washing processes can be significantly reduced. In this case, even if the amount of wastewater can be reduced, there may be an increase in the chemical loads carried by the wastewater. These negative effects can be minimized by ensuring that the washing water containing solvents used in the washing and rinsing processes is reused.

  It is possible to save 25-50% of water by reusing washing water. Reserved tanks and new pipelines may be needed for the application. In alternative cases, the washing solution is kept directly in the system and can be used many times until it loses its properties.

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

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

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

  In today's world where 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, infiltration into the ground, collection from the surface and filter systems are used. Rainwater collected by 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 (Witness et al., 2015).

  In various examples, 50% water savings were achieved in landscape irrigation by using roof rainwater collected in industrial facilities and using it in buildings and landscaping areas after storing it (Yaman, 2009). Perforated stones and green areas can be preferred in order to increase the permeability of the ground and to ensure that rainwater passes and is absorbed into the soil in the field (Yaman, 2009). Rainwater collected on the roofs of buildings can be used for car washing and garden irrigation. It is possible to reuse the collected water by recovering 95% of it with biological treatment after use (Şahin, 2010).

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

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

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

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

  In regeneration processes, washing, regeneration and rinsing wastewater are usually removed directly . However, if the washing and final rinsing water is of raw water quality, it can be sent to the raw water tank or reused in processes that do not require high water quality, such as facility cleaning and green area irrigation (MAF, 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 frequency recommended by the supplier or depending on the flow rate and time entering the softening system, this frequency also varies depending on the calcium concentration in the raw water. For this reason, online hardness measurement is applied when determining the frequency of regeneration. Thus, regeneration frequencies can be optimized, as well as excessive washing, rinsing or backwashing with salt water can be prevented by using online hardness sensors.

- ***Use of automatic equipment 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 provide the necessary hygiene standards. Water consumption can be achieved in various ways in the production processes of industrial facilities, as well as savings in water consumption by using equipment such as sensor taps and smart hand washing systems in the water usage areas of the personnel. Smart hand washing systems adjust the water, soap and air mixture in the right proportion and provide resource efficiency in addition to water savings.

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

  Wastewater generated in industrial facilities is not only industrial wastewater originating from production processes, but also includes wastewater originating from showers, sinks, kitchens, etc. Wastewater consisting of showers, sinks, kitchens, etc. is called gray water. Water savings can be achieved by treating these gray waters with various treatment processes and using them in areas that do not require high water quality .

Water Softening

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

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

  In general, refrigerants are chemical compounds with certain thermodynamic properties that affect the performance of the cooling process, taking heat from the substances to be cooled and cooling them (Kuprasertwong et al., 2021).

  Water is used as a refrigerant in manufacturing industry processes and in many processes led by product cooling. While this cooling process is carried out, the water can be reused through the 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 emerges as a side interaction.

  Heat recovery is also provided by the use of heat exchangers in cooling waters. Generally , closed loop systems are used in facilities where water cooling systems are used. However, the cooling system blowdowns are removed by giving them directly into the wastewater treatment plant channel. These removed blowdown waters can be reused in suitable production processes.

- ***Reuse of nanofiltration (NF) or reverse osmosis (CTR) concentrates with or without purification depending on characterization***

According to wastewater characterization and appropriate points of use, the reuse potentials of other wastewater resulting from membrane processes (backwash without or with the use of chemicals, CIP cleaning, module cleaning, cleaning of chemical tanks, etc.) should be evaluated.

Nanofiltration is a membrane-based liquid separation technique with low energy consumption and low operating pressures, which is suitable for the treatment of well water and surface water Reverse osmosis is also a membrane-based liquid separation technique that can separate smaller substances than nanofiltration (Akgül, 2016).

Depending on the characterization of nanofiltration or reverse osmosis concentrates, savings are achieved by reusing them with or without treatment. Measures should be taken to reuse clean water in the production processes of filter backwash water in filtration processes and to reduce water consumption by using cleaning systems (MAF, 2021).

Reverse Osmosis System

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

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

  Carrying risks for the aquatic environment such as oils, emulsions and binders in industrial facilities dry cleaning techniques to prevent chemicals from entering wastewater streams can be used, and leaks can be avoided. In this way, the protection of water resources can be ensured (TUBITAK MAM, 2016).

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

  In industrial facilities, closed and impermeable waste/scrap storage areas can be built to prevent the transport of toxic or dangerous chemicals to the receiving environments for the aquatic environment. This practice is already being implemented within the scope of the current environmental regulations in our country. Within the scope of the field studies carried out, a separate collection channel can be built in the toxic or hazardous substance storage areas in industrial facilities to prevent the separate collection of the leachate in question and its mixing with the natural water environments.

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

  Since inefficient resource use and environmental problems in industrial facilities are directly related to input-output flows, process inputs-outputs should be defined in the best way specific to production processes (TUBITAK MAM, 2016). Thus, it becomes possible to develop measures to increase resource efficiency, economic and environmental performance. Organizing input-output inventories is considered 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 perform some routine analyzes/measurements specific to the processes. In order to obtain the highest level of efficiency from the application, using computerized monitoring systems as much as possible ensures that the technical, economic and environmental benefits to be obtained are increased (TUBITAK MAM, 2016).

Computer Aided Control System

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

- ***Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality***

  Rinsing wastewater in industrial facilities can be reused without treatment in relatively clean wastewater, floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). In raw water consumption with the recovery of rinse water Savings of 1-5% can be achieved.

- ***Reuse of filter wash water in filtration processes, reuse of relatively clean cleaning water in production processes, and reduction of water consumption by using clean-in-place systems (CIP)***

  Wastewater from backwashes of activated carbon filters and softening devices often contains only a high percentage of suspended solids (AKM). Backwash water, which is one of the easiest wastewater types to recycle, can be recovered by filtering with ultrafiltration plants. In this way, water savings of up to 15% are achieved (URL - 1, 2021).

  Regeneration wastewater formed after the regeneration process is soft water with high salt content and constitutes approximately 5-10% of total water consumption. It is ensured that regeneration wastewater is collected in a separate tank and evaluated in processes with high salt requirements, facility cleaning and domestic use. For this, a reserved tank, plumbing and pump are needed. With the reuse of 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 according to the consumption of regeneration water in production processes, facility cleaning and domestic use. It is estimated that if regeneration water is reused in production processes that require high salt (since both water and salt will be recovered), the potential payback period will be less than one year. It is estimated that the payback period will be over one year for facility and equipment cleaning and domestic uses (MAF, 2021).

  In our country, reverse osmosis (CTR) concentrates are combined with other wastewater streams and given to the wastewater treatment plant channel. The concentrates formed in the CTR systems used for additional hardness removal can be used in garden irrigation, in-plant and tank-equipment cleaning (TUBITAK MAM, 2016; MAF, 2021). In addition, with the structuring of raw water quality monitoring, it is possible to re-evaluate CTR concentrates by feeding them back into raw water reservoirs and mixing them (MAF, 2021).

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

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

- ***Documentation of production procedures and use by employees to prevent waste of water and energy***

In order to make efficient production in an enterprise, effective procedures should be applied in order to identify and evaluate potential problems and their sources and to control the 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 assurance of reliability and quality in production processes (Ayan, 2010). The presence of documented production procedures in production processes contributes to the development of the ability to develop sudden reflexes for the evaluation of operational performance and the solution of problems (TUBITAK MAM, 2016; MAF, 2021). Effective implementation and monitoring of procedures created specifically for production processes is one of the most effective ways to ensure product quality, to receive feedback and to develop solution proposals (Ayan, 2010). Documenting, effectively implementing and monitoring production procedures is a good management practice and is an effective tool in structuring and ensuring the continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, there may be changes in the cost and economic gains of the application depending on the sector or facility structure (TUBITAK MAM, 2016; MAF, 2021). Although the establishment and monitoring of production procedures is not costly, the payback period may be short considering the savings and benefits it will provide (TUBITAK MAM, 2016; MAF, 2021).

- ***Implementation of time optimization 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 transformation using the least process is an effective practice to reduce labor costs, resource use costs and environmental impacts and to ensure efficiency. In this context, it may be necessary to review the production processes and revise them to use the least number of process steps (TUBITAK MAM, 2016). In cases where the desired product quality cannot be achieved due to some inadequacies, inefficiency and design errors in basic production processes, production processes may need to be renewed. Therefore, in this case, the use of resources required in the manufacture of the unit amount of product and the amount of waste, emissions and solid waste generated increase. Time optimization in production processes is an effective practice (TUBITAK MAM, 2016).

https://www.adhesivesmag.com/ext/resources/Default_Images/responsive/general-chemicals.jpg?1554814938

2.1.4Precautions for Auxillary Processes

METs for steam generation

- ***Saving water 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 properly designed in the facilities, routine maintenance and repairs of the steam lines are not carried out, mechanical problems that occur in the lines and the lines are not operated properly, and full insulation of the steam lines and hot surfaces is not made. This affects both the water consumption and energy consumption of the facility. It is necessary to use control systems with automatic control mechanisms in order to make steam insulations and to monitor steam consumption continuously. Due to 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 be reduced with the application, the amount of regeneration water, the amount of salt used in regeneration and reverse osmosis concentrates are also reduced. Automatic control mechanisms for full vapor insulation application and minimization of steam losses are used in many facilities with heavy steam consumption. With the configuration of the application, 2-4% fuel savings are achieved in steam boilers.

In order to prevent losses in production processes, adding the most important parts of equipment such as pumps, valves, adjustment knobs, pressure, flow regulators to the maintenance checklist, inspecting not only water systems but also heating and chemical distribution systems, drums, pumps and valves, regular cleaning of filters and pipelines, 1-6% savings in water consumption can be achieved with regular calibration of measuring equipment (thermometers, chemical scales, dispensing/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 (Hasanbeigi, 2010; Ozturk, 2014; MAF, 2021).

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

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

Industrial Steam Boilers

https://hohwatertechnology.com/wp-content/uploads/2021/03/boiler_175594851-1024x688.jpeg

- ***Reuse of energy generated from the steam condenser***

  By applying a simple modification to the piping system, the water that feeds the water resting/decarbonization unit can be obtained from the outlet of the turbine condenser unit. This water has sufficient temperature for the resting/decarbonization unit. Therefore, this water does not need to be heated by means of steam generated by the heat exchanger system. Thanks to this work, significant steam gain can be achieved. In addition, cooling water consumption can be reduced (CPRAC, 2021).

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

  Free oxygen dissolved in steam boilers, feed water and hot water boilers, and carbon dioxide formed by the breakdown of carbonates in boilers can cause corrosion in the form of pores and rusting and melting in steam boilers, devices using steam and especially in installations. The effects of these gases increase as the proportion of fresh feed water and the operating pressure of the system increases. 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 appliances and condensate pipes. Boiler feed water must be purified from dissolved gases such as oxygen and carbon dioxide by passing through the deaerator. Deaeration systems are mechanical systems that allow dissolved gases to be evaporated from the water by giving air to the water with a fan. Dissolved deaeration can be increased by increasing the water and air contact surface in the deaerator system. In this way, corrosion formation is reduced and boiler efficiency is increased (TUBITAK MAM, 2016; MAF, 2021).

- ***Prevention of frisk steam losses due to boiler draining***

  Steam boiler condensate is generally discharged from the system at atmospheric pressure from the equipment outlets and steam traps outlet. In condensate systems, as the pressure decreases, some of the condensate evaporates again and cools down to the boiling point of water at atmospheric pressure. The re-evaporated condensate, called flash steam, is thrown into the atmosphere and disappears. In the case of condensate return lines, which are usually quite long, cooling and therefore evaporation are inevitable. In order to prevent the condensate from evaporating again, 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 steam formed is collected on the tank and feeds the low pressure steam system from there. The remaining hot condensate is taken into the boiler from the bottom of the tank.

- ***Minimizing boiler discharge water (blowdown) in steam boilers***

Boiler blowdown refers to the water consumed 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, the blowdowns in the boilers are constantly monitored and the system is re-analyzed together 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 frequency of blowdowns is reduced, the amount of wastewater decreases. This saves energy and cooling water used to cool wastewater (IPPC BREF, 2009). By optimizing the steam boiler blowdown process, operating costs are reduced by saving boiler water consumption, waste costs, conditioning and heating.

METs for refrigeration systems

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

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

Cooling Systems (Chiller)

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

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

Cooling towers and evaporative condensers, air conditioning and industrial process cooling systems effective and low-cost systems that remove the heat from the outgoing (IPPC BREF, 2001b; MAF, 2021).

More than 95% of the circulating water in these systems can be recovered (TUBITAK MAM, 2016). In cooling systems, impurities remain in the recirculation water due to the fact that some of the recirculation water is worked on the basis of evaporation, and the impurity concentrations gradually increase in each cycle. Impurities that can be included in the cooling system together with the air can cause contamination in the recirculation water (TUBITAK MAM, 2016). If impurities and contaminants are not effectively controlled, they can cause the formation of boilerstone and corrosion, unwanted biological growth and sludge accumulation. This can become a chronic problem that leads to a decrease in the efficiency of heat transfer surfaces and an increase in operating costs. In this case, it is necessary to implement a water treatment program specially designed in terms of the quality of the feed water supplied to the cooling system, the cooling water system building material and operating conditions. In this context; blowdown control, biological growth control, corrosion control, avoiding the use of hard water, using sludge control chemicals, using filtration and sieve systems may be appropriate (TUBITAK MAM, 2016). In addition, the establishment and periodic implementation of an effective cleaning procedure and program is a good management practice in terms of protecting cooling systems. Corrosion is one of the most important problems in cooling systems. In the tower recirculation water, as the degree of hardness increases, dissolved solids (sulfate, chloride, carbonate, etc.) that cause corrosion as a result of the formation of limestone and deposits on the walls will cause abrasion on the surface over time. In addition, the formation of deposits negatively affects heat transfer and reduces energy efficiency. In order to prevent these negativities, it is necessary to implement a lime and corrosion preventive chemical conditioning program, to disinfect with biocide that prevents biological activation, to clean the sediments by subjecting the cooling towers in use to chemical and mechanical cleaning at least twice a year, and to keep the hardness and conductivity values of the reinforcement water as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). In order to improve the quality of the supplementary water, it may be necessary to treat (condition) it using an appropriate treatment system. In addition, unwanted microbial growth needs to be kept under control (IPPC BREF, 2001b; MAF, 2021). Due to micro-residues and deposits in the cooling water, blowdown occurs in cooling systems as well as in steam boilers. Deliberate draining of the cooling system to bring the increased density of solids in the cooling system to balance is called cooling blowdown. It is possible to reduce the use of biocides and blowdown amounts by pre-treating cooling water with appropriate methods and continuous monitoring of cooling water quality (TUBITAK MAM, 2016). Although the investment cost depends on the scale of the application, the payback period in expected investment expenses varies between 3 and 4 years (IPPC BREF, 2001).

- ***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 refrigeration systems are a combination of evaporative and non-evaporative (wet and dry) refrigeration systems. Depending on the ambient temperature, the hybrid cooling tower can be operated as a completely wet cooling tower or as a combined wet/dry cooling tower (TUBITAK MAM, 2016). In regions where there is not enough cooling water or in cases 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 supplement water (TUBITAK MAM, 2016).

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

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

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

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

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

  Some water evaporates during the cooling of the heated water in the cooling systems. Therefore, in closed-loop cooling systems, cooling water is added as much as the amount of evaporated water. Evaporation losses can be avoided by optimizing cooling systems. In addition, a reduction in the amount of blowdown can be achieved with applications such as the treatment of completion water added to cooling systems and the 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 removed by giving it directly to the wastewater channel. By reusing the cooling system blowdown water, up to 50% of the water consumption of the cooling systems can be saved. To implement this measure, it may be necessary to install new pipelines and reserved tanks. (MAF, 2021).

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

  Cooling water is collected separately and used for cooling purposes or reused in appropriate processes (EC, 2009). In order for this system to work properly, a water softening system is required. It has suitable water quality in terms of cooling water, cleaning and reuse as irrigation water. However, due to the fact that it contains some hardness in its use as cooling water, an additional softening is required in order to prevent corrosion problems that will occur over time. Cooling water or before it can be reused in the process, these waters must be properly disinfected. In addition, it is possible to reuse the water in question not only in cooling processes but also in all production processes by treating it with appropriate treatment techniques (membrane filtration, advanced oxidation, chemical precipitation, granular activated carbon adsorption, etc.) (TUBITAK MAM, 2016). As the hardness of the cooling water increases, limestone and debris formation occurs on the walls. Deposit formation negatively 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, it is necessary to apply lime and anti-corrosion chemical conditioning to the cooling water, to disinfect with a biocide that prevents biological activation, to subject the cooling towers to chemical and mechanical cleaning at least twice a year, to clean the sediments, and to keep the hardness and conductivity values as low as possible (TUBITAK MAM, 2016).

- ***Water recovery with tower cooling application in systems that do not have a closed loop***

  Cooling towers are divided into two as counter-flow and cross-flow according to their working principles. In counter-flow cooling towers, the airflow moves upwards as the water flows downwards, and in cross-flow cooling towers, the airflow moves horizontally as the water flows downwards. The water, which is exposed to fresh air, cools down until it descends into the cold water pool, where it is collected and sent to the facility. During these processes, some of the water evaporates. The air, whose humidity increases as a result of the evaporation of water, is thrown into the atmosphere from the fan chimney at the top of the tower. Evaporation losses in cooling towers must be managed effectively.

  Various chemicals are used in cooling towers to prevent the formation of bacteria and parasites and to control lime residues. These chemicals condense with the evaporation of water and cause unwanted sediment and deposits within the tower. A blowdown system is used to keep this concentration at a certain level. Blowdown water can be recovered by treatment with the use of membrane filtration systems or ion exchange resins. Recycling of blowdown wastewater is important in terms of water efficiency.

- ***In some periods of the year, when the need for cooling is low, cooling with local dry air***

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

METs for ventilation and air conditioning systems

- ***Reuse of the liquid formed by condensation from the ventilation system***

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

- ***Replacement of old equipment in the aeration system with ion exchange resins based on the principle of reverse osmosis (systems that produce demineralized water) and reuse*** of water Conductivity of the final effluent using ion exchange resins in the aeration system It is brought to a conductivity level suitable for use for equipment cleaning. Example In a facility in Spain, effluent with a conductivity value of approximately 1000 µS is obtained by replacing the equipment in the ventilation system with ion exchange resins and reused in the system (MedClean, n.d.).

Bibliography

- Abbassi, B., & Al Baz, İ. (2008). Integrated Wastewater Management: A Review. https://doi.org/10.1007/978-3-540-74492-4_3.
- Adar, E., Delice, E., & Adar, T. (2021). Prioritizing of industrial wastewater management processes using an integrated AHP–CoCoSo model: comparative and sensitivity analyses. International Journal of Environmental Science and Technology, 1-22.
- Akgul, D. (2016). Cost Analysis of Drinking and Potable Water Production with Reverse Osmosis and Nanofiltration Systems in Turkey. Istanbul Technical University Institute of Natural and Applied Sciences.
- Ayan, B. (2010). International Certification Systems in Welded Manufacturing Enterprises. Izmir: Dokuz Eylül University, Institute of Social Sciences, Department of Business Administration, Master's Thesis.
- Christopher, S. (1998). ISO 14001 and Beyond Environmental Management Systems in the Real World.
- CPRAC. (2021). Med No:55. Retrieved from http://www.cprac.org/en/media/medclean
- MoEUB. (2020e). Cleaner Production Practices in Specific Sectors Project. T.R. Ministry of Environment, Urbanization and Climate Change, General Directorate of Environmental Management.
- Delmas, M. (2009). Erratum to "Stakeholders and Competitive Advantage: The Case of ISO 14001. doi:10.1111/j.1937-5956.2004.tb00226.x.
- DEPA. (2002). Danish Environmental Protection Agency (DEPA). Danish Experience, Best Avaible Techniques-Bat in the Clothing and Textile Industry.
- EC. (2009). Resource Paper on the Most Appropriate Techniques for Energy Efficiency. European Commission.
- Greer, L., Keane, S., Lin, C., & James, M. (2013). Natural Resources Defense Council's 10 Best Practices for Textile Mills to Save Money and Reduce Pollution. Natural Resources Defense Council.
- Hasanbeigi, A. (2010). Energy-Efficiency improvement opportunities for the textile industry. China Energy Group Energy Analysis Department Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory.
- Hutchens Jr., S. (2017). Using ISO 9001 or ISO 14001 to Gain a Competitive Advantage.
- IPPC BREF. (2001b). Reference Document on the application of Best Available Techniques to Industrial Cooling Systems. Integrated Pollution Prevention and Control (IPPC).
- IPPC BREF. (2003). Reference Document on Best Available Techniques for the Textiles Industry. https://eippcb.jrc.ec.europa.eu/reference adresinden alındı
- IPPC BREF. (2006). European Commission (EC) Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Surface Treatment of Metals and Plastics.
- IPPC BREF. (2007d). Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers.
- IPPC BREF. (2007e). Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Solids and Others industry.
- IPPC BREF. (2009). Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Energy Efficiency. https://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_Adopted_02-2009.pdf) adresinden alındı
- IPPC BREF. (2019). Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries. https://eippcb.jrc.ec.europa.eu/reference.
- ISO 14001 User Manual. (2015). Generic ISO 14001 EMS Templates User Manual.
- Kayabek, C. Y., Yildirim, A. S., & İnce, F. (2005). Maintenance and Disinfection in Open Loop Refrigeration Systems (ACSS). Journal of Plumbing Engineering, Issue: 88, p. 35-39,.

- Kuprasertwong, N., Padungwatanaroj, O., Robin, A., Udomwong, K., Tula, A., Zhu, L., . . . Gani, R. (2021). Computer-Aided Refrigerant Design: New Developments.
- LCPC. (2010). Lebanese Cleaner Production Center . Cleaner Production Guide for Textile Industries.
- MedClean. (t.y). Pollution Prevention Case Studies No: 46.
- MedClean(c). (t.y). Pollution Prevention Case Studies Nitrate Condensates Treatment No: 130.
- MedClean(d). (t.y). Pollution Prevention Case Studies Energy Efficiency and Air Pollution Abatement No:131.
- Naghedi, R., Moghaddam, M., & Piadeh, F. (2020). Creating functional group alternatives in integrated industrial wastewater recycling system: A case study of Toos Industrial Park (Iran). Journal of Cleaner Production. doi:https://doi.org/10.1016/j.jclepro.2020.120464.
- Oğur, R., Tekbaş, Ö. F., & Hasde, M. (2004). Chlorination Guide: Chlorination of Drinking and Potable Water. Ankara: Gülhane Military Medical Academy, Department of Public Health.
- Özdemir, K., & Toröz, I. (2010). Monitoring of Chlorination By-Products in Drinking Water Sources by Differential UV Spectroscopy Method. Itujournal.
- Ozturk, E. (2014). Integrated Pollution Prevention and Control and Cleaner Production Practices in the Textile Industry. Isparta.
- Potoski, M., & Prakash, A. (2005). Green Clubs and Voluntary Governance: ISO 14001 and Firms' Regulatory Compliance. American Journal of Political Science, 235-248.
- Singh, M., Liang, L., Basu, A., Belsan, M., Hallsby, G., & Morris, W. (2014). 3D TRASAR™ Technologies for Reliable Wastewater Recycling and Reuse. doi:10.1016/B978-0-08-099968-5.00011-8.
- Sahin, N. I. (2010). Water conservation in buildings. Istanbul Technical University, Institute of Natural and Applied Sciences, M.Sc. Thesis.
- Tanık, A., Öztürk, İ., & Cüceloğlu, G. (2015). Reuse of Treated Wastewater and Rainwater Harvesting Systems (Handbook). Ankara: Union of Municipalities of Turkey.
- MAF. (2021). Technical Assistance for Economic Analysis and Water Efficiency Studies within the Scope of River Basin Management Plans in 3 Pilot Basins. T.R. Ministry of Agriculture and Forestry.
- TUBITAK MAM. (2016). Determination of Cleaner Production Opportunities and Applicability in Industry (SANVER) Project, Final Report. The Scientific and Technological Research Council of Turkey Marmara Research Center.
- URL - 1st (2021). Recovery of filter backwash water. Retrieved from https://rielli.com/portfolio/filtre-ters- washing-waters-recovery/
- Yaman, C. (2009). Siemens Gebze Facilities Green Building. IX. National Plumbing Engineering Congress.

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