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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Guidance Documents Series

MINERAL MINING FOR CHEMICAL AND FERTILIZING PURPOSES

NACE CODE: 08.91

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Contents

Abbreviations

WWTP	Wastewater Treatment Plant
EU	European Union
SS	Suspended Solids
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
ÇŞİDB	Republic of Turkey Ministry of Environment, Urbanization and Climate Change
NOM	Natural Organic Matter
EMAS	Eco-Management and Audit Scheme Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Organization for Standardization
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GDWM	General Directorate of Water Management
RO	Reverse Osmosis
TOB	Republic of Turkey Ministry of Agriculture and Forestry
TUIK	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
GW	Surface Water

1 Introduction

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

The usable annual water amount per capita in our country is 1,313 m³ for 2022, and it is expected that the usable annual water amount 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, Türkiye will become a country suffering from water scarcity in the very near future, bringing with it many negative social and economic consequences. As can be understood from the results of the 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". The water efficiency approach is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, primarily drinking water, agriculture, industry and households, by protecting the quantity and quality of water and taking into account the needs of not only people but also all living things with ecosystem sensitivity.

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

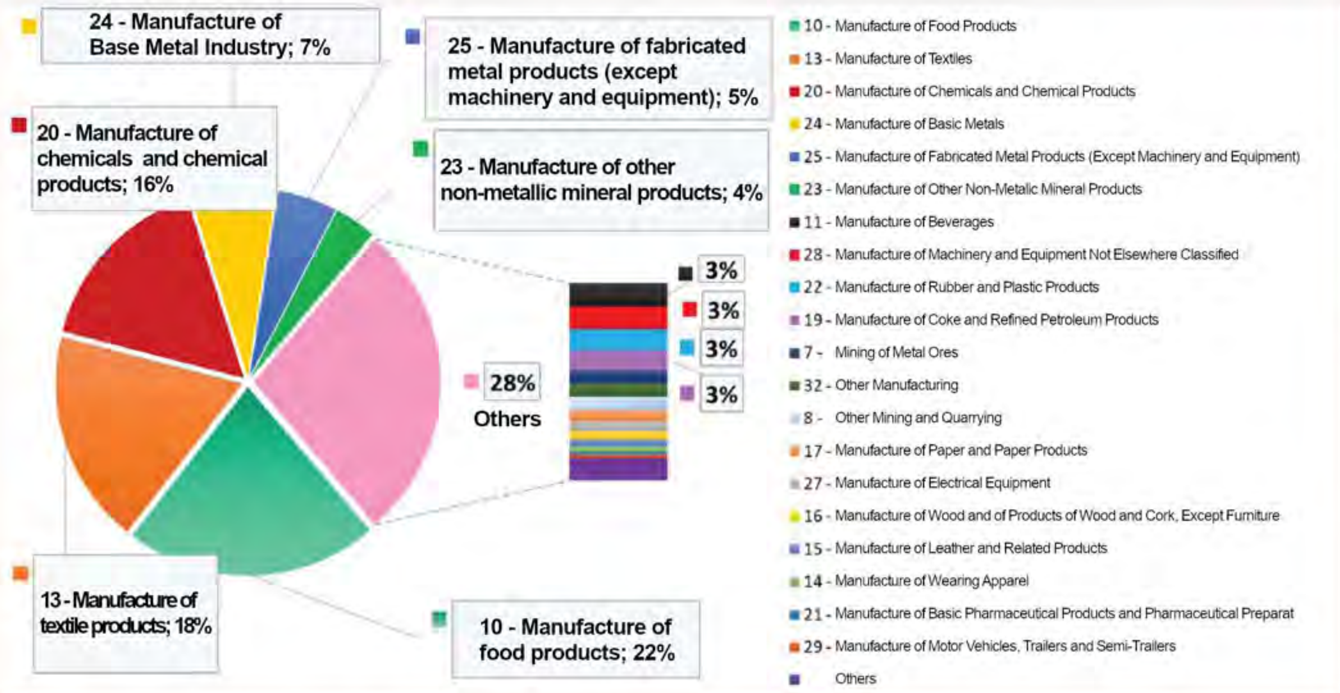
Within the scope of the European Green Deal, in which member countries have agreed on targets such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing environmental impacts, actions emphasizing water and resource efficiency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

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

Ministry of Agriculture and Forestry, General Directorate of Water Management carries out studies aimed at spreading efficient practices in urban, agricultural, industrial and individual water use and increasing social awareness. Within the scope of the ***"Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework of Adaptation to the Changing Climate"***, which entered into force with the Presidential Circular No. 2023/9, water efficiency action plans addressing all sectors and stakeholders have been prepared. A total of 12 actions have been determined for the 2023-33 period in the Industrial Water Efficiency Action Plan, and responsible and relevant institutions have been appointed for the said actions. Within the scope of the said Action Plan; conducting studies on determining specific water use intervals and quality requirements on a sub-sector basis in the industry, organizing technical training programs and workshops on a sectoral basis and preparing water efficiency guide documents have been defined as the responsibility of the General Directorate of Water Management.

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

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



Distribution of water usage in our country in industry on sectoral basis

As a result of the studies, specific water consumption and potential saving rates for the processes of enterprises for 152 different 4-digit NACE codes with high water consumption were determined, and water efficiency guide documents were prepared by considering the EU best available techniques (BAT) and other cleaner production techniques. In the guides, 500 techniques (BAT) for water efficiency were examined under 4 main groups as (i) Good Management Practices, (ii) General Measures, (iii) Measures Related to Auxiliary Processes and (iv) Sector-Specific Measures.

In the determination of BATs for each sector within the scope of the project carried out; environmental benefits, operational data, technical specifications-requirements and applicability criteria were taken into consideration. In determining BATs, it was not limited to BREF documents only, and different data sources such as current literature data on a global scale, real case studies, innovative applications, reports of sector representatives were examined in detail and sectoral BAT lists were created. In order to evaluate the suitability of the created MET lists to our country's local industrial infrastructure and capacity, MET lists prepared specifically for each NACE code were prioritized by businesses by scoring them on the criteria of water saving, economic saving, environmental benefit, applicability, and cross-media impact, and the final MET lists were determined using the scoring results. Sectoral water efficiency guides were created on the basis of NACE codes based on the final MET lists determined by sectoral stakeholders and taking into account the local dynamics specific to our country and the water and wastewater data of the facilities visited within the scope of the project.

2 Scope of the Study

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

- Plant and animal production, hunting and related service activities (including 6 four-digit NACE Code sub-production areas)
- Fishing and aquaculture (including 1 four-digit NACE Code sub-production area)
- Coal and lignite extraction (including 2 four-digit NACE Code sub-production areas)
- Mining support service activities (including 1 four-digit NACE Code sub-production area)
- Metal ore mining (including 2 four-digit NACE Code sub-production areas)
- Other mining and quarrying (including 2 four-digit NACE Code sub-production areas)
- Food products manufacturing (including 22 four-digit NACE Code sub-production areas)
- Beverage manufacturing (including 4 four-digit NACE Code sub-production areas)
- Tobacco products manufacturing (including 1 sub-production area represented by 4-digit NACE Codes)
- Manufacture of textiles (including sub-production area represented by 9 4-digit NACE Codes)
- Manufacture of apparel (including sub-production area represented by 1 4-digit NACE Code)
- Manufacture of leather and related products (incl. sub-prod.area represented by 3 4-digit NACE Codes)
- Manufacture of wood, wood products and cork products (excluding furniture); Manufacture of articles made of straw, straw and similar materials (including sub-area represented by 5 4-digit NACE Codes)
- Manufacture of paper and paper products (including sub-area represented by 3 4-digit NACE Codes)
- Manufacture of coke and refined petroleum products (incl.sub-area represented by 1 4-digit NACE Code)
- Manufacture of chemicals and chemical products (incl. sub-area represented by 13 4-digit NACE Codes)
- Manufacture of basic pharmaceutical products and pharmaceutical preparations (including sub-area represented by 1 4-digit NACE Code)
- Manufacture of rubber and plastic products (including sub-area represented by 6 4-digit NACE Codes)
- Manufacture of other non-metallic mineral products (incl. sub-area represented by 12 4-digit NACE Codes)
- Basic metal industry (including sub-area represented by 11 4-digit NACE Codes)
- Manufacture of fabricated metal products (excluding machinery and equipment) (including sub-area represented by 12 4-digit NACE Codes) (Including sub-area represented by 4-digit NACE Codes)
- Manufacture of computers, electronic and optical products (Incl. sub-area represented by 2 4-digit NACE Codes)
- Manufacture of electrical equipment (Including sub-area represented by 7 4-digit NACE Codes)
- Manufacture of machinery and equipment not elsewhere classified (Incl. sub-area represented by 8 4-digit NACE Codes)
- Manufacture of motor vehicles, trailers and semi-trailers (including sub-area represented by 3 4-digit NACE Codes)

- Manufacture of other transportation equipment (including sub-production area represented by 2 4-digit NACE Codes)
- Other manufacturing (including sub-production area represented by 2 4-digit NACE Codes)
- Installation and repair of machinery and equipment (including sub-production area represented by 2 4-digit NACE Codes)
- Production and distribution of electricity, gas, steam and ventilation systems (including sub-production area represented by 2 4-digit NACE Codes)
- Collection, treatment and disposal activities of waste; materials recovery (including sub-production area represented by 1 4-digit NACE Code)
- Construction of external structures (including sub-production area represented by 1 4-digit NACE Code)
- Storage and support activities for transportation (including sub-production area represented by 1 4-digit NACE Code)
- Accommodation (including sub-production area represented by 1 four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including sub-production area represented by 1 4-digit NACE Code)
- Sports activities, entertainment and recreation activities (including sub-production area represented by 1 4-digit NACE Code)

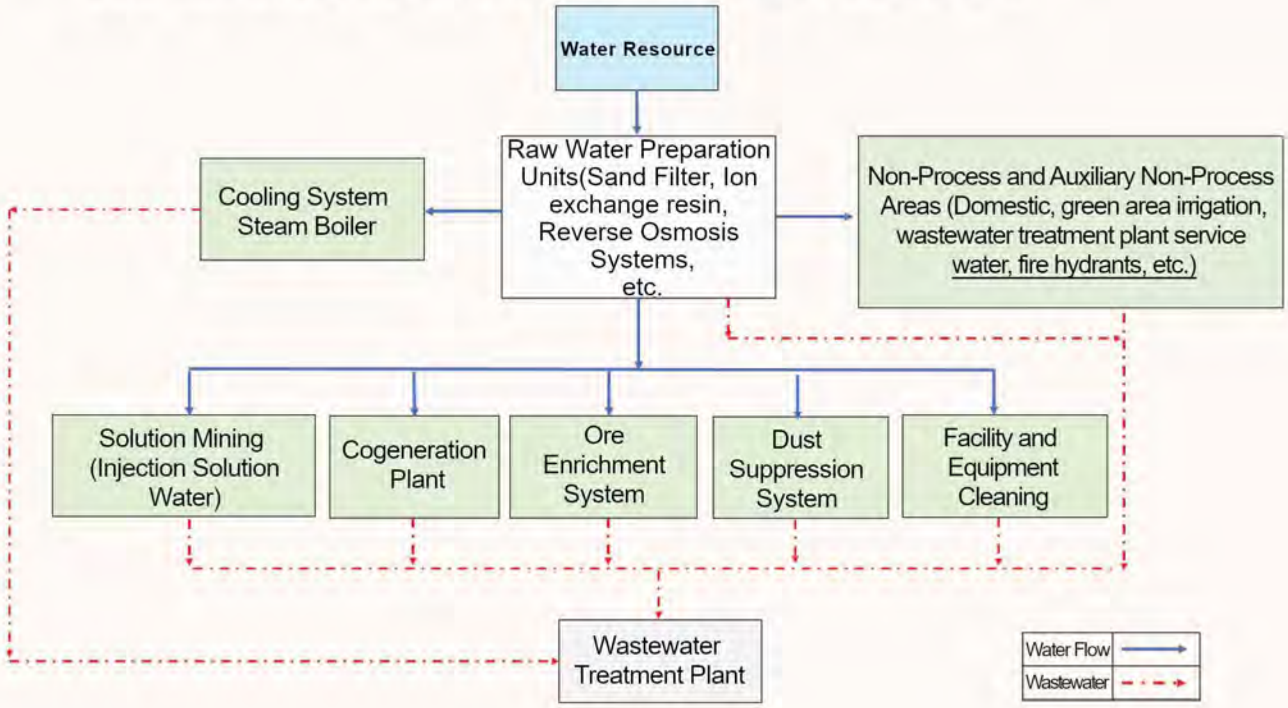
Other mining and quarrying

Under the other mining and quarrying sector, the sub-production branches for which guidance documents have been prepared are as follows:

08.91	Mineral mining for chemical and fertilising purposes
08.93	Salt extraction

2.1 Mineral Mining for Chemical and Fertilizing Purposes (NACE 08.91)

Other non-ferrous metal ore mining Sector Water Flow Diagram



	Minimum	Maximum
Specific Water Consumption of Facilities Visited Witihin the Scope of the Project (L/kg)	1,68	
Reference Specific Water Consumption (L/kg)	1	2

Percentage Distribution of Water Efficiency Practices

Mining activities can be carried out with open mining or underground mining with closed gallery systems. Minerals with economic value and parts without economic value are separated in the ore with the ore preparation or ore enrichment process. Ore enrichment can be done with sorting, specific gravity difference, magnetic separation, electrostatic separation, flotation and chemical methods.

Sodium carbonate and sodium bicarbonate production was examined within the scope of the project. Natural soda ash is obtained from trona ores. Trona mining, which is carried out with the solution mining technique, which is an environmentally friendly method, requires a high amount of water. In solution mining operated with a closed-circuit system, much less energy and water is used compared to other production methods.

There is water consumption in ore enrichment processes, cogeneration systems and dust prevention activities for chemical and fertilizing minerals. If there are raw water preparation units such as active carbon filters, ion exchange resins and reverse osmosis used to produce soft water for use in production processes, significant amounts of water are consumed for filter washing, resin regeneration and membrane cleaning processes. In addition, there is water consumption in auxiliary units such as cooling towers and steam boilers.

In the chemical and fertilization mineral mining sector, the reference specific water consumption is between 1 - 2 L/kg. The specific water consumption of the production branch analyzed within the scope of the study is 1.68 L/kg. With the implementation of good management practices, general measures and measures related to auxiliary processes, it is possible to achieve 9 - 19% water recovery in the sector.

Use of Water to Prevent Dust in Mining Sites

08.91 Mineral Mining for Chemical and Fertilizing Purposes The priority water efficiency application techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Explanation		Prioritized Sectoral Water Efficiency Techniques
08.91	Mineral mining for chemical and fertilising purposes		**Good Management Practices**
		1.	Establishing an environmental management system
		2.	Preparing water flow charts and mass balances for water
		3.	Providing technical training to personnel to reduce and optimize water use
			Measures in the nature of General Measures
		1.	Minimizing spills and leaks
		2.	Using automatic equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets
		3.	Equipment cleaning, general cleaning, etc. using pressure washing systems in processes
		4.	Reusing filter washing water in filtration processes, reusing relatively clean cleaning water in production processes and reducing water consumption by using cleaning in place systems (CIP)
		5.	Avoiding the use of drinking water in production lines
		6.	Detecting and reducing water losses
		7.	Optimizing the frequency and duration of regeneration in water softening systems (including rinsing)
		8.	Creating closed storage and impermeable waste/scrap areas to prevent the transfer of toxic or hazardous chemicals to the aquatic environment
		9.	Preventing substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) from mixing with wastewater after storage, storage and use
		10.	Separate collection and purification of gray water in the facility and use in areas that do not require high water quality (green area irrigation, floor, ground washing, etc.)
		11.	Collecting rainwater and using it as an alternative water source in facility cleaning or in suitable areas

NACE Code	NACE Code Explanation		Prioritized Sectoral Water Efficiency Techniques
08.91	Mineral mining for chemical and fertilising purposes		**Measures regarding Auxiliary Processes**
		1.	Saving water by reusing steam boiler condensate
		2.	Saving water by isolating steam and water lines (hot and cold), preventing water and steam losses in pipes, valves and connection points in the lines and monitoring with a computer system
		3.	Reusing the liquid formed by condensation from the ventilation system
		4.	Avoiding unnecessary cooling processes by determining the processes that need wet cooling
		5.	Reducing water consumption by increasing the number of cycles in closed-loop cooling systems and improving the quality of the make-up water
		6.	Using the hot water produced in the cogeneration system in heating processes
		7.	Installing water softening systems for the healthy operation of cooling water recovery systems
		8.	Collecting the water formed by surface flow with a separate collection system and using it for cooling water, process water, etc.
		9.	Reducing the amount of blowdown by using deaerators in steam boilers
		10.	Reusing the energy produced from the steam condenser

2.1.1 Good Management Practices

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

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

The most widely used Environmental Management Standard is ISO 14001. Among its alternatives, there is the Eco-Management and Audit Program Directive (EMAS) (761/2001). It was developed for the assessment, improvement and reporting of environmental performance of enterprises. It is one of the leading applications within the scope of eco-efficiency (cleaner production) in EU legislation and participation is provided voluntarily (TUBITAK MAM, 2016; TOB, 2021). The benefits of establishing and implementing an Environmental Management System are as follows:

- Economic benefits can be achieved by improving business performance (Christopher, 1998).
- By adopting International Standards Organization (ISO) standards, greater compliance with global legal and regulatory requirements is achieved (Christopher, 1998).

- While the risks of penalties related to environmental liabilities are minimized, there is a decrease in the amount of waste, resource consumption and operating costs (Delmas, 2009).

- The use of internationally accepted environmental standards eliminates the need for multiple registrations and certificates for businesses operating in different locations around the world (Hutchens Jr., 2017).

- Especially in recent years, the improvement of companies' internal control processes has also been considered important by consumers. The implementation of environmental management systems provides a competitive advantage against companies that do not adopt the standard. It also contributes to the institutions' better position in international areas/markets (Potoski & Prakash, 2005).

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

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

Providing technical training to personnel for water use reduction and optimization

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

Preparation of water flow diagrams and mass balances for water

Determination of water usage and wastewater generation points in industrial facilities, creation of water-wastewater balances in production processes and auxiliary processes outside of production processes generally constitute the basis of many good management practices. Creation of process profiles throughout the facility and on the basis of production processes; It facilitates the determination of unnecessary water usage points and high water usage points, evaluation of water recovery opportunities, process modifications and determination of water losses (TOB, 2021).

https://everchem.com.my/wp-content/uploads/2018/07/DAP-fertilizer-.jpg

Some Chemical and Fertilizer Mineral Mining Products - Left to Right: Sodium Carbonate, Potassium Feldspar, Diammonium Phosphate

2.1.2 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 equipment, pumps and pipelines should be regularly maintained and kept in good condition to prevent leaks (IPPC BREF, 2003). Regular maintenance procedures should be established and the following points should be taken into account:

- Inclusion of pumps, valves, level switches, pressure and flow regulators in the maintenance checklist,
- Inspection of broken and leaking pipes, barrels, pumps and valves, not only in the water system but also in heat transfer and chemical distribution systems,
- Regular cleaning of filters and pipelines,
- Calibration of measuring equipment such as chemical measuring and distribution devices, thermometers etc., routine inspection and monitoring at specified intervals (IPPC BREF, 2003).

With effective maintenance-repair, cleaning and loss control practices, savings ranging from 1-6% can be achieved in water consumption (Öztürk, 2014).

- ***Minimizing spills and leaks***

Both raw material and water losses can occur due to spills and leaks in businesses. In addition, if wet cleaning methods are used in cleaning areas where spills occur, increases in water consumption, wastewater amounts and pollution loads of wastewater may occur (TOB, 2021). In order to reduce raw material and product losses, spill and splash losses are reduced by using splash preventers, wings, drip trays and sieves (IPPC BREF, 2019).

Use of pressure washing systems in equipment cleaning, general cleaning, etc.

Water nozzles are widely used in equipment facility cleaning. Effective results can be achieved by using correctly placed, suitable nozzles in reducing water consumption and wastewater pollution loads. Using active sensors and nozzles at points where high water consumption occurs and where possible is very important for efficient use of water. It is possible to achieve significant water savings by replacing mechanical equipment with pressure nozzles (TUBITAK MAM, 2016). The main environmental benefits of the application are the reduction of water consumption, wastewater formation and wastewater pollution load by using nozzles with optimized water pressure in technically suitable processes.

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

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

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

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

In various examples, roof rainwater collected in industrial facilities has been stored and used inside the building and in landscape areas, thus providing 50% water saving in landscape irrigation (Yaman, 2009). Perforated stones and green areas can be preferred in order to increase the permeability of the ground and to ensure that rainwater passes into the soil and is absorbed in the field (Yaman, 2009). Rainwater collected on building roofs can be used for vehicle washing and garden irrigation. After the collected water is used, it is possible to recover 95% of it with biological treatment and reuse it (Şahin, 2010).

- ***Optimizing the regeneration frequency and duration (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, the resin is pre-washed using raw water, regenerated with salt water, and final rinsed, respectively. Regeneration periods are determined depending on the hardness of the water. If the hardness is high, regeneration should be done more frequently in water softening systems.

  In regeneration processes, washing, regeneration, and rinsing wastewater are usually directly removed. However, if the washing and final rinse waters are of raw water quality, they 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 (TOB, 2021).

  Determining the optimum regeneration frequency in regeneration systems is very important. Although regeneration in water softening systems is adjusted according to the frequency recommended by the supplier or depending on the flow rate and duration 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 regeneration frequency. In this way, regeneration frequencies can be optimized and excessive washing, rinsing or backwashing with salt water can be prevented by using online hardness sensors.

- ***Preventing substances that pose a risk to the aquatic environment (such as oils, emulsions, binders) from mixing with wastewater after use***
  In industrial facilities, water recovery is achieved by using dry cleaning techniques and preventing leaks in order to prevent chemicals that pose a risk to the aquatic environment such as oils, emulsions and binders from mixing with wastewater streams (TUBITAK MAM, 2016).

- ***Establishing closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals to the aquatic environment***
  In industrial facilities, closed and impermeable waste/scrap storage areas can be established to prevent the transport of toxic or hazardous chemicals to the aquatic environment to the receiving environments. This practice is currently implemented within the scope of current environmental regulations in our country. Within the scope of the field studies carried out, a separate collection channel can be built for toxic or hazardous substance storage areas in industrial facilities and the leakage water in question can be d prevented from mixing

Water Softening Systems

- ***Reuse of filter wash water in filtration processes, reuse of relatively clean cleaning water in production processes, reduce water consumption by using on-site cleaning systems***

  Wastewater resulting from backwashing of activated carbon filters and softening devices mostly contains only high levels of suspended solids(SS). Backwash water, which is one of the easiest wastewater types to recover, can be filtered and recovered with ultrafiltration facilities. In this way, up to 15% water savings can be achieved.This investment can pay for itself in 1-2 months (URL-1, 2021). Regeneration wastewater formed after the regeneration process is soft water with a high salt content and constitutes approximately 5-10 % of total water consumption. Regeneration wastewater can be collected in a separate tank and used in processes requiring high salt, facility cleaning and domestic uses. For this, a reserve tank, water installation and pump are needed. By reusing regeneration wastewater, approximately 5-10 % reductions can be achieved in water consumption, energy consumption, wastewater quantities and salt content of wastewater (Öztürk E. , 2014). The initial investment cost for the application is expected to be around 250-350 USD/m³ (TUBİTAK MAM, 2016; TOB, 2021). The payback period varies depending on whether regeneration water is consumed in production processes, facility cleaning and domestic purposes. In case of reuse of regeneration water in production processes requiring high salt(since both water and salt will be recovered), it is estimated that the potential payback period will be less than one year. In facility and equipment cleaning and domestic uses, the payback period is estimated to be over one year (TOB, 2021). In our country, reverse osmosis(RO) concentrates are combined with other wastewater streams and given to the wastewater treatment plant channel.It is possible to use the concentrates formed in RO systems used for additional hardness removal in garden irrigation, in-plant and tank-equipment cleaning (TUBITAK MAM, 2016; TOB, 2021). In addition, with the structuring of continuous monitoring applications of raw water quality, it is possible to re-evaluate the RO concentrates by feeding them back to the raw water tanks and mixing them (TOB, 2021).

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

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

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

  Wastewater generated in industrial facilities is not only industrial wastewater originating from production processes, but also includes wastewater originating from areas such as showers, sinks, kitchens, etc. Wastewater generated from areas such as showers, sinks, kitchens, etc. is called gray water. Water savings can be achieved by purifying this gray water with various purification processes and using it in areas that do not require high water quality.

2.1.3 Measures Regarding Auxiliary Processes

BATs Regarding Steam Generation

- ***Water saving by isolating steam and water lines (hot and cold) and preventing water and steam losses in pipes, valves and connection points in the lines and monitoring with a computer system***
  Steam losses may occur if steam lines in facilities are not designed appropriately, routine maintenance and repairs of steam lines are not performed, mechanical problems in the lines and lines are not operated properly, and steam lines and hot surfaces are not fully insulated. This affects both the water consumption and energy consumption of the facility. Automatic control mechanisms must be used in order to perform steam insulation and continuously monitor steam consumption. Similar savings can be achieved in fuel consumption and additional soft water consumption in boilers due to the reduction of steam losses. Since fuel consumption in steam boilers will decrease, it is expected that waste gas emissions will decrease at the same rate. Since the use of additional soft water in steam boilers will decrease with the application, reductions are also achieved in regeneration water amounts, salt amounts used in regeneration and reverse osmosis concentrates. Full steam insulation application and automatic control mechanisms to minimize steam losses are used in many facilities where intensive steam consumption occurs. With the configuration of the application, fuel savings of 2-4% are achieved in steam boilers.

In order to prevent losses in production processes; adding the most important parts of equipment such as pumps, valves, adjustment knobs, pressure, flow regulators to the maintenance checklist, inspections of not only water systems but also heating and chemical distribution systems, drums, pumps and valves, regular cleaning of filters and pipelines, regular calibration of measurement equipment (thermometers, chemical scales, distribution/dosing systems, etc.) and routine inspection and cleaning of heat treatment units (incl. chimneys) at specified periods, effective maintenance-repair, cleaning and loss control applications can provide savings of 1-6% in water consumption (Hasanbeigi, 2010; Öztürk, 2014; TOB, 2021).

Industrial Steam Boilers

- ***Water savings by reusing steam boiler condensate***

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

- ***Reuse of energy produced from steam condenser***

  With a simple change in the piping system, water feeding the water conditioning/decarbonization unit can be obtained from the outlet of the turbine condenser unit. This water has sufficient temperature for the conditioning/decarbonization unit. Therefore, this water does not need to be heated by steam produced by the heat exchanger system. Thanks to this study, significant steam gain can be achieved. Cooling water consumption can also be reduced (CPRAC, 2021).

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

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

Tailings Dams in Mining Sites

BATs for cooling systems

- ***Increasing the number of cycles in closed-loop cooling systems, improving the quality of makeup water and reducing water consumption***
  Water is used as a refrigerant in many processes such as the cooling of products and production processes in the manufacturing industry. Water is recirculated through cooling towers or central cooling systems to perform the cooling process. If unwanted microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MAM, 2016). The number of cycles can be increased by performing good chemical conditioning in the recirculation process. In this way, water savings can be achieved by reducing the amount of fresh water fed to the system. In addition, good conditioning of the cooling makeup water can also increase the number of cycles (TOB, 2021).

- ***Avoiding unnecessary cooling processes by determining the processes that require wet cooling***
  The boundaries of the facility site affect design parameters such as the height of the cooling tower.In cases where it is necessary to reduce the height of the tower, a hybrid cooling system can be applied. Hybrid cooling systems are a combination of evaporative and non-evaporative (wet and dry) cooling systems. Depending on the ambient temperature, the hybrid cooling tower can be operated as a 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 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 make-up water(TUBITAK MAM, 2016).

- ***Collection of surface runoff water with a separate collection system and use for cooling water, process water, etc.***
  In most industrial facilities, wastewater is generated from process sources or non-process 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. Surface runoff water can be collected with a separate collection system and used as cooling water (TOB, 2021).

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

  Cooling waters are collected separately and used for cooling purposes or re-evaluated in appropriate processes (EC, 2009). A water softening system is required for the healthy operation of this system.Cooling water has suitable water quality for re-use as cleaning and irrigation water. However, since it contains some hardness when used as cooling water, additional softening is required to prevent corrosion problems that will occur over time. Before being reused as cooling water or in the process, this water must undergo an appropriate disinfection process. In addition, it is possible to re-use the water in question not only in cooling processes but also in all production processes by purifying it with appropriate treatment techniques (membrane filtration, advanced oxidation, chemical precipitation, granular active carbon adsorption, etc. processes) (TUBITAK MAM, 2016). As the hardness level of the cooling water increases, limestone and deposits form on the walls. Deposit formation negatively affects heat transfer, reduces energy efficiency and increases energy costs. With the increase in evaporation in the system, the ion concentration and conductivity value in the water increase. In order to prevent these negativities, the cooling water should be chemically treated to prevent scale and corrosion, disinfected with a biocide that prevents biological activation, the cooling towers should be subjected to chemical and mechanical cleaning at least twice a year and the sediments should be cleaned, and the hardness and conductivity values should be kept as low as possible (TUBITAK MAM, 2016).

- ***BATs related to ventilation and air conditioning systems***

  Reuse of the liquid formed by condensation from the ventilation system

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

- ***BATs related to cogeneration systems***

  Use of hot water produced in cogeneration systems in heating processes

  By including cooling systems in cogeneration systems (trigeneration), it is possible to convert 10-30% of the efficiency losses into hot water, water vapor, cold air, hot air and water (for this, absorption heat exchangers must be used). Thus, it is possible to meet a portion of the energy required in processes such as cooling and drying within the facility from the waste heat in cogeneration systems. Energy costs can be reduced by up to 40% in facilities using cogeneration systems (TUBITAK MAM, 2016).

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