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THE RESEARCH OF MEMBRANE TECHNOLOGY TREATABILITY IN DIFFERENT INDUSTRIAL WASTEWATERS

ABSTRACT

In this study, the treatability researches which have been held by microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) for Wastewaters of Electro Plating Industry, Leachate Wastewaters, Wastewaters of Textile Industry, Wastewaters of Olive Mill Industry, Whey Wastewaters, Wastewaters of Milk Industry and Leather Industry were investigated and the most probable membrane systems applications were decided. It’s been foreseen that the membrane systems are feasible to use as considering cost, recovery of chemical materials used in industries and re-use of treated wastewaters.

Keywords: Yield of Treatment, Industrial Wastewaters, Recovery, Membrane Technology, Reuse

FARKLI ENDÜSTRİYEL ATIKSULARDA MEMBRANE TEKNOLOJİSİ UYGULAMALARININ İNCELENMESİ

ÖZET

Bu çalışmada; Elektro Kaplama Endüstrisi Atıksuları, Sızıntı Suları, Tekstil Endüstrisi Atıksuları, Zeytinyağı Endüstrisi Atıksuları, Peyniraltı Atıksuları, Süt Endüstrisi ve Deri Endüstrisi Atıksularında Microfiltration (MF), ultrafiltration (UF), Nanofiltration (NF) ve reverse osmosis (TO) membrane sistemleri ile yapılmış arıtılabilirlik çalışmaları incelenmiş ve bu endüstriler için en uygun olabilecek membran sistemleri ortaya konmuştur. Membrane sistemlerinin, endüstrilerde kullanılan kimyasal maddelerin geri kazanımı ve atıksuların arıtılarak tekrar kullanılabilirliği açısından uygun olduğu görülmüştür.

Anahtar Kelimeler: Arıtma Verimi, Endüstriyel Atıksular, Geri Kazanım, Membrane Teknolojisi, Tekrar Kullanım

1. INTRODUCTION (GİRİŞ)

In recent days, physical, chemical and biological treatment units are being used to decrease the level of the pollutants in the industrial wastewaters, to the required discharge criteria's. However, both decreasing to the required discharge criteria's with these treatment systems and recovering both water and chemical materials which are used in industry also does not often possible.

The toxic substances in the wastewater harm biologic treatment systems. The microorganisms in the biologic treatment do not able to adapt to this system and this effect the efficiency of the treatment. In these cases the required treatment efficiency can not be seen. In addition, the sludge that arises due to biological treatment causes souring and smells.

However, the cost increases due to the chemical substances used in chemical treatment. Although, the sludge that arises from this treatment consists harmful and dangerous substances. Thus, removal of the sludge becomes another serious problem. The usage of the membrane filtration systems in wastewater treatments is more appropriate, due to its lower cost of implementation and process, for both recovering chemical substances and recovering the facility water.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

The usage of membrane filtration systems in industrial areas which continuously develops attracts attention. Especially, with a reason of decreasing of drinkable water sources, membrane technology seems appropriate to use due to wastewater treatment, re-use in systems, recovering the chemicals used in production and its performance [1 and 2].

The purpose of this study is, with reviewing all the studies which held by membrane filtration technology in literature, determining the applications in industrial areas and put forward the efficiencies that obtained. Through this purpose, the wastewaters of electro coating industry, landfill leachate waters, textile industry wastewaters, olive mill industry wastewaters, whey wastewaters, wastewaters of milk industry, and leather industry wastewaters reviewed and most appropriate membrane systems have decided for these industries.

3. MEMBRANE FILTRATION (MEMBRANE FİLTRASYONU)

Membrane filters, which restrict the behaviors of some definitive types, are permeable or semi-permeable materials that produced from metal, inorganic or organic polymers. These membranes, are being used for purposes like differentiation separation of gases, differentiation of solid/liquid and differentiation of liquid/liquid

Membrane processes have 3 phases. These phases are, feed flows, permeate flows and concentrate flows. The treatment process basis on the definitive ratio collapse of the components goes into membranes by membranes. As seen in Figure 1, the flow in membranes is as two sections. Filtrate; the flow passes from membrane, Concentrate flow; the flow can not be passed from membrane [3].

Membrane processes can be classified with the driver forces. These are; pressure, electrical power, temperature, grade of the concentration and the combinations that exists more than one. The pressure driven membrane processes are, Reverse Osmosis (RO), Nanofiltration (NF), Ultrafiltration (UF) and Microfiltration (MF).

The differences between the pressure driven membranes occurs due to pore diameters or in another words, detention values of molecule weights, (Molecular Weight Cut-Off: MWCO) and the application pressures that can permeate from the pore diameter. The MWCO value of a membrane is determined according to the molecular weight of the component that is requested to be taken from the wastewater [5]. The dimensions of some components which can be taken from the wastewater are been declared in Figure 2.

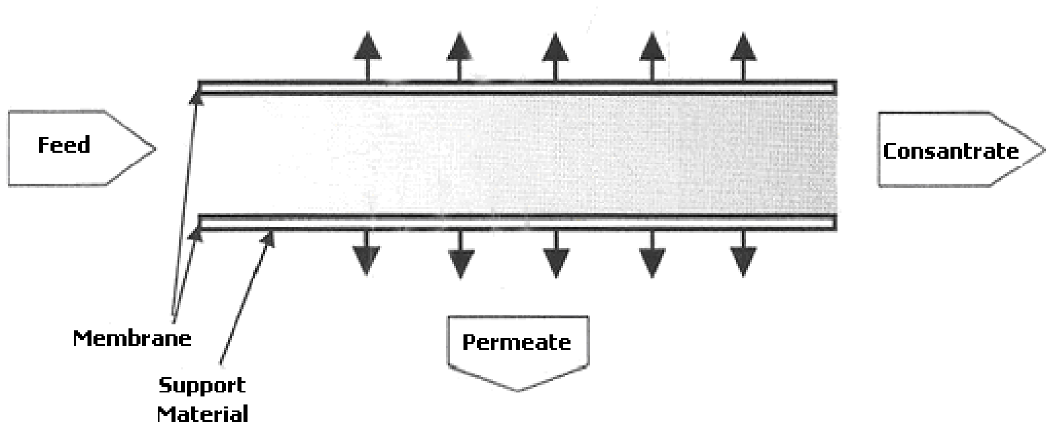

Figure 1. Schematic description of membrane[4]
(Şekil 1. Membranın şematik gösterimi[4])

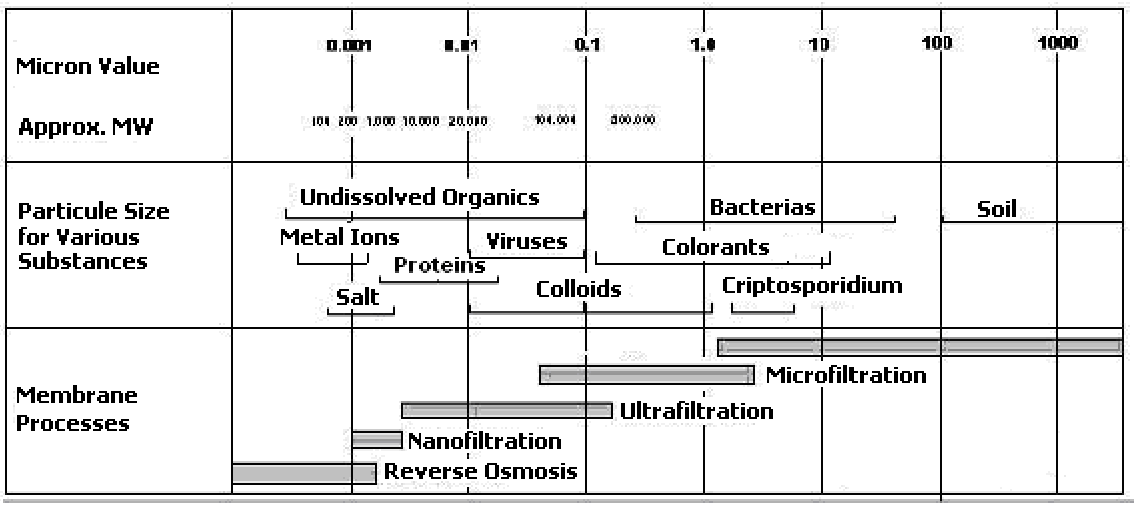

Figure 2. Application guide of pressure driven membrane process[6]
(Şekil 2. Basınç sürücü membrane proses uygulama rehberi[6])

4. INDUSTRIAL APPLICATIONS OF MEMBRANE FILTRATION (MEMBRAN FİLTRASYONUNUN ENDÜSTRİYEL ALANLARDAKİ UYGULAMALARI)

Membrane filters are widely in use in industrial areas due to their capability to cover all ions between 0,1 micron and 0,001 micron and although they can cover organic molecules which has max. 100g/mol molecular weight [7]. In environmental technologies, they are in use as a part of the treatment system or recovering the valuable materials. In spite of using membrane systems in process, they are being used for removal industrial wastewaters.

In this chapter, all the studies with membrane systems are been reviewed like, Electro Plating Industry wastewaters, Leachate Wastewaters, Wastewaters of Textile Industry, Wastewaters of Olive Mill Industry, Whey Wastewaters, Wastewaters of Milk Industry and Leather Industry. With Table 1; application of membrane process to various industries is explained.

Table 1. Application of membrane process to various industries [8 and 9]
(Tablo 1. Membrane prosesinin çeşitli endüstrilere uygulanması [8 and 9])

Industry	Membrane Process	Medicine	Membrane Process
Drink water	NF, UF, RO	Hemodialysis	RO, UF
Pure water	RO, ED, EDI	Chemistry industry	
Wastewater treatment		Gas Separation	
Direct(physical)	MF, NF, RO, ED	Hydrogen recycling	GS
MBR	MF, UF	CO_2 separation	GS
Food industry		Vapour-Liquid separation	
Milk	UF, RO, ED	Ethanol dehydration	PV
Meat	UF, RO	Chlorine-alkali process	Membrane electrolysis
Fruit and vegetables	RO	Energy	
Grain factories	UF	Fuel	Membrane of proton change
Sugar	UF, RO, ED, MF, NF	**NOTION**	
Drinks		**Microfiltration**	**MF**
Fruit juices	MF, UF, RO	**Nanofiltration**	**NF**
Wine and beer	MF, UF, RO, PV	**Reverse osmosis**	**RO**
Tea factories	MF, UF, NF	**Elektrodialysis**	**ED**
Biotechnologies		**Elektrodeionization**	**EDI**
Enzym purity	UF	**Gas Separation**	**GS**
Fermentation concentration of meat broth	MF	**Pervaporasyon**	**PV**
Harvest	MF, UF		
Membrane technology	UF		
Sea biotechnology	MF, UF		

4.1. Wastewaters of Electro Coating Industry (Elektro Kaplama Endüstrisi Atıksuları)

The pollution which has been created by electro coating wastewaters is generally due to heavy metals like cyanide, pH variations, oils, copper, zinc, lead, chrome, nickel and phosphates. [10]. The main pollutants that create problems are cyanides, Cr (VI) and the other heavy metals due to their toxic properties. Other pollutants can be removed more easily but instead these have different treatment methods.

In recent days, the recovering of the metals from industrial diluted liquid wastes, is as important as considered for both economical and protection of environment. In 1960's-1970's most companies in Europe and America experienced recovering systems in their facilities.

In South Africa RO membranes are started to use in electro coating wastewaters. The studies which held with nickel washing waters reflected 92% efficiency and showed that the concentrate has suitable quality to use for coating and not much plugged problems occurred. [11]. A similar study with cadmium washing wastewater plugging problem occurred much more. However, it has declared that membranes are able for cleaning easily by chemicals. And with cyanide washing wastewater trials the evaluation is that the RO membranes have efficiency for recovering the water such as 75-90% and although this water has the quality as deionized water and can be used in production again [12]. The system that used in electro coating wastewaters is shown below in Figure 3.

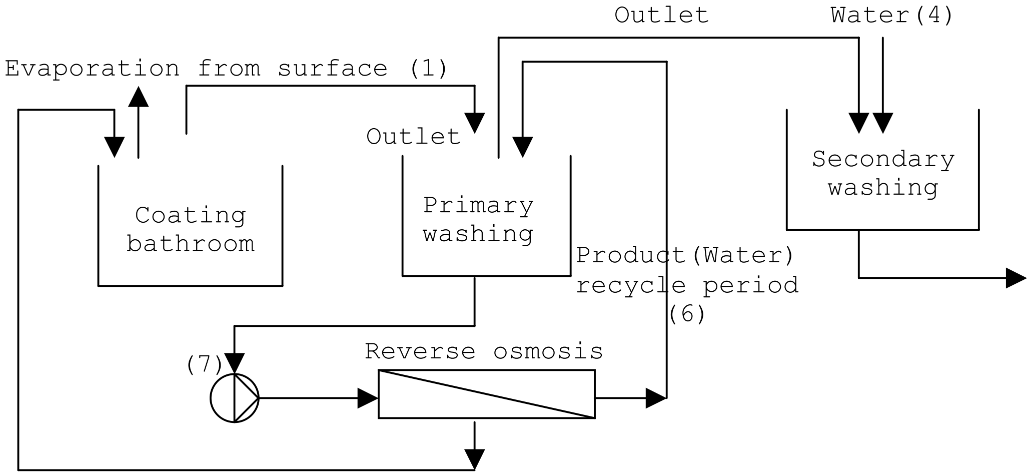

Figure 3. Membrane establishment of electro coating industry flow chart[11]
(Şekil 3. Elektro kaplama endüstrisi membrane tesisi akış şeması[11])

The purifying water of metal coating can be reused with reverse osmosis. Recovery of conductivity, nickel, nitrate and TOC's value as 90% is achieved for alkali, acid and nickel coating waters combinations. Before reverse osmosis, UF application for treatment aim, RO membranes met with less pollutants and water flow increased with a ratio 30-50 [10].

In another case study, it is seen that in the nanofiltration application for the removal of anion and cation in nickel coating waters is more economical when compared with RO and required less energy. The removal ratio is related with pressure, the velocity of wastewaters while passing through the membrane, pH, types of the ions and their concentrations [13].

4.2. Landfill Leachate Waters (Sızıntı Suları)

The landfill leachate waters which grow out of regular solid wastes storages, both causes to become polluted of land and ground water due to their content like organic components with high amounts, azoth components, heavy metals, organic and inorganic chlorate salts. [14]. Thus, to increase the landfill leachate waters to discharge criteria's needed much cost.

To increase the landfill leachate waters 20 technologies are being applied with different combinations. And the solution is determined due to discharge quality and cost.

In Northwestern side of Europe, North America and Fareast countries there are more that 100 solid waste storages. 43 of them are located in Germany and application is disc tube RO membranes. The clean water gained from these storages can be discharged to superficial areas, and the remaining 80% can be reusable. But, in the southern European countries like France, the primary and last processes of RO seen too expensive due to their high energy costs [15].

In Northwestern European countries, NF membranes are being applied for last 10 years and the importance of using NF membranes for the treatment of leachate waters increase in last 5 years. Trebuet and others (2001), applied pre-treatments like neutralization, pre-filtering process and chemical treatments with FeCl(III) then they applied nanofiltration method which contains two organic membranes and reached a lower result for the COD which is under the discharge limitations.

75% COD and 88% ammonia removal is achieved by applying denitrification, nitrification, ultrafiltration to leachate waters in the storage area in Germany, Whischhafen (Figure 4) [16].

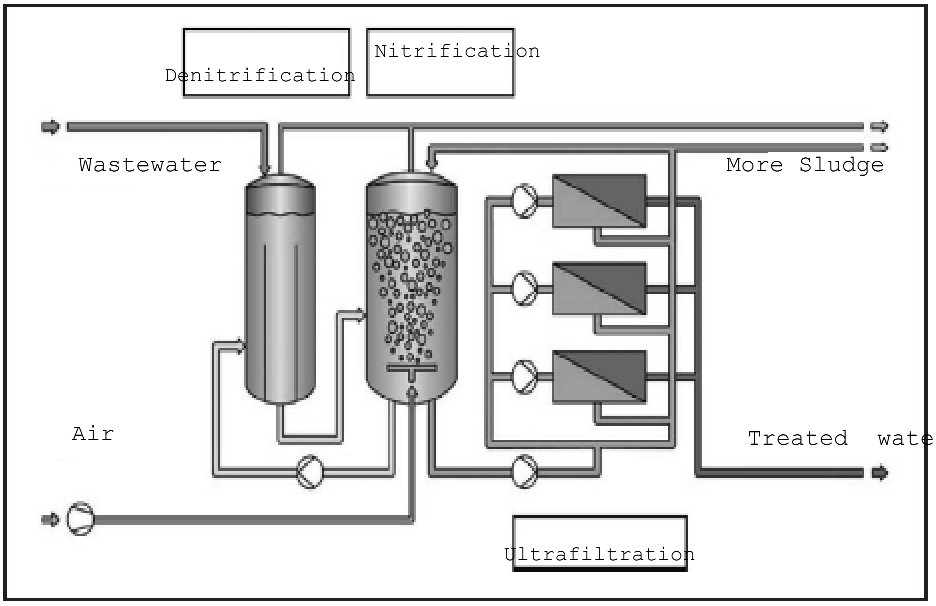

Figure 4. Treatment system which applied to landfill waters at the Whischhafen store field [16]
(Şekil 4. Whischhafen depolama alanındaki sızıntı sularına uygulanan arıtma sistemi [16])

The combinations of nanofiltration membranes and RO membranes are used to recover clean water from leachate waters with a ratio 95-97,5. Scott, in 1995, achieved 80% COD removal and 90% BOD removal with applying RO membrane systems to the leachate waters which also previously been applied biological treatment.

4.3. Wastewaters of Textile Industry (Tekstil Endüstrisi Atıksuları)

Textile wastewaters are hardly defined waters due to the variations of the chemicals used in painting processes and other processes and due to the variations of the processes during the production. Dye, solid material which dissolved with high amounts, higher COD values, wide pH interval and using much water in production processes are the general characteristics of textile waters [17].

There are a lot of studies about the recovery of dyes, auxiliary chemicals, waters, energies with membrane filtration technology [18 and 19]. In all these studies the membrane filtration techniques like MF, UF, NF and RO are tried for dye, auxiliary chemicals, water and energy recovery and to determine the best recovery and treatment efficiencies different membrane configurations have been applied.

Microfiltration, ultrafiltration, nanofiltration and reverse osmosis, approximately for 20 years in complete scaled applications, in use in textile industry. The applications in textile industry are shown in Table 2. Especially they are in the treatments of use in wool wash, bleaching, dress with size or starch, starch separation and dyeing bath wastewaters.

In brief; Microfiltration; removal from wastewater for sulfide, vat, azoic and disperse dyes; nanofiltration; removal from wastewater for dyestuffs and recovery and reverse osmosis; removal of ions and bigger substances from wastewater from the dyeing baths.

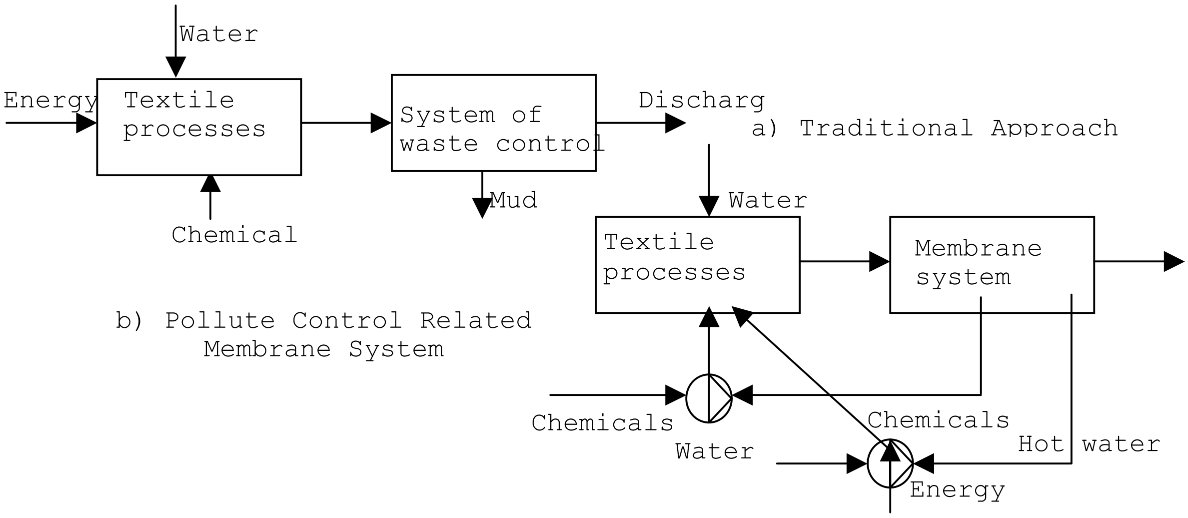

Figure 5. Traditional and membrane system approaches for paint shop wastewaters [3 and 20]
(Şekil 5. Boyahane atıksuları için geleneksel ve membrane sistemli yaklaşımlar [3 and 20])

The first studies about the treatment of the dye-bath wastewaters have held in the beginning of 1970's. In these years, NF membranes were not produced yet. So that, mostly RO and UF membranes were experienced. The studies held with UF and RO membranes, in common, continued till 1990's. After this date, the studies focused on NF membranes. With studies with MF membranes were in limited use. Especially, there are some studies about treatment of disperse dyes and pre-treatments before RO membranes with NF. The traditional and membrane system approaches for textile wastewaters shown in Figure 5 [3 and 20].

Textile industry uses water a lot. Fersi and others, (2005) in their study, experienced different treatment applications with MF, UF, NF membranes with the basis of COD, color, total dissolved salts, conductivity and turbidity which textile wastewaters contains. And it's proved that MF is an appropriate method for textile wastewaters of pre-treatment. If only UF and MF+UF applications held, with MF+UF application the parameters like salinity, color, and turbidity reflected better effectiveness. Also direct NF application on biologically treated textile wastewaters especially for salt removal reflected valuable results. According to the decrease of COD, color, turbidity and total dissolved salts removal resulted with efficiency 90%. According to the studies, NF membranes are appropriate for textile wastewaters reuse [21].

In another study, dye wastewaters which occurred from biological treatment facility, firstly sand filtered and then sent to MF membrane and then to NF membrane. Solid substances, turbidity and COD parameters are removed during sand filtering and MF with a high ratio. Another important parameter for textile wastewaters, color, is removed with NF membrane. Thus, the clean water that achieved can be re-used in dyeing process again. A system that will be constructed for a textile wastewater which has 1500 m^3/G flow can amortize itself in only 3 years [22].

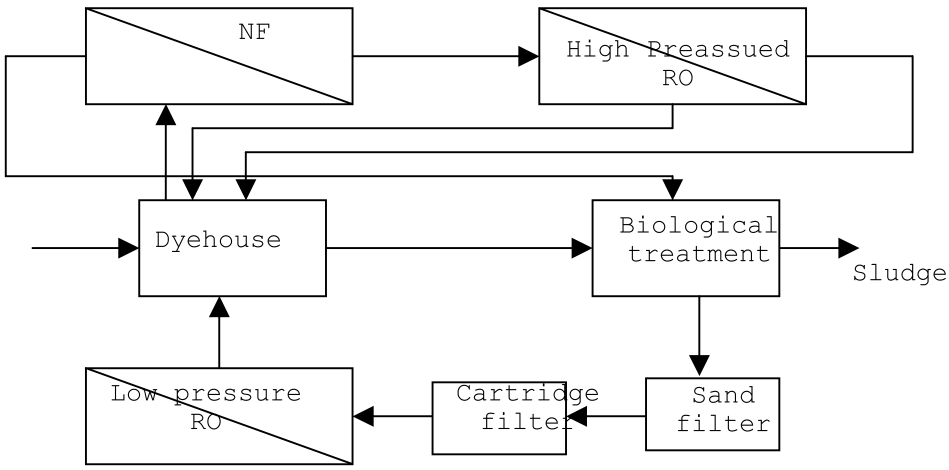

Figure 6. NF-TO membrane systems at dye house wastewaters treatment [20]
(Şekil 6. Boyahane atıksularının arıtımında NF-TO membrane sistemi [20])

For the reuse of stamping, dyeing and finishing textile industry wastewaters physicochemical treatment and then NF membrane is applied. The efficiency of 72,5% removal is provided between Fe^{+2} coagulant and COD value during the physicochemical treatment. The COD of the wastewater decreased 80% with applying NF after physicochemical treatment. The removal of salt and the flow ratio of clean water are related with feed pressure [23].

Gaeta and Fedele (1991); studied about a system which consist of NF, high pressured RO and low pressured RO. The flow chart of this system is shown in Figure 6. And they introduced that 90% water and 95% salt removals can be achievable. The amortization of the cost of the system is between 18 to 30 months.

Table 2. Used fields of membrane filters at textile industry [24]
(Tablo 2. Membrane filtrelerin tekstil işletmelerinde kullanım alanları [24])

Membrane Filter Varieties	Specifications	Application Processes	Aim of Usage	Waste Concentrated	Recovery Permeat
Microfiltration (MF)	Low pressure filters which cover suspended solid material (particular size <0.05 micron)	Dyeing of polyester fibre disperse dyes, dyeing of cotton, viscose fibres with azo, vat and sulphur dyes	Removal of suspanded dye in dyeing and washing wastewater	Suspanded dye particules	Auxiliary chemicals Water Energy
Nanofiltration (NF)	Medium pressure filters which cover biological materials, colloid and proteins	Dyeing of cotton fibre with reactive dyes	Removal of suspanded dye, elektrolytes (sodium chlorid/ sodium sulphade) in dyeing and washing wastewater	Suspanded dye particules, elektrolytes (sodium chlorid/sodium sulphade)	Elektrolytes (sodium chlorid/ sodium sulphade) Water Energy
Ultrafiltration (UF)	Filters which cover particulars (100-300 Da MWCO), generally using with and/or NF/RO	Dyeing of polyester fiber disperse dyes, dyeing of cotton fiber with reactive dyes	Removal of suspanded dye in dyeing and washing wastewater	Suspanded dye particules, elektrolytes (sodium chlorid/sodium sulphade)	Elektrolytes (sodium chlorid/ sodium sülphade) Water Energy
Reverse osmosis (RO)		Dyeing processes with acid, metal complex, direct, bazic and reactive dyes	Removal of ions and larger specieses dyeing and washing wastewater	Suspanded dye particules, elektrolytes (sodium chlorid/sodium sulphade)	Elektrolytes (sodium chlorid/ sodium sulphade) Water Energy

4.4. Olive Mill Industry Wastewaters (Zeytinyağı Endüstrisi Atıksuları)

Olive mill industry wastewaters, are hardly treated waters due to their high level organic substance and its containments substance and phenol. Although all the studies about olive mill industry wastewaters both physicochemical and biological studies did not give enough efficient results [25]. In most countries there are several studies about this treatment to solve these problems.

In the treatment of olive mill industry wastewaters; in recent days, membrane technologies started to be used. In Lamezia region (Italy) Olive mill industry wastewaters directly treated with ultrafiltration membranes then it's mixed with domestic wastewaters with a ratio 1 (domestic wastewater)/16 (olive mill industry wastewater) and its treatability is also investigated. In the wastewaters treated by UF 65-70% BOD_5 and COD removal is achieved. The studies with this mixture held for 3 months and resulted as COD removal efficiency 92-95% [26] (Figure 7).

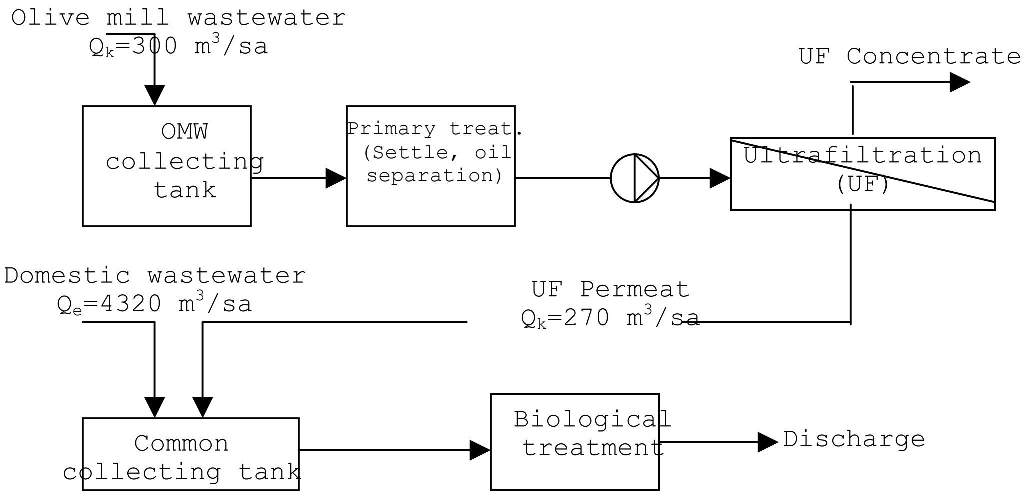

Figure 7. The Common treatment system flow chart of Lamezi Field [26]
(Şekil 7. Lamezia Bölgesi ortak arıtma sistemi akım şeması [26])

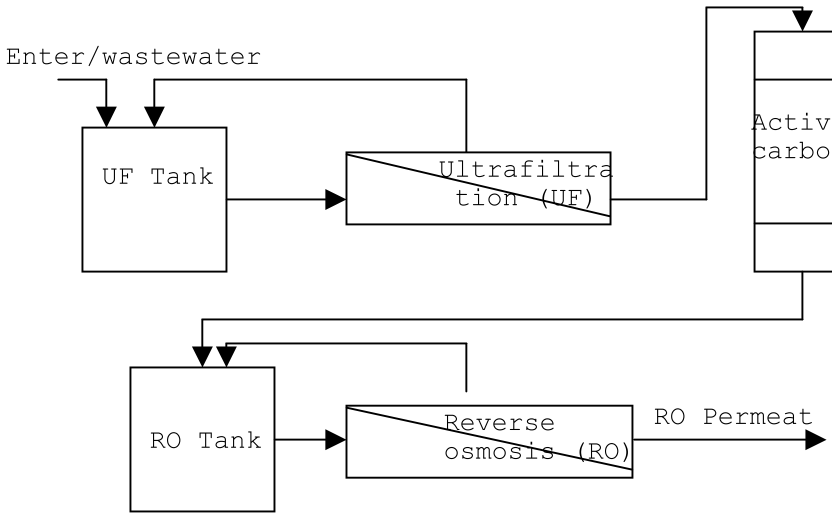

Figure 8. UF and RO pilot plant for olive mill treatment in Avegno Field [26]
(Şekil 8. Avegno(İtalya) bölgesinde, karasu arıtımı için geliştirilmiş UF ve TO pilot tesisi [26])

In California; the wastewaters from black olive process facility investigated by pre-filtering, UF, RO, and evaporation and as a result 50% solid substance containment and 80% water recovery is summarized. In Avegno Region (Italy) a system which contains active carbon and RO is applied to the olive mill industry wastewater which has 130.000 mg/L COD after UF and the COD is decreased to 1000 mg/l and 83% water recovery is achieved (Figure 8) [26].

4.5. Milk and Milk Industry Wastewaters (Süt ve Süt Endüstrisi Atıksuları)

Milk and milk industry wastewaters are equipments and wash waters of tanks, clean waters from cold and heating systems, pasteurization, domestic wastewaters and whey wastewaters. These wastewaters generally contain high amounts dissolved organic substances [27].

Membrane processes are generally in use in Milk and milk industries separation of milk, whey wastewater processing and separation of process wastewaters. The membrane technologies in milk and milk industries are declared in Table 3.

Table 3. Membrane technologies used in milk and milk industry [28]
(Tablo 3. Süt ve süt endüstrisinde kullanılan membran teknolojileri [28])

Industry	Membrane Technology	Application
Milk Industry	RO	Milk concentration
	NF	Whey wastewater concentration
	UF	Milk separation for cheese production
	MF	-Separation of whey wastewaters -Decreasing of microbiological load

4.5.1. Milk Industry Wastewaters (Süt Endüstrisi Atıksuları)

RO system has wide use in milk industry wastewaters since 1960's. UF membranes allows the transition of dissolvable salts and lactose but protein, oil and non-dissolvable or some bivalent salts catch on. MF applications in milk industry are oil separation, bacteria removal, casein concentration. In addition, by MF bacteria and spores are being removed from milk [29].

Koyuncu and others (2000) studied, NF and RO membranes for treatment of milk industry wastewaters and recovery. The pilot facility application done with a NF membrane which has composite type NF (TFC-S) with 2 m^2 surface area and RO(TFC-HR) membranes, system flow meter, pressure sensors, cartridge filters and pumps. Recovery for one membrane for RO and NF is by order of 16% and 30%. So it's reflected that membrane processes can be useful for both before treatment facility and at output waters so, the potential for this water to be reuse is proved [3].

4.5.2. Whey Wastewaters (Peynir Altı Suyu)

Whey wastewaters are the fluid fraction occurred during whey production. In every 100 kg milk that is used in production 10-20 kg whey and 80-90 kg whey wastewater is produced.

Main components of whey wastewaters are proteins and lactose can be used initially but although due to its lactose-protein ratio and 300.000-50.000 ppm and having high BOD value, discharging the whey water is hard and heavy. Whey wastewaters process is the first successful membrane application that is known [29]. In whey waters the usage of RO spiral wound membrane modules increased. The concentration degree with RO is related with actual energy prices.

Recently whey waters produced with UF can provide 10-12% (dry) protein content, 35-50% or 80% protein productions. Whey waters choke up hydrophobic membranes more than hydrophilic membranes (ex: cellulose acetate).

An important application of MF is that it is in use for whey water process for UF as pre-treatment. The centrifuge separation of whey water, generally with 0,2 micron diameter membranes. When the most of the amount of the inappropriate components are being removed, and the decayed salts removed microbiological power is highly decreased. [29]. The membrane application for the whey wastewater treatment is shown in Figure 9.

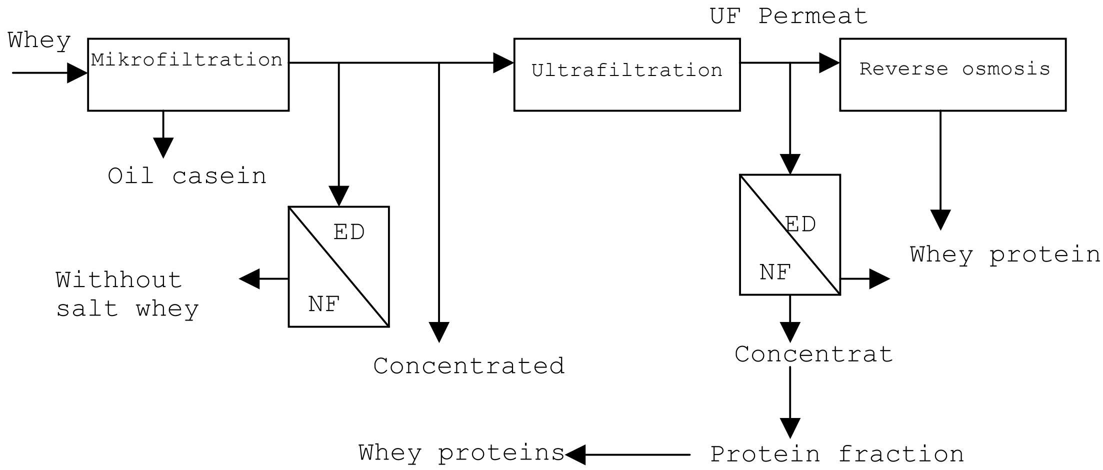

Figure 9. Usage with membrane process of whey water [29]
(Şekil 9. Peynir altı suyunun membrane prosesi ile kullanımı [29])

4.6. Leather Industry Wastewaters (Deri Endüstrisi Atıksuları)

Leather industry has huge amount of water consumption (for 1 ton leather 30-80 m^3). The wastewater of leather industry contains too high pollutants. These contains high salt, organic substance (COD, BOD_5), organic nitrogen and ammoniac, special pollutants (sulfide, chrome) [30].

Most leather industry facilities, appropriate water consumption tanning substance and auxiliary chemicals recovery is required. The chemicals for leather production in most systems directly enter to wastewater. As an example, 60% of the beginning sulfide amount of the hair removal process and in tanning process, 30% of the Cr(III)is directly goes out as an wastewater [31].

Table 4, shows membrane process applications in tanning industry [32]. Different chemicals are used in every leather process. Firstly the wastewaters with sulfide and chrome from different processes should be separated in different channels in plant for the recovery of these chemicals by membrane technology.

Its seen that worldwide studies are being held for recovery of Cr(III) and sulfide from leather wastewaters by UF and NF membranes. Some studies, recovered substances are tested by reusing in production and proved that the quality of the leather does not get worse. In some filtration studies, Cr (III) recovery is done and also the economical evaluation is reviewed [33, 34, 35, 36 and 37].

First step leather production for unhairing, hot saturated salted water (90°C) infiltrates to animal leathers. The current of hair removal process, develops 10% of discharge volume and 40% of pollutants. In leather facilities it's used as Na_2S for the removal of hairs in leather. Also lime and other chemicals are being used together with sulfide to expedite hair separation (Nacheva and others, 2004).

In Figure 10, it's shown as flow chart of UF plant for treating unhairing wastewater. In some cases, the salty water that expensed can have higher concentrations. In this industry, UF and MF, is used in sulfide recovery from unhairing baths, salt removal and recovery from vegetable tanning baths, and chrome removal or recovery from chrome tanning (Cheryan, 1998).

Table 4. Membrane process applications in tanning industry [32]
(Tablo 4. Tabaklama endüstrisinde membrane proses uygulamaları [32])

Waste Variety	Recovery Material	Membrane Processes
Water from primary and secondary treatment plant	Water, Salts	RO
Water from either pre-treatment or non pre-treatment	Water, Proteins, Oils	EMR
Soften + lime removal + waste from tearing	Water, Proteins, Chemicals	UF & RO
Unhairing	Sulfides, Auxiliaries, Chemicals	UF
Grading	Oils, Active material	UF
Chrome tanning	Chrome, Water	SLM
Vegetable tanning	Tannin acid, Sludge, Water	UF-MF/UF
Dyeing	Dyes, Hot water	RO
Tanning	Chrome, Protein	UF / RO-RO

(MF:Microfiltration, UF:Ultrafiltration, NF: Nanofiltration, RO: Reverse osmosis, ED: Elektrodialise, SLM: Liquid membranes)

Cassano and others (1997), in their study they obtained both protein and sulfide waters with tubular membrane systems and flat sheet membrane systems with pre-treated sulfide waters. And they gained 60-65% protein with the tubular membrane in UF system and 85% proteins and colloidal substance with flat sheet membrane in UF system. Besides, the filtrate occurred after this filtration process they also gained sulfide with a ratio 55-60%. The economical valuation of their research system is considered as rantable and applicable [35].

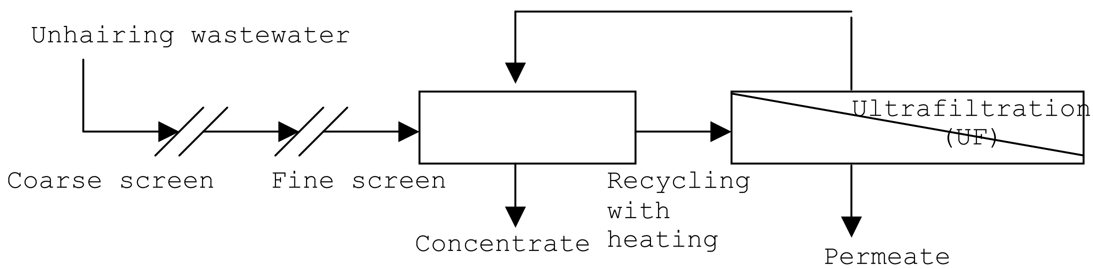

Figure 10. Flow Chart of UF plant for treating unhairing wastewater[31]
(Şekil 10. Kıl giderme atıksuyunun arıtımı için UF tesisinin akım şeması[31])

In 2002, Scholz and his friends, studied about sulfide recovery by using UF membrane system and achieved 30% sodiumhidrosulfide (NaHS), 15% lime and enzyme. Besides the waters arises from liming process can be reused in 90% percent. Also system can amortize itself 2,6 months.

The recovery of salt by RO is tried in leather wastewaters and declared that salty waters can be used in the system [4, 36 and 37].

Chrome wastewaters grow up from chrome tanning process. UF, NF and liquid membranes are in use for the recovery of waters, NaCl, Cr^{+3} salts for this process.

Fabiani and friends (1996), has 42% chrome recovery by applying the processes from chromate wastewaters in below order, as follows, settled Cr(III) with chemical treatment from chromate wastewaters then filter pressed, afterwards dissolved $Cr(OH)_3$ with sulfuric acid and then applied MF (ceramic) and UF. But the cost of the system was not evaluated and the applicability of the recovered chrome did not investigated [34].

In Figure 11, treatment of chromium and sulfide waters by membrane filtration systems is shown. Scholz and friends (2002) studied on sulfide recovery in sulfide wastewaters with UF system and detected that sulfide can be recovered 78% and also the system can be adequate. Also, they settled chemically chrome wastewaters and filter pressed then they carried UF and RO and achieved 100% chrome removal. They made the feasibility with UF system and announced that for every m^3 4,37 € can be recovered although besides system can amortizes itself only in 5.2 months [4].

Cassano and friends studied (2001) in Italy in a Membrane Filtration Institute and with membrane filtration system and they recovered sulfide wastewaters, chrome wastewaters and also dyed wastewaters. They applied reverse osmosis (RO) for recovery dyestuffs from dyed wastewaters. Although, a result to the study that they held, they announced that sulfide wastewaters and chrome wastewaters from leather industry can be recovered and these substances can be reused in leather industry due that these substances does not effect the quality of the leather. As a result, 28% chrome and 60% sulfide recovered [36].

The general wastewaters are grown from wetting, lime removal, retenadge processes. These waters contain high salt values. For the recovery of salt, RO membranes are seen as appropriate.

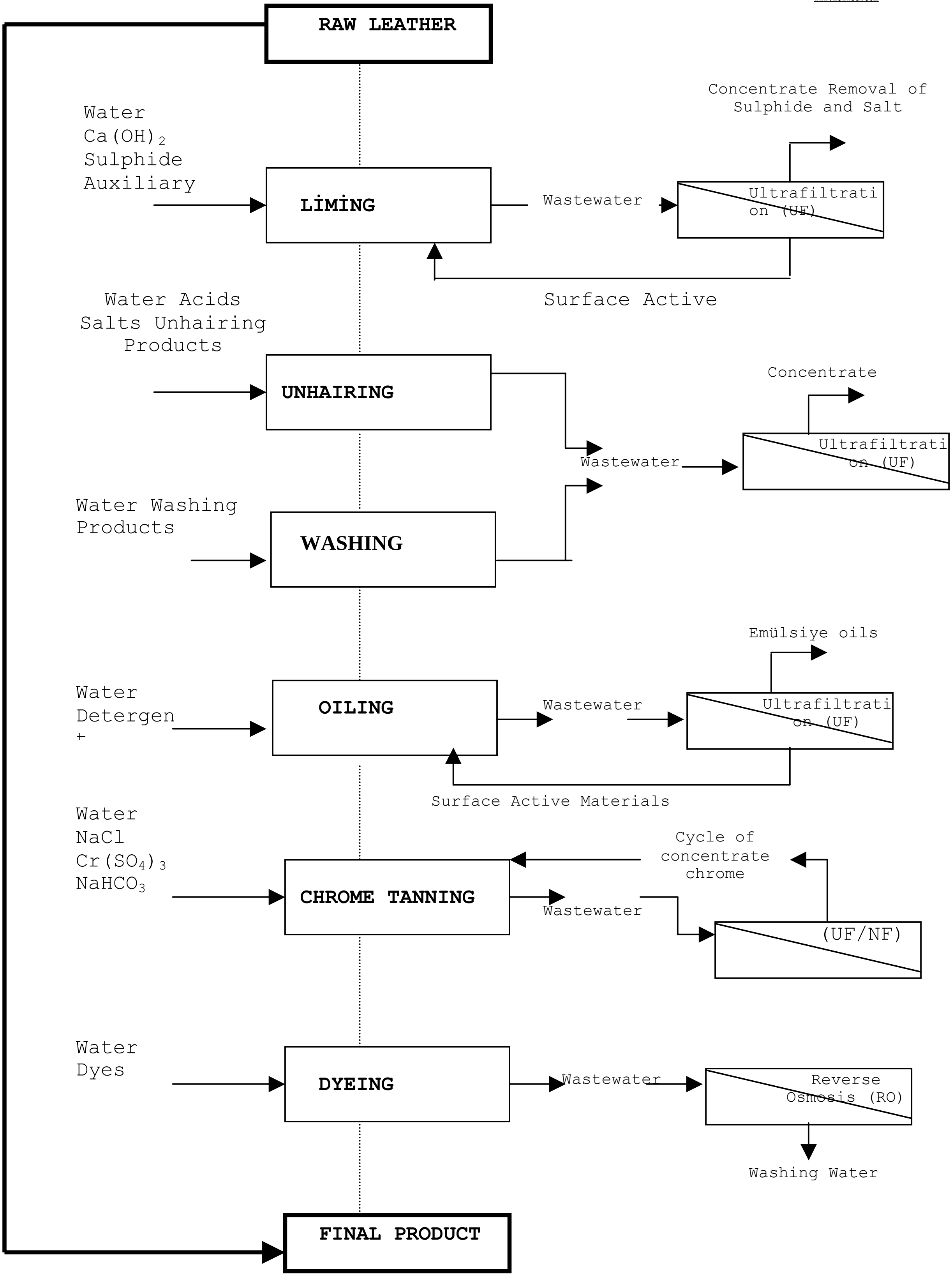

Figure 11. Treatment of chromium and sulphide waters by membrane filtration systems [35]

(Şekil 11. Kromlu ve sülfürlü suların membrane filtrasyon sistemleri ile arıtımı [35])

5. RESULTS AND CONCLUSIONS (SONUÇ VE ÖNERİLER)

The research for appropriate systems became obligation for pollution removal for recovery of chemicals and wastewaters used and re-usage. In recent years, the use of membrane filtration which is being improved attracts attention.

In this study, the studies with membrane filtration technology been investigated and the usage of membrane systems in industrial areas determined and the efficiencies of treatments are exposed.

Membrane filtration systems in general gathered into groups like Microfiltration (MF), ultrafiltration (UF), Nanofiltration (NF) and reverse osmosis (RO). These are all pressure driven systems.

Membrane filtration systems have applications on the areas of Electro Plating Industry, Leachate Wastewaters, Wastewaters of Textile Industry, Wastewaters of Olive Mill Industry, Whey Wastewaters, Wastewaters of Milk Industry and Leather Industry.

As a result of this study;

- In electro coating industry, especially using RO systems for nickel and cadmium washing waters shows recovery of washing waters with a ratio of 92. The removal ratio is related with pressure, the speed of the wastewater on membrane, pH, types of ions, and concentrations.
- UF system applications in olive oil industry wastewaters, 65-70% removal of BOD and COD pollutants are achieved. When this wastewaters mixed with domestic wastewaters its seen that COD removal efficiency is between 92-95%.
- The membrane filtration method in milk industry wastewaters is being used for milk concentration applications with RO, whey waters concentration applications with NF, separation of milk for whey production with UF, separation of whey wastewaters with MF, and microbial decreasing of milk and resulted with high quality water production.
- In treatment of leachate wastewaters, RO application after biological treatment 80% COD removal and 90% BOD removal is achieved.
- Membrane systems applications are more in use in textile wastewaters. Especially MF is appropriate system for pre-treatment of textile wastewaters. When only UF and MF+UF applications are carried on, MF+UF application results in salinity, color, turbidity parameters with better efficiencies. In the textile wastewaters which are already treated biologically direct NF applications especially gives better results for salt removal. Due to the decrease of COD more than 90% removal is achieved for total dissolved salts, color and turbidity.
- In the leather industry studies hair removal waters showed accumulation of 30% sulphide, 15% limes and 15% enzymes by UF and recycling are appropriate. Till today, as a result of all the studies completed, 49% COD removals for treatment of sulphide waters by UF, 78% sulphide removals is achieved. And 67% COD removal for treatment of chrome wastewaters by UF, 50% Cr removal and 95% KOI removal by RO, %cod COD removal and 100% Cr removal is achieved.

As a result of the studies reviewed during literature research, wastewaters from industries with membrane systems can be treated to discharge criteria’s also at the same time the possibility of the recovery of chemicals for production and recovery of wastewater is seen.

Membrane application are appropriate in most industries due to their properties like, decreasing the environmental impact, simplifying the wastewater treatment processes, simplifying re-use of sludge, decreasing the costs, recovery of chemicals and water, low usage of energy, non-additional wastes, surface requirements are minimum, connect ability with other processes, treatment performance, long life. First investment cost for the membrane systems is high instead this cost can be amortized itself between 1 to 3 years.

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