PFAS survey report

The use of PVDF membranes in water treatment applications

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1. Introduction

ECHA is welcoming public consultation on the restriction proposal for per-and polyfluoroalkyl substances (PFAS). The March 22nd, 2023 published draft of the proposal does not recognize the impact to water and waste products and processes.
The purpose of this submission is to provide input from water and wastewater treatment operators/experts and to share information on the use and the effect of a ban for polyvinylidene fluoride (PVDF) membranes in their water treatment systems.

As a reputable industry association, the International Desalination Association (IDA) can facilitate input collection from these end-users. The IDA surveyed operators and/or end-users of membrane-based water treatment systems during July and August 2023.

The IDA is a non-profit association established in 1973 and is the point of connection for the global desalination and water reuse community. The IDA serves members in more than 60 countries and reaches an additional 15 affiliate member organizations, both regional and national. Its membership comprises scientists, developers, off-takers, regulators, end-users, engineers, consultants, media, and researchers from governments, corporations, and academia. The IDA works to promote water scarcity solutions as an NGO with recognized consultative status by the United Nations ECOSOC, and a member of the UN Water Special Framework for Water Scarcity in Agriculture (WASAG) hosted by the UN FAO Land and Water Division.

The IDA is committed to informing the public about desalination and water reuse, and their critical role in providing new, reliable, and sustainable sources of fresh water worldwide.

2. Background Water and Wastewater Treatment

Water is a crucial ingredient for sustaining life. Nature is equipped with a natural water cycle, but it is not always in sync with human impact on water. As the populations grow and the climate changes, the natural water cycle is becoming less and less sustainable and needs more and more water and wastewater treatment interventions. Polymeric PVDF microfiltration (MF) ultrafiltration (UF) and other membranes are used in water and wastewater treatment to help facilitate the water cycle process and protect the environment from water depletion and pollution.

PVDF (polyvinylidene fluoride) membranes have been widely used for more than 30 years in water treatment applications due to their mechanical strength, superior chemical resistance, and high thermal stability. These membranes are mainly used for the removal of organics, suspended solids, and microorganisms from water. Different types of water are treated by these membranes such as wastewater, groundwater, surface water (including sea, lake, canal, river), and process water.

The purified water can either be directly used or treated further by other technologies to produce drinking water, industrial utility water, food and beverage water, agricultural irrigation water, or even high-purity water for the pharmaceutical or semiconductor industries.

The combined material properties of PVDF membranes include a high molecular weight, high mechanical strength, and chemical and thermal resistance. Membranes made from PVDF are assembled into pressurized filtration modules, submerged UF systems, and membrane bioreactors.

Approximately 30 years ago, PVDF ultrafiltration membranes were sparingly used. Conventional water treatment technologies were employed to serve drinking water to communities.

In 1993 the limitation of conventional technologies became obvious in Milwaukee, Wisconsin (USA) when a widespread cryptosporidium outbreak occurred that resulted in widespread hospitalizations. The city sourced their drinking water from Lake Michigan which became contaminated from the overflow of sewers and a nearby sewage treatment plant due to heavy rains.

The city's conventional water treatment – including normal chlorination – offered no barrier of protection from the microscopic, chlorine-resistant protozoan parasite (including its eggs) leading to the cryptosporidium outbreak. PVDF ultrafiltration membranes are effective at removing cryptosporidium and once installed in the city water treatment process, the city was able to regain confidence in the quality assurance of their water supply. Since then, PVDF ultrafiltration membranes has become a material of choice for these applications as well as many other applications globally.

3. Water and Wastewater Treatment System End User Survey

To obtain feedback from water and wastewater treatment system end-users, the IDA prepared a survey to which any water or wastewater treatment end-user could respond. The compiled results of the survey offer a perspective related to the use of PVDF membranes, typical end-of-life practices, the challenges with replacing existing PVDF membranes with alternatives, and the types of alternatives considered.

The survey was conducted between July 1st and August 31st, 2023.

The survey was posted on the IDA website. Responses were generated by means of IDA social media communications and individual member outreach. For this reason, it is not possible to determine the response rate. In addition, the survey was conducted during the summer period.

The target region of the survey was the EU, however, the IDA received responses from outside the EU.

The responses provided information on the use of PVDF membranes in water and wastewater treatment varying from producing potable water to producing water that can be discharged into the environment.
This document provides information on the results of the survey.

3.1 Survey results discussion

3.1.1 Company

Company A
Company A is a global group that develops and manages sustainable infrastructure solutions, especially in renewable energy and water treatment. It provides water utility line construction services. The company designs, constructs, operates, and maintains drinking water treatment, residual purification, and tertiary treatment plants for re-use and reverse-osmosis desalination plants. The company serves customers globally including Spain, Australia, Middle East, and United States.
It completed the survey for their seawater desalination plant in South Australia.

Company B
Company B owns and operates water treatment and wastewater treatment systems in Spain and Latin America including the Catalonian municipality (5 million clients) on the northeastern coast of Spain. Their systems produce drinking water and process water. Its customer base includes households and companies.
Five surveys were submitted for five different municipal sewage water treatment plants in Spain.

Company C
Company C is a water company that was founded in 1867. It is located in the capital of the province Catalonia, Spain. The company collects, purifies, transports, and distributes water to other companies and to residents. It provides water to over 3 million people. The company also reuses water and return it to the environment.

Company D
Company D is responsible for the production and distribution of potable water to several counties and towns on the North Sea coast of West Flanders, Belgium. It also treats wastewater from several counties.
The company serves 61,000 residents.

Company E
Company E is a multinational Japanese chemical company. Its main products are chemicals and materials science. It produces hollow fiber membranes for water and

wastewater treatment. The company sells its membranes to equipment suppliers and water treatment plant owners/operators. Their survey results did not provide specific information on sites. It provided information on three membrane models. Therefore, Company E was not included in section 3 “Discussion of survey results”.

Company F
Company F is a water utility company that provides drinking water and treats wastewater in a municipality of the province of Brescia in Italy.
The company provides services to 91,637 inhabitants.

Company G.
Company G is a nuclear research facility located in Mumbai, India.
It owns and operates a water treatment system to support its research center.

Company H
Company H is a wholly publicly owned company that manages the water assets (networks and plants) of municipalities, invests in knowledge and computerization, performs strategic direction and financial control functions, and plans and implements investments, ensuring experience, expertise, quality, and safety every day. The company is located in the province of Lombardy, Italy. Its clients include households and companies.

Company I
Company I provides a wide range of water treatment systems and services in India and Bangladesh. The company utilizes pressurized and submerged PVDF ultrafiltration membranes for its water treatment systems.

Company J
Company J is a global energy company, active at every stage of the value chain: from natural gas and oil to co-generated electricity and renewables, including both traditional and biorefining and chemicals. The corporate headquarters are located in Rome, Italy. It is one of the largest oil companies in the world. The survey form was completed for a system located in Italy.

Company K
Company K is a water utility company that provides a range of services in the public domain for the participating cities and municipalities. It provides the distribution and transport of drinking water, water sanitation, and management of sports facilities. In addition to buying water from other water companies, the company also produces potable water which is provided to companies and households through a distribution network. The company is in the province of East Flanders, Belgium.
The survey was completed for the Ostend municipality drinking water plant.

Company L
Company L provides water treatment systems, products, and services to operate and maintain water treatment systems globally. The headquarters are located in Quebec, Canada.
The company provided general information pertaining to water treatment systems in Canada, Chile, France, Spain, and the United Kingdom. Therefore, company L was not included in section 3 "Discussion of survey results".

Company M
Company M is a wholesale water provider and resource planning agency. It serves approximately 3.2 million residents through 28 retail water agencies in Orange County, California, USA. The company manages the groundwater basin beneath central and northern Orange County.
Company M owns and operates its water and wastewater treatment plants.

Company N
Company N is the largest supplier of water in Flanders, Belgium. The company provides drinking water to residents and companies. Further, it provides process water for industries. The company owns and operates several water treatment installations in Flanders.

Company O
Company O provides integrated water services to its customers in the province of Brescia, Italy. The company offers water utility services which include the distribution of water for domestic, commercial, and industrial use.
The survey was completed for two sewage treatment systems.

Company P
Company P is a municipality in Italy. No information was provided pertaining to the company and its location in Italy.

Company Q
Company Q is a company in Germany. It operates an industrial sewage water treatment plant. No information was provided pertaining to the company and its location in Germany.

Company R
Company R is a company in Italy. It operates an industrial sewage water treatment plant. No information was provided pertaining to the company and its location in Italy.

Company S
Company S is a company in Germany. It operates a municipal sewage water treatment plant. No information was provided pertaining to the company and its location in Germany.

Company T
Company T provides water treatment and wastewater treatment systems globally. The company is located in Germany. Company T provided general information pertaining to two water treatment systems. The company does not own and/or does not operate water treatment systems. Therefore, company T was not included in section 3 "Discussion of survey results".

3.1.2 Type of water treatment plant

The table below summarizes the type of water treatment plant.

The term direct use means that the treated water is directly supplied to the client (businesses and/or inhabitants). The term indirect use means that the treated water is mixed with other water sources before it is supplied to the client.

Company B submitted surveys of five different water treatment plants. The number between the brackets indicates how many of their surveys were treating the same type of water.

Type of water treatment plant	Survey response
Supply of drinking water	A, C, E, F, G, I, K , P
Supply of industrial process water	E, I, K, N
Supply of water for food and beverages	E, K
Supply of water for agricultural applications (crops)	
Supply of water for industrial applications	E, I
Treatment of municipal sewage water for discharge to the environment	B, H, I, O, T
Treatment of municipal sewage water for potable water – direct use	
Treatment of municipal sewage water for potable water – indirect use	D, M
Treatment of municipal sewage water for reuse	B (3), H, I, R, T
Treatment of industrial sewage water discharge to the environment	Q, R
Treatment of industrial sewage water for potable water – direct use	
Treatment of industrial sewage water for potable water – indirect use	
Type of water treatment plant	**Survey response**
Treatment of industrial sewage water for reuse	B, J
Treatment of sewage by membrane bioreactor (MBR) for discharge to the environment	B, F, O, S
Treatment of sewage by membrane bioreactor (MBR) for indirect use	B
Treatment of sewage by membrane bioreactor (MBR) for direct use	B

The majority of the submitted responses pertain to the supply of drinking water and treatment of Municipal Sewage Water for Reuse.

3.1.3 Plant capacity and/or population served by the Water treatment plant.

Some companies provided information on the capacity of their water treatment plants with PVDF membranes and/or provided information on the population served. Missing information such as population information was supplemented by online research by the authors of this report.

Company	Water treatment plant capacity	Population served
A	300,000 m^3/day	650,000
B	40,000 m^3/d	
	No information provided	
	64,000 m^3/d	375,000
	12,000 m^3/d	
	12,500 m^3/d	
C	240,000 m^3/d PVDF UF membrane system The total capacity of the whole water treatment system is 432,000 m^3/d	
D	2,500,000 m^3/yr (approx. 6,850 m^3/d)	61,000
E	2 m^3/h per module. Their customers use multiple modules in order to treat /produce the required amount of water.	
F		91,637
G	100 m^3/day	Not applicable
H		300,000
I	60 m^3/day to 70,000 m^3/day. The company supplies equipment in India and Bangladesh and did not provide specific on its clients (population, companies etc.)	
J	500 m^3/hr (12,000 m^3/d)	
K	1,200 m^3/hr (28,800 m^3/day)	> 300,000
M	492,000 m^3/day (130 MGD)	2.5 million
N	3 systems: 500 – 200 – 150 m^3/hr (12,000- 4,800- 3,600 m^3/day)	
O	4,400 m^3/hr (105,600 m^3/day)	296,000
P	100,000 m^3/day	
Q	2000 m^3/h (48,000 m^3/day)	
R	250 - 300 m^3/h (6,000 – 7,200 m^3/day)	
S	7,000 m^3/day	10,000
T	No information provided	

The majority of the submitted responses are from medium to very large water utilities.

3.1.4 Age of the water treatment system

The respondents provided information on their water treatment systems with PVDF membranes. The age varied from less than 1 year to more than 20 years. In some cases, the respondent has water treatment systems with different ages. This can be attributed to capacity expansion that required additional water treatment systems.
The typical lifetime of the membranes used in water treatment systems vary from 3 years to 10 years.
Some of these systems have had several membrane replacements during the life of their water treatment system.
Membrane modules are a consumable product. They are replaced by the operator of the water treatment system when they do not provide the required quality and quantity of water.
When replacing membrane modules, the same model is typically used for the replacement during a scheduled plant shutdown.
If a competitor or an alternative product is considered as a replacement, then this may require major mechanical modifications to the water treatment system. These mechanical changes can become expensive, and the plant would not be treating or producing water while it is being retrofitted.

Company	less than 1 year	1 – 5 years	5 – 10 years	10 – 20 years	more than 20 years
A				X	
B		X	X	X	X
C				X	
D					X
F	X	X			
G		X			
H		X			
Company	**less than 1 year**	**1 – 5 years**	**5 – 10 years**	**10 – 20 years**	**more than 20 years**
I	X	X			
J			X		
K		X			
M				X	
N		X		X	
O			X		X
P			X		
Q			X		
R		X			
S				X	

The majority of the submitted responses are from owners and operators of water treatment systems more than 5 years old.

3.1.5 Membrane selection criteria for PVDF membranes installed in the water treatment systems

The survey responses provided different reasons why PVDF membranes had been selected for the water treatment systems.

The selection of the PVDF membranes for the water treatment systems was based on different criteria. The table below provides information on the selection criteria and reasons for the selection of the PVDF membranes.

Selection criteria of PVDF membranes	Responding companies
Pilot test/field test comparing PVDF and with other membrane materials (ceramic, chlorinated PE, PES/PS etc.)	C, D, I, K, M, N
Footprint constraints	D, F, H, J, K, M, R
Service life	I, N, P, R, S
Higher fluxes (amount of filtered water per hr and per m^2)	B, H, I, K, M, P, S
Capital cost (CAPEX)	H
Operation cost (OPEX)	I, S
Both CAPEX and OPEX (total cost of ownership)	A, B, G, J, K, N, P, Q
Fouling resistant	H, I, K, N, P, Q
Cleaning frequency	B, D, H, J, P, S
Ease of maintenance	B, D, I, J, K, N, P, Q, S
Recommended by system supplier/consulting company/membrane manufacturer	B, K

Other	
K	A different system with PES membranes will be replaced with PVDF membranes as PVDF membranes perform better on better on this water (comparison with neighboring plant that uses PVDF membranes).
F	High rejection of organic compounds
O	Treated water quality
R	Stable and reliable effluent quality and a potential of reuse of product water

Microfiltration (MF) and Ultrafiltration (UF) are membrane separation technologies applied for the removal of organics, microorganisms, suspended and colloidal matter from water. These technologies are used as a stand-alone or these systems are used as a pretreatment step for other separation technologies such as nanofiltration (NF) and reverse osmosis (RO). It depends on the required water quality that needs to be achieved.

Nanofiltration and reverse osmosis membrane systems require feed waters free from suspended matter, colloids and other impurities in order to ensure stable operation and optimum removal of salts, metals, organics, and pesticides/herbicides.
The membrane selection depends on the water quantity to be treated/produced and the required water output quality. The feed water composition also has a large impact on the membrane selection and system design.
Therefore, the total cost of ownership selection criteria was included as switching to a different product may result in the installation of additional equipment and/or increased costs for the operation and maintenance.

The main criteria for the PVDF membrane selection were footprint constraints, total cost of ownership, and ease of maintenance.
Six companies had selected PVDF membranes due to the pilot test/field test results. These companies were comparing PVDF with other membrane materials for their water treatment application.

3.1.6 Current challenges for water/wastewater treatment and their significance

The survey asked for input on the challenges faced by owners and operators of water treatment systems today.

Challenge	Not important	Somewhat important	Important	Critical
ENVIRONMENTAL				
Carbon footprint	A, B, G, M, R, S	I, N, P, Q	B, C, D, F, H, O	J, K
Waste management		A, D, G, K, M, P, Q, S	B, C, H, J, N, O, R	B, F, I
Micropollutants	N, S	A, B, G, J, M, O, Q	B, C, D, F, H, K, P	I, R
PFAS	H, Q, S	B, G, K, O, R	A, B, C, D, F, I, J, M, P	N
Bacteria and/or viruses	A, N	C, D, G, H, J, S	B, F, O, Q, R	B, I, K, M, P
Deterioration of feed water	A, H	B, F, G, P, S	B, D, J, K, M, N, O, Q, R	B, C, I
More stringent discharge requirements to the environment (for wastewater treatment)	A	F, G, M	B, C, D, H, J, K, O, P, Q, S	I, N, R
ECONOMICAL				
Energy costs		G	B, D, F, I, M, N, P, Q, R, S	A, B, C, H, J, K, O
Chemical cost		G, N, R	B, D, F, I, J, M, O, P, Q, S	A, B, C, H, K
Cost of raw water	A, H, M, N, Q, S	B, C, D, F, G, I, J, O	B, K, P, R	
TECHNICAL/OTHER				
Availability of qualified resources (people)	M	A, B, G, K, P	B, C, D, F, H, I, J, N, O, Q, S	R
Limited space for extension capacity	A	B, D, G, J, O, P, R, S	B, C, I, K, M, N, Q	B, F, H
Increasing demand	A, C	B, D, F, G, H, J, K, M, O, P, Q, S	B, I, N, R	B
Ability to perform an integrity test	A, F, H, Q, R, S	B, D, G, N, O, P	B, C, I, J, M	K
Regulatory approval for the membrane modules	A, F, N, Q, R, S	B, D, G, H, J, M, O	B, C, I, K, P	
Successful application at nearby plants	A, C, S	B, D, G, H, M, N, P, R	B, I, J, K, O, Q	F
Supplier's track record with PVDF at other plants	A, S	B, D, G, J, O, R	B, C, F, H, K, M, N, P, Q	B, I
Membrane recycling vs disposal	F, H, N	A, B, D, G, K, M, Q, R, S	B, C, I, J, O, P	B

Other	
Sludge generation and disposal due to chemical pretreatment for drinking water plant	I
Less awareness about PFAS in developing countries and its impact on health of human as well as irrigation	I
Cyber security	A
Climate change: imbalances in rainfall patterns are observed resulting in periods of drought	C
Maintenance costs	B

The most significant challenges faced by the owners and operators of water treatment systems are carbon footprint, concerns about PFAS, more stringent discharge requirements to the environment, energy costs, chemical costs, availability of qualified resources, limited space for extension capacity, and suppliers track record with PVDF at other plants.

3.1.7 Disposal

The responding companies apply different methods for the current and/or planned disposal of their PVDF membranes when these membranes reach the end of life.

Disposal "end of life" PVDF membranes						
Non-hazardous landfill	**Hazardous landfill**	**Municipal incineration**	**Hazardous waste incineration**	**Reuse and/or recycle**	**Specialized waste collection**	**No plan developed yet**
A, B, C, F, M, R	J, K	D, I, N, O, P, S,	H, Q	B	K	B

The majority of the respondents do not recycle or reuse the membranes. Instead, the majority sends the membranes to the landfill or incineration.

3.1.8 PVDF membrane alternatives

The following table provides information on alternative membranes and alternative technologies available if PVDF membranes are no longer available.

Alternative technologies for PVDF membranes	Responding companies
Microfiltration membrane – hollow-fiber	B, I, M, O, Q
Microfiltration membrane – flat sheet	B, Q
Ultrafiltration membrane – hollow-fiber	J, G, K, M, O, P, R, S
Ultrafiltration membrane –flat sheet	J
Ceramic membranes	I
Another alternative membrane	M, R
Alternative technology	A, H
No alternative	B, C, D, F, N, S

In case of the users with PVDF micro filtration membranes, an alternative is switching to ultrafiltration membranes (including PVDF membranes).
Thirty percent indicated that they don't have an alternative for their PVDF membrane system.

3.1.9 Impact of having to replace the PVDF membranes for alternative membranes and/or technologies

The following table provides information on the technical and economic impact on the design and operation for the water treatment systems operators and their clients if PVDF membranes were no longer available.

Impact of working with alternative membranes/technologies	Responding companies
major losses in treated water quality	B, C, H, I, J, K, N, Q, R, S
major losses in treated water quantity	C, I, J, K, Q, S
without major losses in treated water quality	B, D, F, O, P
without major losses in treated water quantity	B, D, F, G, M
substantial increases in costs	A, B, M, N, Q, R, S
other	

The majority of the submitted responses are concerned whether the PVDF membrane alternative (membrane and/or technology) will produce the required water quality. Substantial increases in costs are a major concern as the PVDF alternative may result in additional capital expenses (such as equipment and infrastructure) and operational expenses (such as chemicals, energy, and component replacements).

3.1.10 Direct and indirect consequences for operation and surroundings if the PVDF membranes cannot be delivered anymore

Direct and indirect consequences	**Responding companies**
increase of operational costs	B, C, D, J, K, M, N, Q, S
Additional costs for your supply chain	B, I, J, M, N, S
Costs of planning	A, B, D, F, N, O, Q, S
Additional costs for re-construction of your plant	A, B, C, D, F, K, N, O, P, Q, R, S
Additional costs for procurement of new machinery and equipment	A, B, C, F, I, J, K, N, O, Q, R, S
Additional transport costs	
Loss in water/wastewater quality	B, D, H, J, Q, R, S
Disruption in the delivery of water/wastewater	B, C, F, G, I, N, P, Q, R, S
Disruption in the downstream supply chain (profit loss)	J, K, N, Q, S
Other costs/profit loss impacts, please define	Water shortage and probable lower quality - D

The majority of the responses indicate an increase in operational costs, additional costs for plant re-construction, additional costs for procurement of new machinery and equipment in addition to a disruption in delivery of water/wastewater.

3.1.11 Direct and indirect consequences for the clients/consumers if the PVDF membranes cannot be delivered anymore

Direct and indirect consequences for consumers	**Responding companies**
Cost increase	B, M, P, Q, R, S
Cost increase due to water treatment plant remodeling in order to maintain the quality of the water	B, M, Q, R
Cost increase due to the necessity of having to install additional water treatment systems	B, Q
Less purified water available	C, D, H, K, N
Reduced purified water quality	C, D, K, N, O, Q
Increased wastewater fines as less purified water is produced (resulting in a higher wastewater flow from the water treatment system)	H
Less wastewater can be reused due to the lack of PVDF membranes	J

Less purified water available, reduced water quality and a cost increase would be a consequence for clients/consumers when PVDF membranes are no longer available.

4. Findings

Based on the survey results from the different companies, the following observations can be made:

PVDF membranes are essential in water treatment applications as they provide currently optimum operation cost savings and reduced capital costs while producing the required water quality and water quantity for the client.

It seems that a significant number of plant operators/owners have no alternative if PVDF membranes are no longer available.

In the case of existing PVDF water treatment systems:
Replacing PVDF membranes with non-PVDF membranes may contribute to higher costs for the operation of the water treatment systems especially when plant modifications and/or installation of additional equipment/technologies are needed in order to meet the required water quality and water quantity.

Some sites have footprint limitations which makes it difficult to install additional equipment.

In the case of new water treatment systems:
Non-PVDF membranes and/or other technologies can be considered. However, it is possible that the capital costs and operation costs may be higher when compared with PVDF membranes. It is recommended to include economic evaluations and the impact on the environment and consumers.