High Purity Water: Hints and Tips

Good Practices in Using a Water Purification System and Handling High Purity Water

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Introduction

The usage of water purification systems is widespread in laboratories. When it comes to utilizing the purification system and the ultrapure water, however, each laboratory and user develops a number of habits. While some practices are rational and based on sound experience, others simply arise and set up over time. Working with high purity water actually requires taking a number of precautions and following some simple rules. Some of these "good laboratory practices" are described here.

Overview
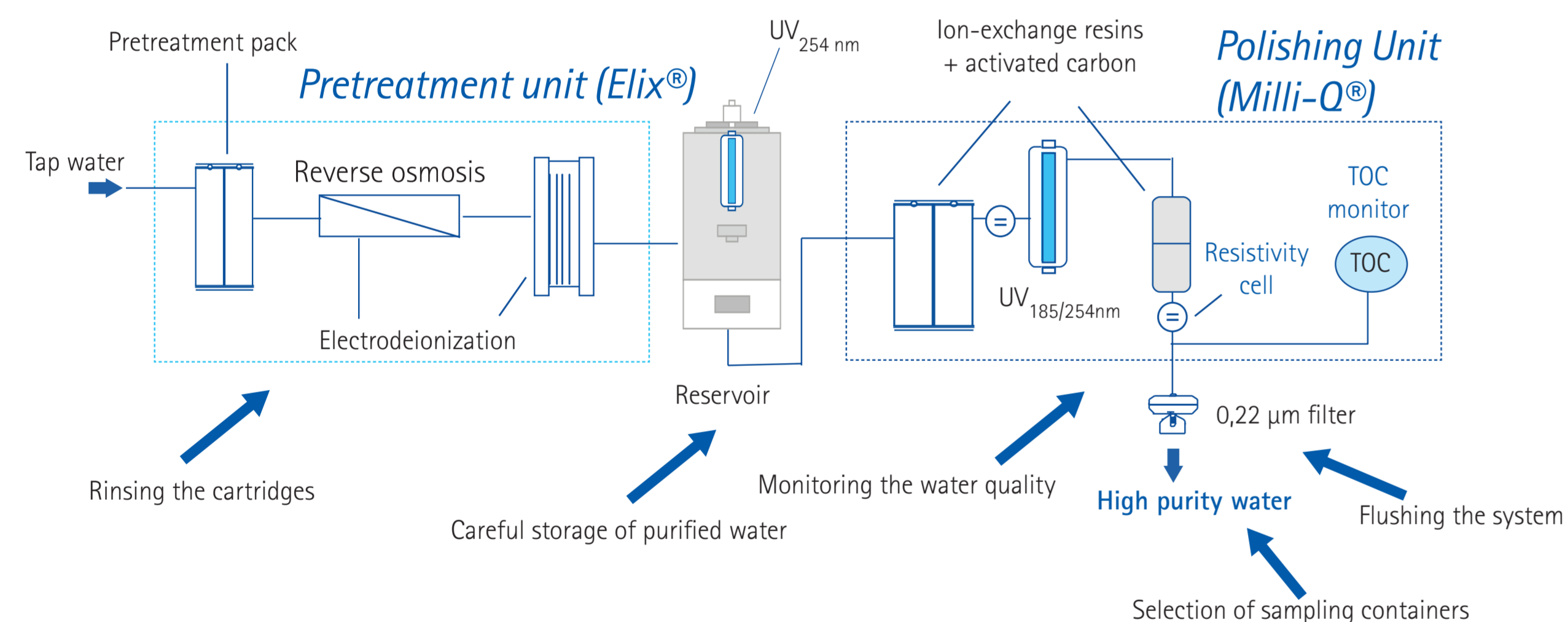
Rinsing the cartridges

Water purification cartridges often are manufactured with preservatives for long-term storage. In particular, this is the case for reverse-osmosis (RO) cartridges.
Figure 1 shows the importance of rinsing a newly- installed RO cartridge. Initial organic contamination (TOC levels) is high (~500 ppb), then decreases with time as rinsing occurs (~95 ppb after 300 min).
Polishing cartridges, containing ion-exchange resins and activated carbon, also must be rinsed initially. Figures 2 and 3 demonstrate the decrease in resistivity level and TOC level with rinsing time.
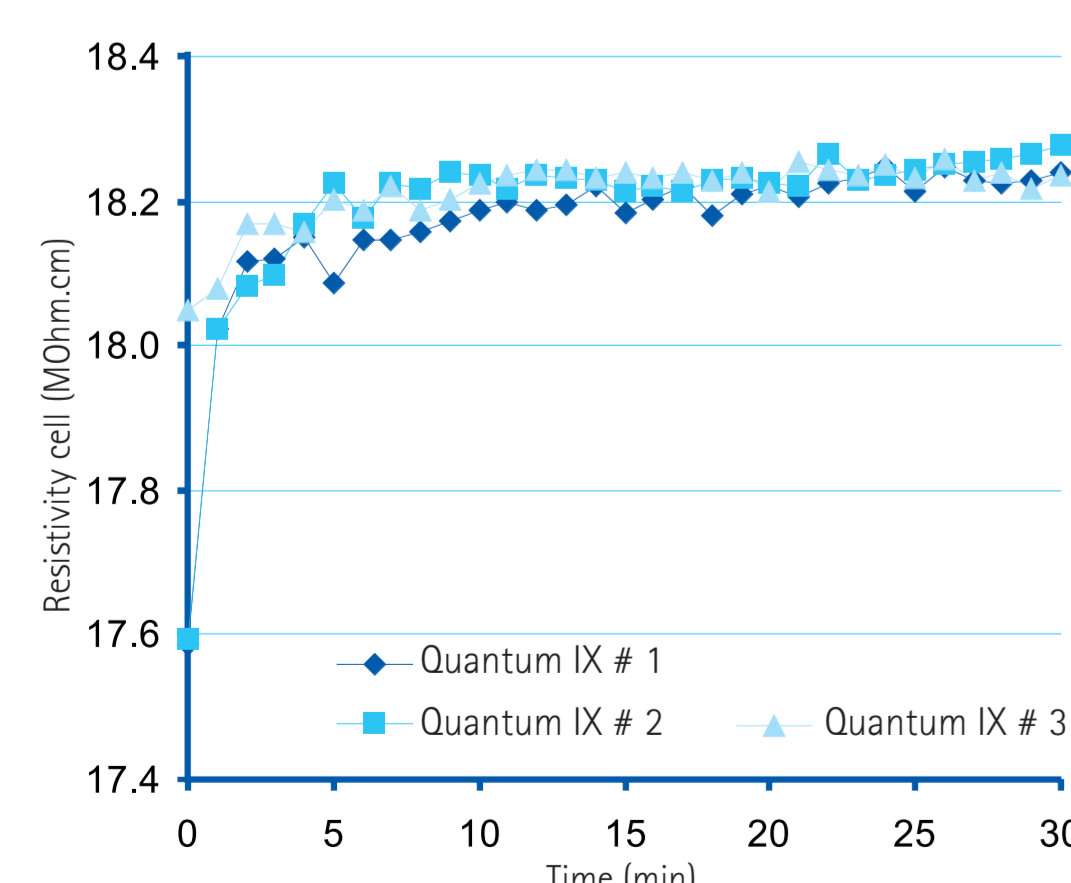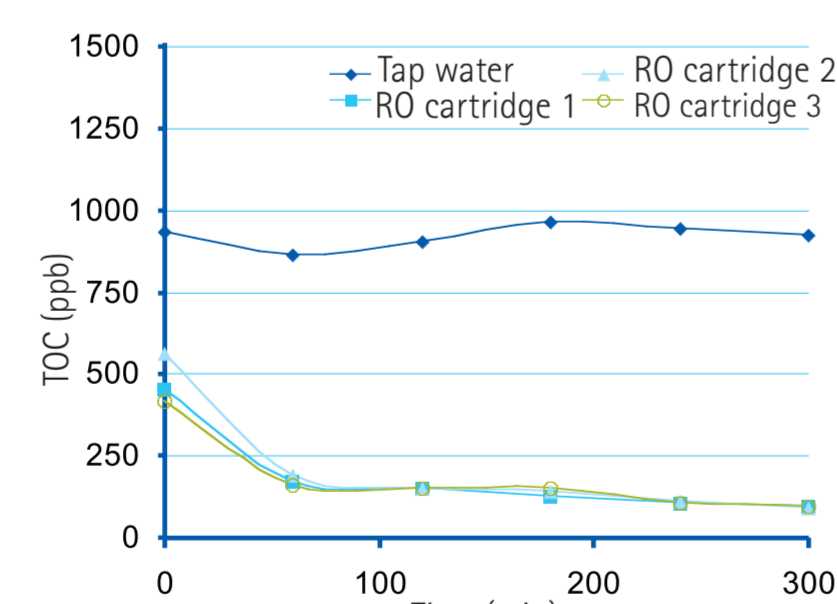
Figure 1: Initial rinsing of reverse-osmosis cartridges: evolution of TOC levels of permeate with time.

Figure 2: Initial rinsing of polishing cartridges: changes in resistivity levels of effluent water with time.
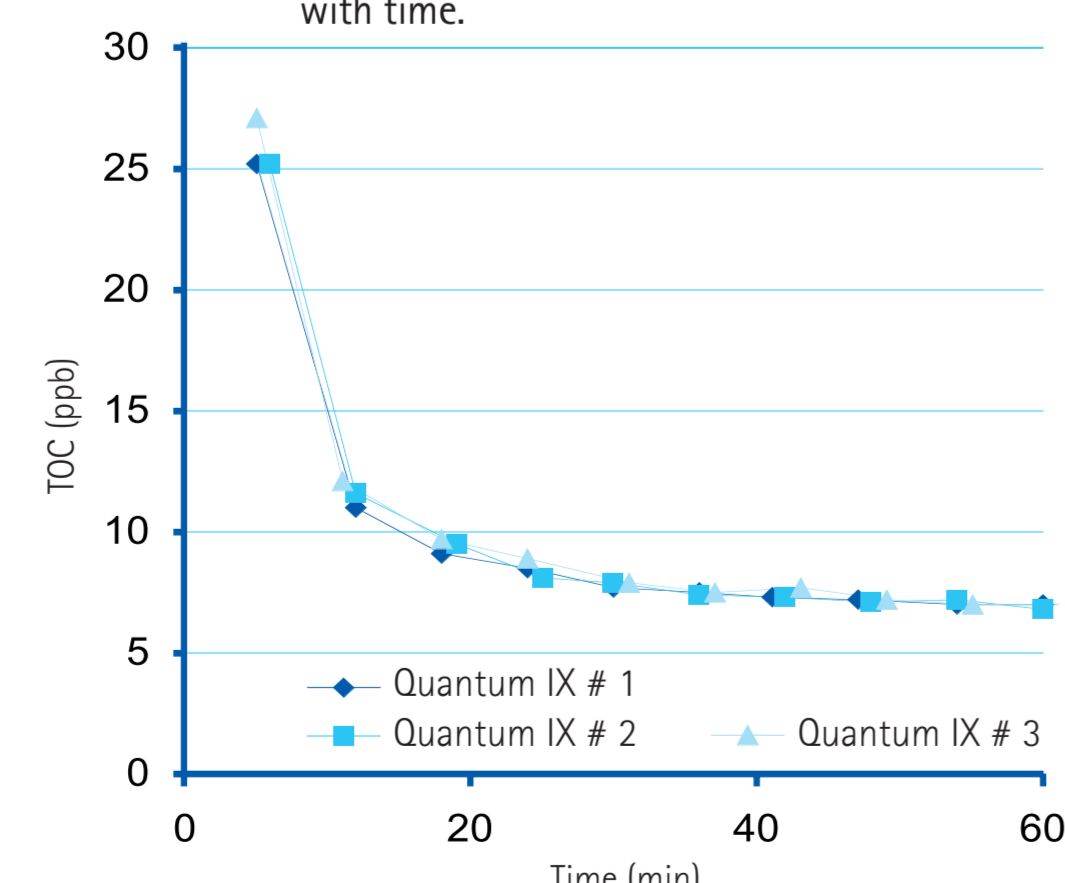
Figure 3: Initial rinsing of polishing cartridges: changes in TOC levels of effluent water with time.

Storage of purified water

Ultrapure water should not be stored, as it may absorb impurities from the air or the container used for storage. However, it is often necessary to store pure water before further purification with a polishing system. The water will be in contact with the reservoir for an extended period of time. Therefore, the reservoir material should be chosen carefully as it may leach organic and/or ionic compounds into the water.
High-density polyethylene (HDPE) and polypropylene (PP) were tested. Ultrapure water was stored in carefully rinsed bottles for 24 h, water was analyzed then discarded. The procedure was repeated 3 times. Table 1 and Figure 4 show that reservoirs made of HDPE are a better choice than those made of PP.
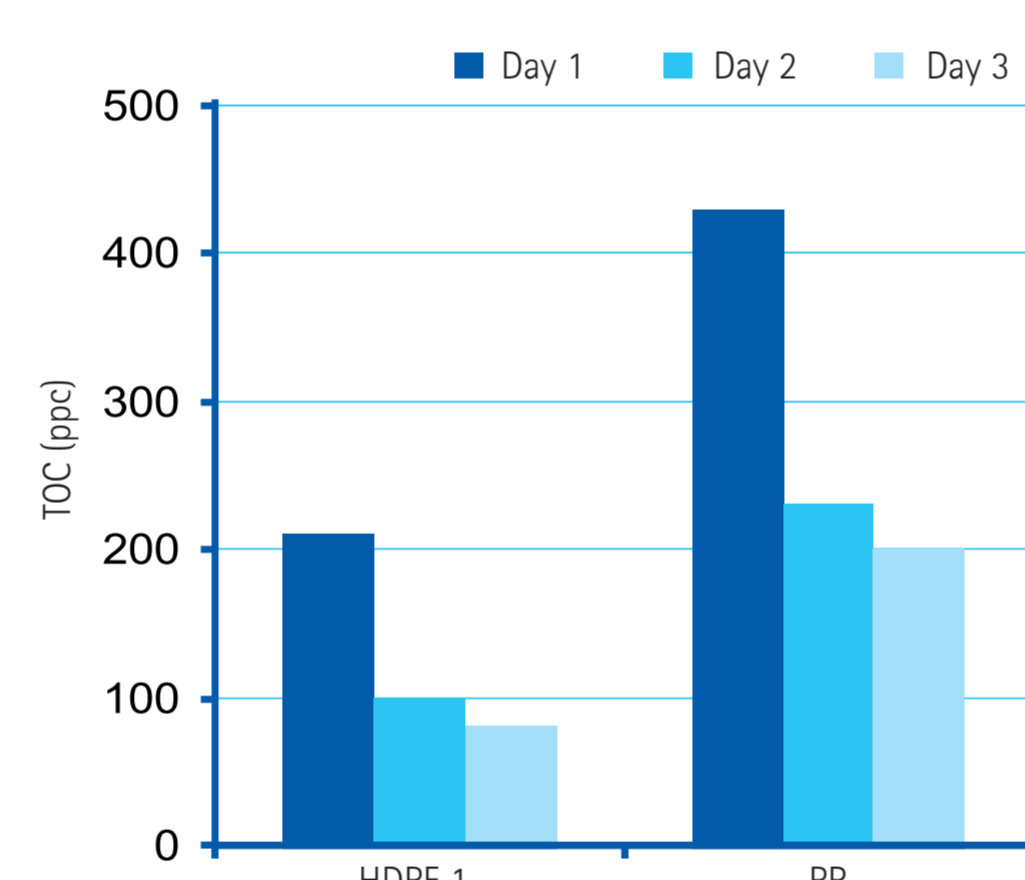
Figure 4: Total organic carbon (TOC) extractables from polyethylene and polypropylene.

Ions (ppb)	HDPE 1				PP		
	Day 1	Day 2	Day 3		Day 1	Day 2	Day3
Fluoride	ND	ND	ND		ND	ND	ND
Chloride	11,7	0,9	0,5		6,0	3,8	2,2
Nitrite	2,2	0,5	< 0,1		0,3	ND	ND
Phosphate	ND	ND	ND		ND	ND	ND
Bromide	ND	ND	ND		ND	ND	ND
Nitrate	1,4	0,3	< 0,1		1,3	1,0	0,7
Sulfate	6,2	0,4	0,1		1,1	1,1	1,0
Calcium	9,0	2,0	1,0		5,0	1,0	1,0
Magnesium	1,7	0,3	< 0,1		0,4	0,3	0,3
Potassium	2,0	< 1	< 1		3,0	< 1	< 1
Sodium	8,0	< 1	< 1		4,0	< 1	< 1

Table 1: Ionic extractables from polyethylene and polypropylene.

Monitoring the water quality

Monitoring water quality ensures experiment repeatability and quality results. Commonly used monitoring tools are conductivity and total organic carbon (TOC) meters.
- **Conductivity** measures the flow of electrons through a fluid, which is proportional to the concentration of ions, their charge and mobility.
- **TOC measurement** indicates the total amount of organic material present in water.

Many organic molecules do not ionize readily and, as a result, do not influence the conductivity of water. Therefore, purified water may contain some organic compounds and have an excellent resistivity reading. Similarly, a low TOC value only indicates that there are no organic molecules present in water without indicating the levels of metals or salts. Combining these two monitoring tools reflects the level of water purity more precisely.

Large amounts of sucrose were added to pure water. Figure 7 shows that it was first retained by the activated carbon of the polishing unit, then broke through the purification system. Resistivity levels remained unchanged, although TOC levels rose with time.
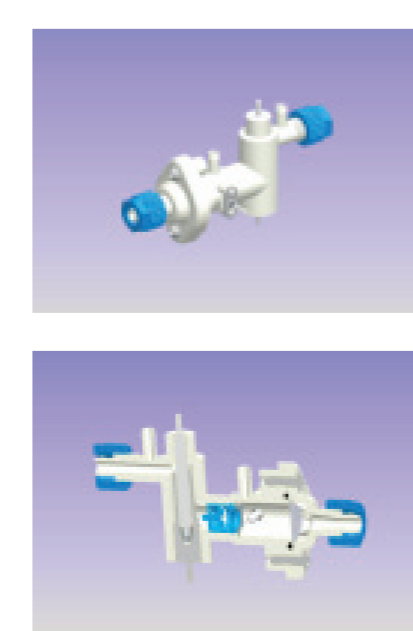
Figure 5: Stand-alone A10 TOC meter

Figure 6: EMD Millipore flow-through coaxial resistivity cell
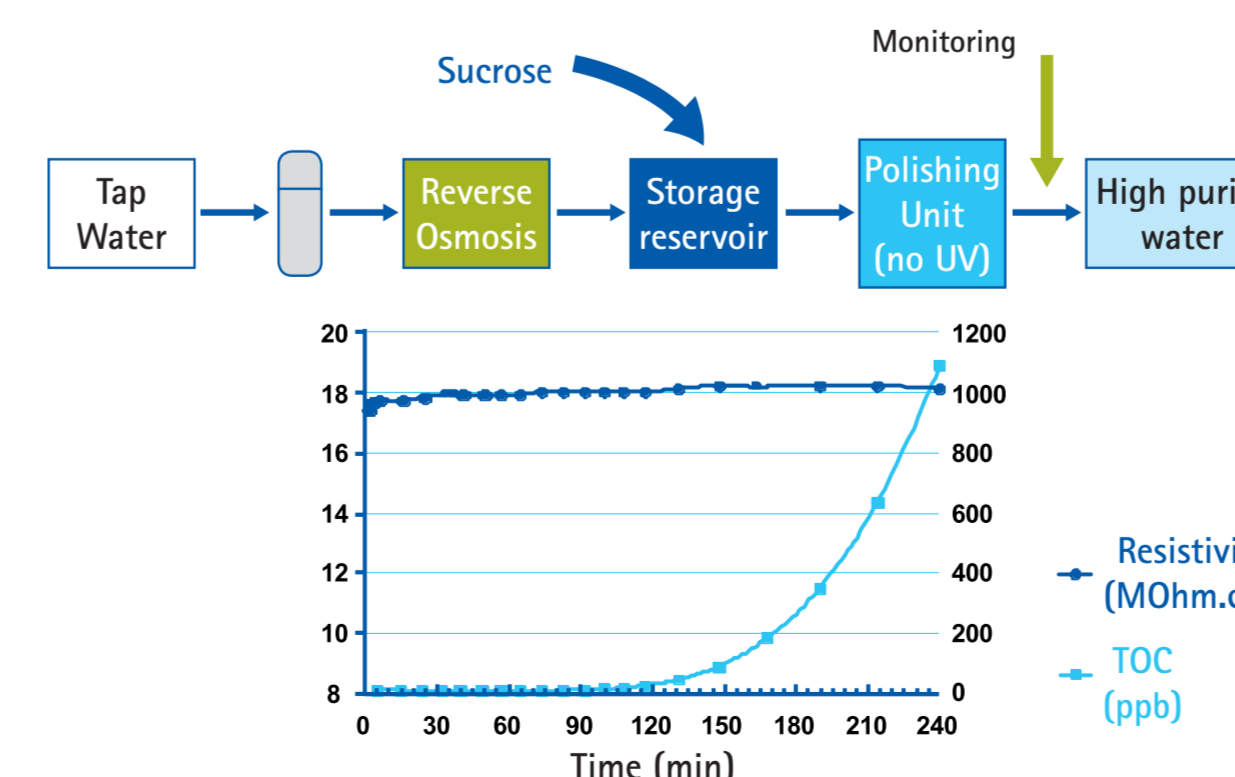
Figure 7: Evolution of resistivity and TOC levels in ultrapure water after addition of sucrose in the storage reservoir

Flushing the water system

While a water purification system is left idle, the quality of the water remaining inside the system will slowly degrade. Therefore, it is best to discard the first few liters of water produced when water is drawn from an idling system, and collect only freshly purified water.
HPLC: Figure 8 demonstrates that some organic contaminants may be present in the water initially drawn from a water purification system.
Bacteria: Table 2 shows a reduction in bacteria levels downstream of the membrane when more water is drawn. This suggests that the bacteria observed at the outlet of the filter are of airborne origin. To have bacteria-free water, it is recommended to draw some water (>1 L) through the filter to remove downstream bacteria. Even better results can be obtained by locating the filter outlet in a sterile area such as a laminar flow hood.
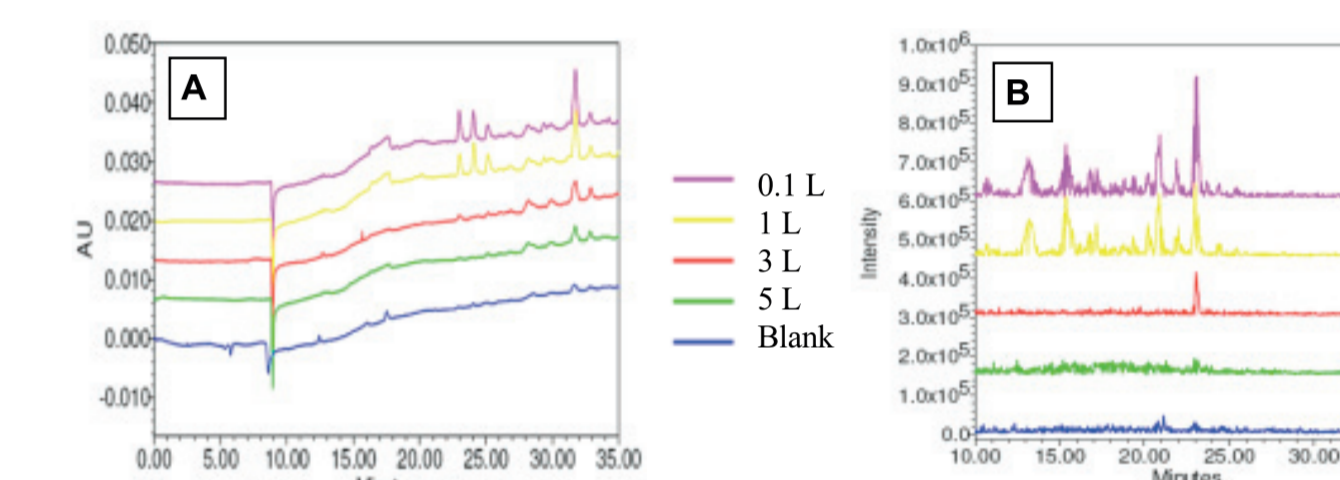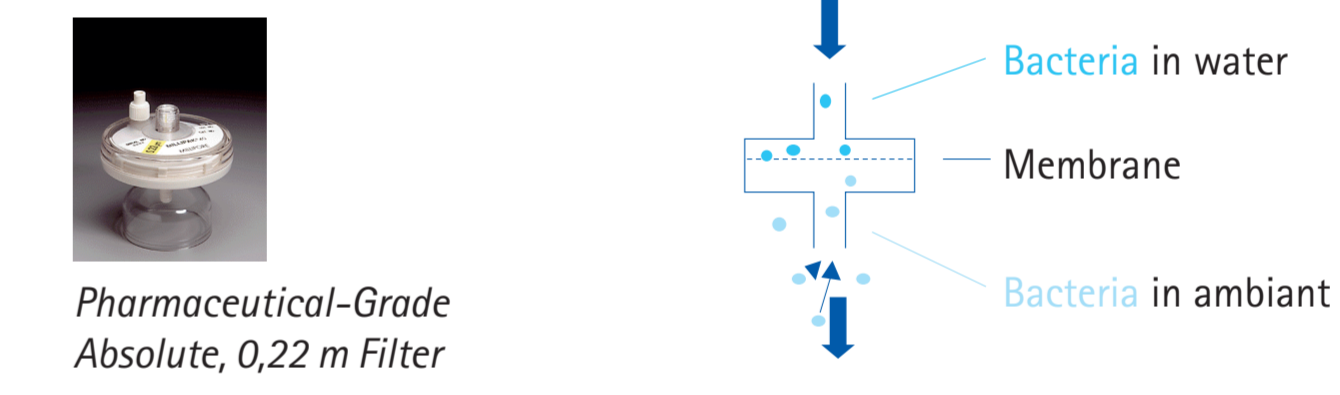
Figure 8: Effect of flushing on HPLC (A) and LC-MS (B) baselines

Pharmaceutical-Grade Absolute, 0,22 m Filter

Volume delivered (L)	Week 1 (CFU/ml)	Week 2 (CFU/ml)	Week 3 (CFU/ml)	Week 4 (CFU/ml)
0,0	73	5	35	86
0,5	22	1	2	25
1,0	0	0	2	3
3,0	0	0	0	0

Flushing the water system

Ultrapure water is an excellent solvent. It has a high affinity for chemicals in its surroundings and can absorb chemicals readily from storage containers, as well as chemical vapors from the laboratory air. Figure 9 shows that the polyethylene carboys and wash bottles commonly used to store water in laboratories can leach organic molecules into ultrapure water. Glass containers leach less organics, however they may leach inorganic compounds. Polyvinyl chloride (PVC) and fluoropolymers (PFA) are also commonly used sample containers. Table 3 shows that many compounds may leach from these polymers into ultrapure water, as seen by ICP-MS. Figure 10 shows that chemicals present in laboratory air may also be absorbed by ultrapure water and affect LC-MS results.

It is therefore important to use freshly produced ultrapure water and to select a sample container compatible with the analyses to be done
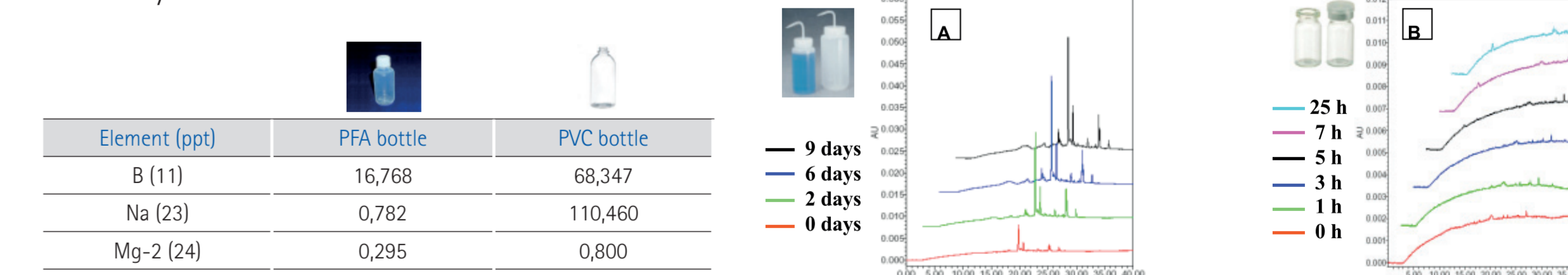
Element (ppt)	PFA bottle	PVC bottle
B (11)	16,768	68,347
Na (23)	0,782	110,460
Mg-2 (24)	0,295	0,800
Al-2 (27)	0,832	0,788
K (39)	15,932	28,058
Ca (40)	0,565	5,834
Fe (56)	9,776	4,428
Cu (63)	0,883	1,191
Zn-1 (64)	12,092	18,489
Ag (107)	0,258	0,266
Cd (111)	2,417	1,381
Pb-2 (208)	0,055	0,049

Table 3: Effect of container material on sample purity. After rinsing each container 5 times with Milli-Q® Element water, fresh Milli-Q® Element water was collected in the containers and analyzed by ICP-MS.
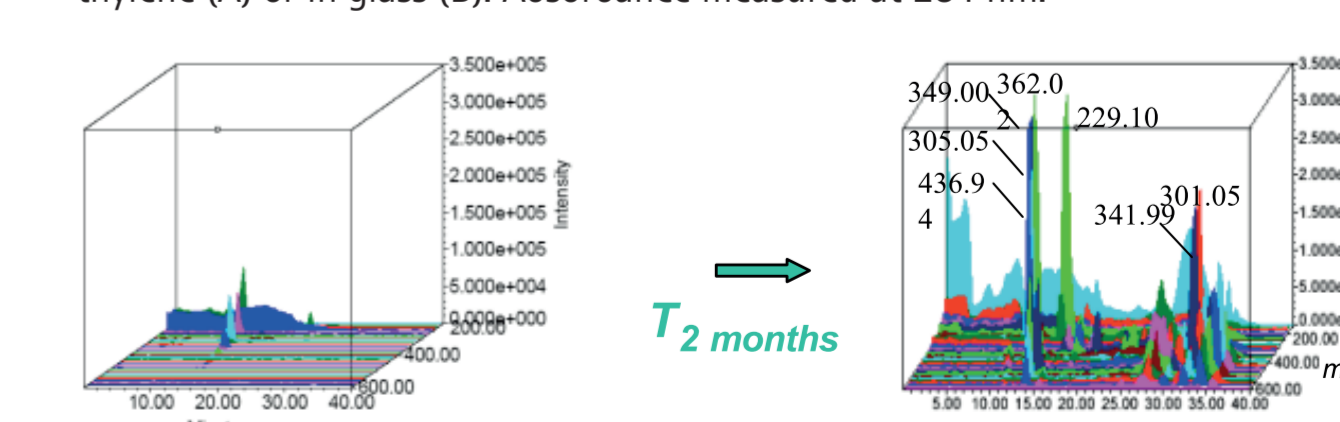
Figure 9: Reverse-phase HPLC chromatogram of ultrapure water stored in polyethylene (A) or in glass (B). Absorbance measured at 254 nm.

Figure 10: Total ESI+ plot (from m/z 150 to 600) of HPLC- grade water kept at room temperature, opened to atmosphere three times a week for 15 minutes during a 2-month period.

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