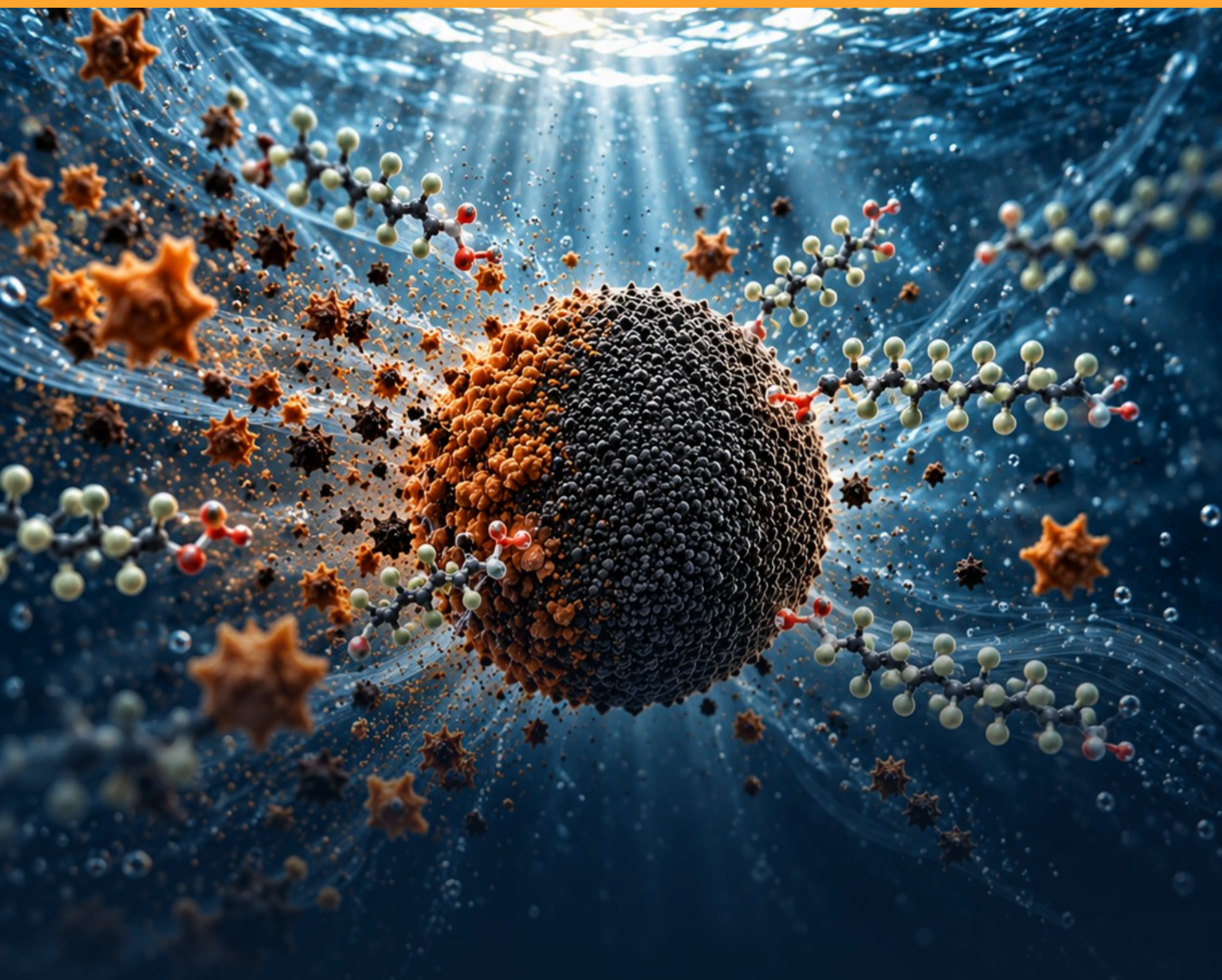




FILTRATION · CATALYTIC FILTER MEDIA

KATALOX-LIGHT[®]

**PFAS removal combined with
iron & manganese removal**

SURFACE CHEMISTRY / MECHANISMS / DOCUMENTED CASE STUDIES

320 m²/g

Specified surface area

10% MnO₂

On a ZEOSORB[®] matrix

≈3 μm

Fine-particle filtration

5.8–10.5 pH

Inlet range

01 / KATALOX-LIGHT AT A GLANCE

ONE TREATMENT TRAIN. THREE CONNECTED FUNCTIONS.

Katalox-Light brings together catalytic metal treatment, mineral surface contact and fine-solids retention.

In iron-bearing water, oxidation generates fresh iron hydroxide surfaces. Under favourable water chemistry, these surfaces can adsorb selected PFAS; filtration then separates the loaded particles.^{1,2}

SURFACE INVENTORY

320 m²/g

Specified surface area

CATALYTIC COATING

10% MnO₂

On a ZEOSORB® matrix

SOLIDS RETENTION

≈3 μm

Fine-particle filtration

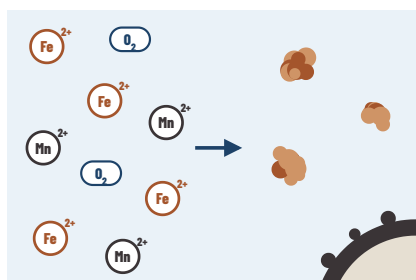
Katalox-Light specifications.¹ PFAS capacity is established for each water by adsorption measurements.



KATALOX-LIGHT® FILTER MEDIA

01 FORM

Oxidation creates new solids

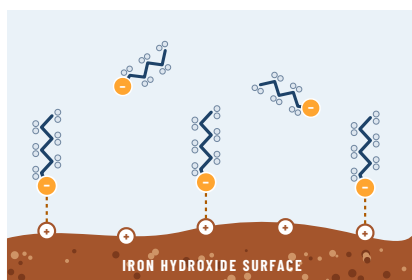


Fe Dissolved Fe²⁺ - Mn²⁺ Fe(OH)₃ solids

Oxidise dissolved iron and manganese; create hydroxide and oxide solids.

02 ADSORB

PFAS meets the surface

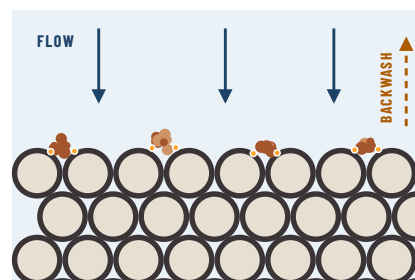


MnO₂-coated granule PFAS (head group + fluorinated tail)

Bring PFAS into contact with accessible sites with favourable charge and affinity.

03 SEPARATE

The bed retains the solids



Positive site

Retain PFAS-bearing solids in the bed and remove collected solids during washing.

WHY SURFACE CHEMISTRY MATTERS

High surface area supplies contact space. Accessible pores, reactive hydroxyl groups and their electrical charge determine how that space participates in PFAS capture.

INSIDE THIS BROCHURE

02 MEDIA ARCHITECTURE	03	03 FE & MN CHEMISTRY	04	04 PFAS AT THE INTERFACE	05	05 COMBINED TREATMENT	06
06 PFAS RESEARCH	07	07 HANOI & PACHUCA	08	08 TURKEY & VERIFICATION	09	09 REFERENCES	10

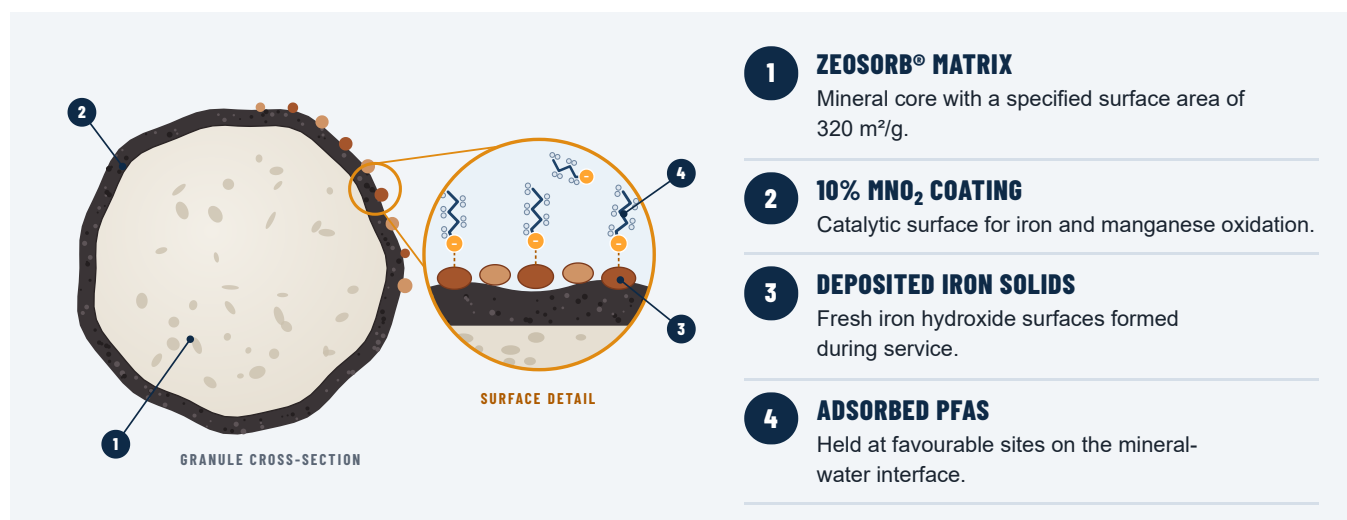
The research cases explain the iron-mineral PFAS adsorption mechanism. The Katalox-Light field cases document metals and solids treatment at full scale.

SOURCES 1 Watch Water, Katalox-Light product information 2 Campos-Pereira et al. (2020), Environ. Sci. Technol. 54

02 / MEDIA ARCHITECTURE

MINERAL MATRIX. CATALYTIC COATING.

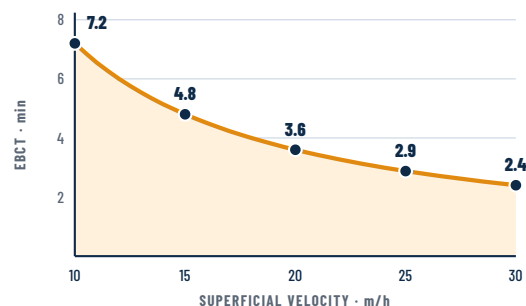
Katalox-Light combines a ZEOSORB® matrix with a 10% MnO₂ coating for catalytic metals treatment and fine filtration.¹



PROPERTY	KATALOX-LIGHT®
Matrix	ZEOSORB® mineral matrix
Catalytic coating	10% MnO ₂
Specified surface area	320 m ² /g
Filtration	Approximately 3 µm, fine-particle filtration
Inlet pH range	5.8–10.5
Superficial velocity	10–30 m/h
Media bed depth	1.2 m
Empty-bed contact time	7.2–2.4 min at 10–30 m/h

CONTACT TIME AT DESIGN VELOCITY

1.2 m media bed · EBCT = bed depth ÷ velocity × 60¹



THE ACTIVE BED CHANGES DURING OPERATION

A working bed contains the original MnO₂ coating, newly deposited iron solids and adsorbed water constituents. The iron-rich deposits can add adsorption sites while accumulated solids can cover existing surfaces. Contact, solids loading and washing therefore influence the available mineral-water interface.^{2–4}

CONNECT SURFACE INVENTORY TO TREATMENT PERFORMANCE

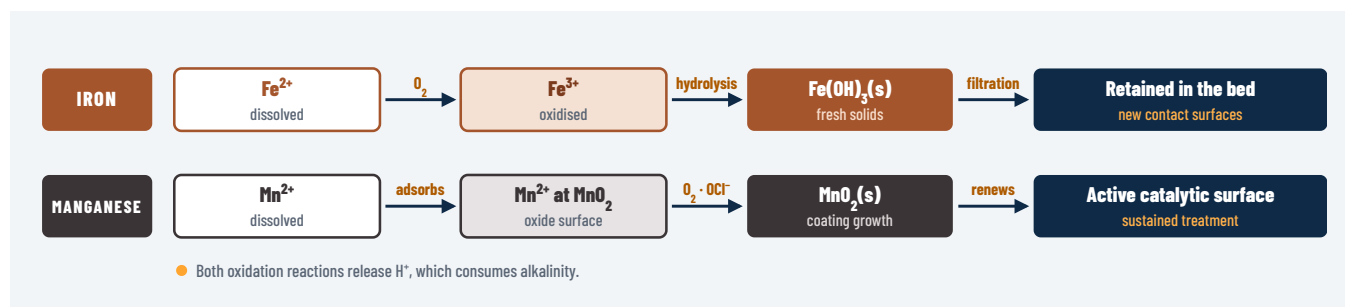
Katalox-Light's specified area gives it a large mineral contact inventory. The treatment value of that inventory depends on water-accessible sites, coating chemistry, deposited iron solids and contact conditions. PFAS results are evaluated at matched pH, PFAS mixture, metal loading, oxidant conditions and hydraulic contact.

SOURCES 1 Watch Water, Katalox-Light product information 2 Campos-Pereira et al. (2020), Environ. Sci. Technol. 54 3 Vries et al. (2017), Water Research 109 4 Hargette & Knoke (2001), J. Environ. Eng. 127

03 / IRON & MANGANESE CHEMISTRY

OXIDATION CHANGES THE METAL.

Precipitation creates the surface.



IRON: FROM Fe^{2+} TO FRESH HYDROXIDE

Oxygen oxidises ferrous iron to ferric iron, which hydrolyses and precipitates. $\text{Fe}(\text{OH})_3$ represents hydrous ferric solids, including poorly crystalline iron oxyhydroxides. Hydroxyl groups at their surfaces form the mineral-water interface.^{3,5}

Fresh precipitates provide new contact surfaces as treatment proceeds. Where PFAS adsorbs during solid formation, growing flocs can incorporate the loaded surfaces. Filtration then completes the separation. This is the iron-assisted capture pathway of a working Katalox-Light bed.^{2,8}

MANGANESE: CATALYTIC OXIDE GROWTH

Dissolved Mn^{2+} adsorbs at oxide surfaces and is oxidised to insoluble manganese oxides. MnO_2 is an idealised product; real coatings contain different manganese oxidation states. Oxidant supply and coating condition govern sustained treatment.^{3,4}

The oxygen reaction is a net balance. Mn^{2+} oxidation by oxygen alone is slow near neutral pH; treatment uses an appropriate catalytic, biological or stronger-oxidant pathway, such as hypochlorite-assisted oxidation.^{3,4}

IRON · OXYGEN

Ferrous iron to ferric hydroxide



MANGANESE · OXYGEN

Net balance



MANGANESE · HYPOCHLORITE

Hypochlorite-assisted oxidation



ALKALINITY SUPPORTS THE REACTION

METAL	OXYGEN DEMAND	ALKALINITY CONSUMED
Iron	0.143 mg O_2 / mg Fe	1.79 mg as CaCO_3 / mg Fe
Manganese	0.291 mg O_2 / mg Mn	1.82 mg as CaCO_3 / mg Mn

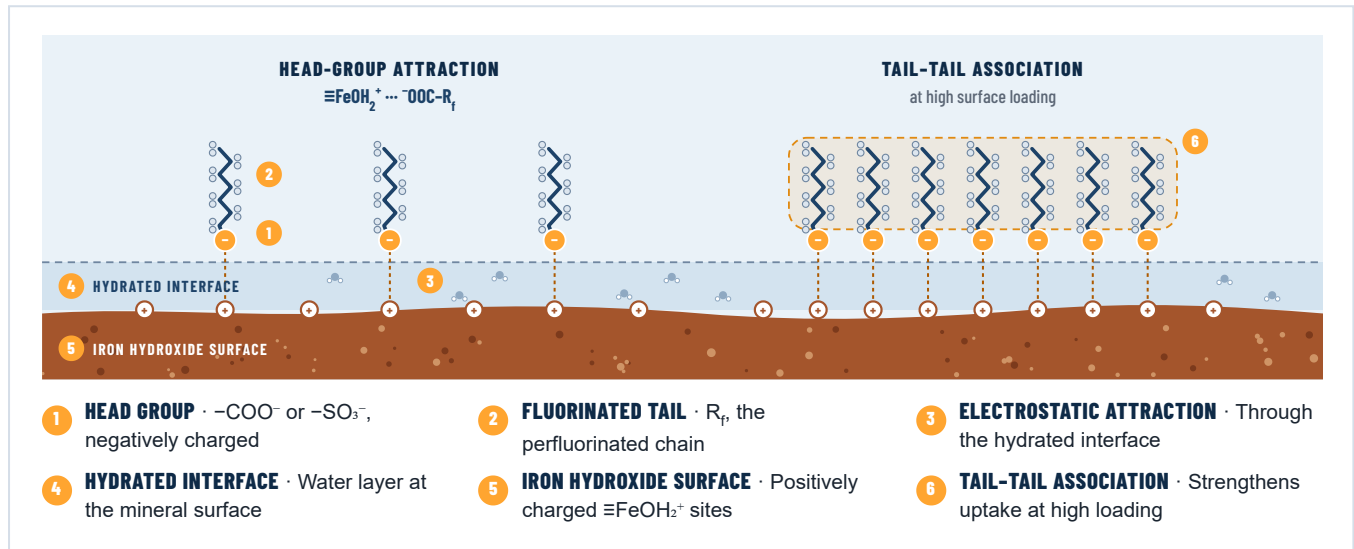
Stoichiometric requirements from the balanced oxygen equations. Released H^+ consumes alkalinity; other oxidants, sulfide, organics and additional reactions change actual demand, so operating doses are set from the full water analysis.

SOURCES 2 Campos-Pereira et al. (2020), Environ. Sci. Technol. 54 3 Vries et al. (2017), Water Research 109 4 Hargette & Knocke (2001), J. Environ. Eng. 127 5 Hazrati et al., Colloids and Surfaces A 141738 8 U.S. EPA (2021), Multi-Industry PFAS Study

04 / PFAS AT THE MINERAL-WATER INTERFACE

HOW SURFACES HOLD PFAS.

Area supplies sites. Chemistry determines their affinity and availability.



THE HEAD GROUP MEETS THE SURFACE

At typical drinking-water pH, PFOA ($\text{C}_7\text{F}_{15}\text{COO}^-$) and PFOS ($\text{C}_8\text{F}_{17}\text{SO}_3^-$) have negatively charged head groups. Positive mineral sites can attract these anions. PFAS also includes neutral, cationic and zwitterionic compounds, so the identity of each compound matters.^{2,5}

PROTONATION	$\equiv\text{FeOH} + \text{H}^+ \rightleftharpoons \equiv\text{FeOH}_2^+$
DEPROTONATION	$\equiv\text{FeOH} \rightleftharpoons \equiv\text{FeO}^- + \text{H}^+$

Lower pH favours protonated, positively charged sites; higher pH promotes deprotonation. Ferrihydrite research links adsorption to these changes in charge and supports outer-sphere association: the PFAS head group remains associated through the hydrated interface.²

ACCESSIBLE AREA AND TRANSPORT

BET surface area is measured using a gas probe. In water, pore openings, molecular dimensions, hydration and diffusion govern access to internal surfaces. A useful conceptual relation is accessible area $\times$ reactive site density: this describes the inventory of potential sites. Affinity and water composition determine their occupation.⁶

HEAD-GROUP ATTRACTION AND TAIL INTERACTIONS

PFOS/PFOA mixture experiments show additional tail-tail association at high surface loading. This concentration-dependent process can strengthen uptake after initial surface attraction. It was studied at 0.1–20 $\mu\text{mol/L}$.⁵

SEPARATION COMPLETES CAPTURE

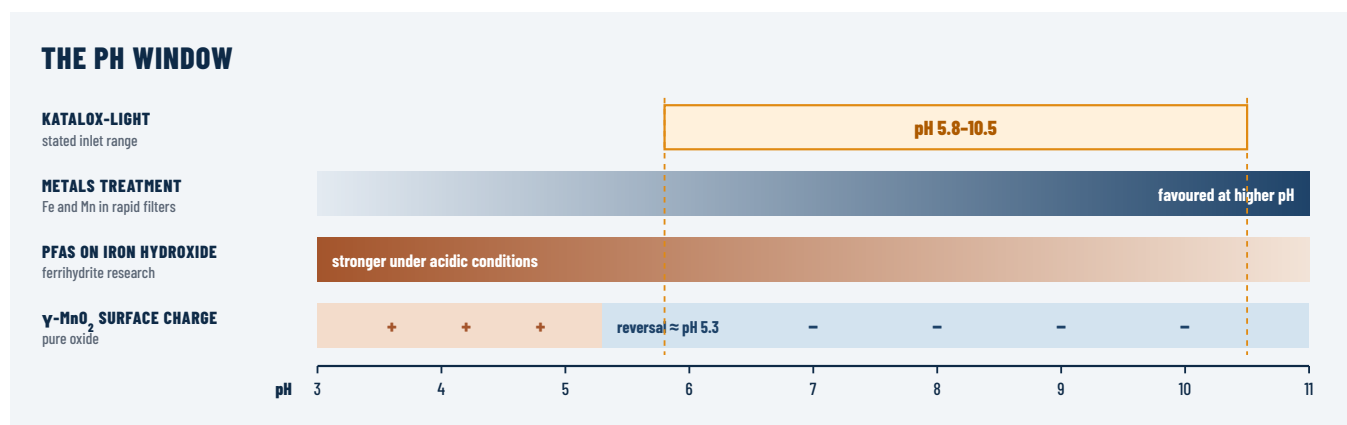
A micrometre filtration rating describes particles. Dissolved PFAS first adsorbs onto media or retained solids; filtration retains these solids and backwashing exports the captured material for residual management.⁸

05 / COMBINED TREATMENT IN PRACTICE

BALANCE THE OPERATING CONDITIONS.

Control pH, contact and solids separation for metal treatment and PFAS capture.

CONTROL	CHEMICAL EFFECT AND PRACTICAL MEANING
 pH	Higher pH generally favours metal adsorption/oxidation in rapid filters. Ferrihydrite PFAS adsorption is stronger under acidic conditions. Establish the combined result at the actual operating pH. ^{2,3}
 SURFACE CHARGE	The point of zero charge indicates zero net charge; zeta potential describes the electrokinetic environment near the surface. Coatings and adsorbed ions change both. ⁷
 PHOSPHATE AND ORGANICS	Phosphate can occupy sites and reduce positive surface charge. Organic coatings alter the interface. Include these constituents when interpreting adsorption. ²
 CONTACT AND LOADING	Bed depth, flow, particle transport and available sites determine contact. Track individual PFAS against treated bed volumes to identify breakthrough.
 SOLIDS RETENTION	Retain loaded flocs and maintain washing performance. Evaluate dissolved and particle-associated PFAS to identify the capture route. ⁸
 RESIDUALS	Include backwash water, collected solids and spent media in the PFAS mass account. Separation transfers PFAS into these streams. ⁸



IRON AND MANGANESE SURFACES HAVE DIFFERENT CHARGES

A study of pure γ -MnO₂ measured charge reversal near pH 5.3 and negative charge above that value. The composite surface of an operating Katalox-Light bed is therefore considered together with deposited iron solids and water constituents.⁷

SET THE OPERATING WINDOW

Katalox-Light's stated inlet range is pH 5.8–10.5. Watch Water selects operating conditions for catalytic metals treatment, verifies the PFAS contribution at those conditions and sizes any additional PFAS stage to the required finished-water target.^{1,9}

SOURCES 1 Watch Water, Katalox-Light product information 2 Campos-Pereira et al. (2020), Environ. Sci. Technol. 54 3 Vries et al. (2017), Water Research 109 7 Fuerstenau & Shibata (1999), Int. J. Miner. Process. 57 8 U.S. EPA (2021), Multi-Industry PFAS Study 9 Appleman et al. (2014), Water Research 51

06 / PFAS RESEARCH CASE STUDIES

WHAT THE PFAS STUDIES SHOW.

Two primary studies explain iron-mineral adsorption and its dependence on surface chemistry.



RESEARCH CASE 1 SURFACE CHARGE CONTROLS UPTAKE

Campos-Pereira et al. (2020)²

Material: laboratory ferrihydrite. Methods: adsorption experiments with 12 PFAS, phosphate competition, zeta-potential measurements and sulfur XANES spectroscopy.

TEST FOCUS	REPORTED FINDING
 PH AND COMPOUND IDENTITY	Adsorption decreased as pH increased for all 12 tested PFAS. The mineral was particularly relevant for PFAS with six or more perfluorinated carbons at pH ≤5 with low competition.
 PHOSPHATE COMPETITION	Adding phosphate reduced PFAS adsorption in association with a decrease in positive surface charge.
 BINDING MECHANISM	Spectroscopy supports outer-sphere association for the tested sulfonated PFAS; no inner-sphere complexes were indicated.

RELEVANCE Freshly formed iron hydroxides in a Katalox-Light bed provide this type of capture surface. Charge and competitors explain why the same surface inventory can behave differently in different waters. The study supplies the scientific basis for evaluating newly formed iron-hydroxide surfaces.

RESEARCH CASE 2 PFOS/PFOA MIXTURE INTERACTIONS

Hazrati et al.⁵

Material: laboratory ferrihydrite. Conditions: pH 3–9; initial PFAS concentrations of 0.1–20 µmol/L; single-compound and binary mixtures.

RESULT	REPORTED OBSERVATION
Maximum uptake at pH 3	15.83 mg/g for PFOS and 12.04 mg/g for PFOA in the reported single-compound experiments.
Mixture behaviour	Both compounds adsorbed more strongly together, particularly at pH 3–5; high loading favoured surface aggregation and tail-tail association.

MAXIMUM UPTAKE · PH 3

PFOS		15.83 mg/g
PFOA		12.04 mg/g

Laboratory ferrihydrite, single-compound experiments.

RELEVANCE PFAS mixture composition and surface coverage can influence iron-mineral uptake.

THE SHARED SCIENTIFIC MESSAGE

Surface area, surface charge, water composition and PFAS identity work together. These studies support the mineral-adsorption mechanism used to interpret combined treatment.

07 / KATALOX-LIGHT FIELD CASE STUDIES

HANOI AND PACHUCA. DOCUMENTED AT FULL SCALE.

Documented Katalox-Light installations for metal removal and solids separation.



FIELD CASE 1 HA DONG, HANOI, VIETNAM 10

MUNICIPAL DRINKING-WATER PLANT

Municipal drinking-water plant commissioned in July 2018. The published case describes 30,000 m³/day capacity, 30 continuous upflow Katalox-Light filters and a population served of 250,000. Water flows upward through the media; an air-lift and washer continuously clean and return the media.

30,000 m³/day
Plant capacity

30 filters
Continuous upflow

250,000 people
Population served

PARAMETER	INFLUENT	ACTUAL OUTLET
IRON	>3 mg/L	→ 0.03–0.15 mg/L
TURBIDITY	3.35–7.29 NTU	→ 0.13–0.21 NTU
ARSENIC	>0.101 mg/L	→ <0.01 mg/L

PROCESS RELEVANCE

A municipal-scale example of iron treatment and retention of precipitated material. Arsenic removal illustrates the published co-removal application through its own mineral-surface chemistry.



FIELD CASE 2 PACHUCA, HIDALGO, MEXICO 11

SAN JUAN MINE-WATER WELL

Raw water: pH 6.8–6.9, manganese 3.8–5.0 mg/L and iron 0.017 mg/L. Treatment: Katalox-Light with OXYDES dosing and pH adjustment.

7.5–8.0 pH
At the sampled operating points

1.5–2.0 L/s
Flow

3.54–4.72 min
Reported EBCT

SAMPLING DATE	MN INLET	MN OUTLET	REPORTED REMOVAL
26 Aug 2014	3.88 mg/L	0.01 mg/L	99.74%
1 Sep 2014	4.34 mg/L	0.02 mg/L	99.53%
3 Sep 2014	4.36 mg/L	0.02 mg/L	99.54%

WHAT THESE TWO CASES ESTABLISH

The Hanoi case documents municipal iron and solids treatment. The Mexico case documents high manganese reduction with specified oxidation and pH conditions. Together they document the oxidation, surface formation and solids-separation functions relevant to combined treatment.

08 / MUNICIPAL OPERATION & VERIFICATION

TURKEY: MEASURED INLET AND OUTLET.

A third field example, followed by the measurements that define combined PFAS removal.



FIELD CASE 3 MUNICIPAL DRINKING WATER, TURKEY 12

The case report identifies a commissioned 240 m³/h Katalox-Light plant treating groundwater.

240 m³/h

Groundwater treatment

0.41 NTU

Purified-water turbidity

The data document simultaneous metal and solids reduction in this installation. Metal values are reported in µg/L.

PARAMETER	RAW WATER	PURIFIED WATER
Turbidity	2.4 NTU	0.41 NTU
Colour	7 Pt-Co	1 Pt-Co
Iron	23.8 µg/L	11.3 µg/L
Manganese	1.75 µg/L	0.62 µg/L
pH	8.24	8.16

DOCUMENTING PFAS REMOVAL ALONGSIDE FE AND MN

A combined-removal case connects each PFAS result to the water chemistry and the filter's operating condition. The following record makes the mechanism and delivered performance assessable:



01

INDIVIDUAL PFAS, INLET/OUTLET

Removal by compound, with reporting limits and matched sampling; include short- and long-chain species.

02

FLOW, BED VOLUME AND TIME

Empty-bed contact time, cumulative bed volumes and development of breakthrough.

03

FE, MN, PH, ALKALINITY, TURBIDITY

Metal conversion, buffering and solids retention during the same operating period.

04

DISSOLVED PFAS, SOLIDS, WASH WATER

The capture pathway and location of the removed PFAS; use laboratory-controlled preparation and blanks.

$$\text{Removal (\%)} = 100 \times (C_{\text{in}} - C_{\text{out}}) / C_{\text{in}}$$

Outlet results below the reporting limit are reported with that limit, not as a measured zero.

DESIGN CONCLUSION

Katalox-Light combines high specified surface area, catalytic mineral chemistry and fine-solids capture. Iron-assisted PFAS capture is explained by accessible surfaces and favourable interfacial chemistry, and is quantified through compound-specific treatment data.

09 / REFERENCES

RESEARCH AND PRODUCT SOURCES.

Numbered references distinguish product specifications, mineral research and field measurements. Equations are balanced net representations.



CATALYTIC FE & MN REMOVAL

10% MnO₂ coating on a
ZEOSORB® matrix



PFAS CAPTURE SURFACES

Fresh iron hydroxide formed
during service



FINE FILTRATION

Approximately 3 µm
particle retention



DOCUMENTED AT SCALE

Municipal installations in
Vietnam and Turkey

- 1** **PRODUCT** Watch Water. Katalox-Light product information. Composition, surface area, filtration and operating conditions.
<https://www.watchwater.de>
- 2** **RESEARCH** Campos-Pereira et al. (2020). The Adsorption of PFASs onto Ferrihydrite Is Governed by Surface Charge. Environmental Science & Technology 54, 15722–15730.
<https://doi.org/10.1021/acs.est.0c01646>
- 3** **RESEARCH** Vries et al. (2017). Iron and manganese removal: advances in modelling rapid sand filtration. Water Research 109, 35–45.
<https://doi.org/10.1016/j.watres.2016.11.032>
- 4** **RESEARCH** Hargette & Knoke (2001). Assessment of fate of manganese in oxide-coated filtration systems. Journal of Environmental Engineering 127, 1132–1138.
[https://doi.org/10.1061/\(ASCE\)0733-9372\(2001\)127:12\(1132\)](https://doi.org/10.1061/(ASCE)0733-9372(2001)127:12(1132))
- 5** **RESEARCH** Hazrati et al. Individual and synergetic adsorption of PFOS and PFOA on ferrihydrite. Colloids and Surfaces A, 141738.
<https://doi.org/10.1016/j.colsurfa.2026.141738>
- 6** **STANDARD** Thommes et al. (2015). Physisorption of gases: surface area and pore size distribution. IUPAC Technical Report. Pure and Applied Chemistry 87, 1051–1069.
<https://doi.org/10.1515/pac-2014-1117>
- 7** **RESEARCH** Fuerstenau & Shibata (1999). Electrokinetics and the interfacial behaviour of manganese dioxide. International Journal of Mineral Processing 57, 205–217.
[https://doi.org/10.1016/S0301-7516\(99\)00018-6](https://doi.org/10.1016/S0301-7516(99)00018-6)
- 8** **REGULATORY** U.S. EPA (2021). Multi-Industry PFAS Study: Preliminary Report. Section 10: treatment processes, separation and residual streams.
- 9** **RESEARCH** Appleman et al. (2014). Treatment of poly- and perfluoroalkyl substances in U.S. full-scale water treatment systems. Water Research 51, 246–255.
<https://doi.org/10.1016/j.watres.2013.10.067>
- 10** **FIELD CASE** Watch Water. Katalox-Light: Municipal Water Supply, Hanoi, Vietnam. Case report, pp. 2–5.
- 11** **FIELD CASE** Watch Water. Katalox-Light: Remoción de manganeso, Pachuca, Hidalgo. Field case, three sampling dates.
- 12** **FIELD CASE** Watch Water Turkey. Municipal Drinking Water Treatment, 240 m³/h. Case report: inlet/outlet metals, turbidity, colour and pH.



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