الجمعية العربية السعودية للبيئة المائية
Saudi Arabian Water Environment Association

Water Arabia 2011
CONFERENCE & EXHIBITION

INNOVATIVE WATER AND WASTEWATER
TECHNOLOGIES FOR A SUSTAINABLE ENVIRONMENT

Cleaning Clay from Fouled Membranes

Authors: Matthew Armstrong, Silvia Gallego, Fernando del Vigo, Stephen Chesters.

Stephen Chesters – Managing Director

Genesys International Limited

400,000 year old Estonia clay

GENESYS INTERNATIONAL

Clay - UK

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Why is this a membrane issue?

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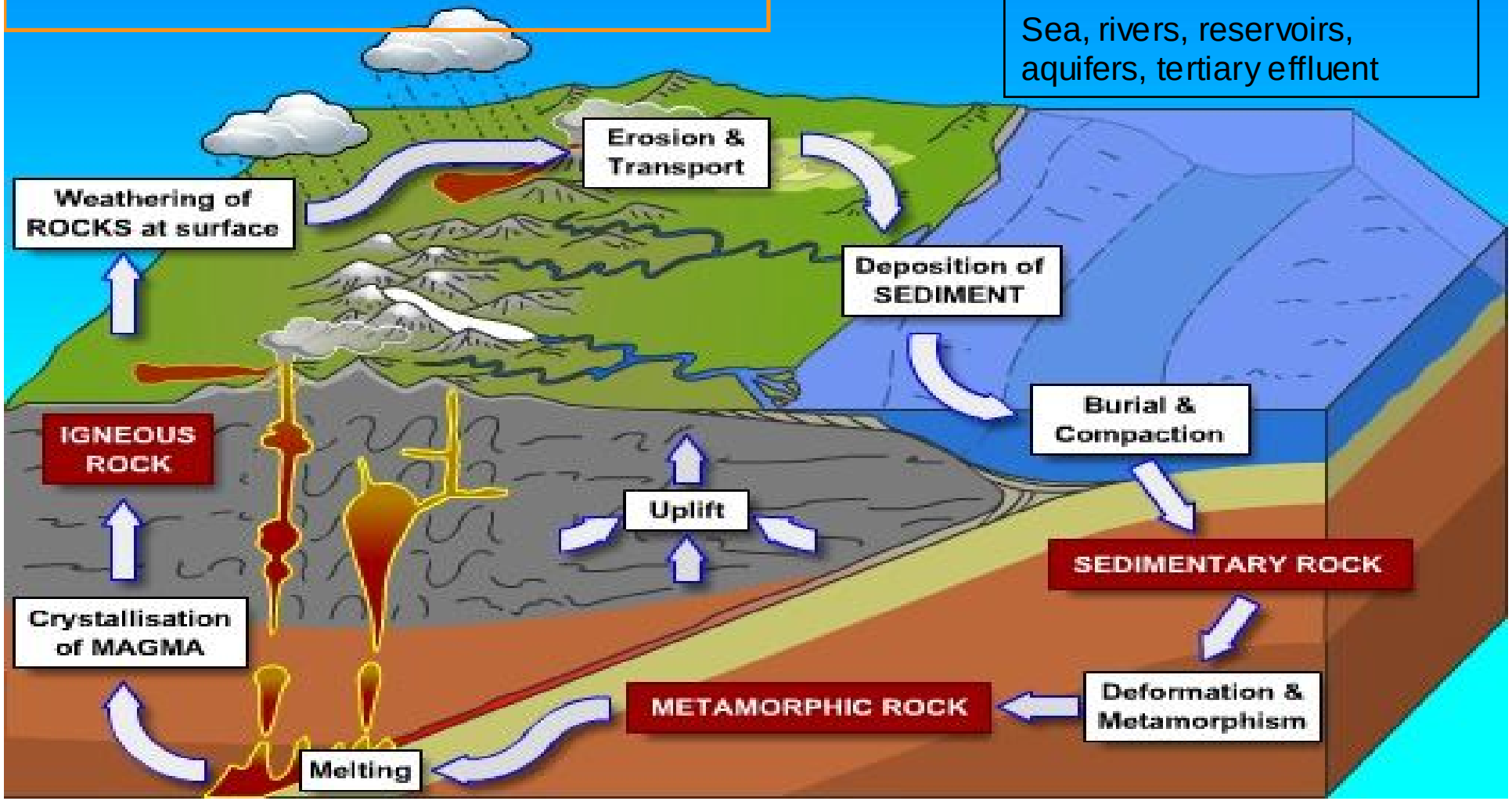
Silicate rock chemically weathered by carbonic acid

FEED SOURCES:

Sea, rivers, reservoirs, aquifers, tertiary effluent



Occurrence in Membrane Autopsy

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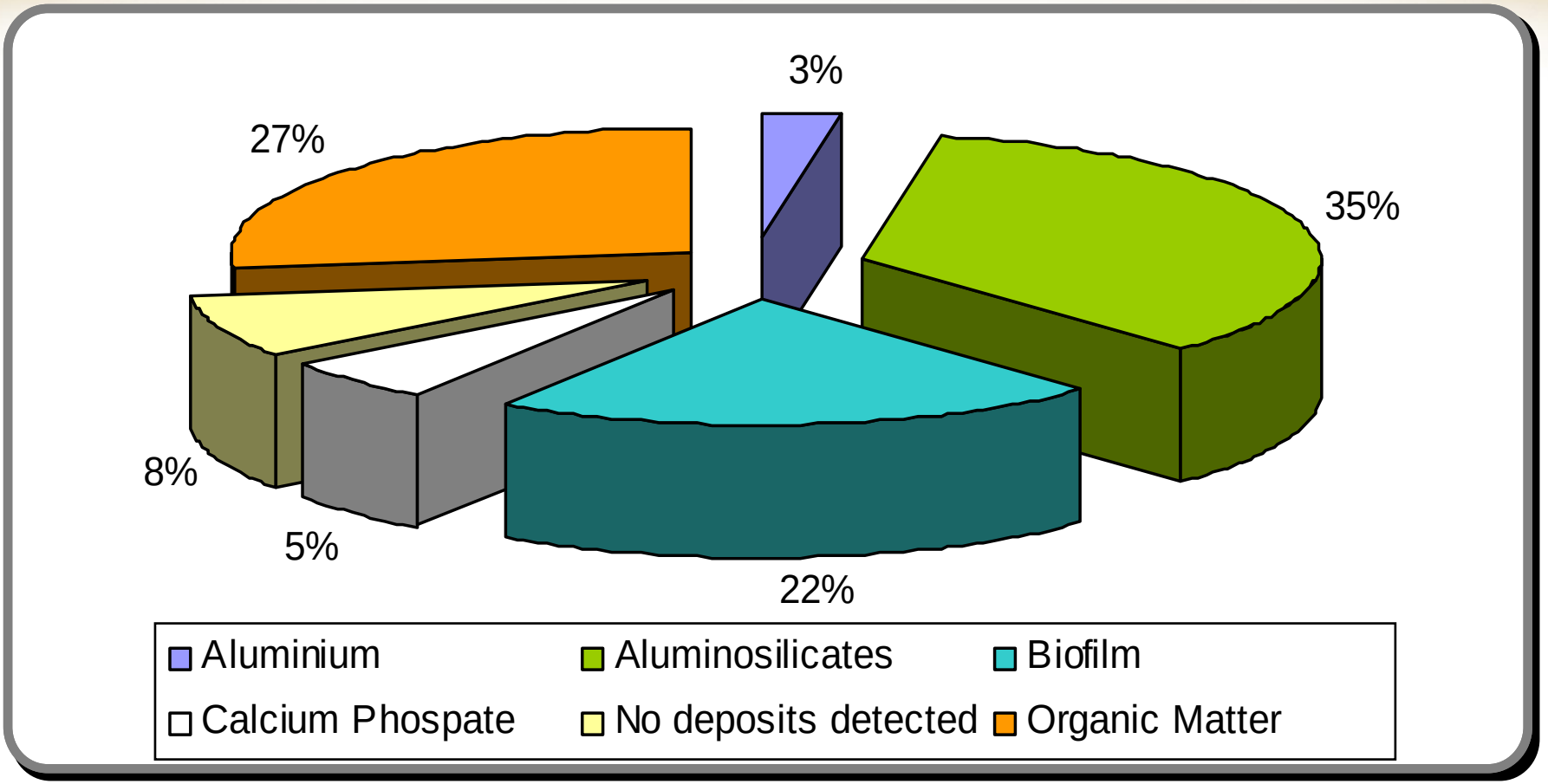
Lead Elements 2002-2010Source: GMP Laboratory Madrid



Clay Fouling

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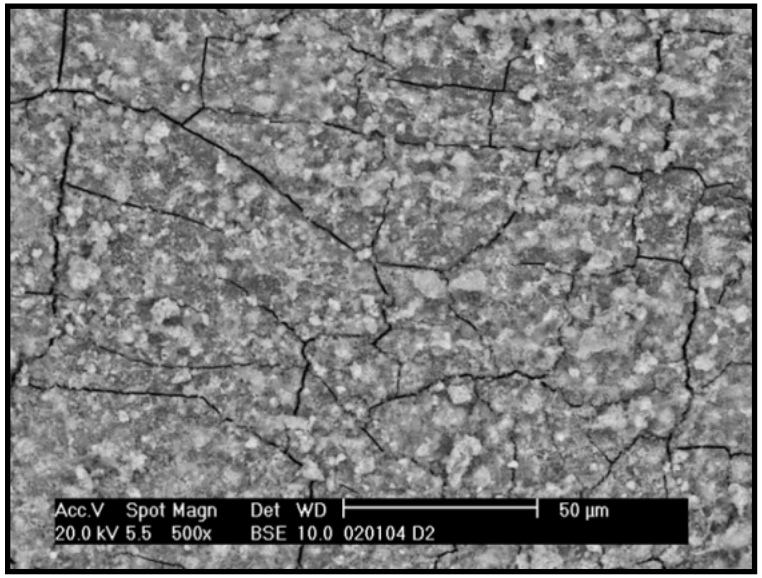
- Source is erosion products in surface waters
- Clay detected as colloidal alumino-silicates
- Most common foulant in lead membrane elements
- Reduced flux and increased ΔP



Clay Chemistry

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Clay Type	Structure and Property
Kaolinite	$Al_2Si_2O_5(OH)_4$ silicate sheets bonded to aluminium oxide/hydroxide layers Hot moist climates
Illite	Structure contains a wide range of cations including Al, Mg, Fe & Potassium. Cold Climates
Montmorillonite Smectite	Structure includes Ca, Na, Al, Mg. Notable for losing and adsorbing water Drier Climates

Resistance to Cleaning

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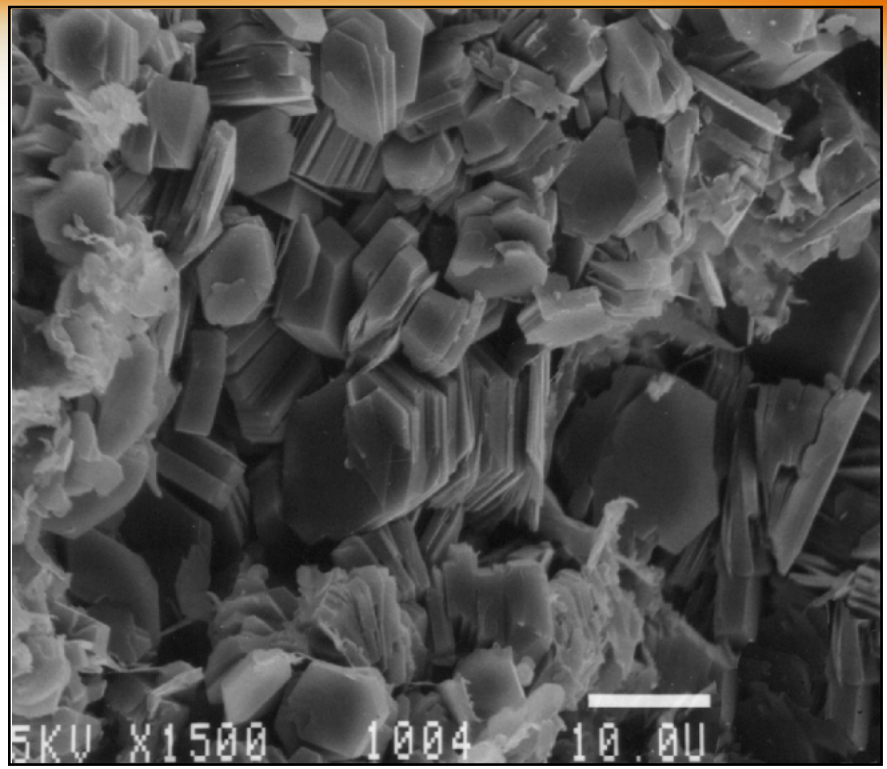

- Sheet structure – Tetrahedron rings
- Water in mineral crystal structure Can expand
- Plasticity – irreversible deformation under pressure

Clay Resistance to cleaning

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- Hydroxyl groups hold crystal sheets together
- Charges allow floc formation increasing particle size & protection
- Cations protect the internal structure from chemical attack
- Deformation & swelling result in pore blocking

Membrane Damage

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- **Reduction in flux**
- **Increase in pressure**
- **Membrane damage**

Membrane Damage

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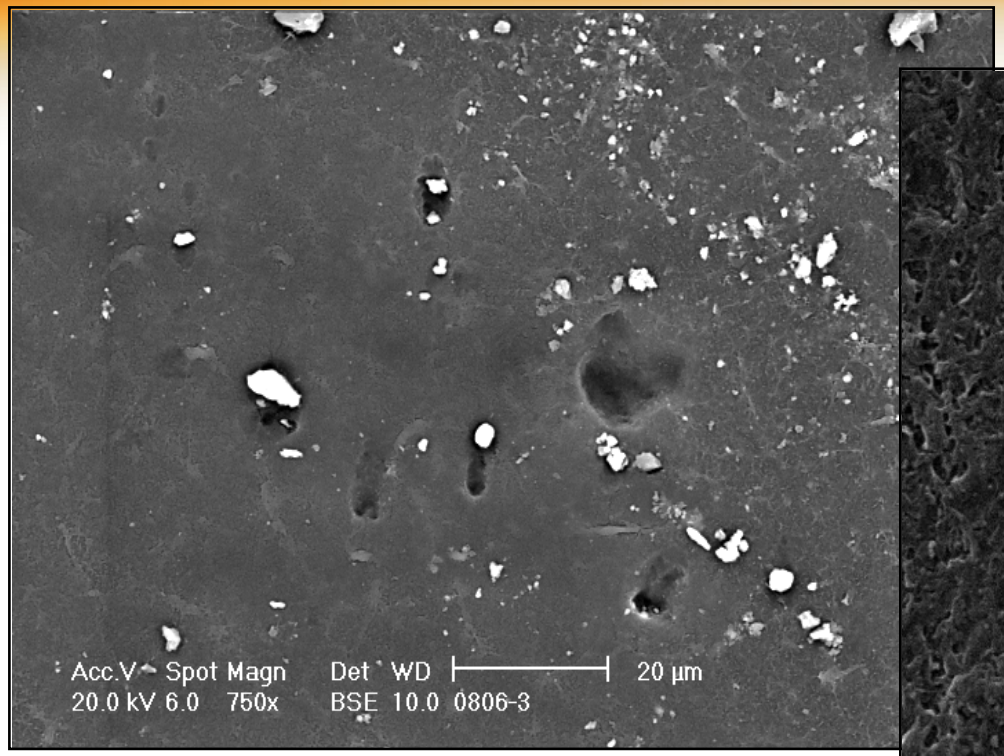

- Swelling causes abrasive damage

Solution - Genesol 703

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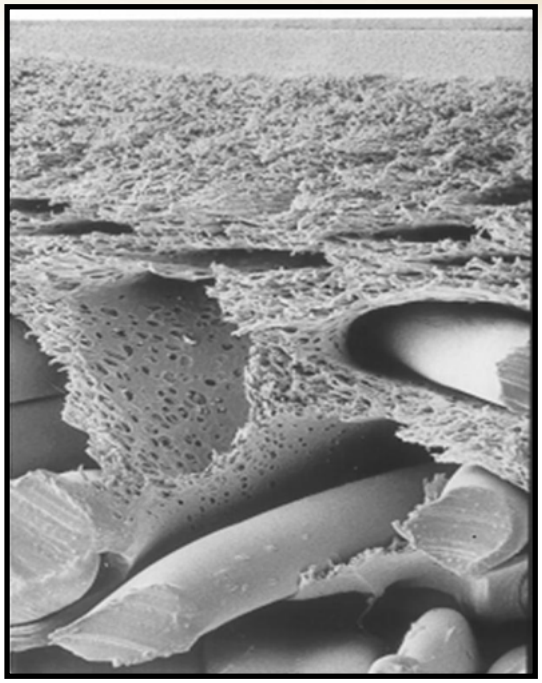
- Powdered product - 100% active
- Phosphate cleaner, detergent,
- Surfactant
- Ionic strength builder to generate normal osmosis, helps “clear” the pores.

Normal Osmosis



ReverseO smosis

CASE STUDIES

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CASE STUDY

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Hydranautics LFC3 **Characterization conditions:** 150 psi, 1000 ml/min, 1,500 ppm NaCl	Dark brown homogenous deposit covering membrane surface. Deposit mainly inorganic (> 90 % dry mass). Composed of aluminosilicates and iron oxides.

CASE STUDY

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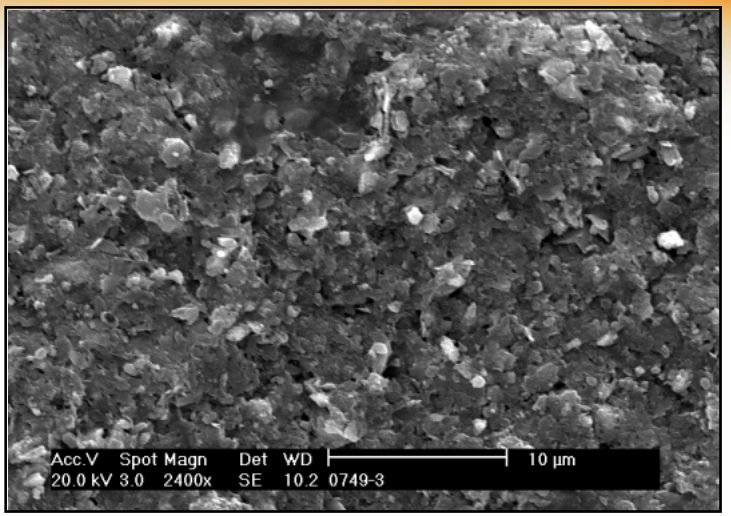

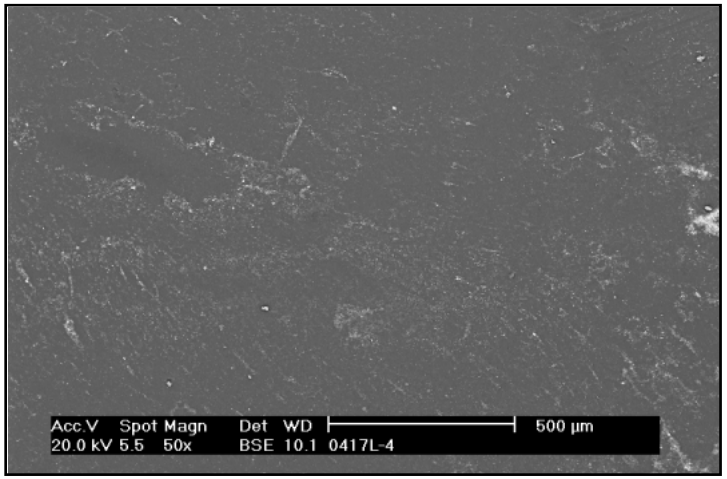

CASE STUDY 3

GENESYS INTERNATIONAL

Hydranautics LFC3 **Characterization conditions:** 150 psi, 1000 ml/min, 1,500 ppm NaCl	Dark brown homogenous deposit covering membrane surface. Deposit mainly inorganic (> 90 % dry mass). Composed of aluminosilicates and iron oxides.

	Cleaning solution	**Temp**	**pH**	**Time**	**Flowrate (l/m^{2}h 25°C)**			**% Salt Rejection**	
					Before	After	%	Before	After
Case 3	Genesol 703 (1 wt%)	35°C	11.5	4 hrs	17.33	58.43	+237.2	93.8	96.5

Clay Fouling Mechanism

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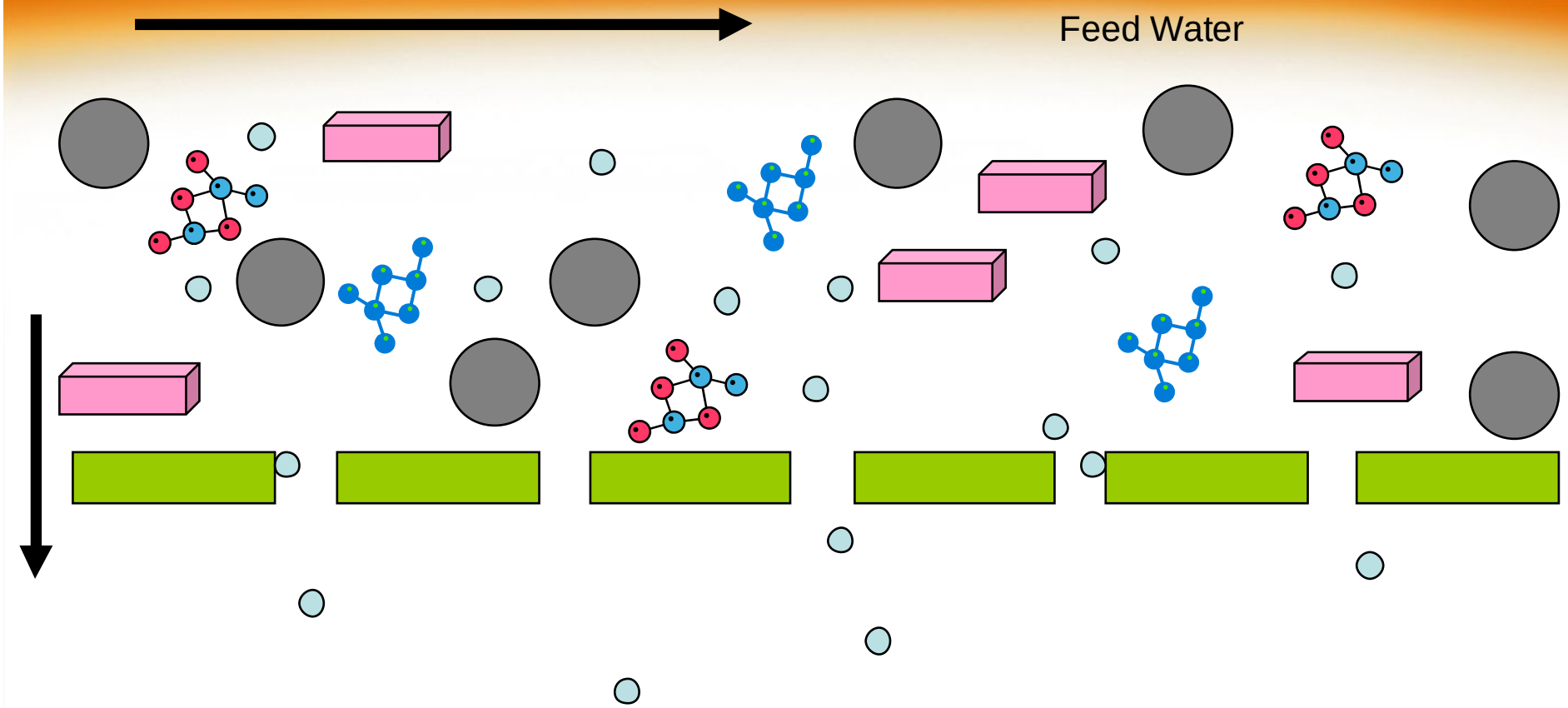
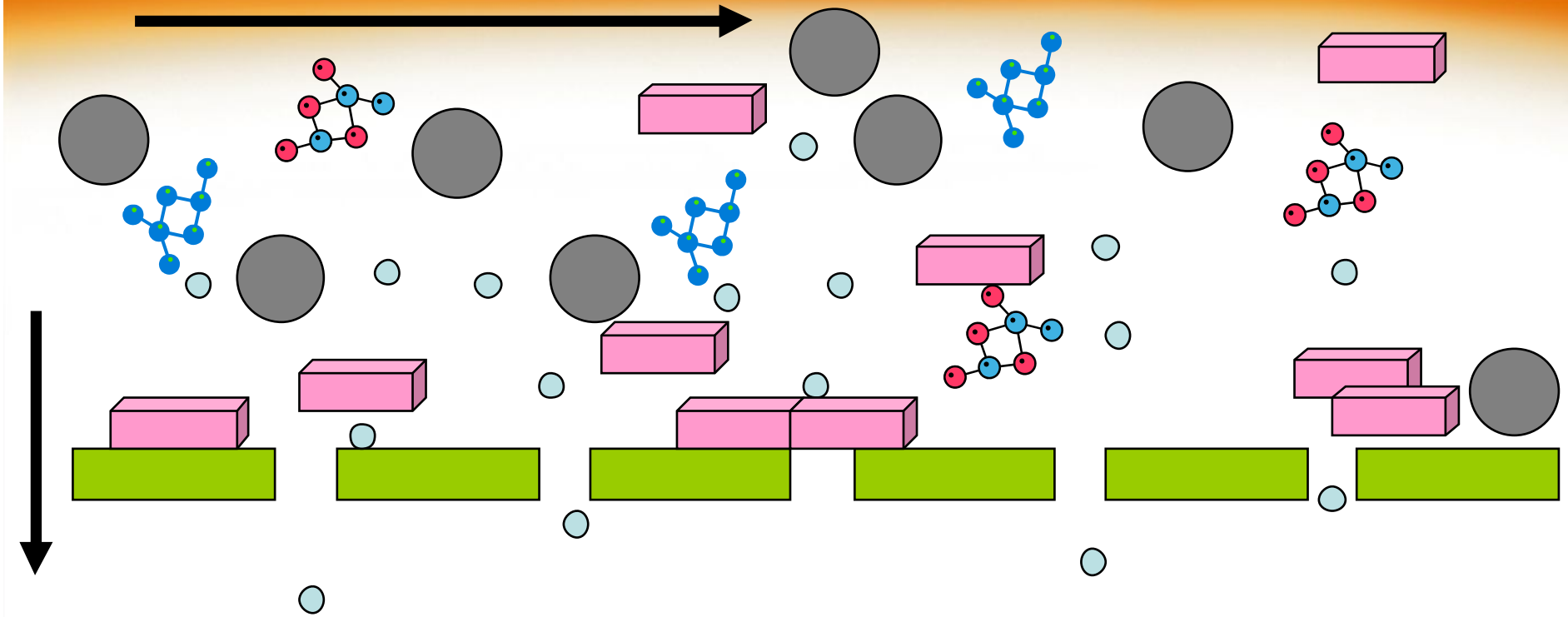


•Particles <2µm pass through pre-treatment system

Clay Fouling Mechanism

GENESYS INTERNATIONAL



•Clay particles begin to foul membrane surface forming cake layer

Clay Fouling Mechanism

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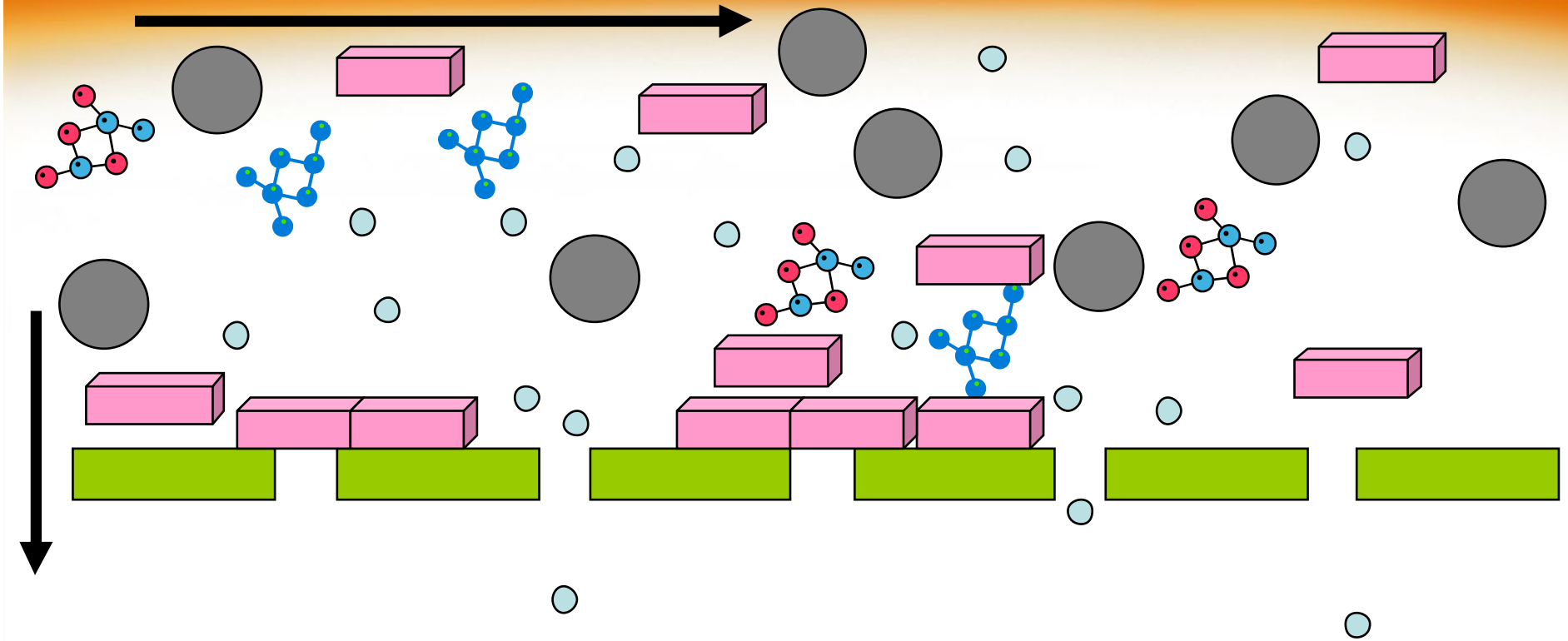

- Fouling begins to reduce flow
- Feed pressure increased to compensate

Clay Fouling Mechanism

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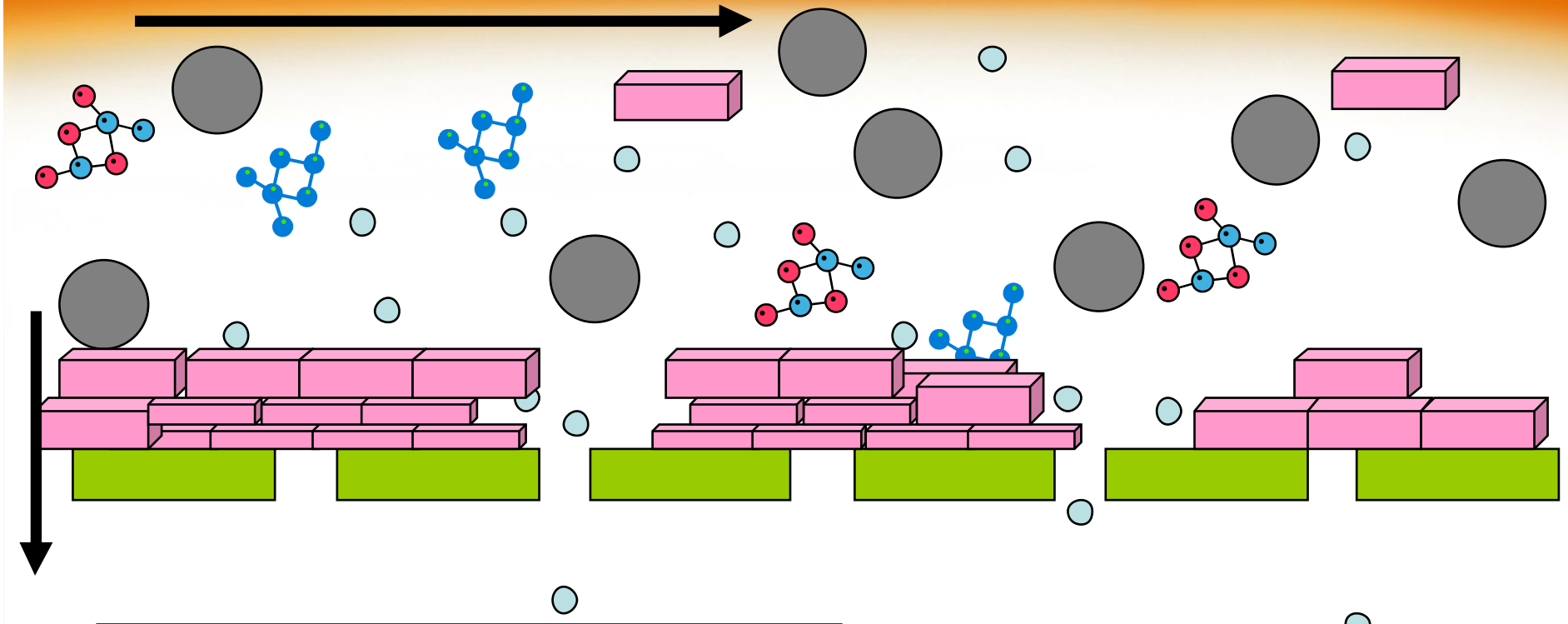

- Plasticity – increased feed pressure deforms & compresses particles
- Pores become blocked & foulant less permeable to water.

Clay Fouling Mechanism

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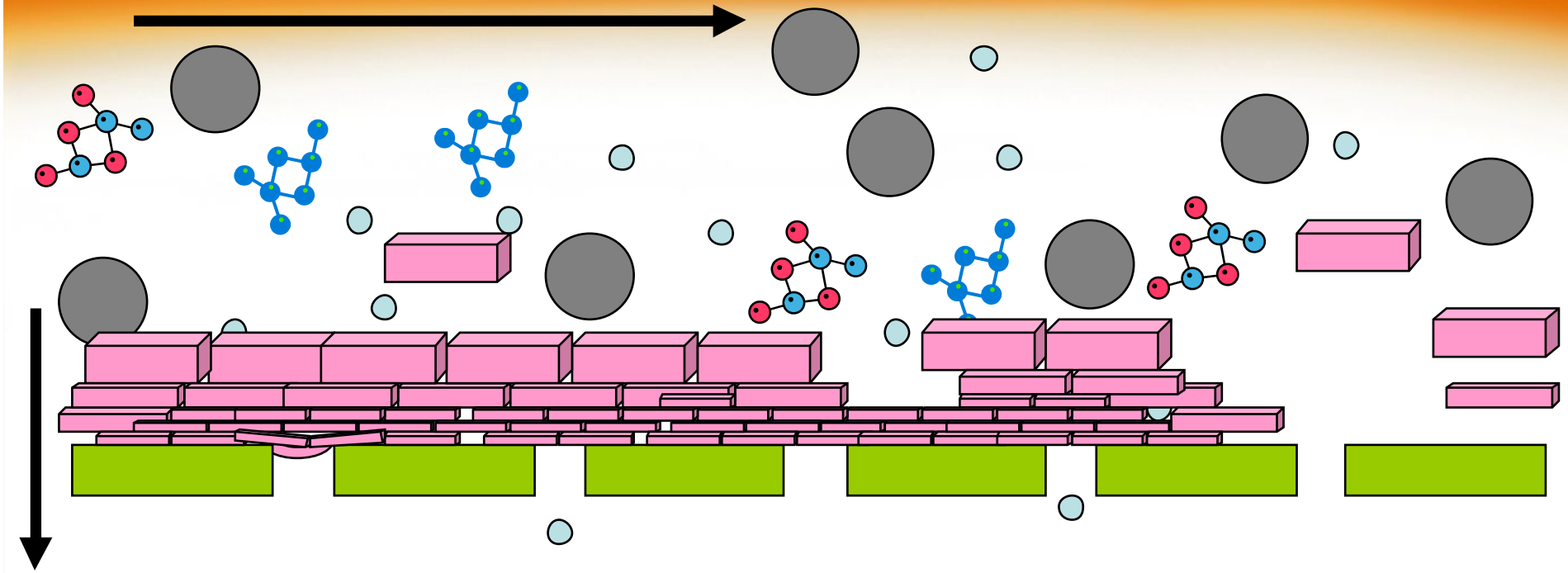

- Cake layer continues to compress & becomes impermeable to water
- Permeate flow reduced
- Normal Cleaning solution can't penetrate layer

Genesol 703 Cleaning low pressure

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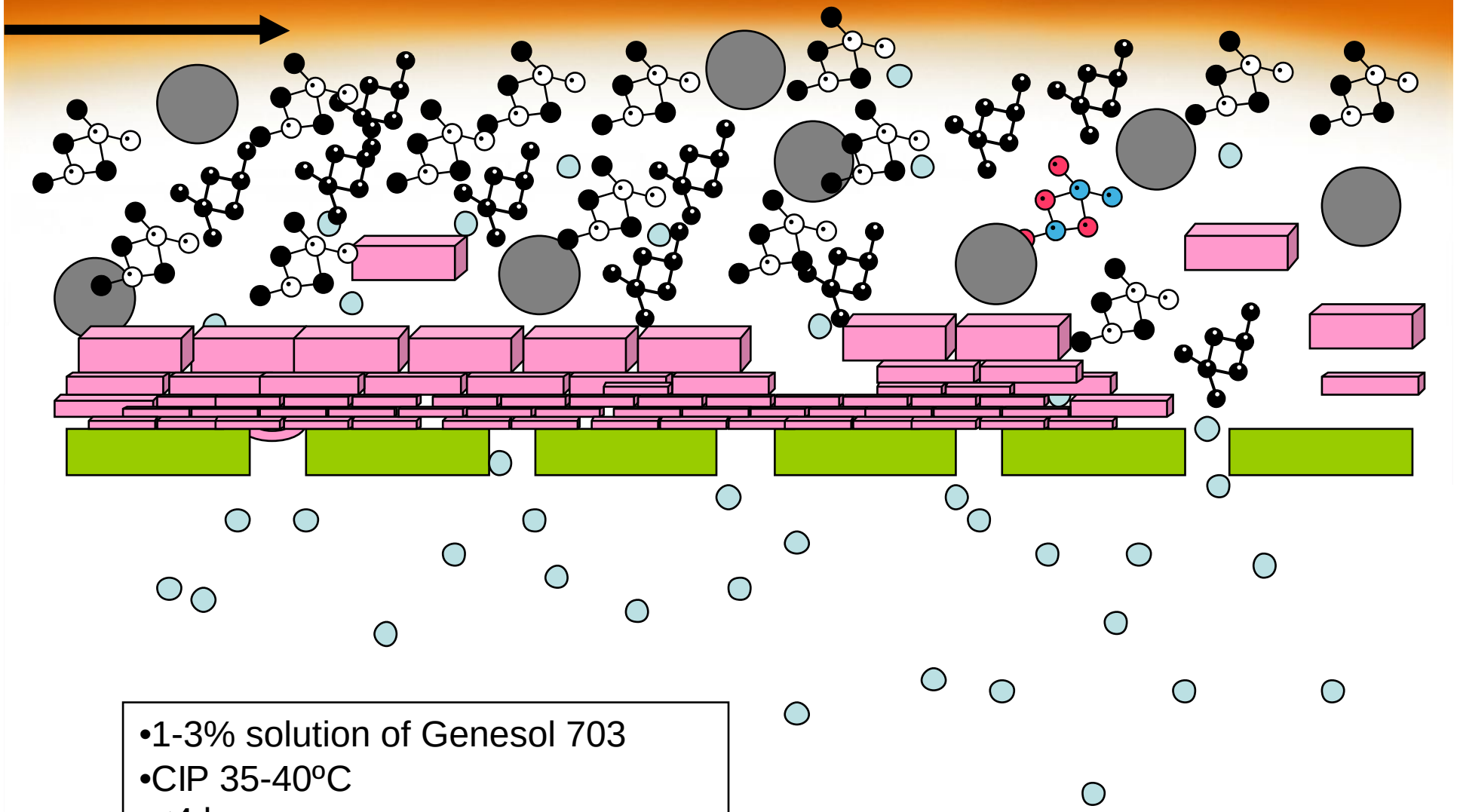

- 1-3% solution of Genesol 703
- CIP 35-40ºC
- <4 bar

Add Cleaning Solution

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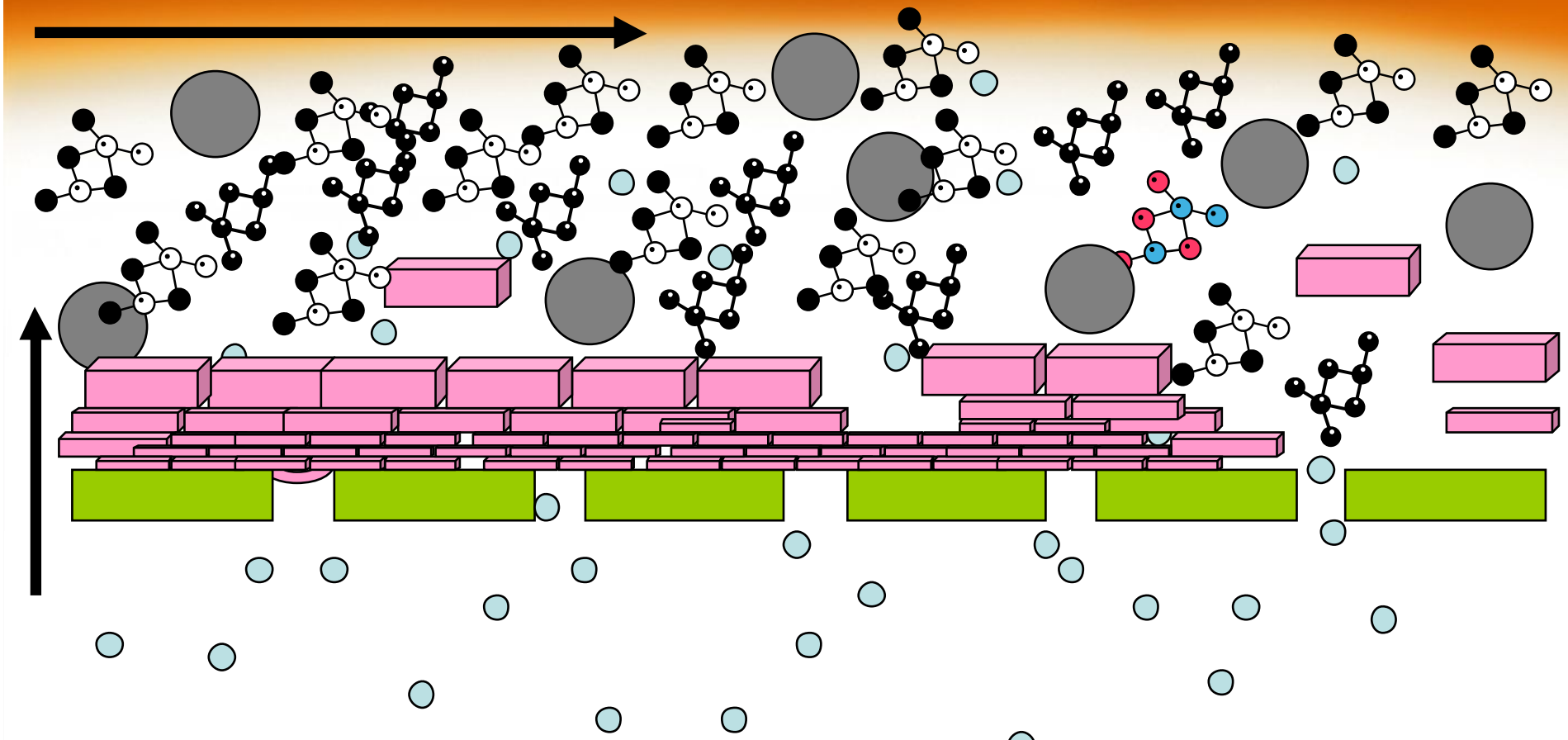

- 1-3% solution of Genesol 703
- CIP 35-40ºC

Mode of Action – surface tension

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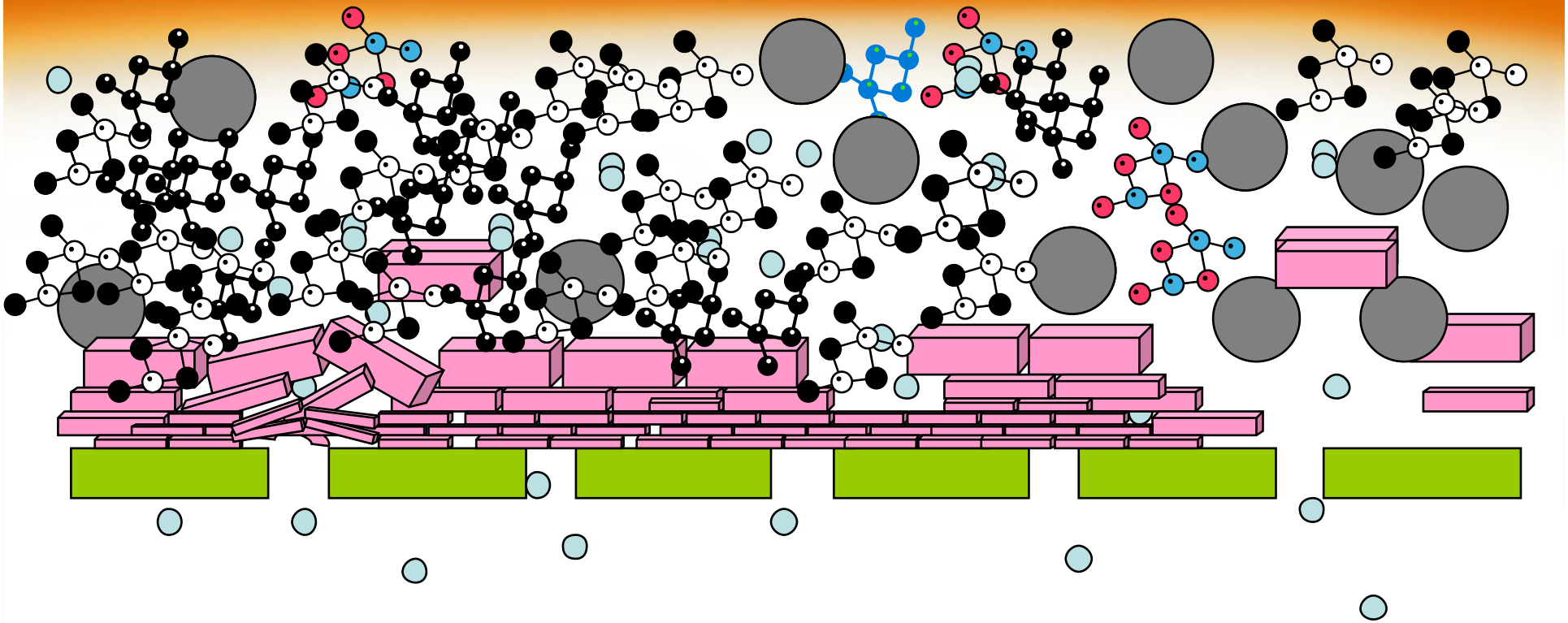

- Water/surface inter-phase – surface tension reduced, surfactant penetrates deposit
- Deposit becomes more permeable allowing G703 to penetrate

Mode of Action – deposit removal

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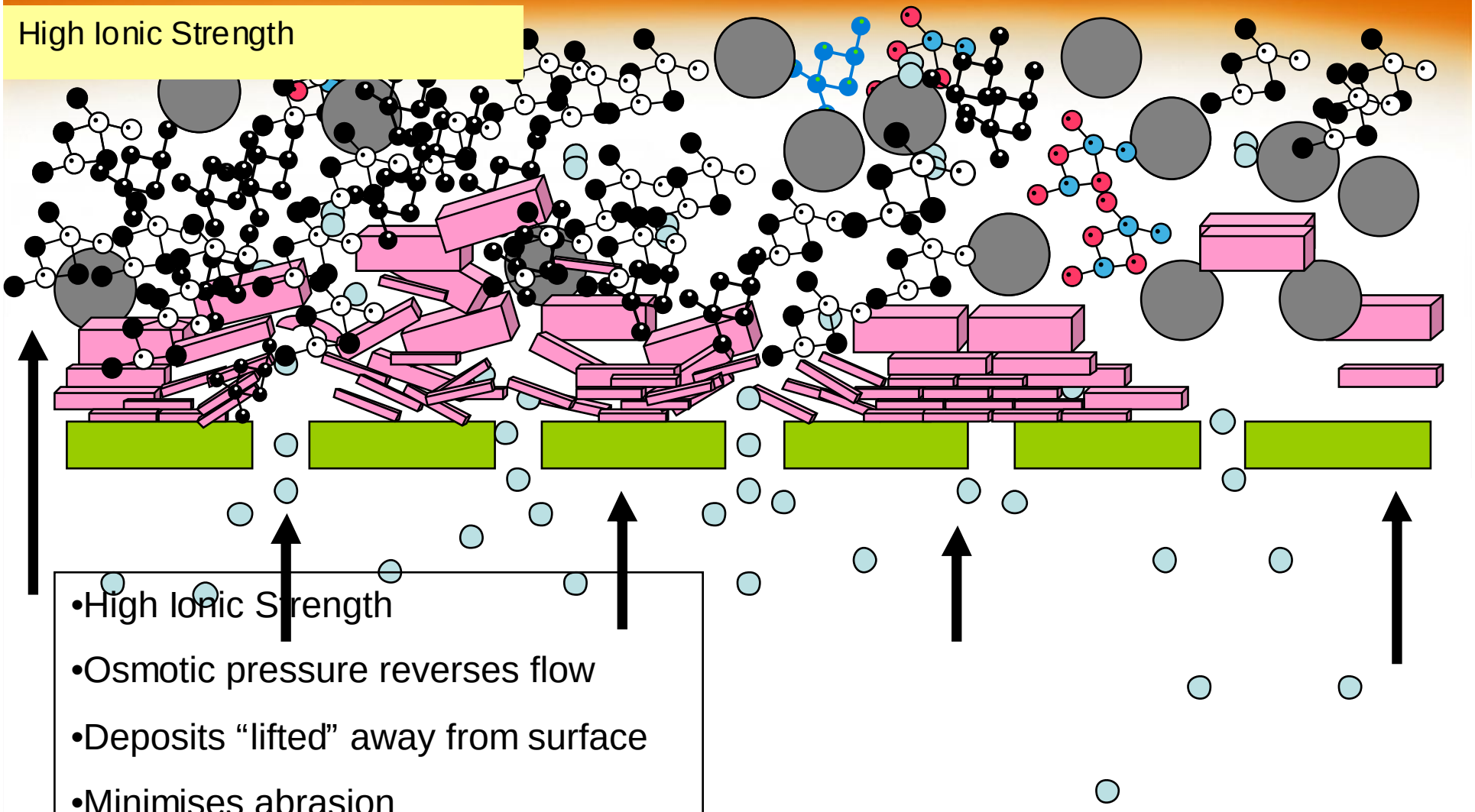
High Ionic Strength



- High Ionic Strength
- Osmotic pressure reverses flow
- Deposits “lifted” away from surface
- Minimises abrasion

Low pressure flush

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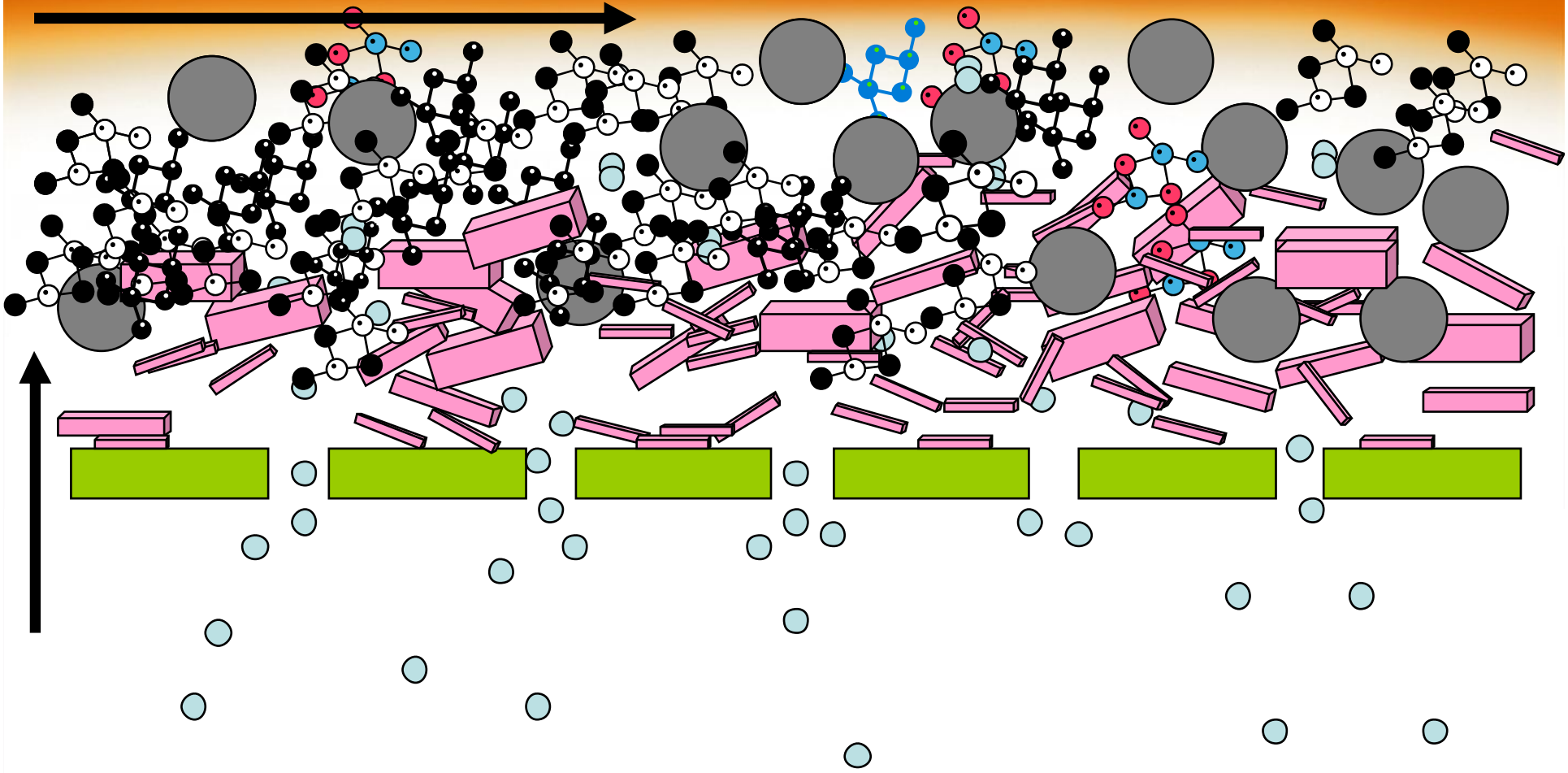

•Flushing removes particles

Large SWRO Lead element

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Hydranautics SWC5
Lead element first stage, first pass

Thin brown gelatinous deposit
Bacteria, fungi, iron, clay
(alumino-silicate)

Design flux	38.3 l/m²h
Actual flux	28.1 l/m²h

SEM EDAX Results

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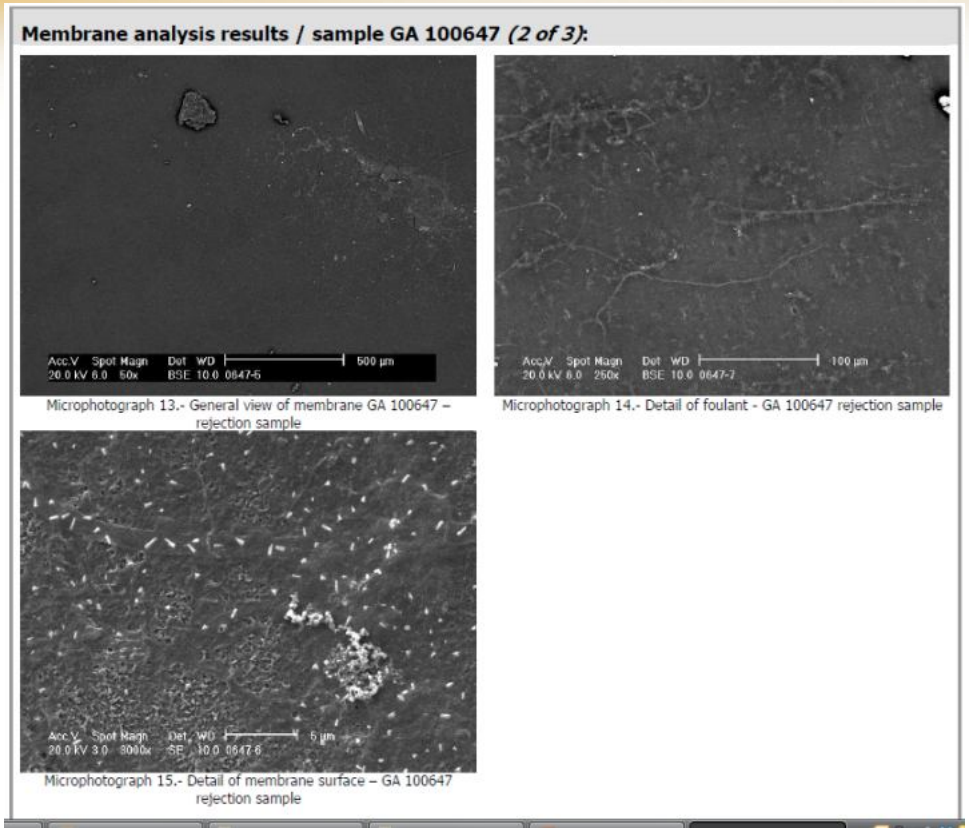

- Anthracite particles
- Bacteria, Biofilm
- Aluminosilicate
- Iron

Cleaning test

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SWC5 Hydranautics membrane

Charachterisation conditions: 800 psi, 32,000 ppm NaCl, 1,000ml/min

Cleaning solutions recirculated at 40 psi

Design specification 38.3 l/m²h ± 15%		Flow Rate l/m²h		
		Before	After	% Improvement
Clean 4	**2% Genesol 703 at 35-40 ° C (2 hours)**	**28.12**	**39.3**	**39.7**
Clean 1	Sodium hydroxide solution at 35-40 ° C (2 hours)	**28.6**	**29.4**	**2.8**
Clean 2	2% Genesol 40 alkaline cleaner at 35-40 ° C (2 hours)	**29.4**	**32.38**	**10.2**
Clean 3	2% Genesol 40 alkaline cleaner at 35-40 ° C (2 hours)	31.95	*	*
	300mg/l Genesol 30 biocide (1hour)	*	*	*
	2% Genesol 40 alkaline cleaner at 35-40 ° C (2 hours)	31.95	34.02	6.5
	3% Genesol 38 mild acid cleaner 25 ° C (2 hours)	34.02	22.21	-34.7
	2% Genesol 40 alkaline cleaner at 35-40 ° C (2 hours)	22.21	25.75	15.9
	TOTAL	**31.95**	**25.75**	**-19.4**

Ursus Brewery Buzau Romania

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5 off BWRO 6,650m3/day

Well water feed

Nov 2008 permeate 50% of capacity

Membranes replaced after 18 months

Cleans carried out every 4-6 weeks

Used alkaline - acid - alkaline clean

Cleans were taking 13 hours

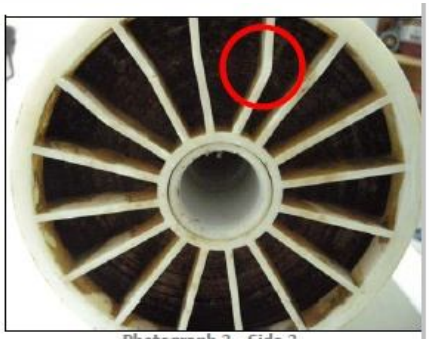
Downtime was affecting production

Ursus brewery autopsy

GENESYS INTERNATIONAL

Dow Filmtec BW 30LE-440 last element second stage

Photograph 1.- Side 1



Photograph 2.- Side 2

Photograph 3.- Side 1-detail

Photograph 4.- Side 2-detail

- Damage to casing
- Damage to ATD
- Dark brown inorganic deposit

Autopsy Results

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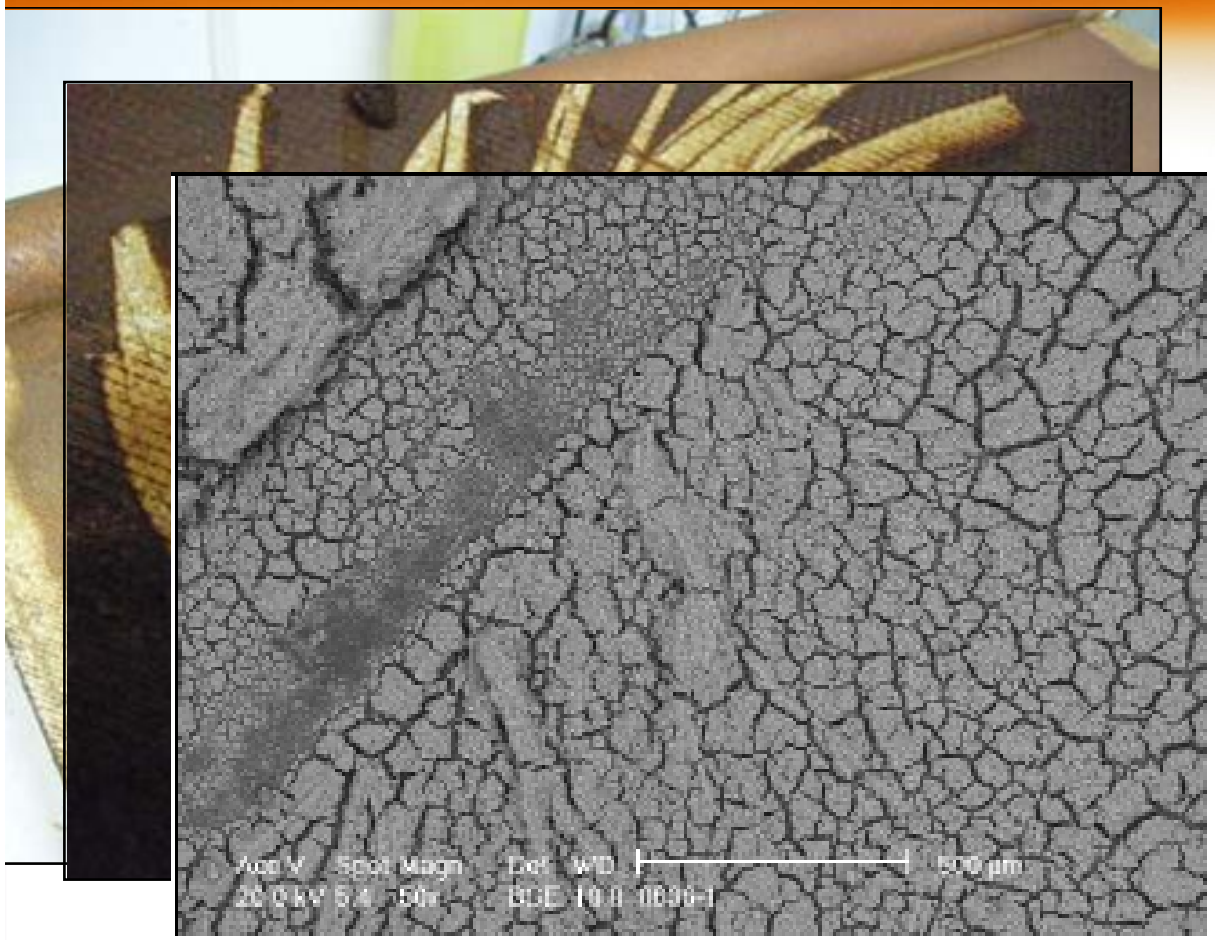
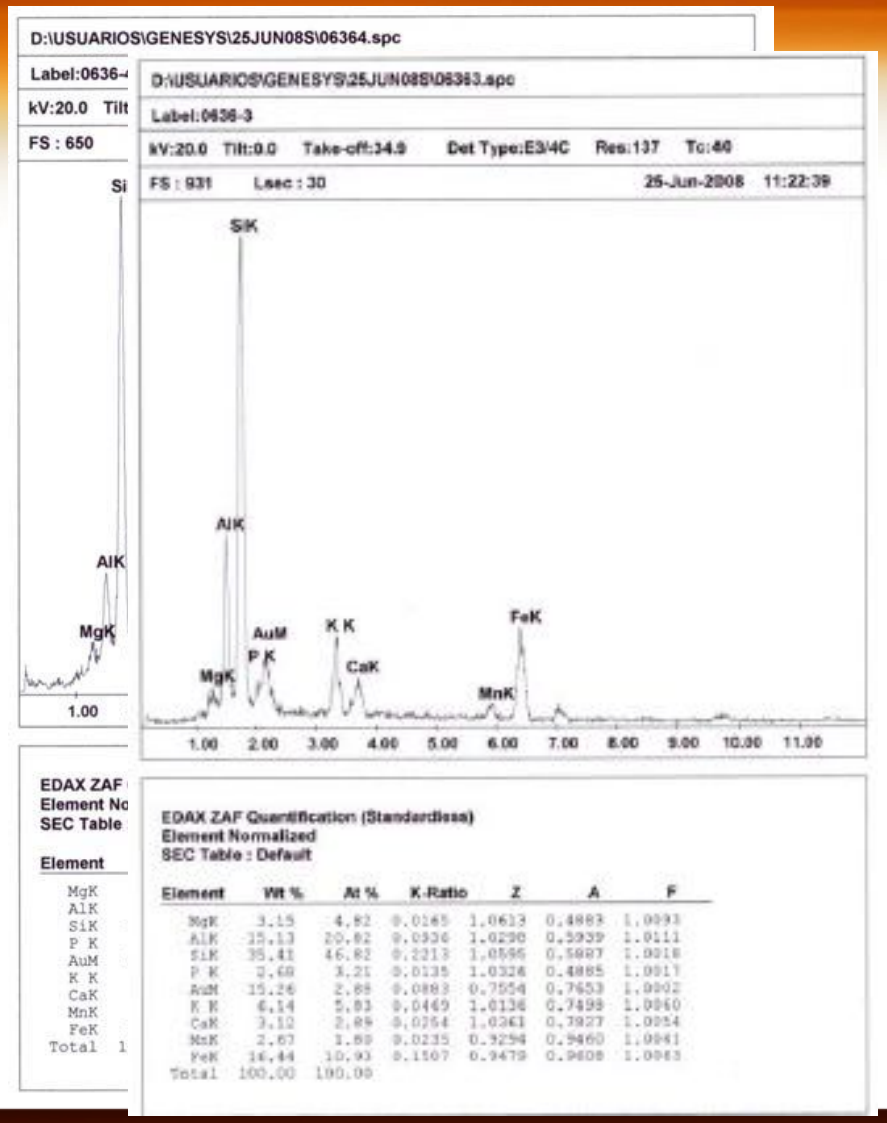


Ursus brewery autopsy

GENESYS INTERNATIONAL



- Scanning Electron Microscopy – Energy Dispersive X-ray Analysis
- Elemental peaks of deposits
- Aluminium 5-15%
- Silica 19-35%
- Iron 16-38%
- Alumino-silicate (clay) and iron

Previous Cleaning Regime

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RO Cleaned at 25% reduction in actual flow

Unable to separate stages during CIP

Step 1: Alkaline Clean pH12 @ 35ºC – 150 min contact time

Step 2: Acid clean – pH 3.5 @25ºC for 150 minutes

Step 3: Alkaline clean as per step 1

Cleaning frequency, every 3-4 weeks

Membranes replaced after 12 months

2% solution Genesol 703

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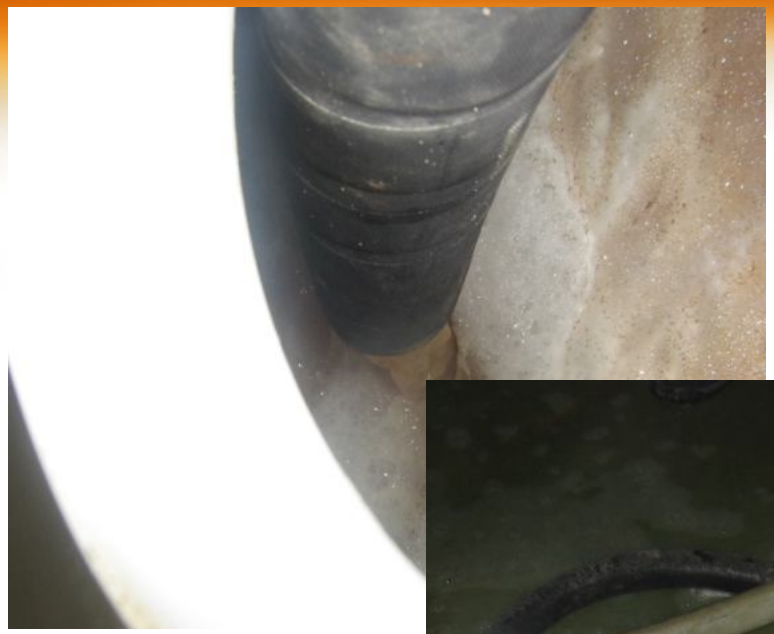

pH measurement = 11,8

1 alkaline cleaning

Genesol 703 clean

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Rinsing after alkaline

Second Genesol 703 clean

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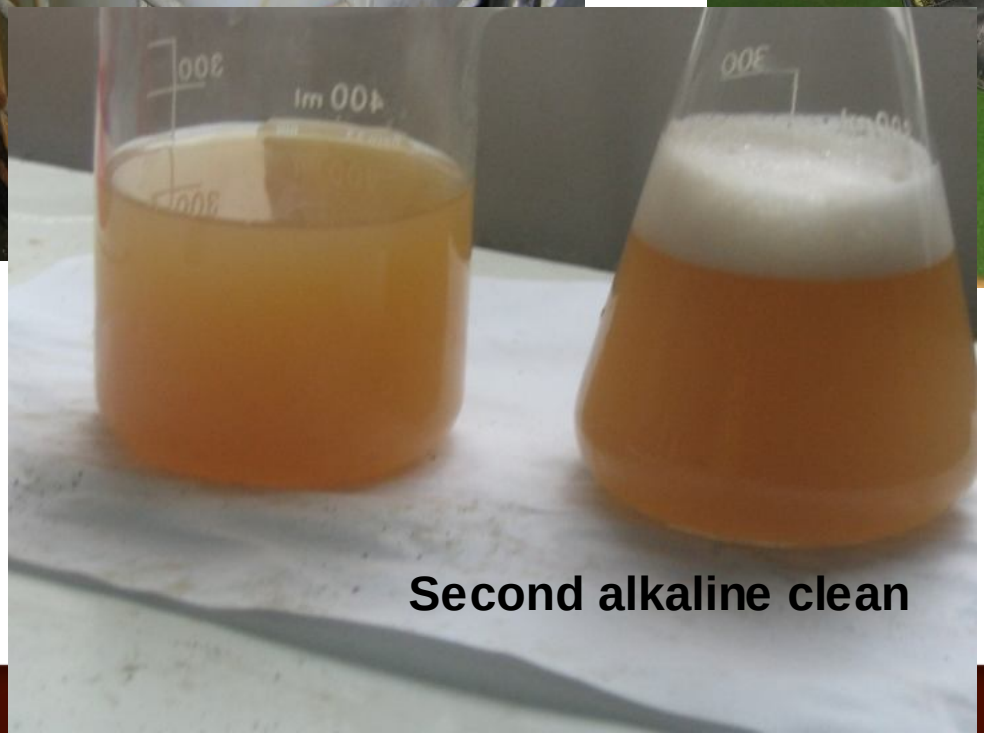

Second alkaline clean

Genesol 703 clean

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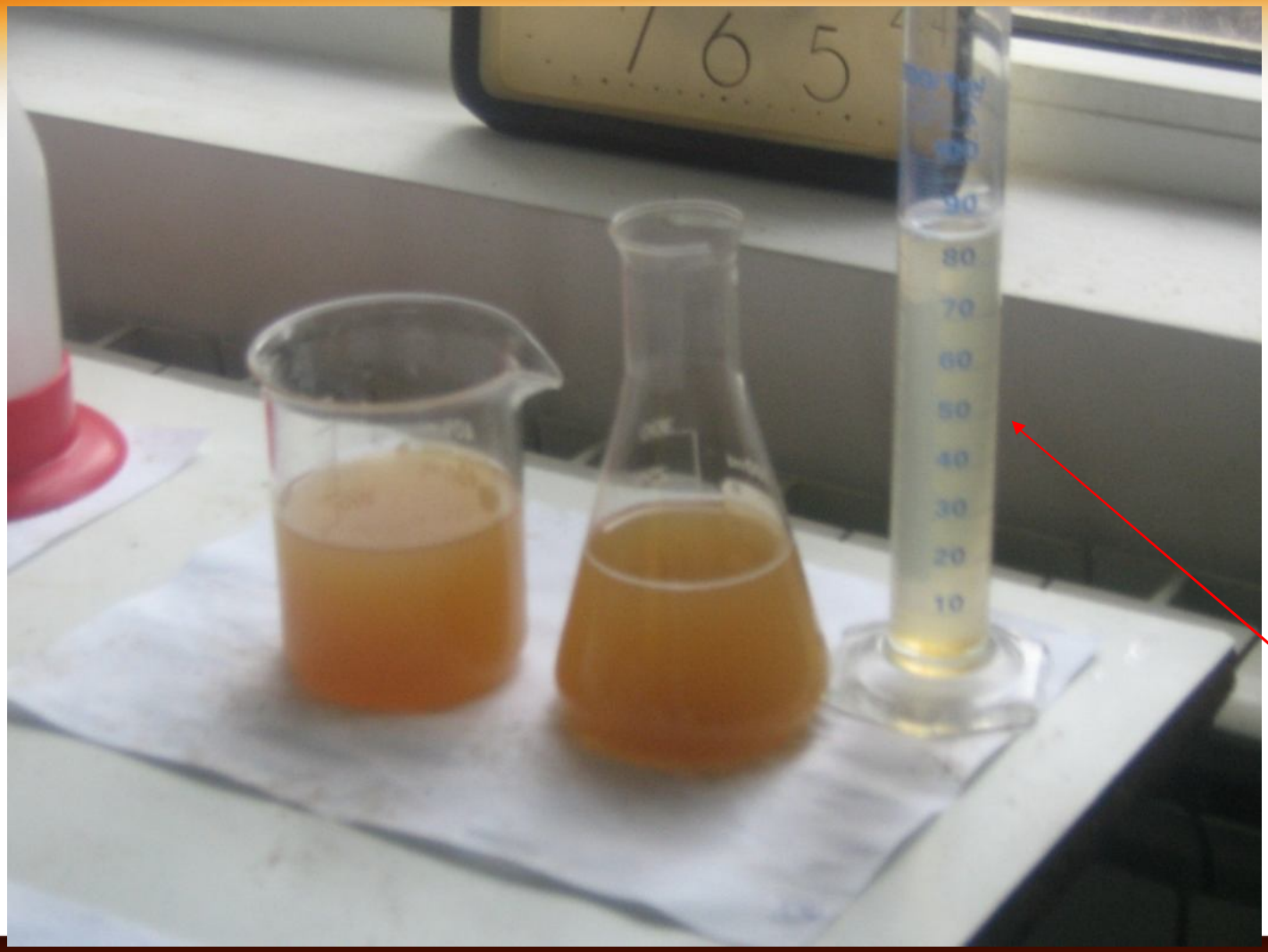

Second rinsing

Genesol 703 clean

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Clay removal

Genesol 38 Acidic clean

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First acid cleaning iron removal pH 3.8

Genesol 38 acidic clean

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2nd acid cleaning

Genesol 38 acidic clean

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3rd acid clean and rinse

Genesol 38 acidic clean

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After 3rd cleaning

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INTERNATIONAL

After shower – hard worker

Results

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- Permeate flow restored
- Cleaning frequency reduced from every 4 weeks to 3 months
- Actual CIP downtime reduced by 4 hours/day
- Membranes not replaced for 18 months
- Iron removal achieved after clay removed

CONCLUSIONS

- CLAY IS AN INCREASINGLY COMMON FOULANT
- Genesol 703 is an effective low dose rate cleaner
- EXTREMELY EFFECTIVE AGAINST BIOFILM & ORGANICS
- Successfully used on over 100 RO/UF/NF plants
- NSF/ANSI 60 APPROVED


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