11TH WATER DISALINATION CONFERENCE
IN THE ARAB COUNTRIES

18-19 APRIL 2017

INTERCONTINENTAL CITY STARS - CAIRO - EGYPT

Nanofiltration in Water Desalination,
Membrane Fouling, Definition, Mechanism and Remedy Guidelines

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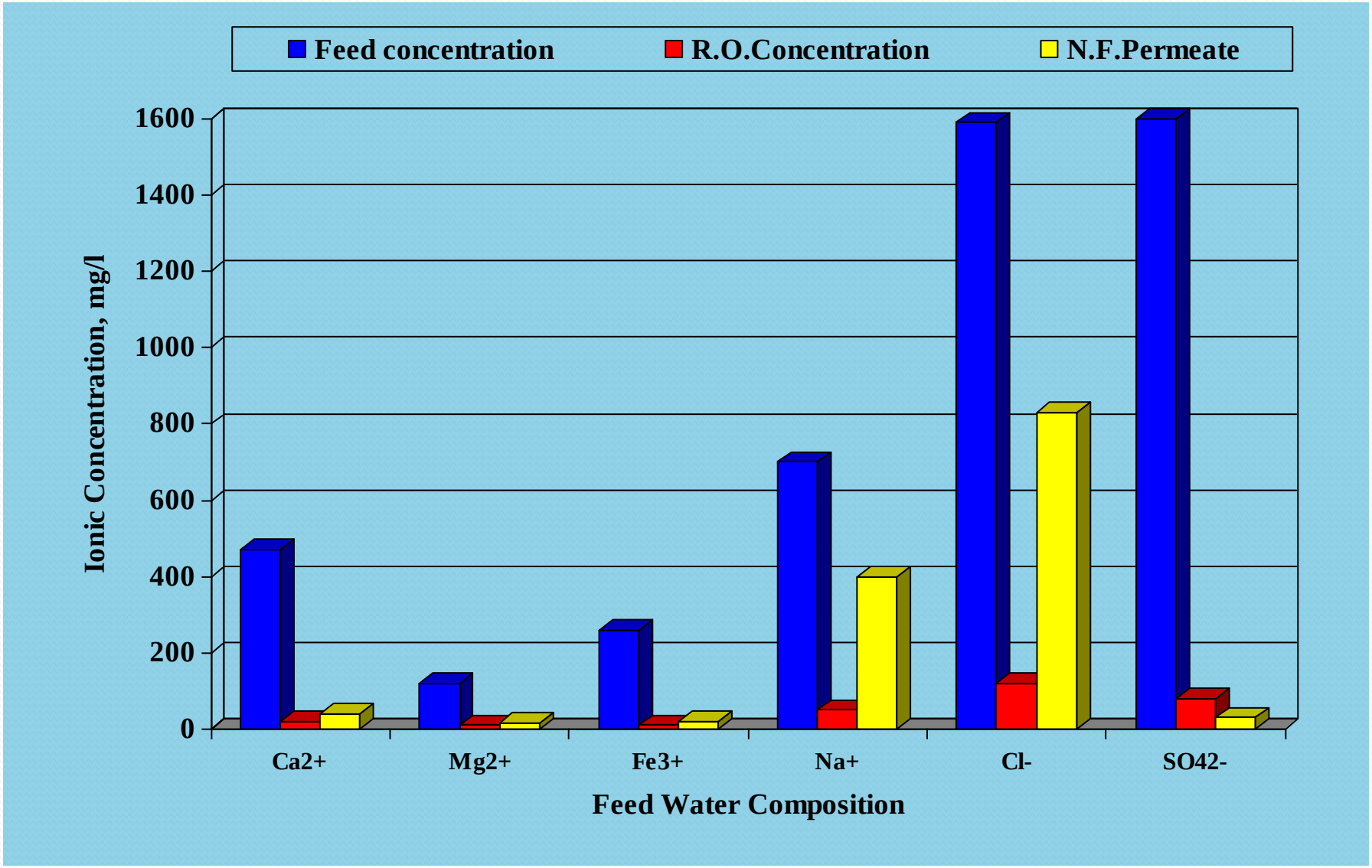
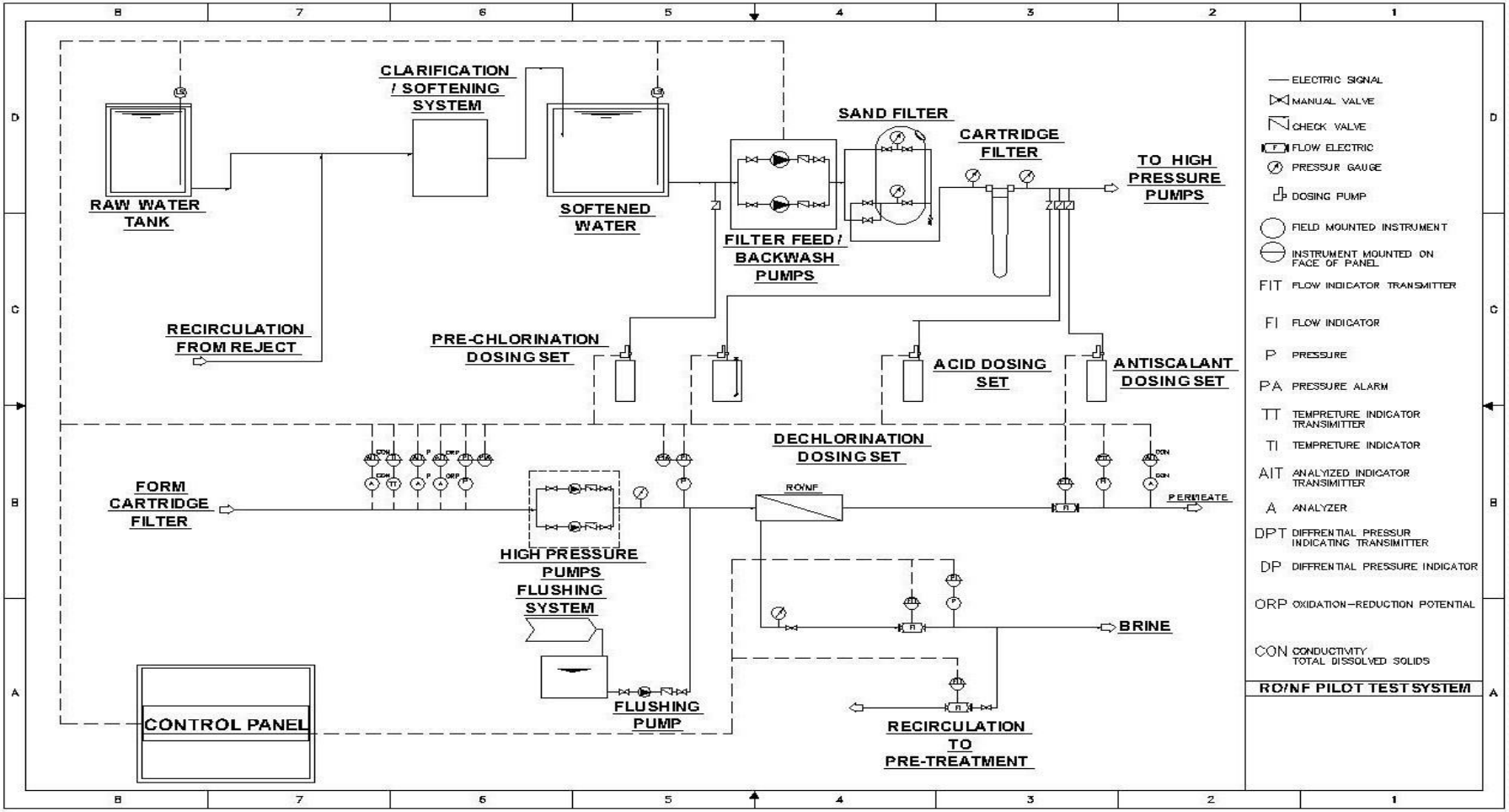
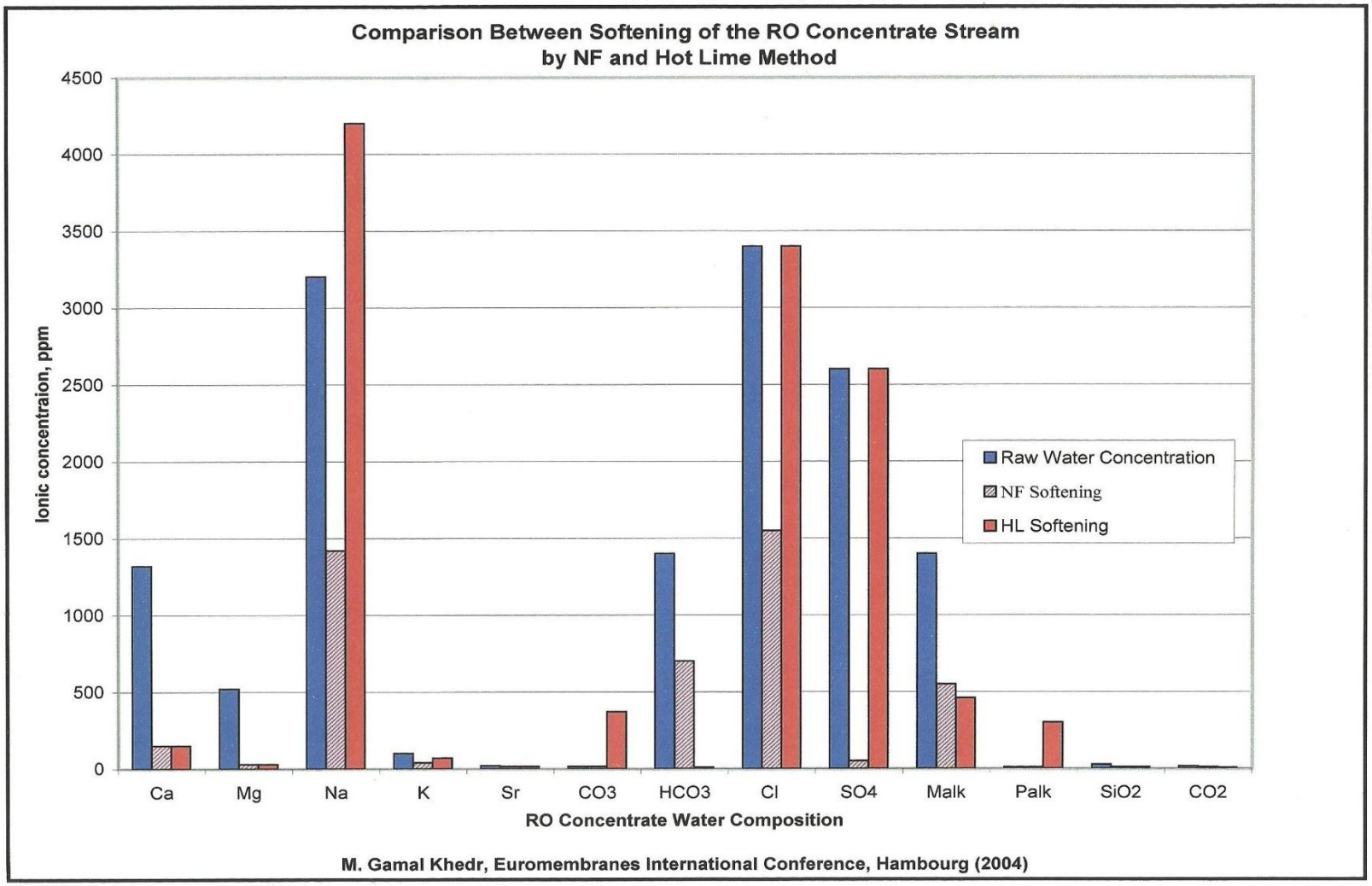
Comparison between Individual Ionic Rejection by RO and NF in Salt Mixture Solution

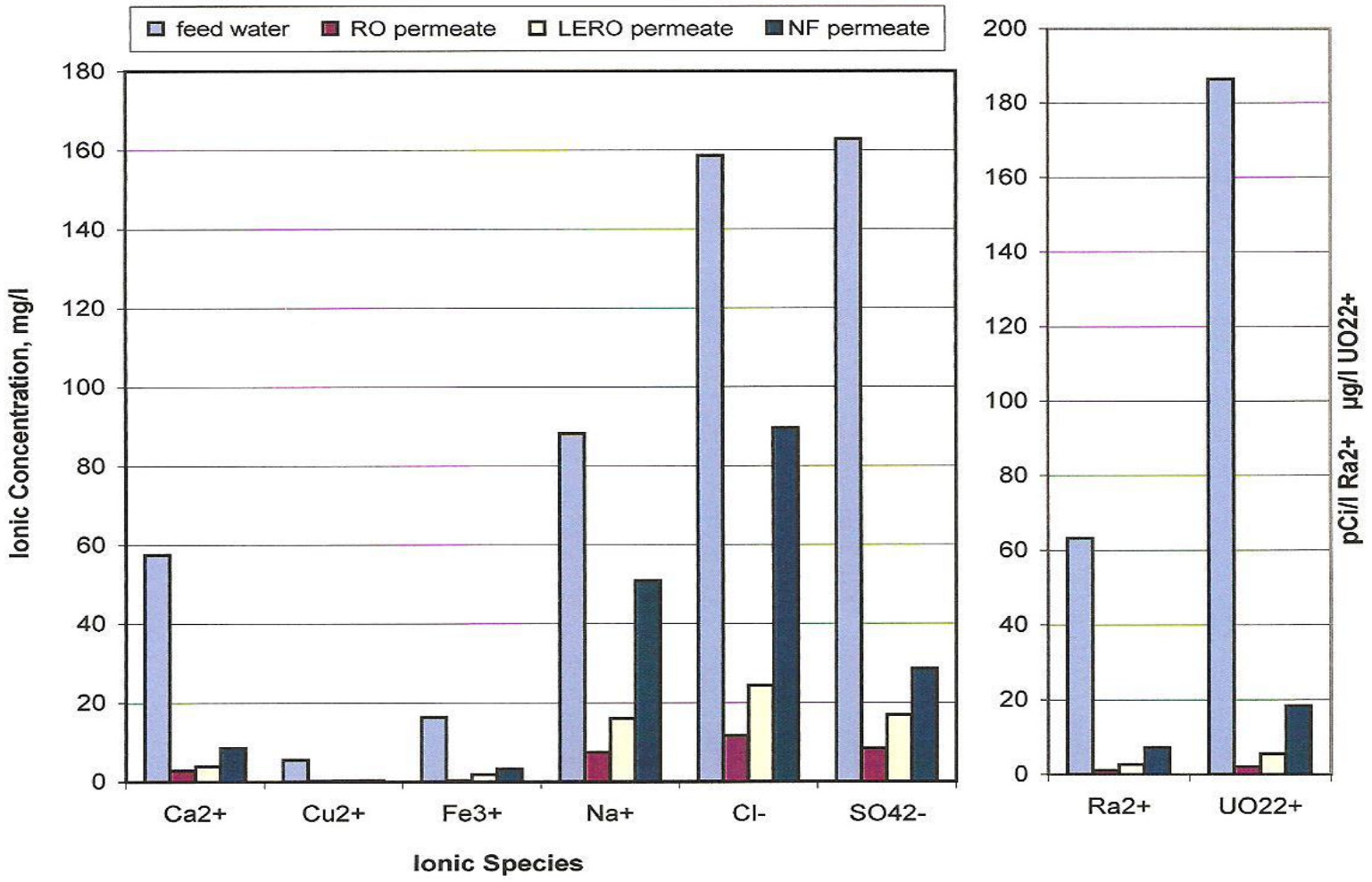


M.Gamal Khedr, Euromembranes International Conference, Hamburg (2004)

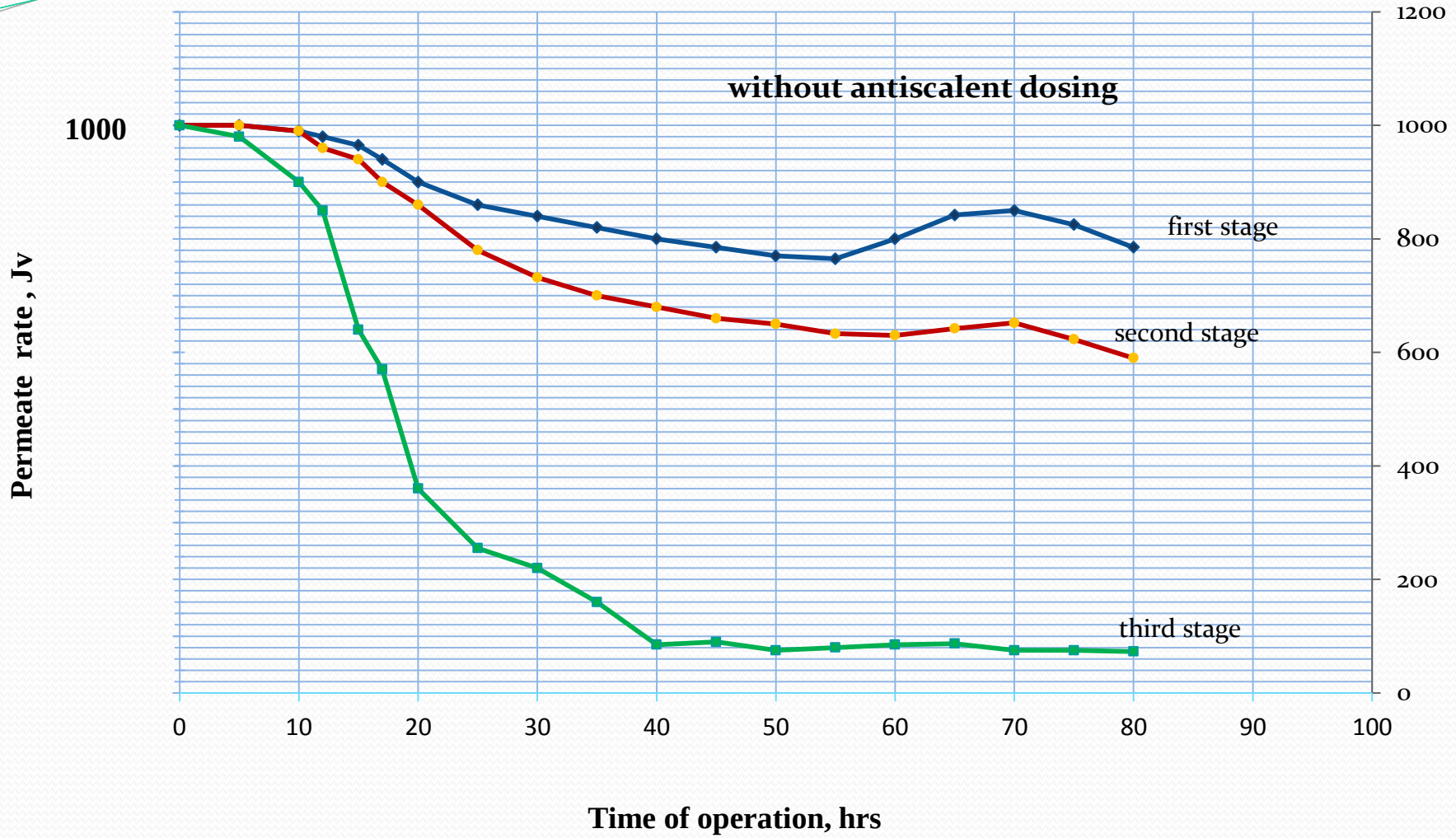


Schematic Representation of the Plot Plant

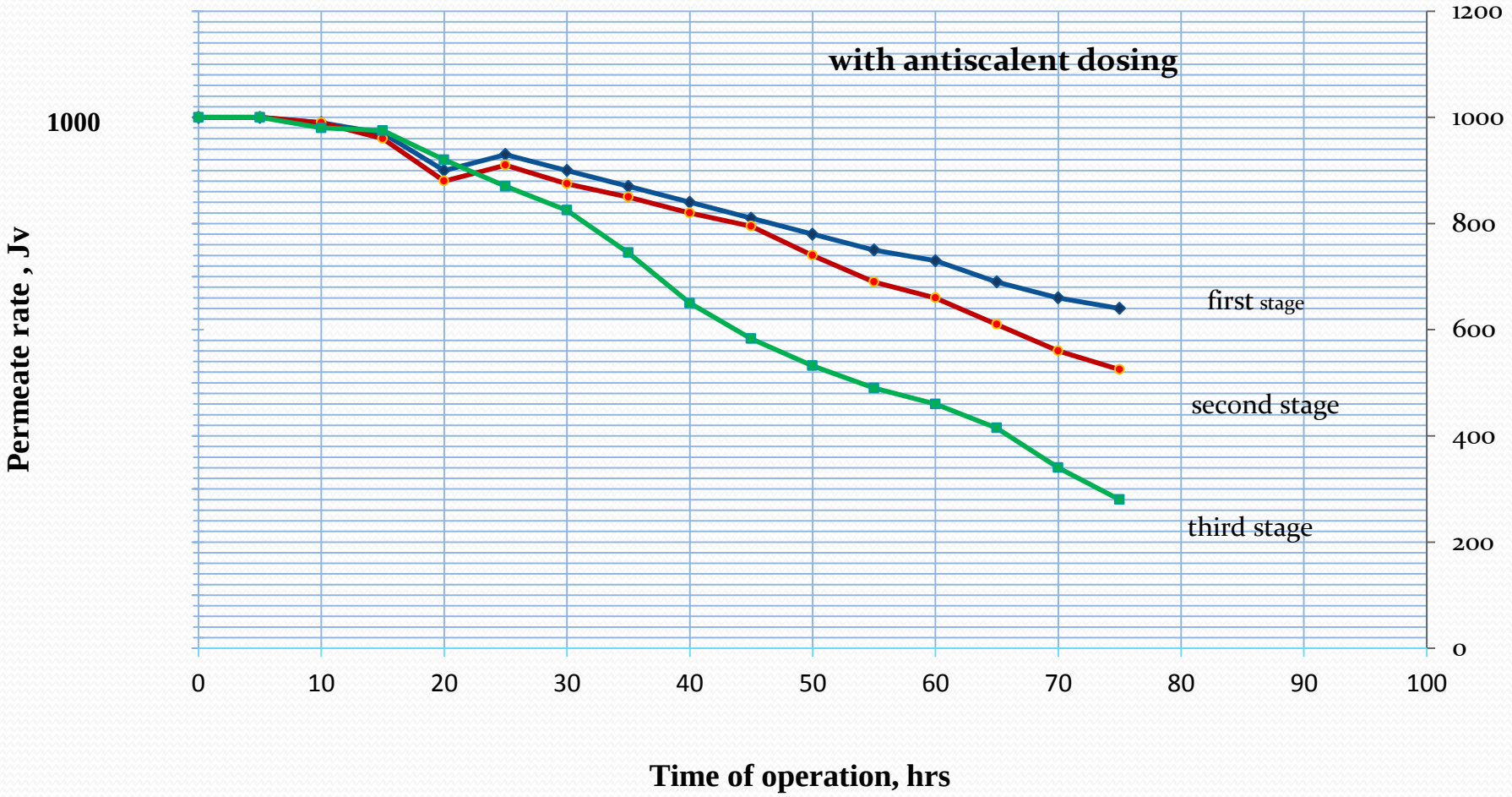

Comparison Between Softening of the RO Concentrate Stream
by NF and Hot Lime Method
Ionic concentraion, ppm
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Ca
Mg
Na
K
Sr
CO3
HCO3
Cl
SO4
Malk
Palk
SiO2
CO2
RO Concentrate Water Composition
Raw Water Concentration
NF Softening
HL Softening
M. Gamal Khedr, Euromembranes International Conference, Hambourg (2004)



Comparison of performance of membrane methods RO, LERO, and NF in treatment of contaminated water



Variation of permeate rate with time for the three stages of the NF system



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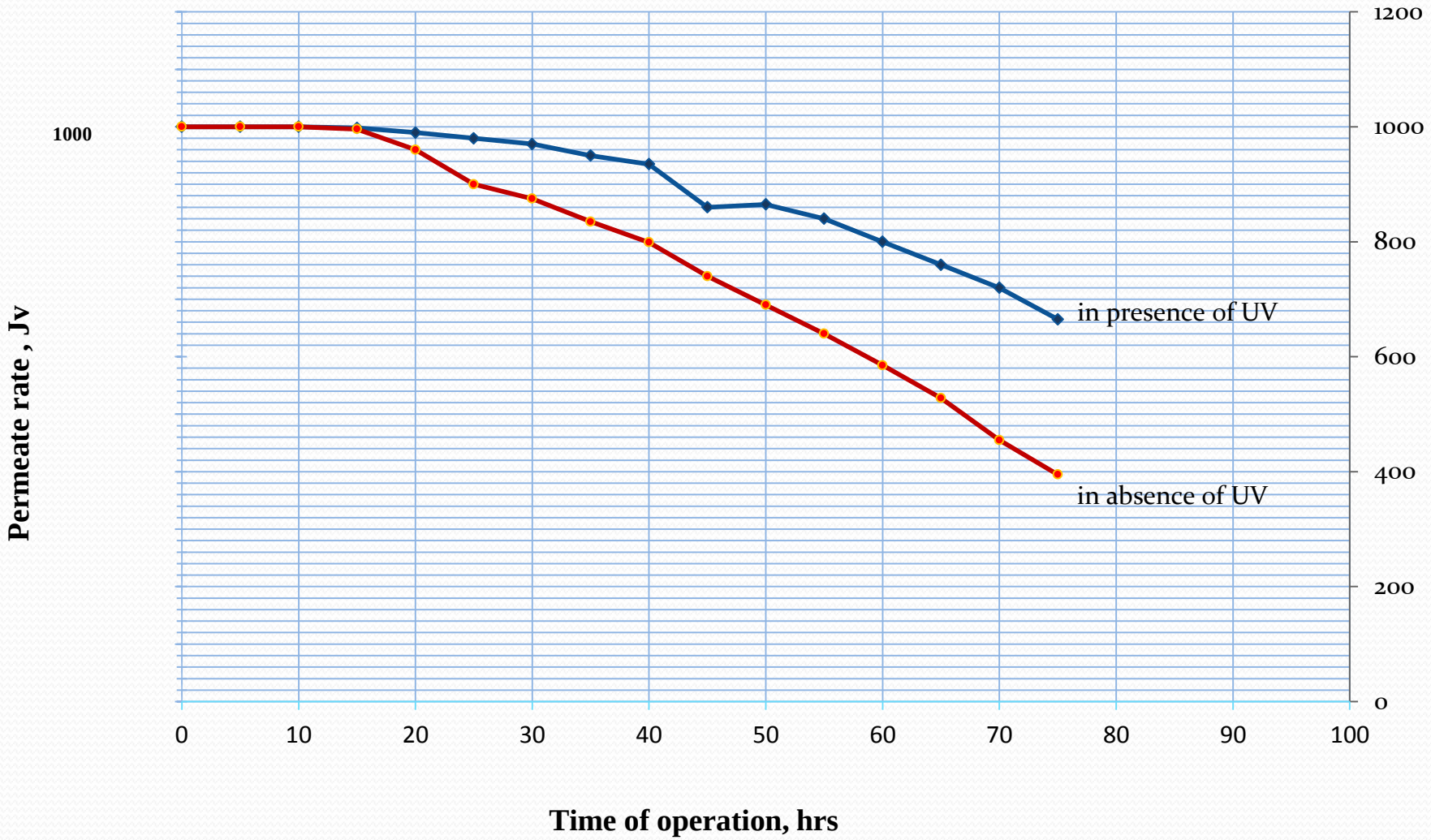
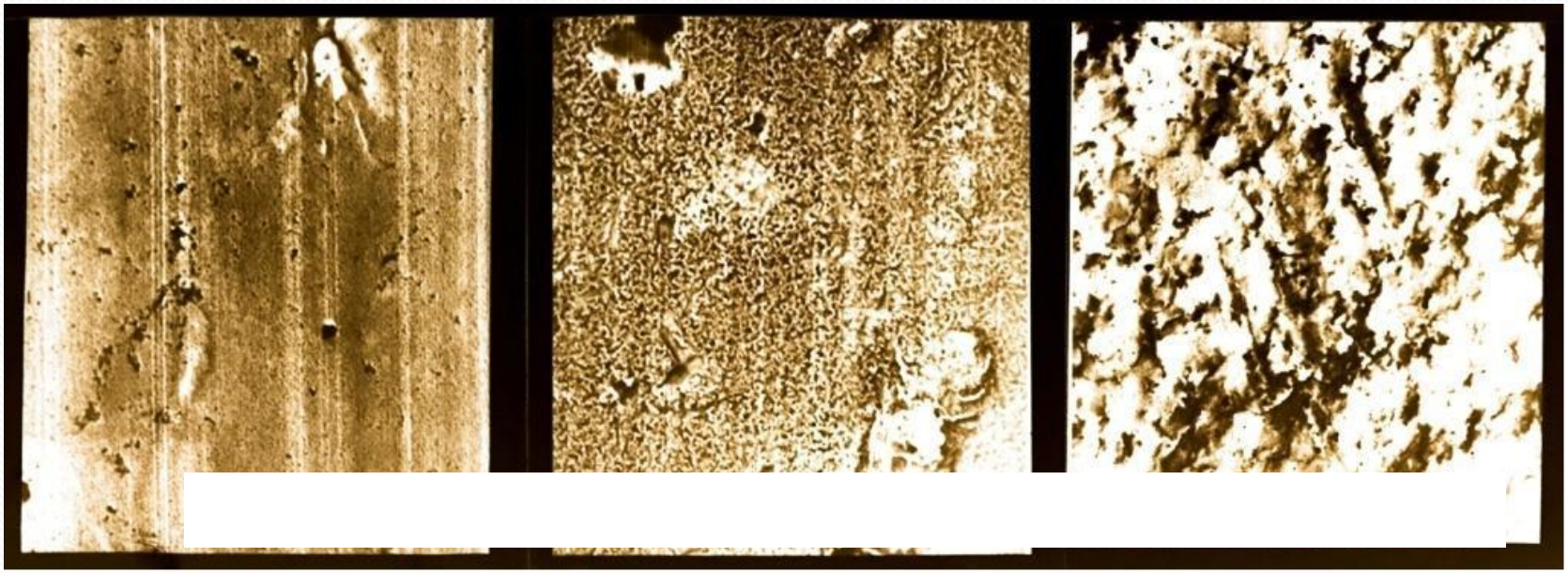


Variation of permeation rate with time in presence of organic or organic/biofouling



SE micrograph for membrane samples showing advance of fouling as function of time

Development of The Fouling Film

1. Colloidal Fouling

- Through **convective entrainment** of organic, silt, and colloidal particles and adsorption on membrane surface.
- Through **electrostatic interaction** between the surfaces charge s of the colloid particles, and/or **chemical interaction** through,
- The interaction between the polyvalent cations like iron or aluminum accumulated by membrane rejection in the diffusion layer with the stabilizing charge of colloidal particles.

2. Primary Scale Deposition

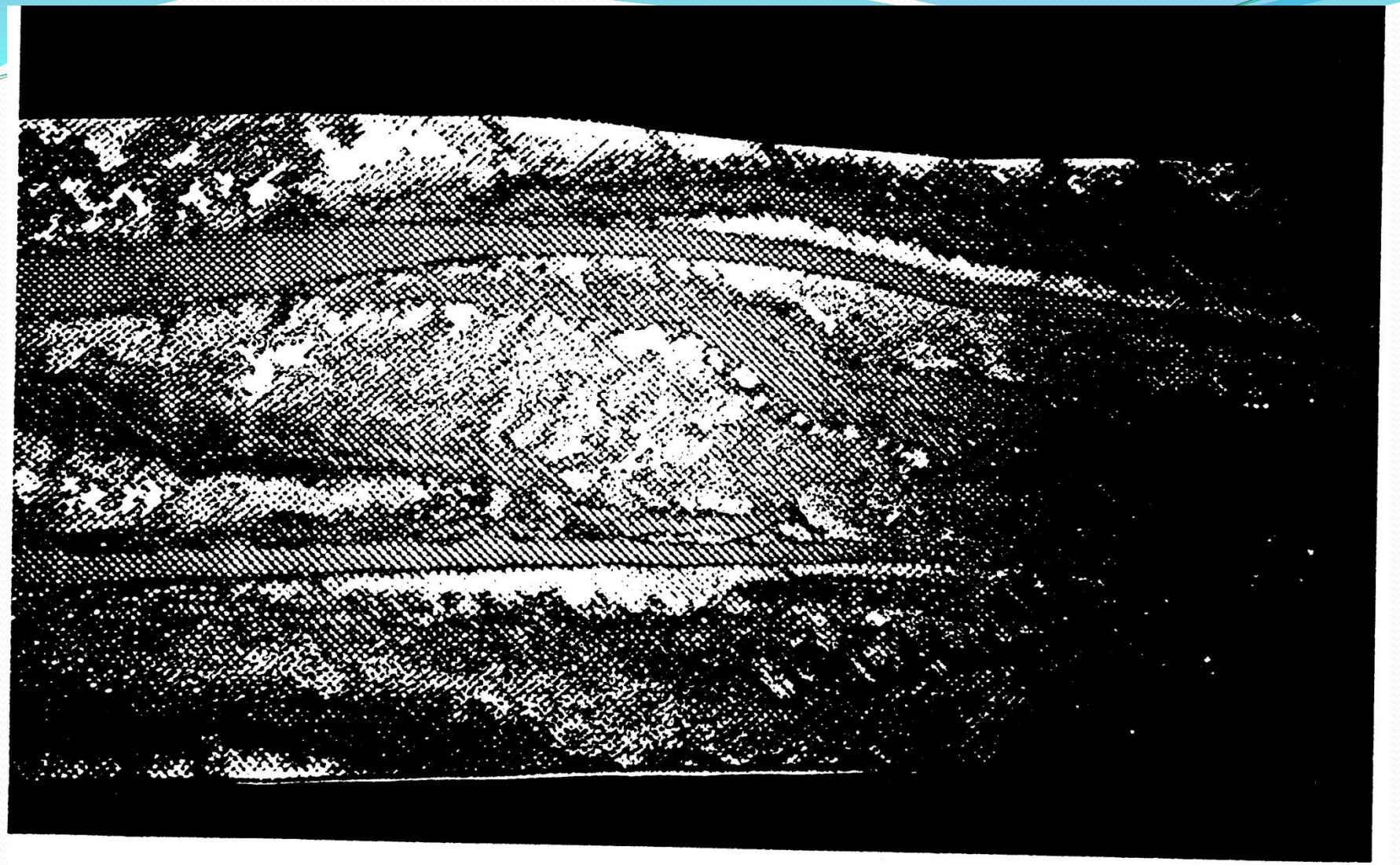
Parallel to 1 particularly in the last stages:

Deposition of supersaturating of sparingly soluble salts/compounds in view of:

- Inadequate acid or antiscalent dosage.
- Exceeded system design parameters:

  Too high recovery

  Too slow brine flow



Scale deposition, channeling, Strong concentration polarization, damage of hydrodynamic conditions.

3. Biofouling

a) Primary bacterial adhesion

is controlled by**:** Interfacial forces

- Long range forces
- Short range forces

Surface free energies interaction.

b) Film Growth and propagation

is controlled by :

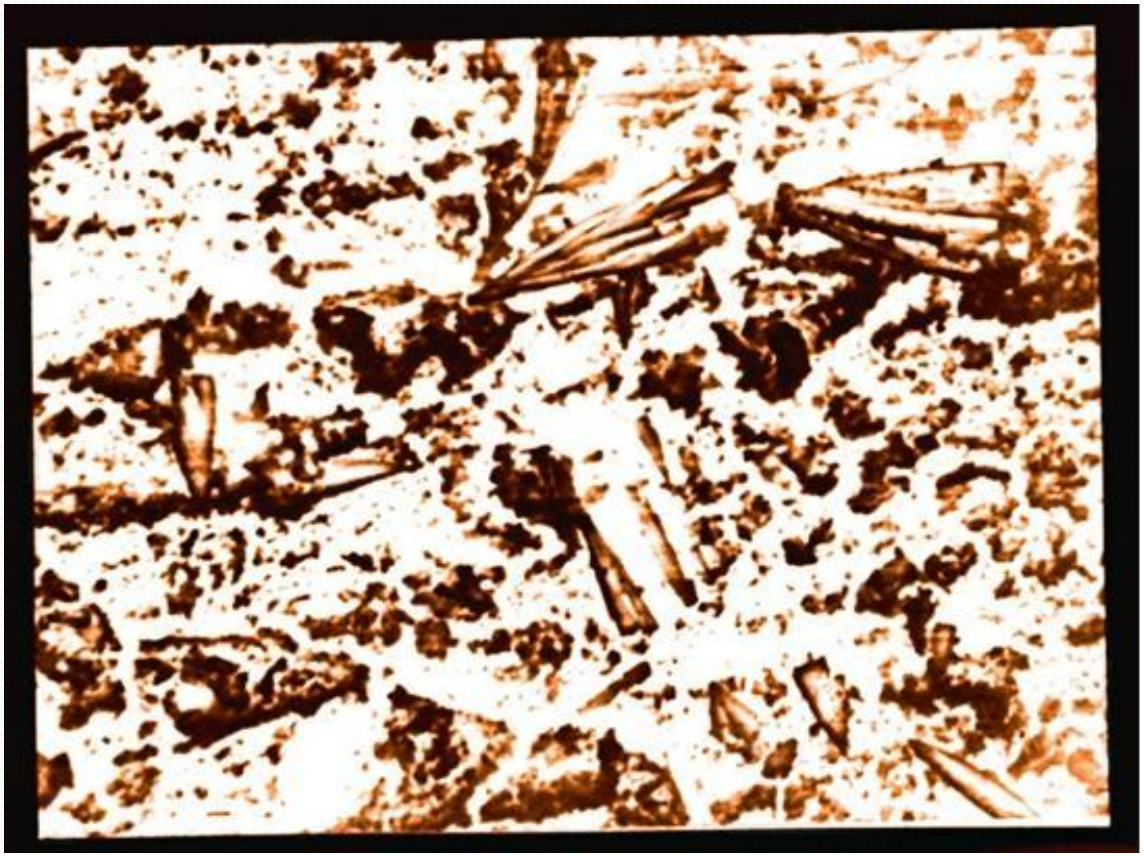
- Type of bacteria
- Temperature
- Availability and nature of nutrition:
  - C-rich compounds → Important growth + weak adhesion
  - N-rich compounds → Limited growth + Strong adhesion

c) Film Denaturation

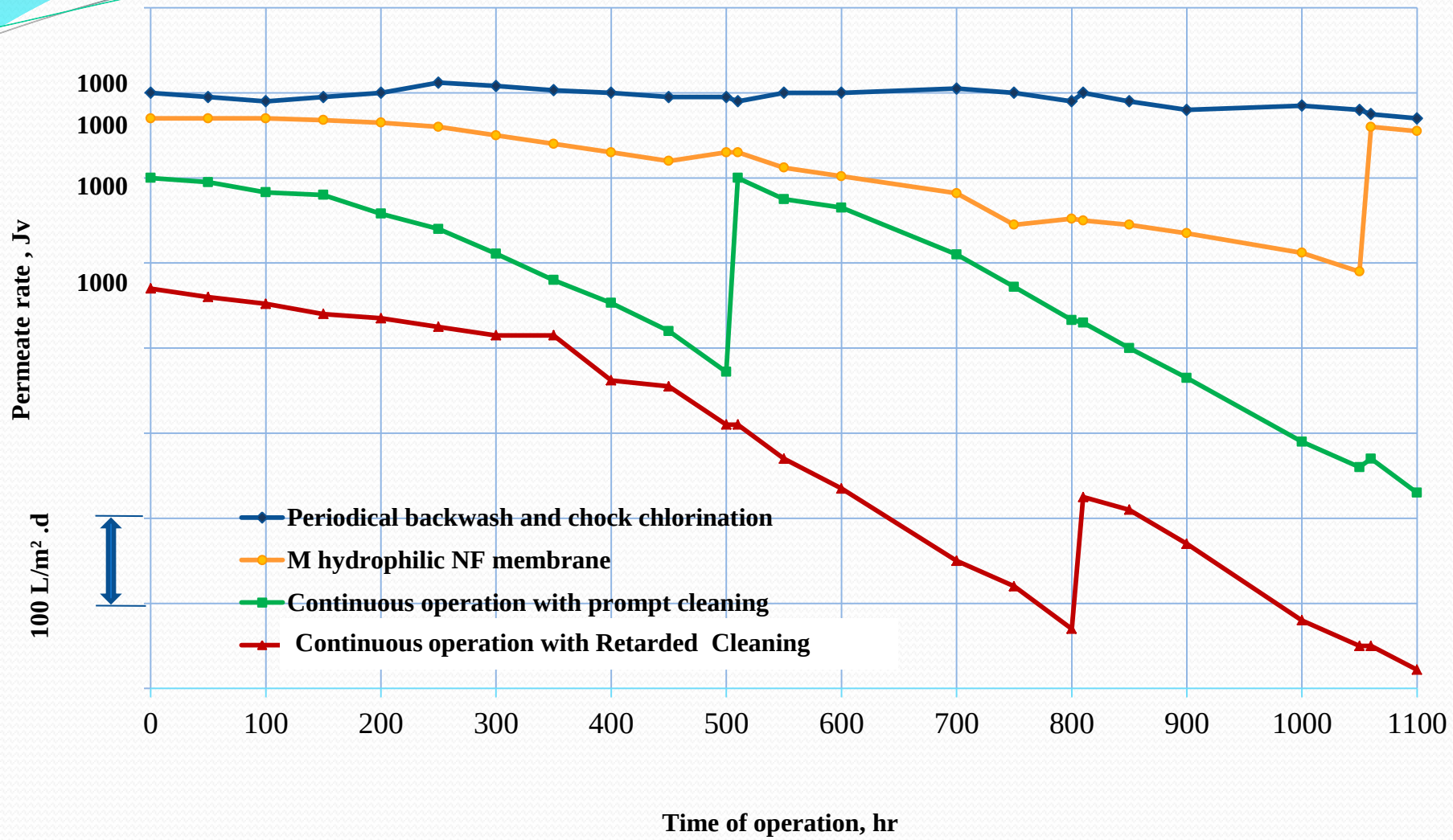
- Physical
- Chemical
- Biological

Biofilm further interferes with other wastewater components


Membrane
Autopsy



Inorganic scale crystal bundles embedded in the organic/biofilm matrix



Decline of product rate for various types of NF membranes upon fouling

Conclusions

- NF treatment of contaminated industrial wastewater resulted in organic/biofouling of membranes.
- **Results of inspection of fouled membrane surface by SE microscopy and of periodical analysis of the accumulated fouling deposit were correlated to the observed decline in NF performance.**
- **Mechanism of development of fouling film is established.**
- **Importance of interaction between the different forms of fouling on the decline of NF performance is demonstrated.**

- **The main factors that enabled to control the fouling of NF membranes are**:

a) Hindrance of the adsorption of organics and microorganisms on membrane surface through promoting its hydrophilicity.
b) Selection of membranes of lower surface charge and surface roughness.
c) Periodical backwash of membranes coupled with intermittent choc chlorination.
d) High temperature NF.