Biofilm control by On-line dosing of Genesol 80

Background:

Genesol 80 was introduced by Genesys about two years ago as a cleaning product to remove troublesome biofilms. Its use as an effective CIP cleaner for membranes has been well established. Laboratory data showed its potential for an online cleaner but a carefully monitored trial was required to establish this aspect.

As experienced operators will know, the biofilm formation in membranes is a result of

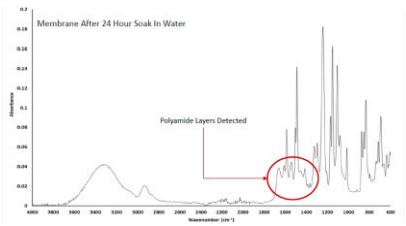
a) Spores, Cysts and well encapsulated bacteria that have survived chlorination – especially in alkaline feed water where chlorine has limited effect
b) Bacterial colonies post ACF and SMBS dosing that grow in a competition free and chlorine free environment by metabolizing trace levels of organic nutrients to form biofilms.
c) Biofilms act as a glue to accumulate clay and precipitates that might otherwise have been washed out of the system.

Media filters and activated carbon filters (ACF) are expected to be protected by chlorination but very often, the protection is not 100%. Over a period, biofilms form in these causing channeling that allows further growth. Unless the entire pre-treatment is thoroughly disinfected regularly, the RO membranes are likely to be inoculated by bacteria from these. Frequent disinfection of pre-treatment is a time-consuming affair and unless there is spare capacity, it also means disruption of RO operation.

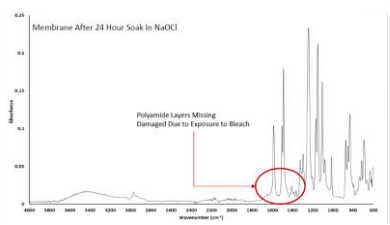
Dosing of non-oxidising biocides – especially DBNPA – is sometimes resorted to, but, as with all non-oxidising biocides, development of resistance by bacteria is always a possibility. Continuous dosing is therefore technically not a sound practice and would in any case be too expensive.

Effect on polyamide membranes:

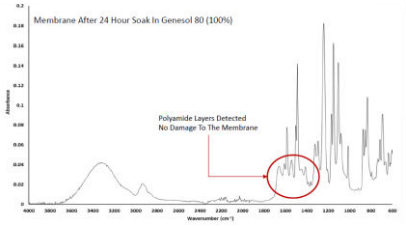
Genesol 80 is a weak oxidizing biocide. As a part of its development, its effect on membranes was thoroughly investigated.



Membrane after 24 hours soak in water



Membrane after 24 hours soak in NaOCl



Membrane after 24 hours soak in neat G 80

The polyamide layer after a 24-hour soak in neat Genesol 80 shows no damage whereas exposure to NaOCl shows significant damage.

With the well-established capability of Genesol 80 in removing biofilms, it was thought dosing this upstream of the pretreatment could reduce biofilm formation throughout the system.

Accordingly, a trial was designed and implemented at a paper mill in South India. The RO plants are supplied with borewell water and required frequent cleaning, replacement of cartridge filters and generally operated well below its design capacity.

Plant Description:

Two RO plants with identical pre-treatment scheme were in operation, only the capacities differed.

Both systems had heavy fouling and as a result, operated well above design feed pressure, lower feed, lower recovery and high DeltaP.

DESIGN DATA		
Array	**2:1**	**Single stage-2PV**
Total Number of vessels	**3**	**2**
RO Membranes in Each vessel	**4**	**3**
Total Number of RO Membranes	**12**	**6**
RO Membrane Make	**Hydranautics**	**Hydranautics**
Membrane Model Number	**CPA-2**	**CPA-2**
Design Feed flow in m^3/hr	**16**	**10**
Design Reject Flow in m^3/hr	**6**	**6**
Design Permeate Flow in m^3/hr	**10**	**4**
Design Recovery in %	**62.5%**	**40%**
Membrane Age	**4 months**	**2 Years**

Feed Water Quality:

Parameter	UoM	Raw Water
pH	-	8
TDS	mg/L	2000
Total Hardness, as CaCO3	mg/L as CaCO3	605
Ca	mg/L as Ca	160
Mg	mg/L as Mg	50
Na	mg/L as Na	460
Fe+2	mg/L as Fe	0.1
CO3	mg/L as CO3	3.19
HCO3	mg/L as HCO3	305
SO4	mg/L as SO4	250
Cl	mg/L as Cl	773
SiO2	mg/L as SiO2	20
CO2	mg/L as CO2	3.9

Pre-trial investigation:

Inspection of micron cartridge filters showed biofouling, clay, organics and a small amount of iron oxide. Accordingly, CIP was carried out with Genesol 703, Genesol 80 and Genesol 38 on 29th April 2021.

CIP with Genesol Cleaners:

Genesol 703: 2.5%, 3 rounds of circulation and intermittent soaking

Genesol 80: 2.0%

Genesol 38: 2.5%

Cleaning temperature: Ambient (~ 32 deg C)

Sl. No	Parameters	RO 1			RO 2		
		Before cleaning	After cleaning	Differ.	Before Cleaning	After Cleaning	Difference
1	**RO Feed flow in m^3/hr**	9.3	10.3	1	14.6	14.0	- 0.6
2	**RO Reject flow in m^3/hr**	6	6.3	-	7.8	5.0	- 2.8
3	**RO Permeate flow in m^3/hr**	3.3	4	0.7	6.8	9.0	+ 2.2
4	**Recovery in %**	35.48	38.83	3.4	46.6%	64.3%	+ 17.7%
5	**RO Feed pressure in kg/cm^2**	15.5	13.5	-2	14.0	7.2	- 6.8
6	**RO Reject Pr. in kg/cm^2**	12.5	12.5	-	12.5	6.4	- 6.1
7	**RO DP in kg/cm^2**	3.0	1.0	-2.0	1.5	0.8	- 0.7
8	**RO Feed TDS in ppm**	710	720	-	680	770	
9	**RO Permeate TDS**	90	85	-	38	65	
10	**Salt Passage in %**	12.68	11.81	-	5.59	8.44	

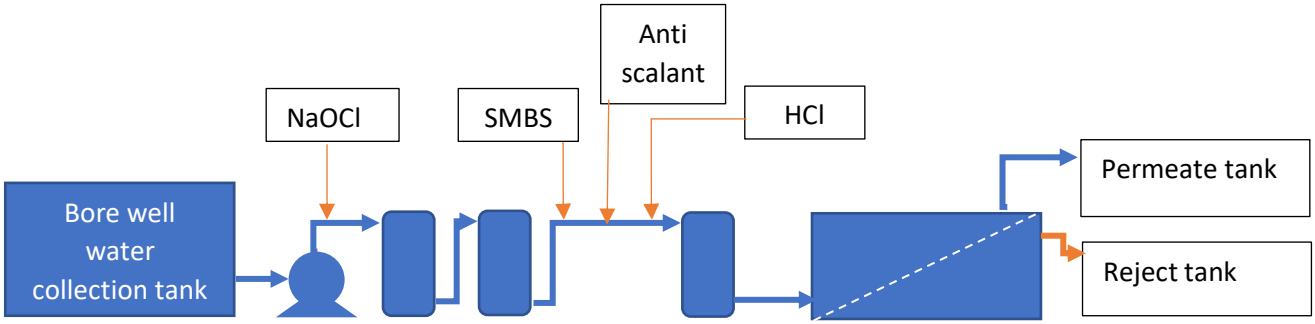
CIP Solutions after each circulation

The customer's team alongwith Wex team

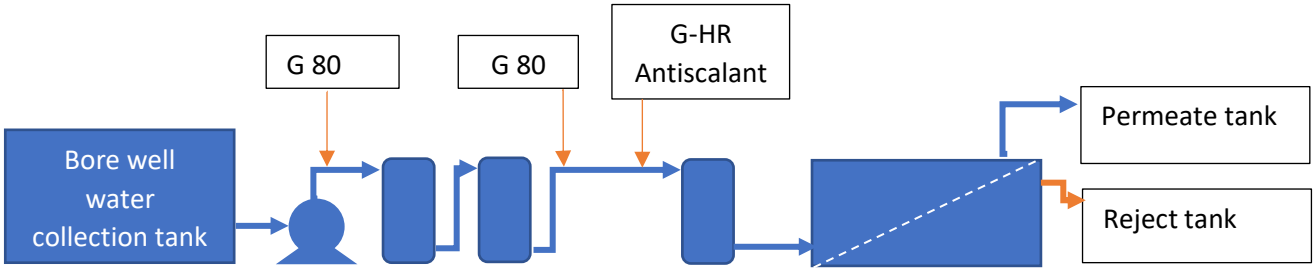
Genesol 80 dosing was started immpediately after CIP at pump discharge @ 10 ppm to prevent biofilm in the PSF and ACF. An additional 10 ppm was dosed at ACF outlet to protect the MCF and RO membranes. Dosing of SMBS was stopped. MM5 projections showed HCl dosing was not needed and hence only antiscalant Genesys HR was dosed along with Genesol 80 (separate tanks and dosing pumps).

The overall plant schematic – before and after introduction of Genesol 80 are summarised below:

Before Genesol 80:



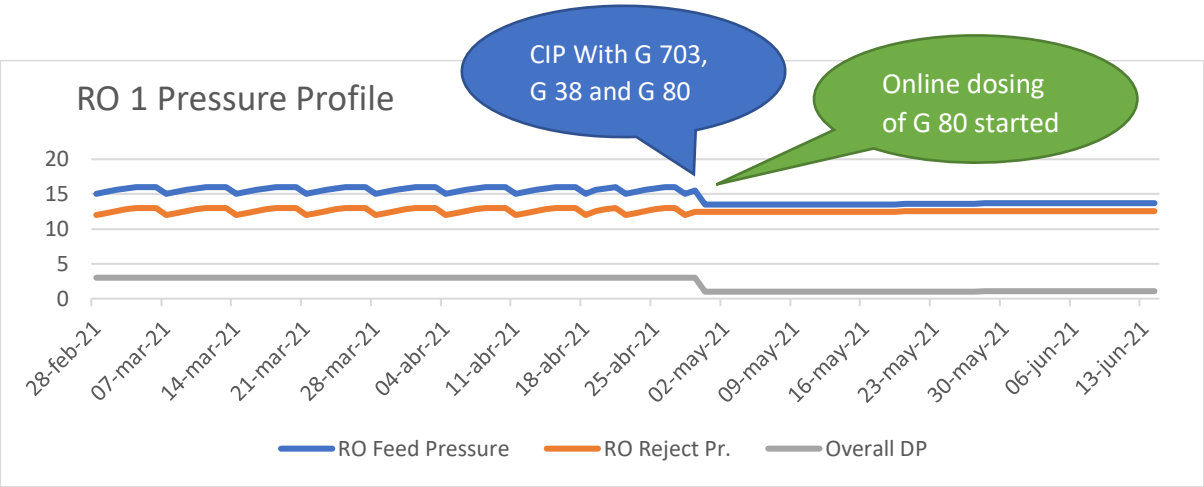
After Genesol 80:

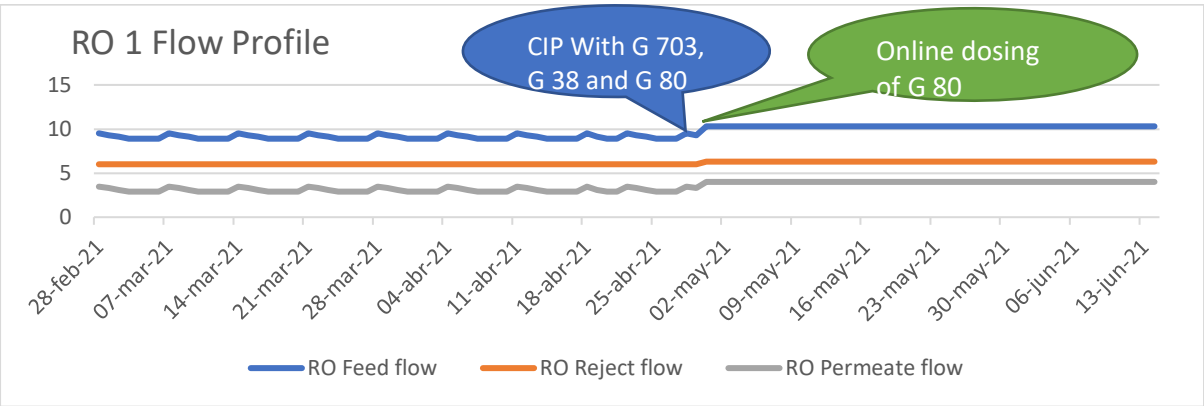


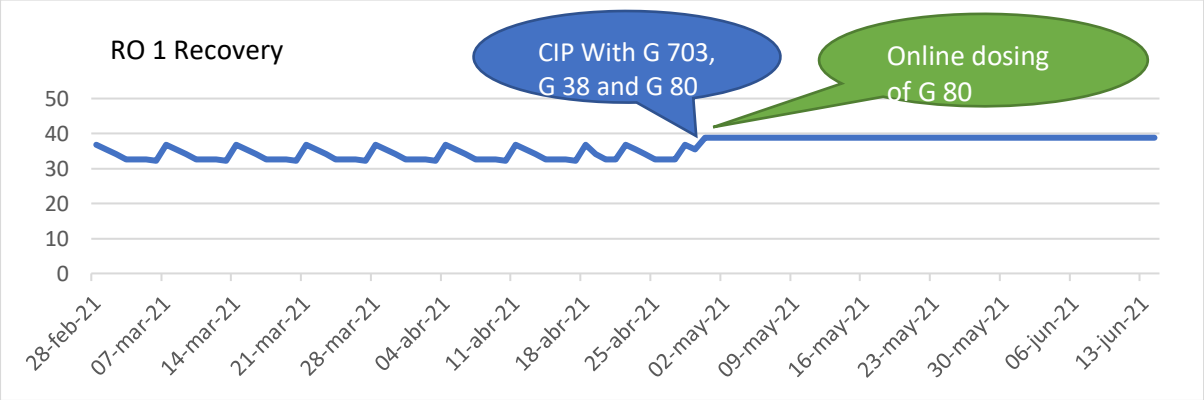
Permeate is further passed through a degasser and ion excahnge column and feed the boiler.

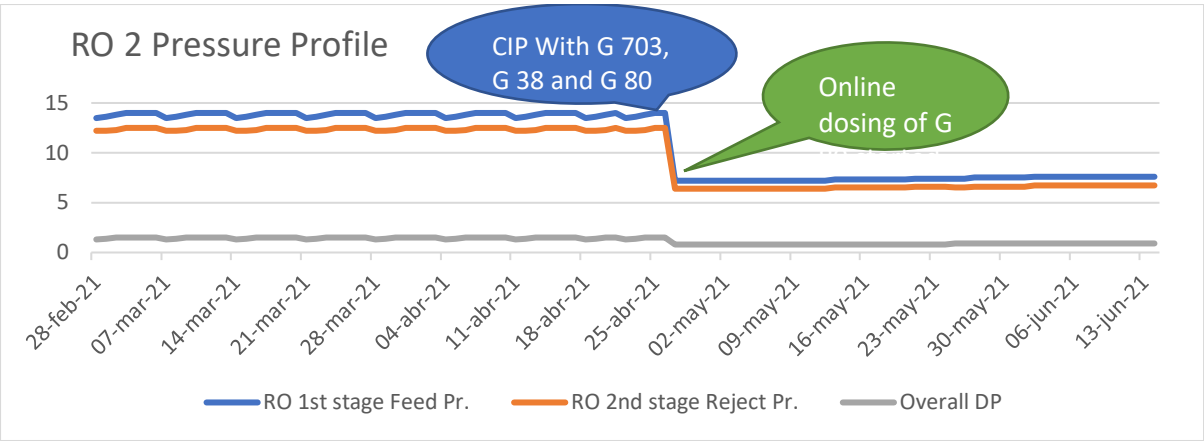
Effect of Genesol 80:

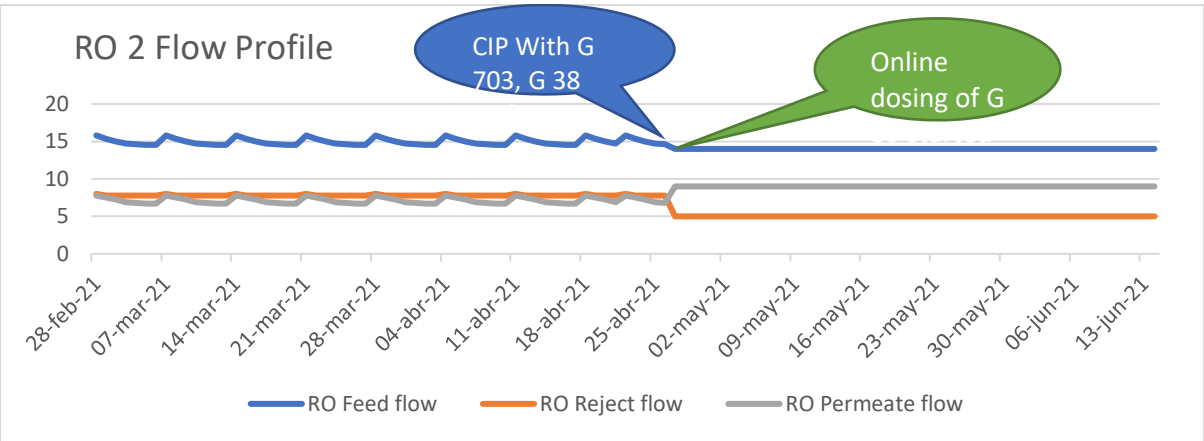
Cleaning that used to be done once in 5 – 7 days was not required for over a month of monitoring post introduction of Genesol 80. Recent feedback confirms the feed pressure, production and permeate water quality are well maintained even after 75 days of Genesol 80 dosing.

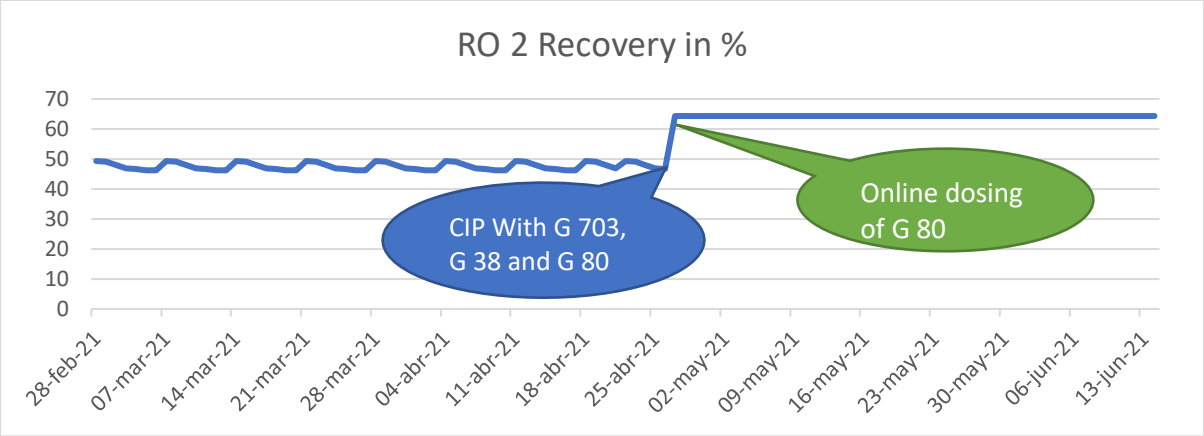







RO 2 Pressure Profile
CIP With G 703, G 38 and G 80
Online dosing of G
15
10
5
0
28-feb-21
07-mar-21
14-mar-21
21-mar-21
28-mar-21
04-abr-21
11-abr-21
18-abr-21
25-abr-21
02-may-21
09-may-21
16-may-21
23-may-21
30-may-21
06-jun-21
13-jun-21
RO 1st stage Feed Pr.
RO 2nd stage Reject Pr.
Overall DP


RO 2 Flow Profile
CIP With G 703, G 38
Online dosing of G
20
15
10
5
0
28-feb-21
07-mar-21
14-mar-21
21-mar-21
28-mar-21
04-abr-21
11-abr-21
18-abr-21
25-abr-21
02-may-21
09-may-21
16-may-21
23-may-21
30-may-21
06-jun-21
13-jun-21
RO Feed flow
RO Reject flow
RO Permeate flow


RO 2 Recovery in %
70
60
50
40
30
20
10
0
CIP With G 703, G 38 and G 80
Online dosing of G 80
28-feb-21
07-mar-21
14-mar-21
21-mar-21
28-mar-21
04-abr-21
11-abr-21
18-abr-21
25-abr-21
02-may-21
09-may-21
16-may-21
23-may-21
30-may-21
06-jun-21
13-jun-21

Cost Benefits:

1. **Reduction in raw water consumption**

Weighted average of RO 1 and RO 2	Before Cleaning/G80 Dosage	After Cleaning/G80 Dosage
Feed Flow in m^3/hr	**14.6**	**14**
Permeate Flow in m^3/hr	**6.8**	**9**
Recovery	**46.58%**	**64.3%**
Target RO Permeate water Production- m^3/day (Present Condition Requirement)	**72** (10.6 hrs*6.8)	**72** (8 hrs*9)
To achieve the Target RO Production, RO Running hours required & RO Feed Flow m^3/day	**10.6 hrs & 155 m^3** (10.6*14.6)	**8 hrs & 112 m^3** (8*14)
Total Raw water consumption in m^3/Day (with Backwash water of 2 Filters=20 m^3/day considered)	**175** (155+20)	**132** (112+20)
Saving of Raw water consumption per Day in m^3/day	**43**	
Raw Water Cost Saving Per Day in Rs. (App.Rs.65/- per m^3)	**2795/-** (43 m^3*Rs.65/-)	
Raw Water Cost Saving Per Month in Rs.	**83,850/-**	
Raw Water Cost Saving Per Year in Rs.	**Rs.10,20,175/-**	

2. **Power Savings: Energy consumption estimated from Hydranautics IMSD RO Projection Programme**

Weighted Average of RO 1 and RO 2	**Before Cleaning/G80 Dosage**	**After Cleaning/G80 Dosage**
Feed Flow in m^3/hr	**14.6**	**14**
Permeate Flow in m^3/hr	**6.8**	**9**
Recovery	**46.58%**	**64.3%**
Feed Pressure in kg/cm^2	**14**	**7.2**
Average RO Permeate Quantity in m^3/day (Present Condition)	**70**	**70**
Specific Power consumption in kwh/m^3 (Pump Energy kwhr/m^3)	**1.04**	**0.31**
Total Power consumption in kwh	**72.8**	**21.7**
Cost of Power consumption per Day in Rs. (Rs.6.5/- per kwhr)	**473**	**141**
Power Cost Saving Per Day in Rs.	**332/-**	
Power Cost Saving Per year in Rs.	**119,520/-**	

3. **Increased membrane life:** Membrane life is directly affected by number of cleanings – especially alkaline cleanings. By reducing cleaning frequency from once a week to once in two – three months, it is reasonable to expect at least doubling of membrane life.

   Total number of membranes: 18

   Replaced annually (current): 9

   Cost of one membrane: Rs. 32,000/-

   Annual membrane replacement cost: 2,88,000/-

   Savings by doubling membrane life: 1,44,000/- (50% of above)

4. **Other costs saved:**
   a. Cleaning chemicals, SMBS, HCl
   b. Cartridge filter replacement
   c. Manpower costs for cleaning

Summary

Genesol 80 is a safe and effective product for on-line dosing to prevent biofilm formation not just in the membranes but also in pre-treatment equipment.

Acknowledgement:

The trial was supervised by J. Parathvairam of Wex Technologies Pvt. Ltd. – our distributor in India – and we would like to acknowledge his contribution to this.