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International Water Resources Association
IWRA

XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
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Kingdom of Morocco
Ministry of Equipment and Water

Antibiotic tetracycline removal by nanofiltration membrane: Experimentation and statistical modeling

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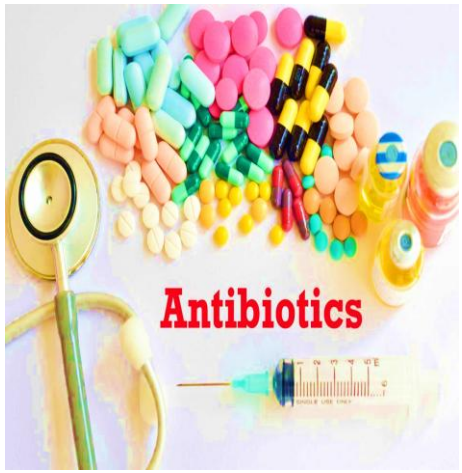
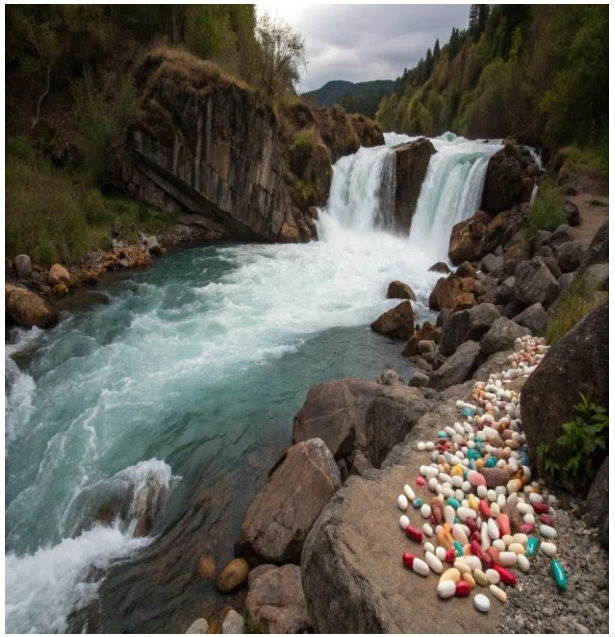
Plan

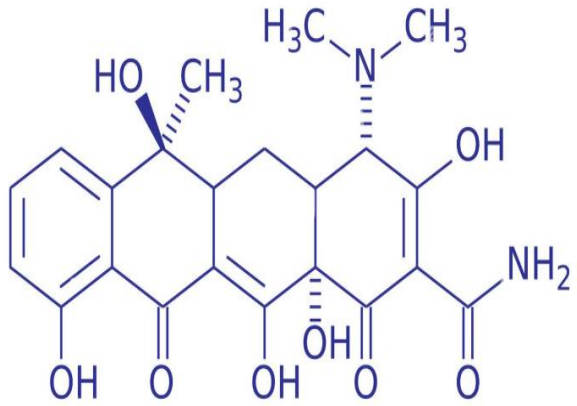
1. Introduction and General Background
2. Problem Statement and Objectives
3. Materials and methodes
4. Resultats and discussions
5. Conclusion


Antibiotics



Problem

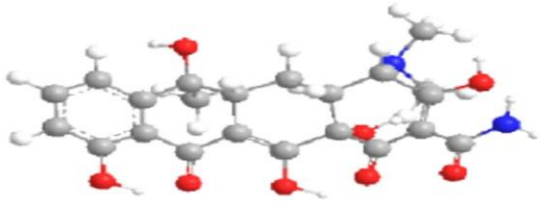
Tetracycline



Gastrointestinal disease

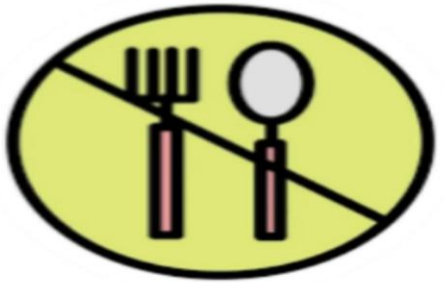
Environmental health

Skin infections

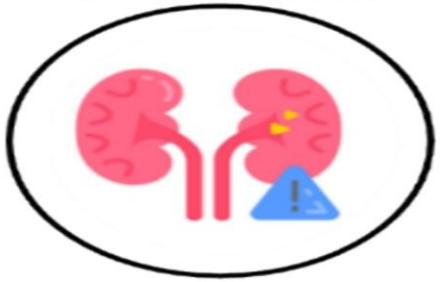


Tetracycline

Intracranial hypertension

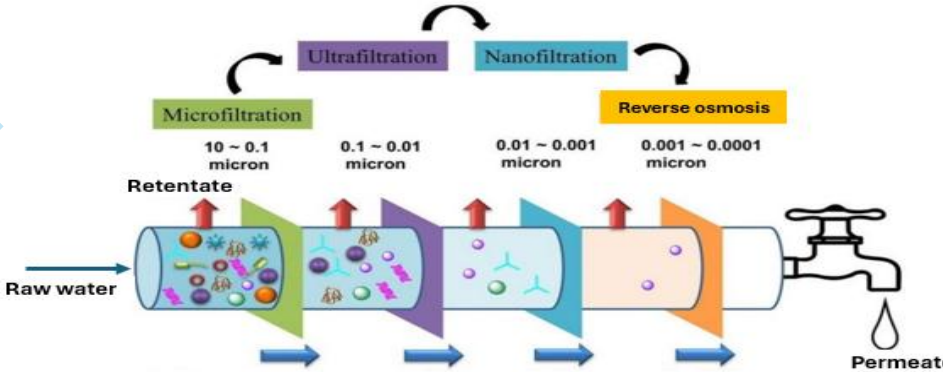


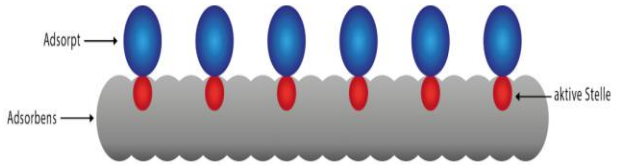
Food safety

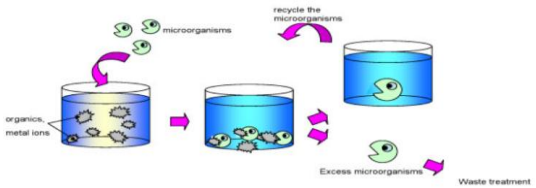


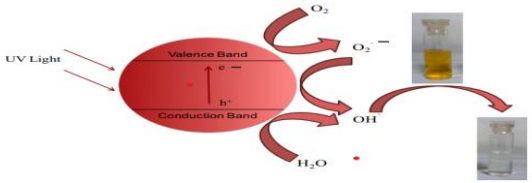
Renal dysfunction

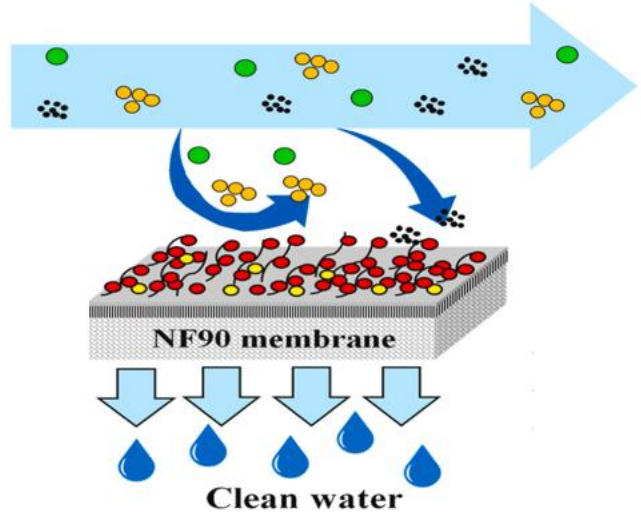

Antibiotic waste water
treatment technologies


Ultrafiltration
Nanofiltration
Microfiltration
Reverse osmosis
10 ~ 0.1 micron
0.1 ~ 0.01 micron
0.01 ~ 0.001 micron
0.001 ~ 0.0001 micron
Retentate
Raw water
Permeat


Adsorpt
Adsorbens
aktive Stelle

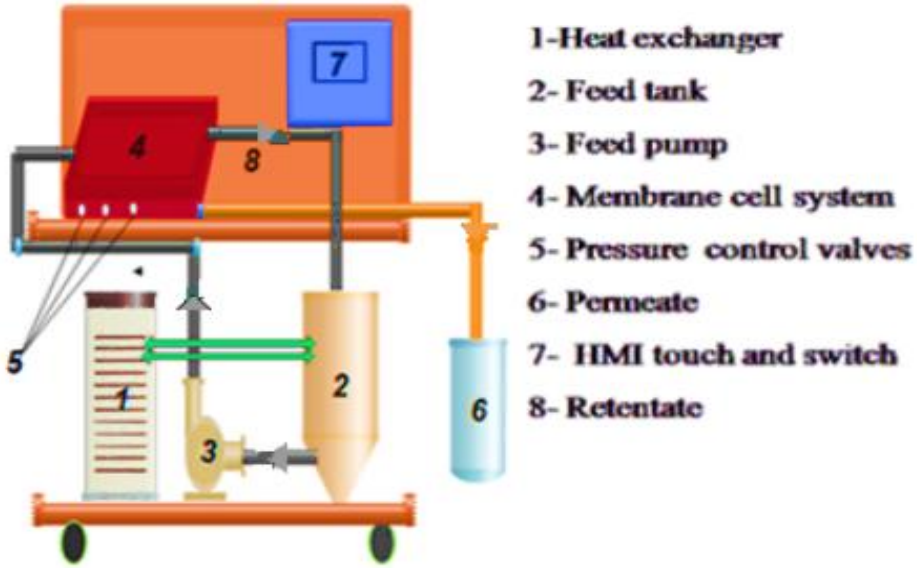

microorganisms
recycle the microorganisms
organics, metal ions
Excess microorganisms
Waste treatment


UV Light
Valence Band
Conduction Band
OH


Feed
NF90 membrane
Clean water

Experimental setup and membrane characteristics

Scheme of the NF pilot laboratory



1-Heat exchanger
2- Feed tank
3- Feed pump
4- Membrane cell system
5- Pressure control valves
6- Permeate
7- HMI touch and switch
8- Retentate

Membrane : Nanofiltration NF 90

NF90*4040 membrane characteristics	
Area (cm2)	140
Salt rejection (%)	97%
Pmax (bar)	41
Material	Polyamide
Contact angle (°)	54
Zeta potential (mV)	-19.4 (pH=12) & 3.7 (pH=3)

Experimental design methodology

Application of Central Composite Design

Variables		Factor levels				
Input	**Unit**	-2	-1	0	+2	+2
Concentration (A)	**mg/l**	2,5	15	27,5	40	52,5
TMP (B)	**bar**	2,5	10	17,5	25	32,5
pH (C)		4	5,5	7	8,5	10
Qf (D)	**L/h**	73,2	128,1	183	237,9	292,8

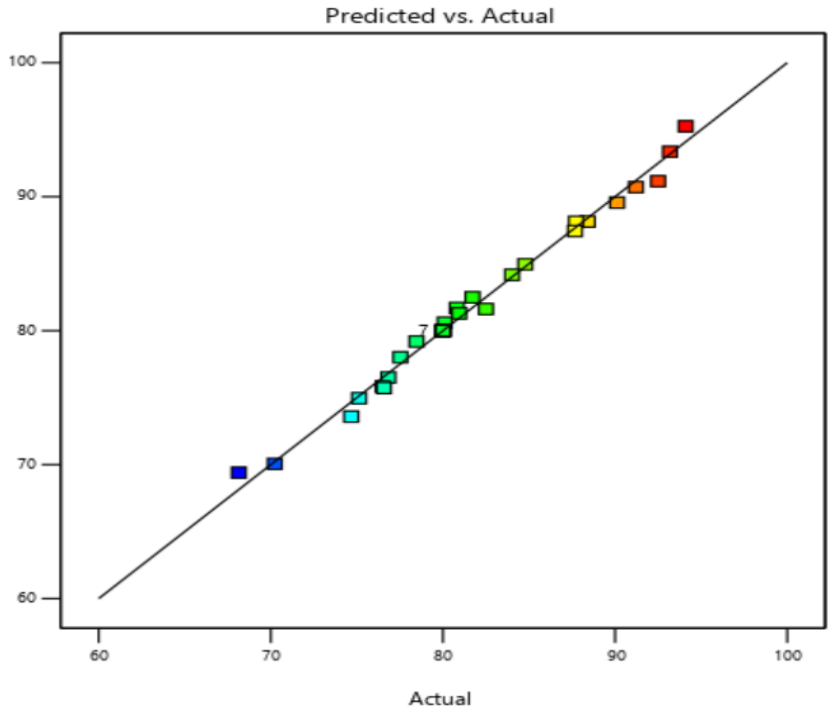
Experimental design methodology

Run	Input				Output
	A	B	C	D	Rejection %
1	0	0	0	0	80
2	-1	-1	+1	-1	76,5
3	0	0	0	0	80
4	0	0	0	0	80
5	0	0	0	0	80
6	-1	-1	+1	1	93,19
7	+1	+1	-1	-1	75,13
8	+2	+2	0	0	76,57
9	0	0	0	0	90,12
10	0	0	+2	0	84,02
11	0	0	0	0	80
12	-1	-1	-1	1	94,1
13	0	0	0	0	80
14	0	0	0	2	92,5
15	+1	1	+1	-1	80,1
16	0	0	-2	0	87,67

Run	Input				Output
	A	B	C	D	Rejection %
17	+1	1	+1	-1	74,67
18	1	0	0	0	80,95
19	1	-1	1	-1	78,46
20	-1	+1	-1	-1	70,23
21	-1	-1	-1	1	82,5
22	-1	-1	1	-1	91,21
23	0	0	0	-2	77,53
24	0	0	-2	0	68,14
25	-1	+1	1	-1	88,41
26	0	0	0	0	80
27	1	+1	1	1	87,73
28	1	-1	1	1	84,78
29	-1	-1	-1	-1	76,83
30	1	+1	1	-1	80,81
31	-2	0	0	0	81,72

ANOVA of the Model and Model-Based Comparison of Predicted and Actual Tetracycline Rejection (%)

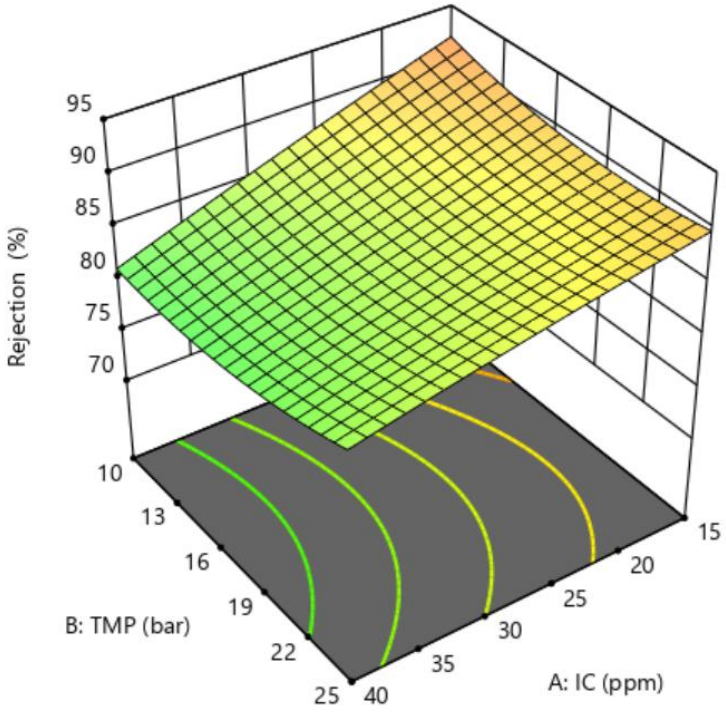
Response	Rejection %
Degree of freedom	14
Sum of squares	1221,91
Mean squares	87,28
F-value	121,88
p-value	<0.0001
Significance	Significant
R^2	0,9907



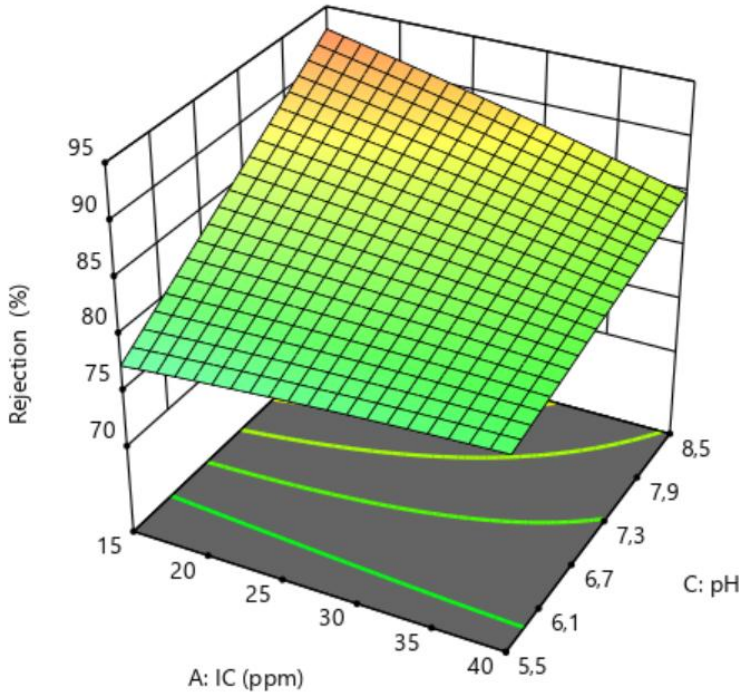
Modeling Tetracycline Rejection as a Function of Operating Parameters

Rejection (%) =80,00-1,69A-0,8175B+5,44C+2,89D+1,27AB-2,49AC+0,3050AD+0,9688BC+0,1688BD-0,1425CD-0,2235 A^2+1,45B^2+1,45B^2+0,0702 C^2+0,9465 D^2

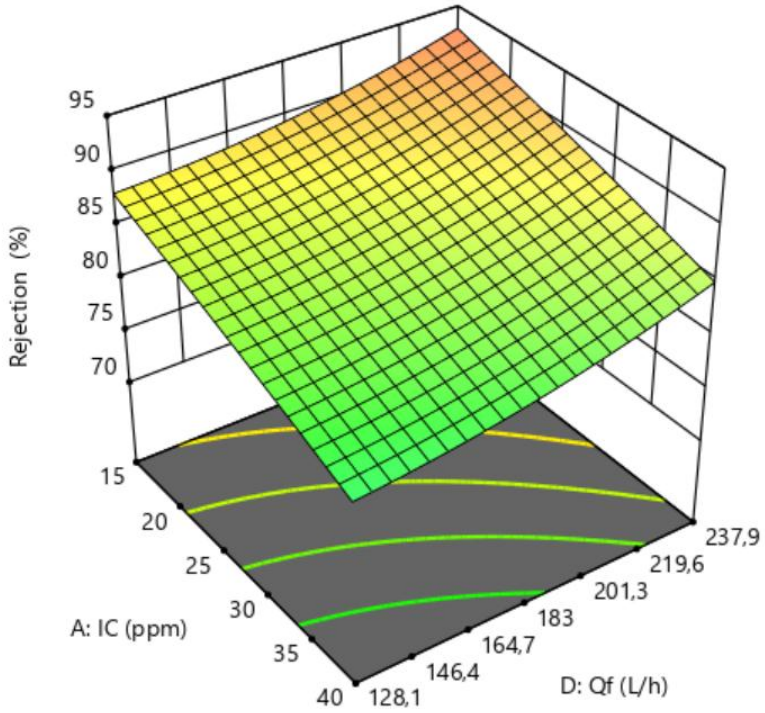
Response surface of A and B, A and C, A and D interactions



a

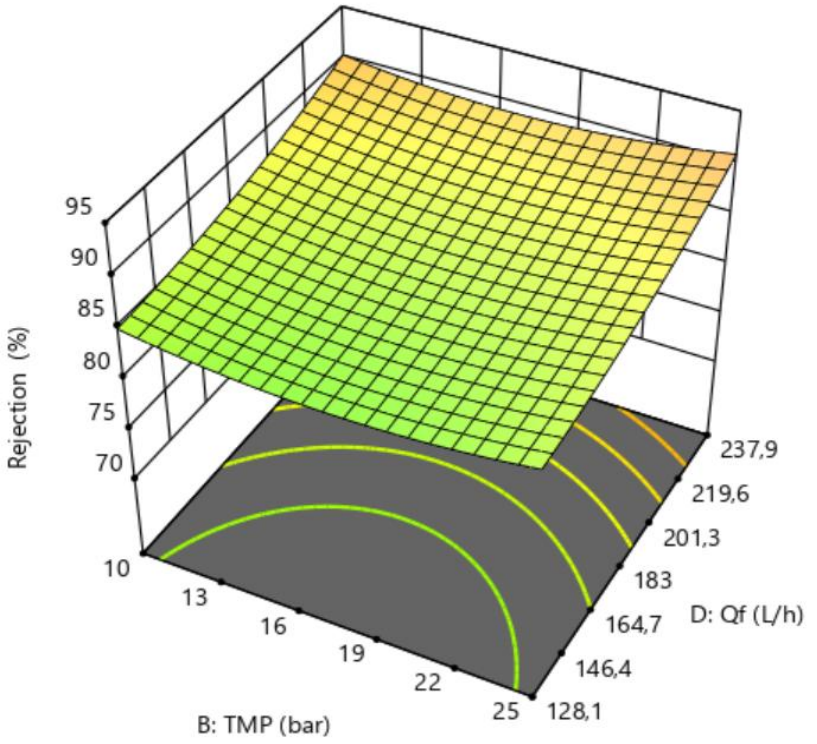


b

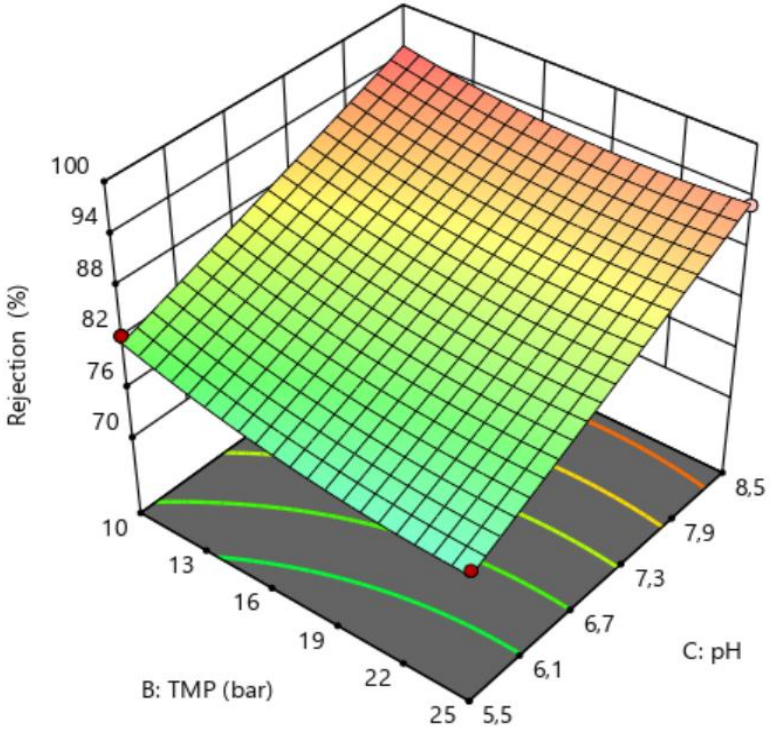


c

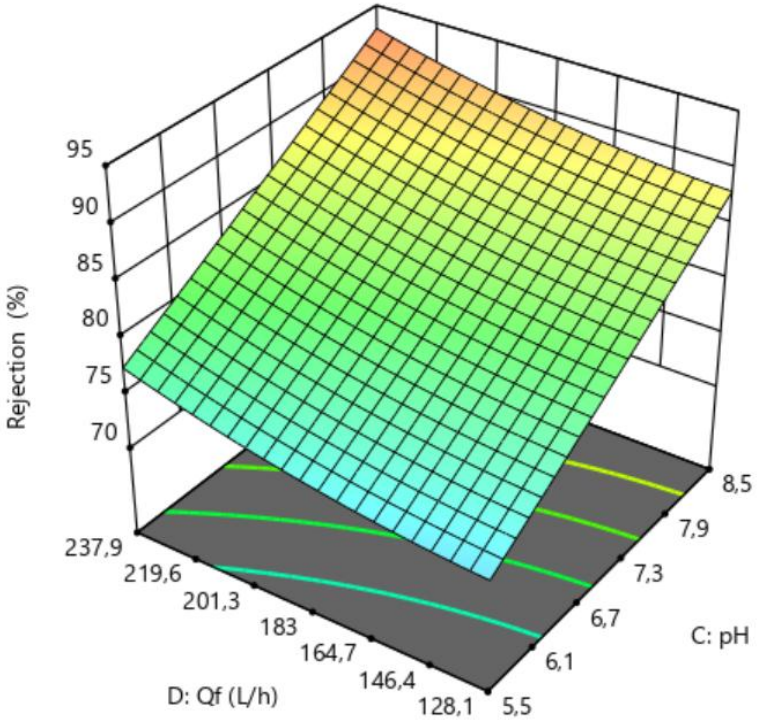
Response surface of B and D, B and C, D and C interactions



d



e



f

Nanofiltration proved to be highly effective for tetracycline removal, achieving up to 94.1% at 10 bar, with a feed flow rate of 237.9 L/h, a concentration of 15 mg/L, and pH 8.5, with pH and feed flow rate being the most influential parameters while pressure and concentration had a limited impact; these results were confirmed by the RSM analysis, which showed excellent accuracy (R^2 = 0.99) and strong predictive capability of the model.

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Thank you!

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