Experimental Results on N-NH_3 Destruction Using AOP

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February 2nd, 2022

Context

Use of Explosives (ANFO)

Use of Cyanides

Human Activities

Thiocyanates (SCN^-)

Ammonia (NH_4^+)

Cyanides (CN^-)

Cyanates (OCN^-)

Management and effective treatment !!

Context

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Problematic

- Gold mine effluents are generally loaded with nitrogen compounds that must be treated effectively to meet federal and provincial discharge standards.
- Conventional treatment processes are the most commonly used but are either costly and add further contamination and complexity to the matrix for toxicity removal, or less effective for treating high levels of contamination especially in cold climates

Objective:

- Evaluate and optimize the advanced oxidation processes using to remove toxic nitrogen compounds from mine effluents

An Innovative Approach

Problematic : contamination

ANFO → Ammonia (NH_4^+)

Cyanidation → Cyanate (OCN^-)

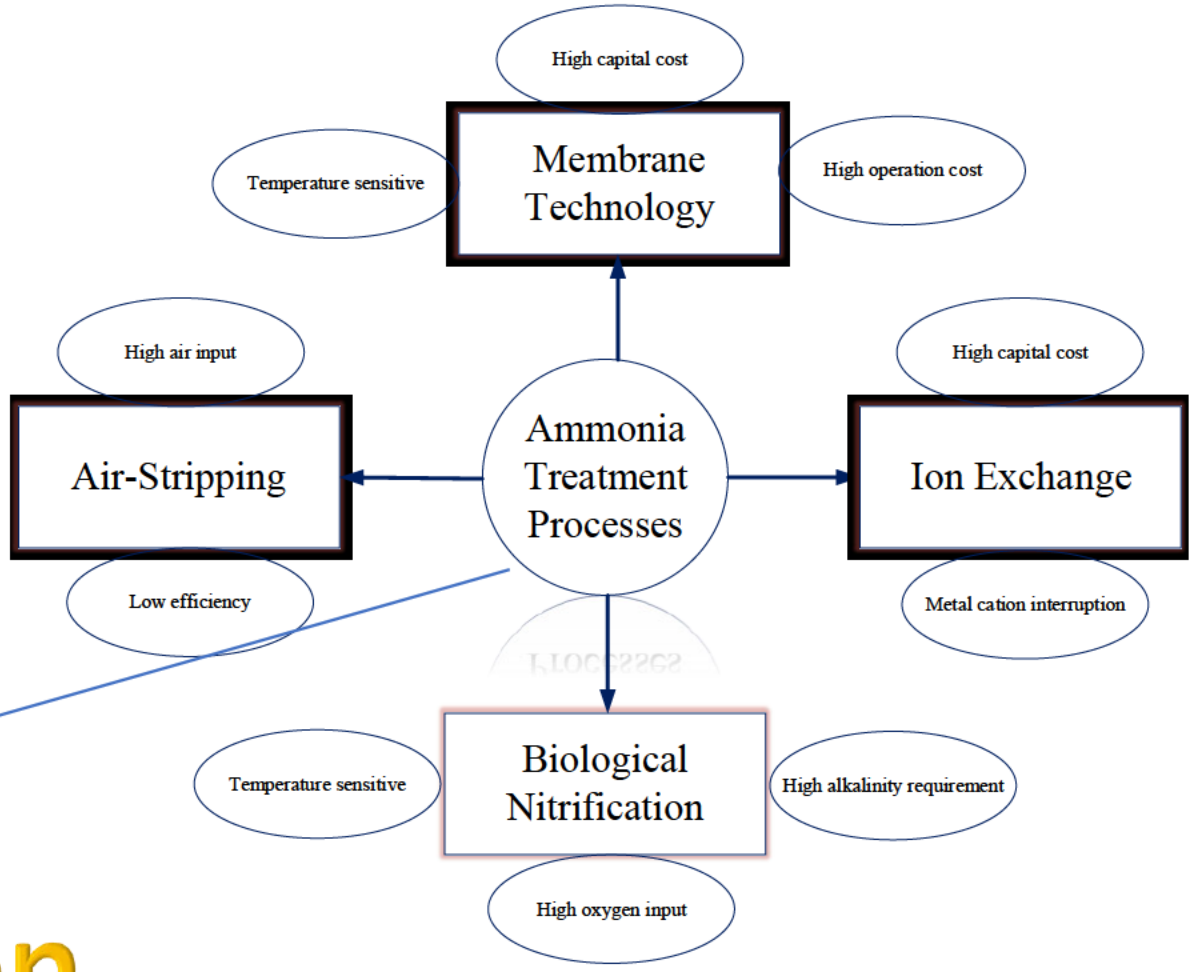
Sulfur-based ores → Thiocyanate (SCN^-)

Ore composition → Metals and metalloids

(Zn, As, Pb, Cu, Pb, Fe, B, Se, Sb, Si, etc.)

pH, Acidity, Alkalinity, etc.

Solution : Treatment



Advanced Oxydation

Collaboration & Partnership

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Technology provider: Kairospace

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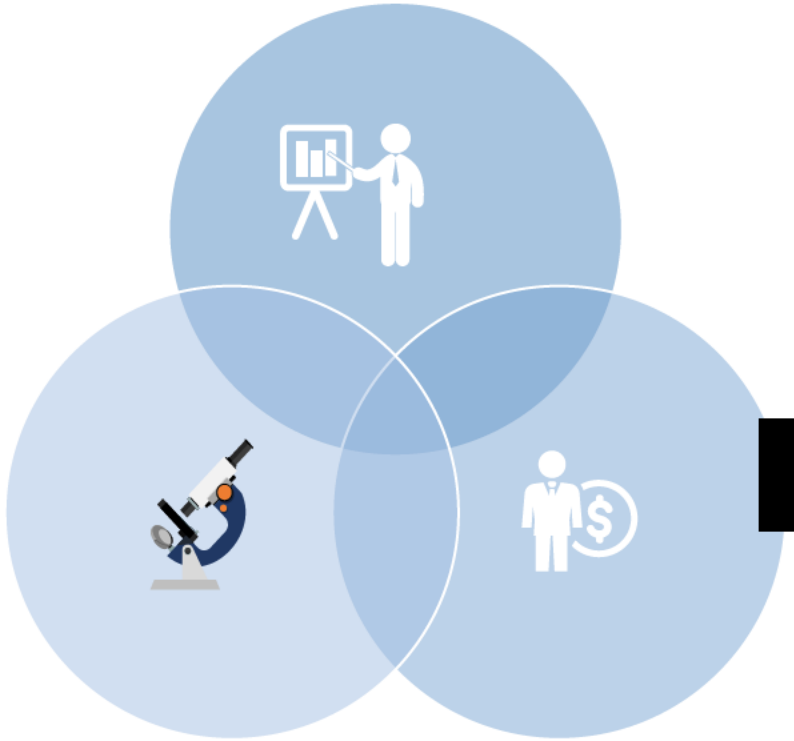

[redacted] **old corporation**

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Funding program: [redacted]

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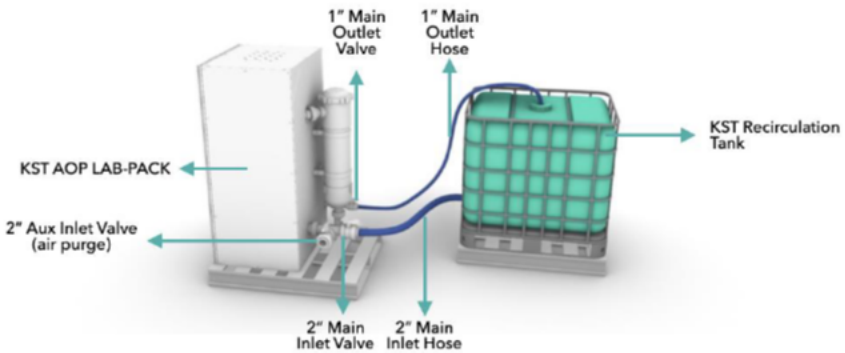
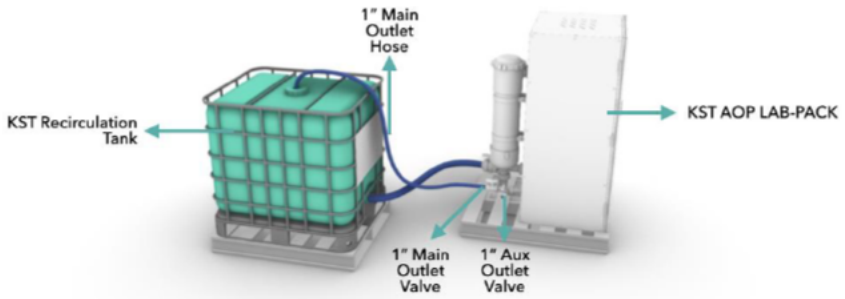
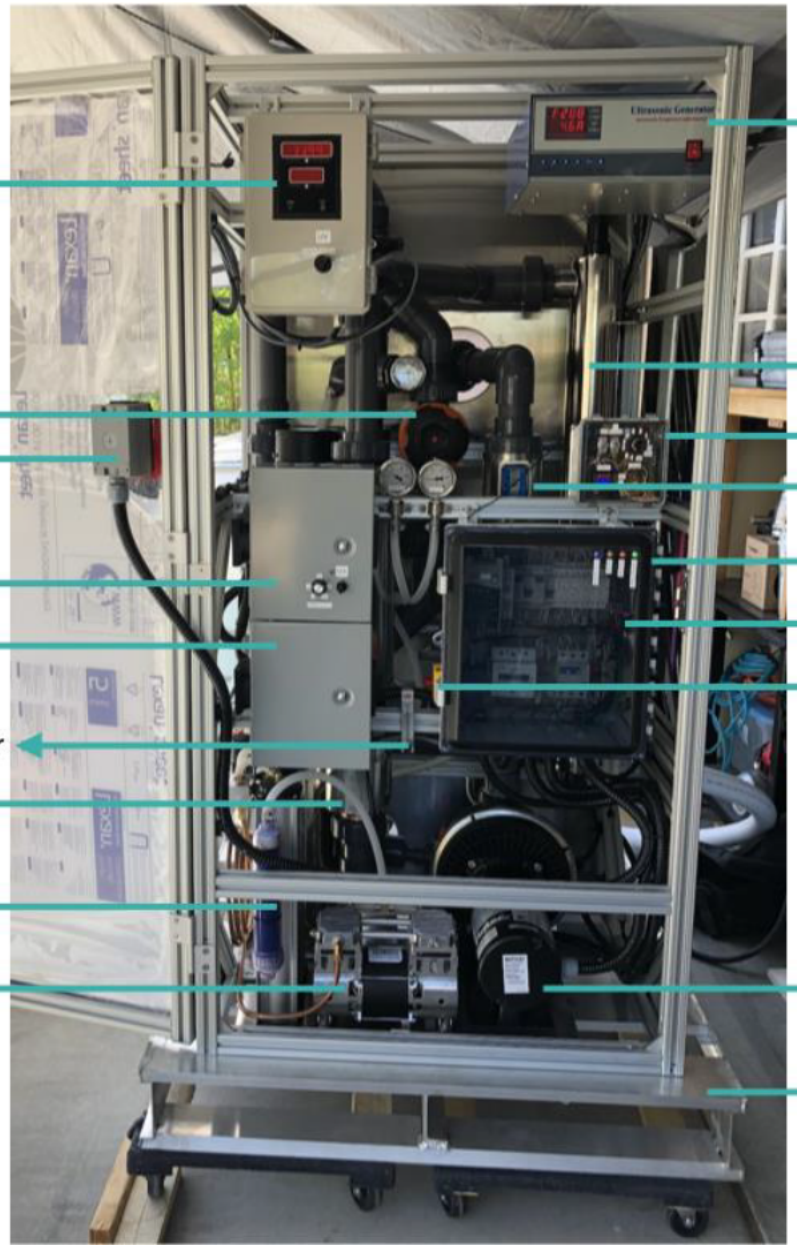




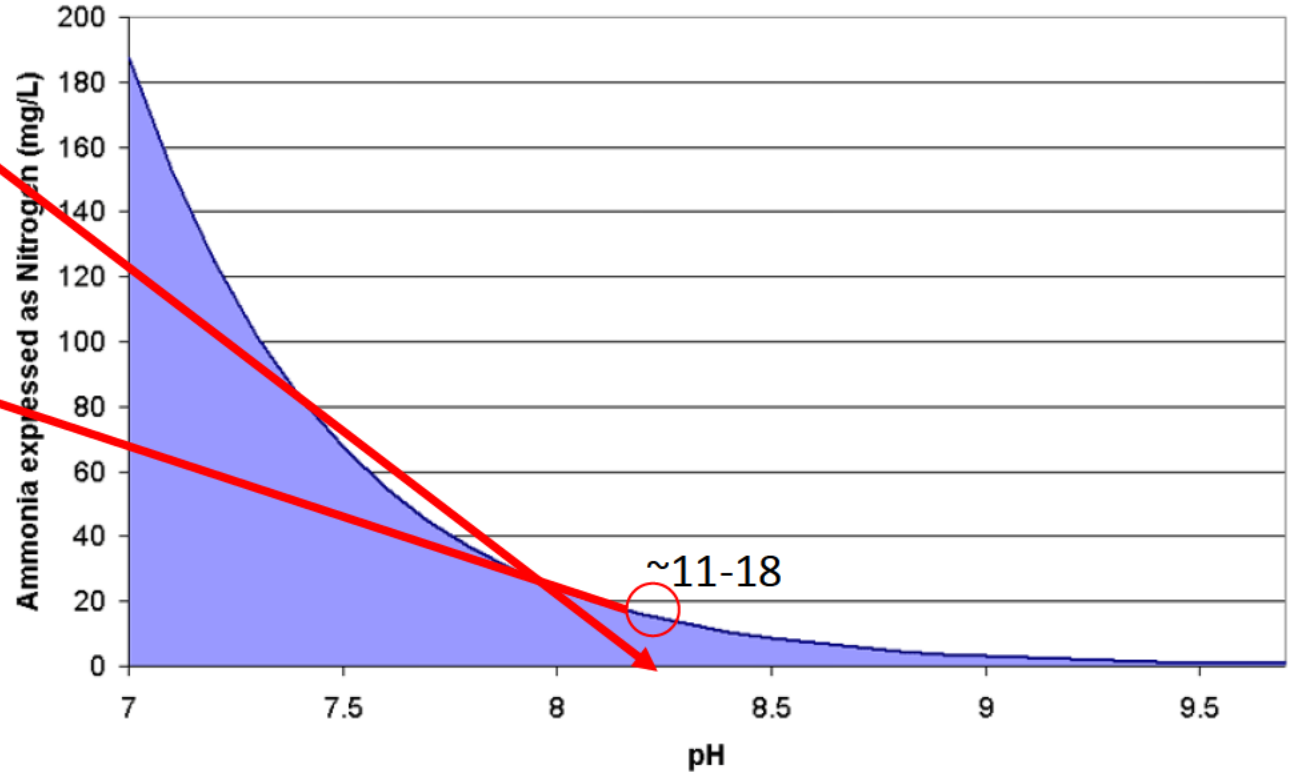
Front View



- UV Light Controller
- Diaphragm Control Valve
- System Start /Stop
- Ozone Controller
- Ozone Electric Box
- Gas Flowmeter
- Shielded Magnetic Resonance System (Electromagnetic Coil)
- Oxygen Concentrator
- Oxygen Compressor (Caution: high operating temp)
- Ultrasonic Controller
- UV Light System
- System Operation Controls
- Shielded Flowmeter
- System Function LED Indicators
- Main Electrical Box
- Main Power Switch (Reset)
- Pump
- Permanently Mounted Aluminum-skid

Mine effluent Characterisation

Analysis	Parameter	Unit	Values
			Eldorado
Physico-chemical	pH	-	8.23 ±0.11
	ORP	mV	150.8 ±6.7
	Dissolved Oxygen	mg O_2/L	6.8 ±0.1
	Conductivity	mS/cm	4.12 ±0.04
	Temperature	°C	20.0 ±0.0
	Turbidity	NTU	0.7 ±0.3
	Alkalinity	mg eq. $CaCO_3$/L	159 ±4
	N-NH_3	mg/L	55.0 ±19.9
Anions	Cl		223.2 ±12.7
	NO_2		12.2 ±0.4
	CNO		24.6 ±1.3
	NO_3		81.2 ±2.7
	SO_4		1611.9 ±46.0
	PO_4		< 3.0
	SCN		1.0 ±0.6
Metals (ICP-MS)	Na		566.3 ±36.0
	Mg		3.7 ±0.6
	K		64.7 ±3.6
	Ca		130.7 ±6.4



Threshold Acute Concentration for Ammonia versus pH

$$y = 306132466.34 \times (2.7183^{(-2.0437 \times pH)})$$

First Insights

Fast saturation of the effluent in terms of dissolved oxygen

			pH	ORP	Cond.	DO	Tair	Tsolu	T sam	Turbidity	N-NH3
		Time	-	mV	mS/cm	mg/L		°C		NTU	mg/L
Cycle	ini	00:00	8.1	532	4.15	6.86		18.9		1.35	55.1
1	T(i)	01:52	8	234	3.94	>22		19.5		0.32	59.1
		06:15	8.1	231	3.96	>22		19.6		0.18	57
2	T(i)	0:08:44	8	225	3.97	>22		19.8		0.14	59.4
	0:12:30		8	215	3.96	>22		19.7		0.72	57.1
3	T(i)	0:14:22	8	212	3.98	>22		19.9		0.12	58
	0:18:45		8	210	3.96	>22		19.7		0.05	58.1
4	T(i)	0:20:37	8	202	3.95	>22		19.8		0.05	57.5
		0:25:00	8	201	3.96	>22		19.8		0.11	57.7
5	T(i)	0:26:52	8	197	3.96	>22		20.1		0.08	57.9
	0:31:15		8	195	3.95	>22		19.9		0.03	56.3
	T(i+4h)		8	112	3.88	>22		20.6		0.45	48.5
	T(i+24h)		8.2	215	3.24	8.87		23.8		0.67	44.5

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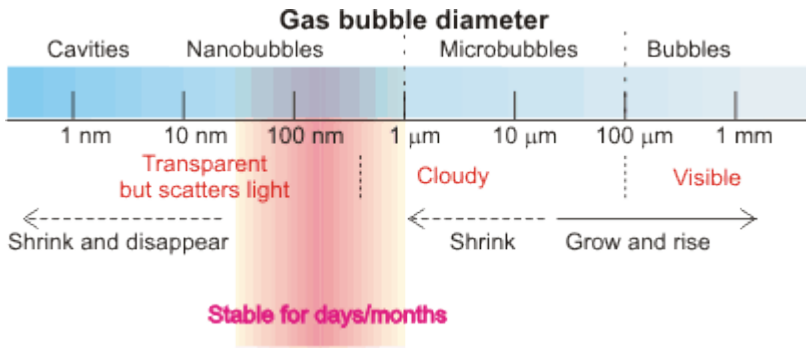
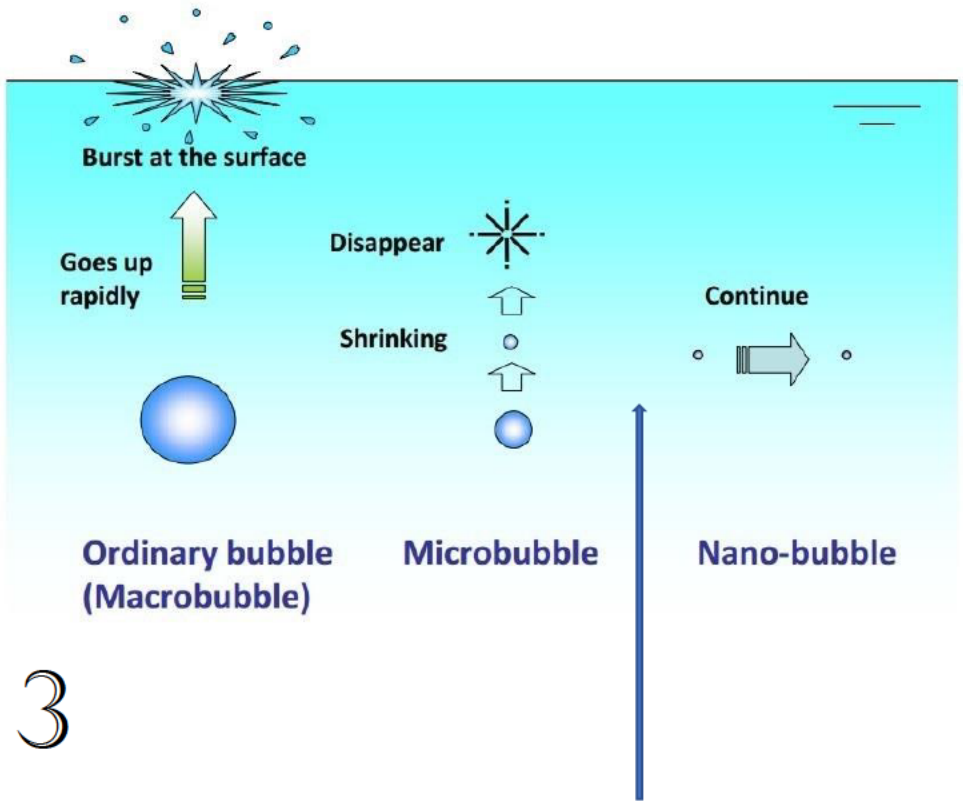


First Insights

6	T(i)	33:07	8	194	3.95	>22		20.1		0.02	58
		37:30	8	191	3.95	>22		20.2		0.12	57.8
	T(i)	0:39:22	8	189	3.96	>22		20.3		0.07	56.9
	0:43:45		8	189	3.97	>22		20.2		0.36	56.1
7	T(i+4h)		8.1	153	3.91	>22		20.2		0.05	49
	T(i+24h)		8.1	215	3.9	9.17		20.6		0.13	56.2
8	T(i)	45:37	8	188	3.97	>22		20.4		0.21	55.9
		50:00	8	186	3.95	>22		20.3		0.03	56.4
9	T(i)	51:52	8	187	3.97	>22		20.5		0.27	54.8
		56:15	8	187	3.98	>22		20.5		0.37	56.7
	T(i)	0:58:07	8	188	3.96	>22		20.8		0.02	56.9
10	1:02:30		8	189	3.97	>22		20.8		0.18	56.7
	T(i+4h)		8.1	154	3.91	>22		20.3		0.09	49.4
	T(i+24h)		8.2	214	3.89	8.78		20.5		0.01	62.8



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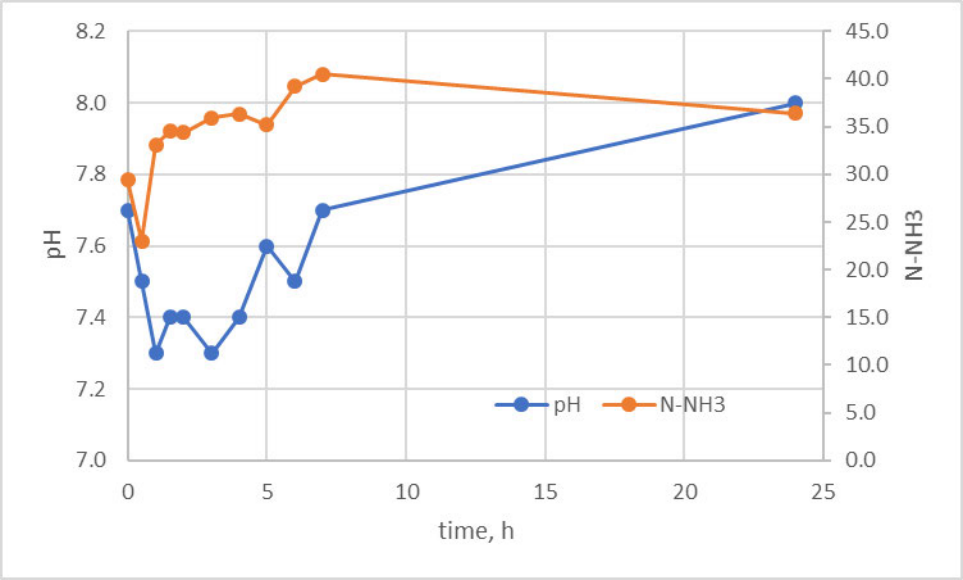
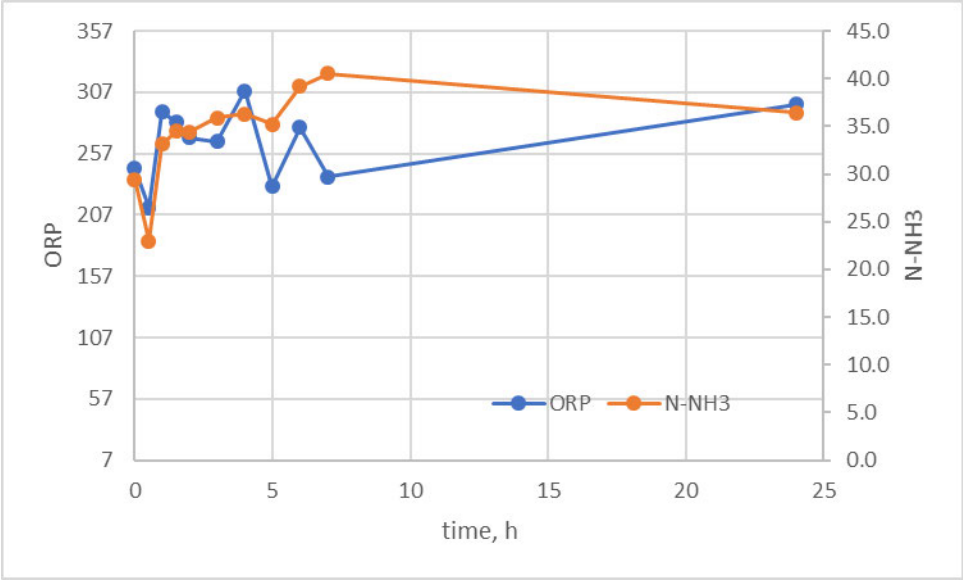
KST AOP unit

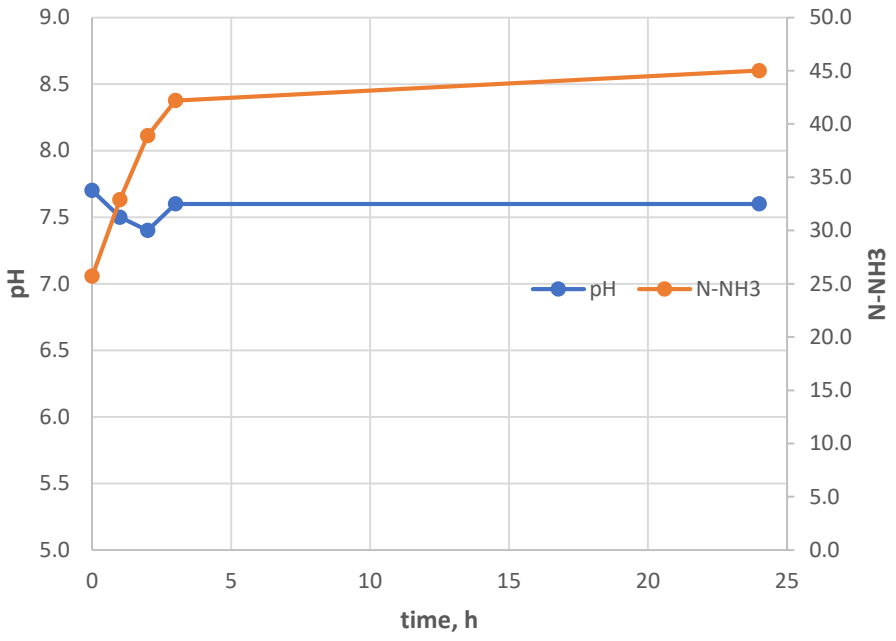
Preliminary Tests

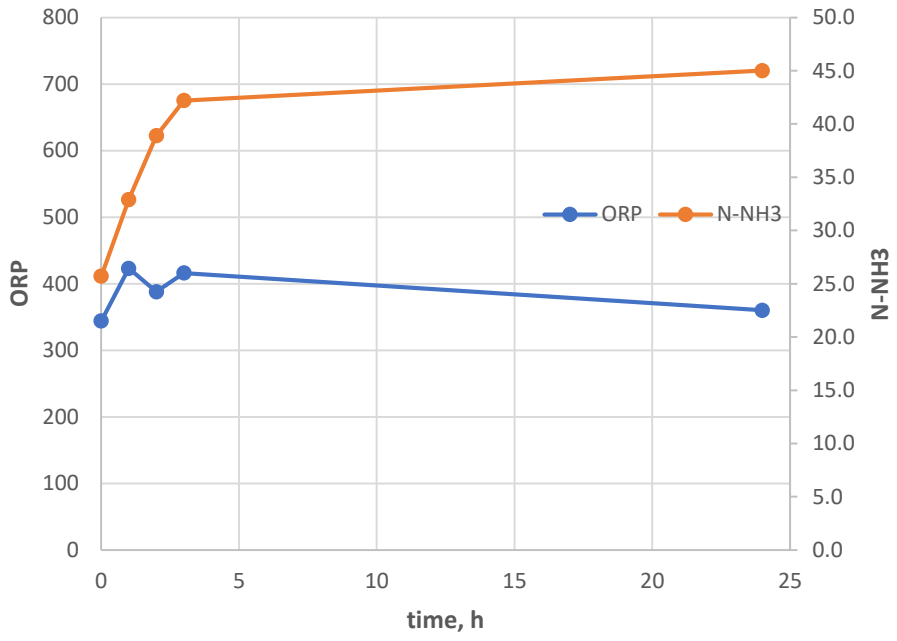




All Techs ON, original pH (8.5), no treatment, increase due to partial oxidation.

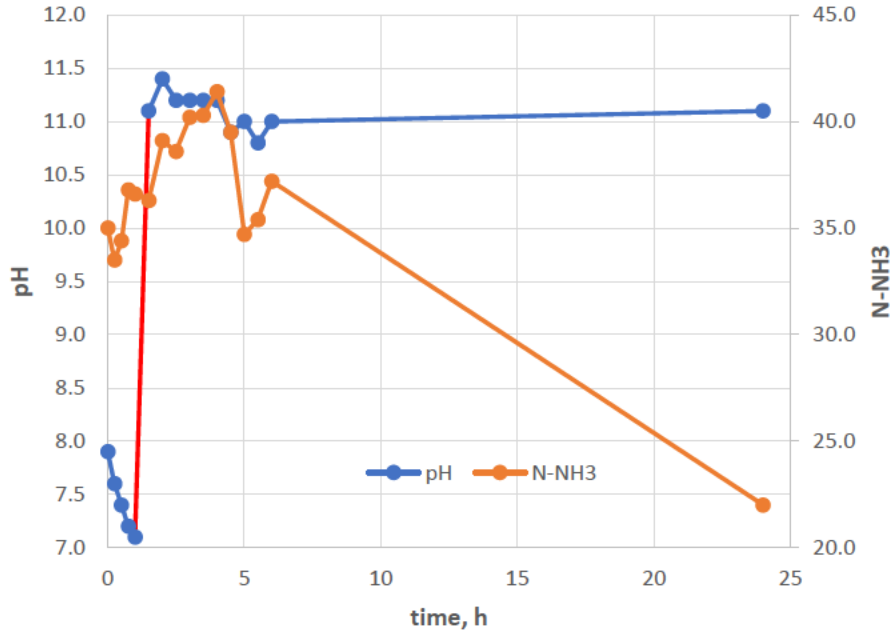
Preliminary Tests

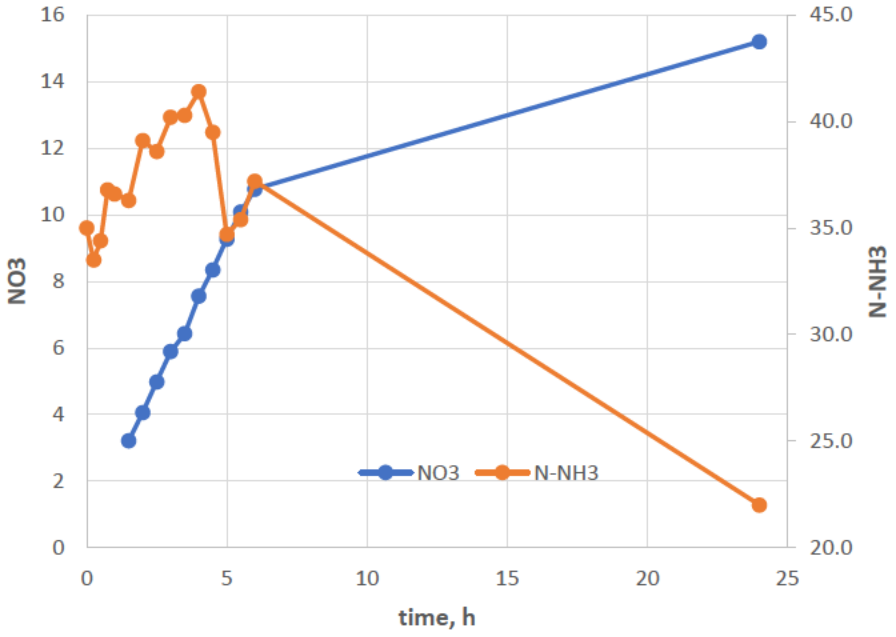




Changing the oxygen unit by a pure O2 capsule, original pH, No treatment.

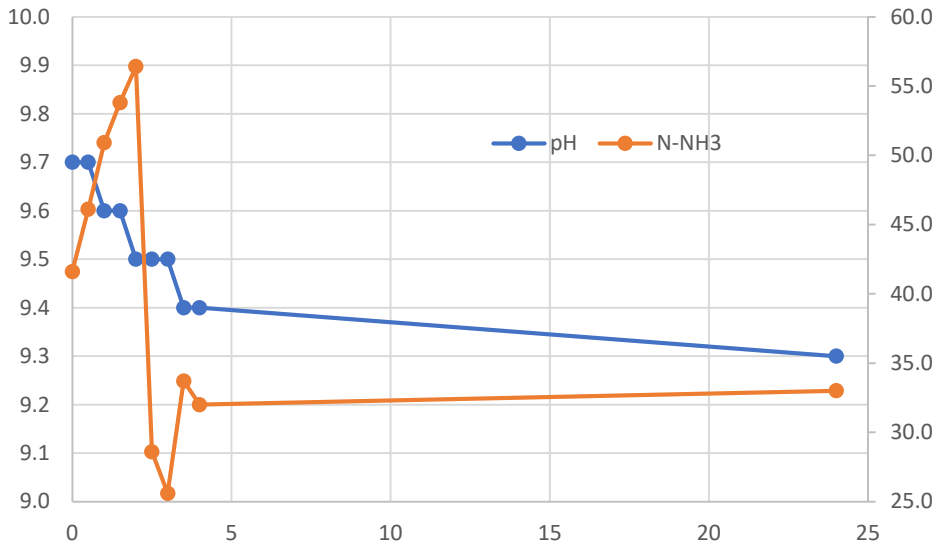
Effect of pH on Degradation

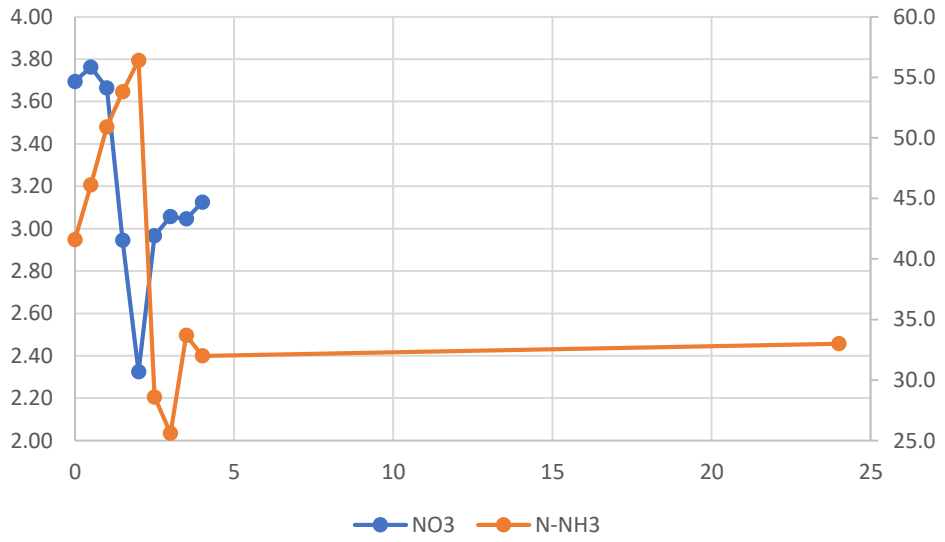




pH adjustment to 11 after 90 min. general decrease in N-NH3. after 24h to 22 and after 48 h to 19.5 ppm.

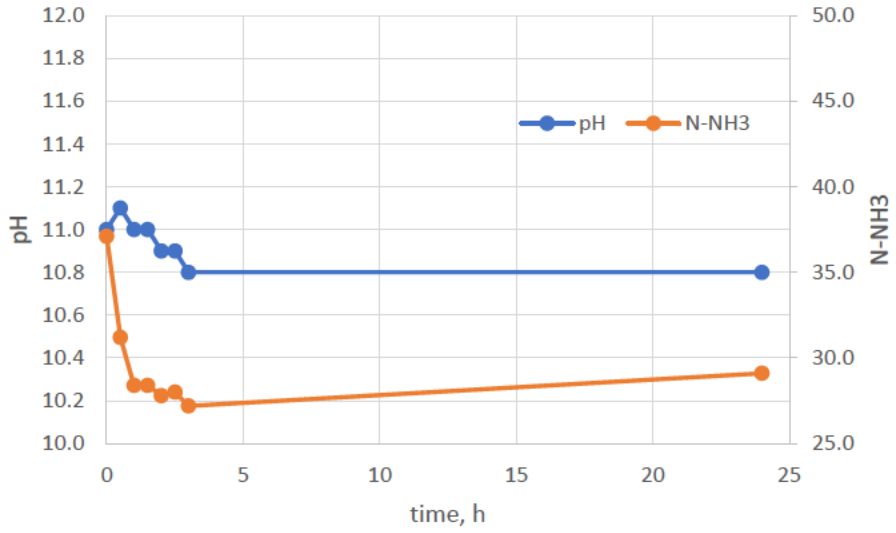
Effect of pH on Degradation





pH adjustment to 10. marginal treatment.

Effect of Residence Time



pH adjustment to 11.1, fast treatment (ca. 10 ppm in 3 hours). After 24 h almost no change.

Ozonation of un-Detoxified Effluent

Gold effluent produced in CTRI mini-pilot

Ozonation of un-Detoxified Effluent

Gold effluent produced in CTRI mini-pilot

Sampling Date	Sample Name	Cl (ppm)	NO_2 (ppm)	CNO (ppm)	NO_3 (ppm)	SO_4 (ppm)	PO_4 (ppm)	SCN (ppm)
2021-12-07	Tank 2 (24h)	25,8	<0.30	<0.30	8,43	2,010	<3.00	<0.30
2021-12-07	Tank 3 (24h)	27,1	<0.30	<0.30	9,30	2,159	<3.00	<0.30
2022-01-04	Detox	22,5	<0.30	<0.30	**38,6**	**1,224**	<3.00	<0.30

Initial Ammonia level = pH

Ozonation of un-Detoxified Effluent

Gold effluent produced in CTRI mini-pilot

Date	Heure	Action	pH	CN-	N-NH3
15-12-2021	9h00		10.3	1.3	12
		ajout 4,6 g Ca(OH)2	11.3	1.3	12
	9h40	20 min ozonation			
	10h00		10.2	< 0,05	3.75
	11h00		11.6		3.67
	12h00		11.5		3.71
	13h00		11.4		3.56
	14h00		11.3		3.44
	14h10	ajout 13 g Ca(OH)2	11.9		
	14h15	20 min ozonation			
	14h35		11.7		2.27
	15h00		11.7		2.09
	16h00		11.6		2.14
	17h00		11.6		1.7
16-12-2021	9h00		8.6	< 0,05	1.32
	11h00		11.8		1.08
	16h00		11.2		0.85
	16h45	réajustement pH	11.9		
20-12-2021	13h00		9		3.33
	15h00		9.2		4.19
		ajout Ca(OH)2	11.8		4.51
		traitement 300 (300) gallons	11.7		4.36
		traitement 300 (600) gallons	11.7		5.02
		traitement 300 (900) gallons	11.7		4.72
		traitement 300 (1200) gallons	11.7		6.1
		traitement 300 (1500) gallons	11.6		4.83
		traitement 300 (1800) gallons	11.7		6.29
		traitement 300 (2100) gallons	11.9		5.78
		traitement 300 (2400) gallons	11.9		7.14
		traitement 300 (2700) gallons	11.9		5.47
		traitement 300 (3000) gallons	11.8		4.95
21-12-2021	9h00	aération toute la nuit	8.4		2.51
	10h45	ajustement pH	12.1		2.79
	11h00	traitement 300 (300) gallons	12.1		3.35
	11h45	traitement 300 (600) gallons	12		3.08
	12h30	traitement 300 (900) gallons	12		3.29
	13h25	traitement 300 (1200) gallons	12		3.3
	14h30	traitement 300 (1500) gallons	12		3.37
	15h00	traitement 300 (1800) gallons	12		3.11
	16h15	traitement 300 (2100) gallons	11.9		3.44
	17h00	traitement 300 (2400) gallons	12		3.42
	17h15	traitement 300 (2700) gallons	11.9		3.27
	17h30	traitement 300 (3000) gallons	12		3.74
22-12-2021	9h00	repos toute la nuit sans aération	12.1		2.45

Effect of MgO catalysed ozonation

Date	heure	Action	pH	N-NH3	dup	QC N-NH3
24-12-21	12 h 30	fin aération	11,9	0,673	0,616	1,11
26-12-21	12 h 30		10,9	0,18	0,196	1,15
		ajout 15,1 g MgO + réajustement pH 12,2				
	12 h 45	traitement O3 300 gallons	12,5	0,515		
	12 h 55	aération 10 min	12,4	0,57		
	13 h 05	traitement O3 300 gallons	12,4	ND		1,01
	13 h 15	aération 10 min	12,4	ND		

ND Non détecté

Conclusion and Recommendations

- DO levels increase drastically in less than 2 minutes
- DO is in saturated mode at least for 4 hours
- pH governs the efficient ammonia degradation using O_3
- O_3 can deliver fast degradation of N-NH_3 (with MgO present) reaching to non detectable levels in a reduced period compared to biological treatments
- Residual cyanides, cyanates, and thiocyanates degraded very fast using O_3 delivered in the form of ultra-fine bubbles

Next Actions

- Further testing to validate the efficiency of system in lower temperature
- The results are encouraging in increasing the DO level and that can be helpful in increased metal dissolution

Merci de votre attention !

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