Technical Committee Meeting

Forum & Technical Field Visit

Abu Dhabi, UAE

2009

30 September - 2 October

ifa

International Fertilizer Industry Association

REVERSE OSMOSIS OF PHOSPHATE PLANT POND WATER BY USE OF NOVEL PRE-TREATMENT TECHNOLOGY

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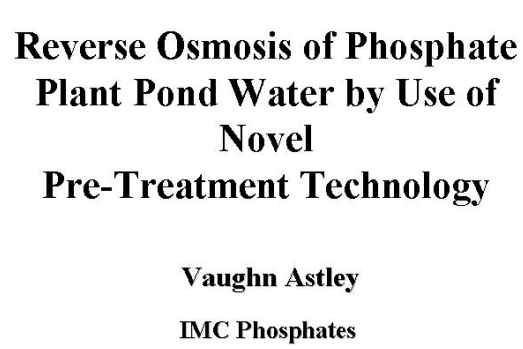
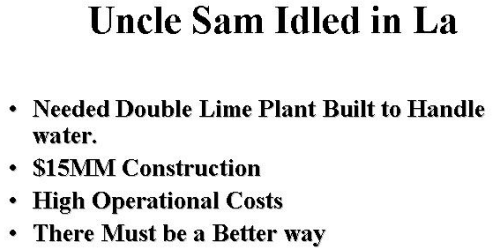
Phosphate plant pond water or process water is an acidic mixture of ions, and saturated with many compounds. In an operating plant this water is normally recycled internally and the discharge of water is not necessary. However, during extended periods of heavy rain or when a plant is shut down, as in the case of Piney Point, this acidic water must be treated and discharged. The traditional method of treating pond water has been lime treatment in two stages (double liming). However, double liming suffers from several disadvantages. Large settling ponds are required for the second stage solids separation. Only about 50-60% of the water ends up being discharged, but even after lime treatment, air stripping is often required to reduce the ammonia concentration to acceptable levels.

We have developed a pre-treatment method that allows phosphate plant pond water to be treated using reverse osmosis without the usual scaling problems. The advantages of our method are that large settling ponds are not required; upwards of 75% of the water can be discharged; the discharge water is of exceptionally high quality (exceeds Class III Groundwater Standards); up to 75% of the P_2O_5 in the water can be recovered as a non-scaling liquid and operating costs are lower than double liming. Our process is flexible and can be adapted to dilute pond water, such as at Piney Point, or more concentrated pond water, typically found at an operating phosphoric acid plant.

We have demonstrated this technology at the bench and on a small pilot scale, and hope to operate at several hundred thousand GPD at Piney Point to both demonstrate the viability of the pre-treatment process and to assist in the remediation of the facility.





IMC Presented at the IFA meeting of the Technical Committee on October 1, 2003 at the Hilton Abu Dhabi
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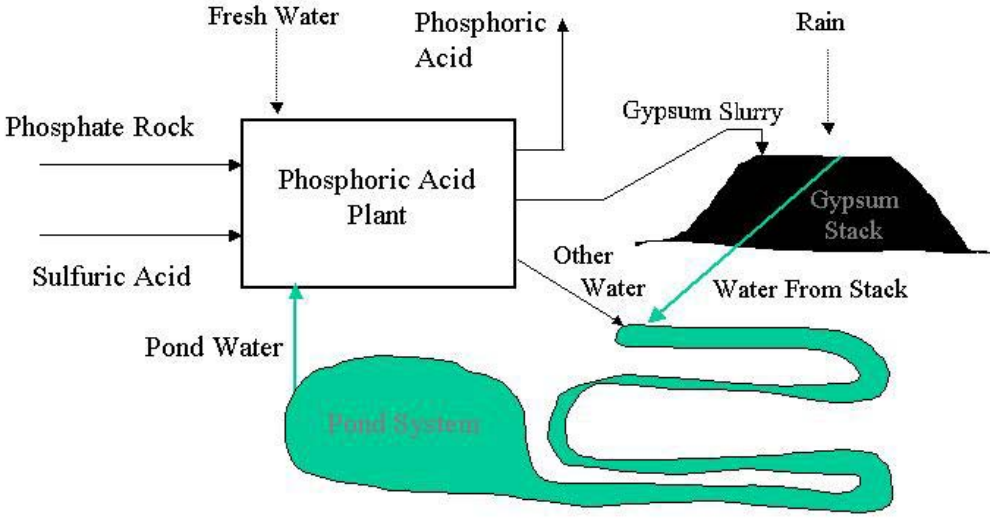
Pond Water – Source

Phosphoric Acid Process
Origin of Pond Water



"Typical" Pond Water

CHEMICAL COMPONENT	RANGE OF CONCENTRATION
P	1700-12,000 ppm
SO_4	4300-9600 ppm
F	200-15,000 ppm
Si	100-4100 ppm
(ammoniacal) N	40-1500 ppm
Na	1200-2500 ppm
Mg	160-510 ppm
Ca	450-3500 ppm
K	80-370 ppm
Fe	5-350 ppm
Al	10-430 ppm
Cl	10-300 ppm

Traditional Treatment
"Double Liming"

- **Lime Slurry Addition to pH ~5.5**
- **Settling and Sludge Separation**
- **2nd Lime Addition to pH 12-12.5**
- **Settling and Sludge Separation**
- **Air Stripping for NH_3 Removal**
- **Sulfuric Acid Addition to pH 8**

Double Liming
Limitations

- **Clear Water Recovery Only 50-60%**
- **Remaining Sludge Difficult to Dewater**
  - **Large Impoundment Ponds**
- **Precipitated Phosphate Difficult to Recover**
- **Difficulty Meeting Ammonia Limits**
- **High Cost**

Pond Water – Reverse Osmosis

- **Previous Efforts** (~1980's)
  - **Failed Because of Irreversible Membrane Fouling**
- **Pretreatment is Essential**
  - **Pond Water is Normally a Saturated Solution**
  - **Saturation Must be Relieved to Allow Removal of Water Without Precipitation**
  - **Pretreatment Allows Higher Recovery of Permeate**

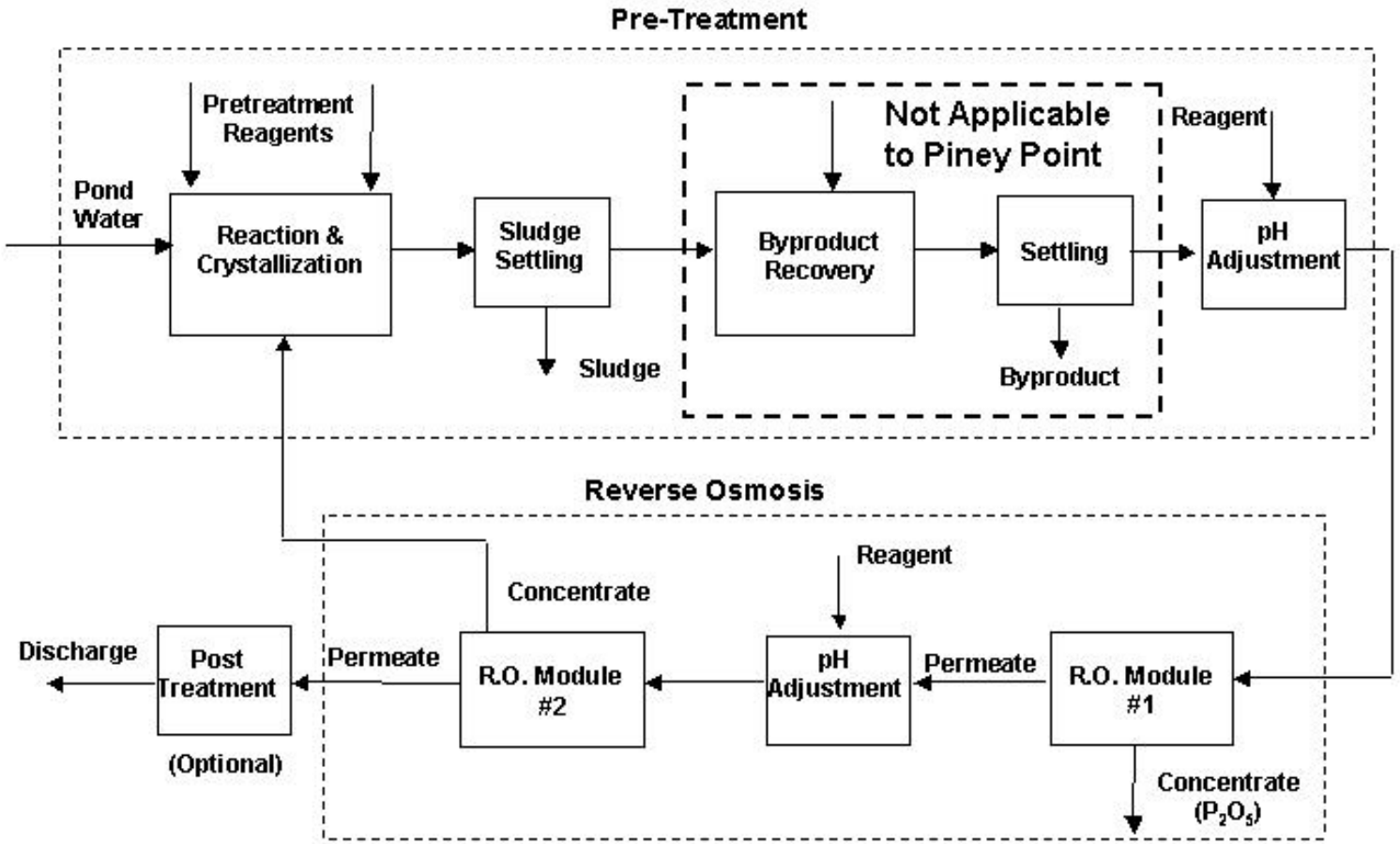
Pond Water – Pretreatment

- **Previous RO Work Identified Compounds Responsible for Membrane Fouling**
- **Objectives of Pretreatment**
  - **Economically Reduce Saturation of the Species Causing Scaling**
- **Retain as Much Phosphate as Possible in Solution**

Pond Water – Pretreatment

- **Pre-Treatment Developed that Allows Pond Water to be Processed Through R. O. System**
  - **Up to 75% of Feed Volume meets (exceeds) discharge requirements**
  - **Sludge Volume reduced ~75%** (vs. Double Liming)
  - **~70% of P_2O_5 Can Be Recovered in Concentrate**
- **Process Chemistry Confirmed at Bench Scale** (Including R.O. System)
- **Three Patents Filed** (Have Provisional)

Overall Process



Bench Scale Results
Uncle Sam LA Pond Water

	Raw Pond Water	R.O. Final Permeate
Volume %	100	74.4
P_2O_5	1.61%	0.5 ppm
CaO	0.167%	0.1 ppm
F	0.470%	0.8 ppm
SiO_2	0.440%	1.0 ppm
Na_2O	0.310%	10.9 ppm
SO_4	0.440%	1.0 ppm
NH_3 N	0.200%	0.92 ppm
As	2.76 ppm	<0.010 ppm
Cond. umhos/cm	19,800	63

Reject P_2O_5 – 5.65%

Cost Comparison
Uncle Sam
Reverse Osmosis vs Double Liming

- Capital Investments Will Run Around $15 to $20MM for 2MM Gal/Day DL projects.
- For Temporary Remediation Projects by RO, $3 to $5MM Invested for 1MM Gal/Day
- Capital Recovery over One to Three Years
- Project Fixed Costs/000 Gals Defined by Plant Capacity

Cost Comparison
Uncle Sam
Reverse Osmosis vs Double Liming

- 2 MM GPD of Permeate
- Variable Costs
  - Double Liming $13,
    - P2O5 Credit $3
  - RO with Pre-Treatment $11.40,
    - Credit $7.40

Uncle Sam Restarted

Project Shelved
2001

IMC Technology

- 1986-88 Testing with Reverse Osmosis to Concentrate Pond Water, Failed
- 1999-2001 Developed Pretreatment Technology for Uncle Sam, Success
- 2001-2002 a Provisional and Two Applications

Piney Point

- Mulberry Phosphates Declares Bankruptcy Early 2001
- Water Inventory Concerns End of 2001
- DEP, FIPR

Piney Point

Piney Point

- **Bankruptcy Trustee**
- **FDEP, Receiver, Shaw Environmental**
- **Originally 1.2 Billion Gallons**
- **Environmental Liability**

Current Water Treatment

- **Trucking $40-60 per kgal)**
- **US Filter $18.90/kgal (Bonus $25.00/kgal)**
- **Double Lime Aerated ($15.00/kgal)**
- **Evaporator Systems $25.00/kgal**
- **Barging $35-$40 per kgal**

Results for Piney Point Pond Water - Pilot Tests

Component	Initial Process Water	Feed to R.O. Systems	R. O. Reject	Final Permeate
Total P_2O_5	0,3267%	0,2072%	0,8815%	0.37 ppm
Ca	0,0405%	0,0117%	0,0557%	0.01 ppm
F	0,0099%	0,0099%	0,0400%	3.5 ppm
SiO_2	0,0207%	0,0194%	0,0760%	3.0 ppm
SO_4	0,6014%	0,7612%	2,8022%	1.0 ppm
Na	0,0978%	0,2390%	0,7370%	6.2 ppm
Total N	0,0666%			
NH3 N	0,0662%	0,0739%	0,7874%	<1.0 ppm *
Nitrate-Nitrite	0,0001%			
As	0.48 ppm	0.47 ppm	2.51 ppm	<10 ppb**
TDS	11 970			
Conductivity (umho/cm)	12 002	9 600	>20,000	37
pH	3,21	3,01	~3.0	~6.8

* With Optional Post Treatment
** Limit of Detection

Cost Comparison

Piney Point

Reverse Osmosis vs Double Liming

- **800M GPD of Permeate**
- **Variable Costs**
  - **Double Liming $10.00,**
    - **P2O5 Credit $0**
  - **RO with Pre-Treatment $5.00,**
    - **P2O5 Credit $0**

Commercialization Partners

- **Florida Institute of Phosphate Research**
- **Mobile Process Technology**

Piney Point Project
Others Involved

- **Florida Institute of Phosphate Research – Capital Grant for Non-RO Equipment & Construction**
- **KEMWorks Technology Inc. – Preliminary Engineering**
- **FDEP – Operating Costs**

Pond Water R.O.
IMC Phosphates Contribution

- **R.O. Pretreatment Technology**
- **R.O. Equipment**
  - **Two 1st Stage R.O. Modules**
  - **Two 2nd Stage R.O Modules**
  - **Multimedia Filter System**
- **R.O. Equipment Modification**
- **Technical & Engineering Assistance, Continued Research**

Equipment

Mobile Process Technology

- **Experienced in industrial water treatment**
- **Over 30 years of Operation**
- **Originally worked in the Petrochemical Industry**
- **Annual sales $10 million (approx.)**
- **Small, Aggressive, Entrepreneurial**
- **Service Oriented**

Reverse Osmosis
Piney Point Project

- **Design Flow 800,000 GPD Final Permeate**
- **Design Permeate Recovery 70%**
  - **Medium Pressure (600 psi) 1st Stage RO**
- **Re-Use as Much Existing Equipment as Possible**

Piney Point Project
Status

- **Reverse Osmosis Equipment On Hand**
  - **Modifications in Progress**
- **Preliminary Engineering Finished**
  - **Detail Engineering in Progress**
- **Contracts and Agreements in Negotiation**
- **Start of Operation Anticipated Late 2003**

PINEY POINT
POND WATER TREATMENT
JOINT VENTURE

Project Structure