INDUSTRIAL WASTEWATER TREATMENT FOR FERTILIZER INDUSTRY

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A CASE STUDY

Vinay M. Bhandari, Laxmi Gayatri Sorokhaibam[1] and Vivek V. Ranade

Chemical Engineering & Process Development Division
National Chemical Laboratory
Pune 411008, India
vm.bhandari@ncl.res.in
[1] Department of Applied Chemistry
VNIT Nagpur

Create Innovations & Knowledgebase to Solve Relevant Problems

Outline

- Industrial water
  - Usage
  - Treatment and recycle
- Industrial wastewater treatment, recycle and reuse
  - Some general comments
  - Fertilizer Industry Wastewater Treatment
  - Hydrodynamic Cavitation- An emerging technology
- Future trends
  - Hybrid technologies
- Summary

Water Usage

- Key usage [INDIA]
  - Drinking and other domestic uses [< 10 %]
  - Agriculture [> 80 %]
  - Industry [~ 10 %]

  - Since 1950, world population has doubled – water consumption has increased SIX fold

  - Industrial consumption is expected to grow rapidly

  - Focus of this talk is on industrial waste water treatment, recycle and reuse
    - With specific emphasis on Fertilizer chemical industry

Key Issues

- Availability of fresh water
  - Reducing day by day
  - Industries facing closure due to non-availability of water
- Increasingly stricter regulations on discharged water
  - Industries are facing closure due to non-compliance with the regulations
- Essential to adapt effective water treatment processes for complying with regulations and for meeting the daily water requirements!

Key Issues in Wastewater Treatment

- Can we avoid liquid discharge?
  - Dream of zero liquid discharge
- Can we reuse treated water?
  - At least as cooling water or boiler make-up if not as process water
- How to manage process economics?
  - In terms of money & space

Where is space for process plant?

Treatment cost: ~ X paise/lit

Industrial Wastewater Treatment- Challenges

- Highly Polluting Industries
  - Cement
  - Thermal Power plants
  - Distilleries
  - **Fertilizers**
  - Tanneries
  - Dye/Dye Intermediates/ Textile
  - Oil refineries
  - Petrochemicals
  - Iron and Steel
  - Pulp and Paper
  - Pesticides

Wastewater from Fertilizer Industry

Typical fertilizer complex includes manufacturing plants for ammonia, acids, alcohol and fertlizers

- Presence of –
  - Organics, alcohols
  - Ammonia
  - Nitrates
  - Phosphorous
  - Other heavy metals

Wastewater treatment is a complex problem from environmental pollution point of view

Existing practices employ different physico-chemical/ Biological methods of treatment

Industrial Water Treatment

Hybrid technologies

- Physical methods
  - Screening, settling
  - Filtration/ membrane separation

Basic clean-up/ physical methods

- Chemical methods
  - Oxidation: chemical, electrical-chemical oxidation
  - Neutralization

removes 85% - 95% of BOD/COD and TSS
removes 20% - 40% P
removes 0% - 50% N

- Physico-chemical methods
  - Coagulation
  - Sorption, ion exchange
  - Extraction, Membrane separations, cavitation
- Tertiary/ Polishing

removes > 99% of pollutants

Key Technologies

- Coagulation
- Adsorption/ ion exchange
- Membranes
- Biological
  - Anaerobic/ aerobic
- Oxidation
  - Fenton, ozonation, wet air oxidation
- Hydrodynamic cavitation

Adsorption

- Inorganic adsorbents
  - Zeolites
    - A, X, Y, ZSM-5, silicalite, ALPO
  - Oxides
    - Silica, alumina
- Organic adsorbents
  - Activated carbon
    - powder, granules, molecular sieves, carbon fibre
  - Polymeric adsorbents
  - Ion exchange resins
  - Biomass

Industrial Wastewater Treatment- *Strategy*

- Characterization of wastewater and identify important Effluent Treatment options.
  - Devising schemes for effective separation of organics, inorganics etc.
  - Evaluating suitable methods, materials and processes
  - Evaluating process viability under various conditions

- Evaluating physico-chemical methods for real life problems:
  - Hydrodynamic Cavitation/Adsorption/Ion exchange/ coagulation/ membrane separation/solvent extraction studies on real applications...

    in isolation and in combination.

- Development of Integrated approach for Industrial applications

Fertilizer Industry

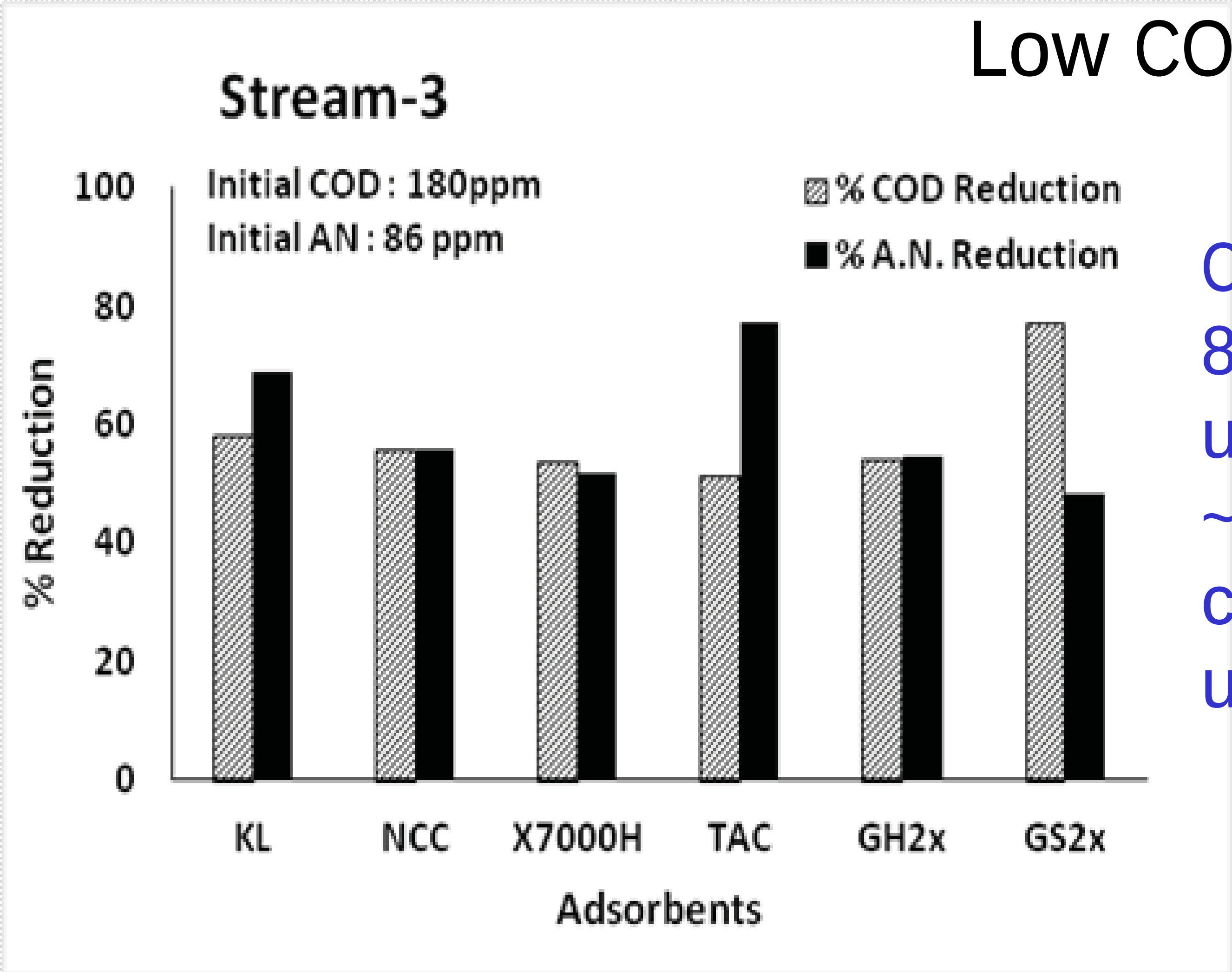
Characterization of Effluents

Effluent Stream	Initial COD (ppm)	Initial NH_3-N (ppm)	Remarks
1	125000	2	pH 7-8, Colored, characteristic odor, low TDS/TSS, presence of alcohols/ organics
2	946	1710	Very high AN
3	460	86	pH 10.6, Low TSS, TDS<2000
4	130	1330	pH 10, High AN, Very low TDS/TSS
5	44	530	pH 9.6, Low COD
6	170	276	pH 11, TDS<2000

Key Results - Fertilizer Industry

Industrial effluent treatment using Adsorption

Low COD, Low AN Stream

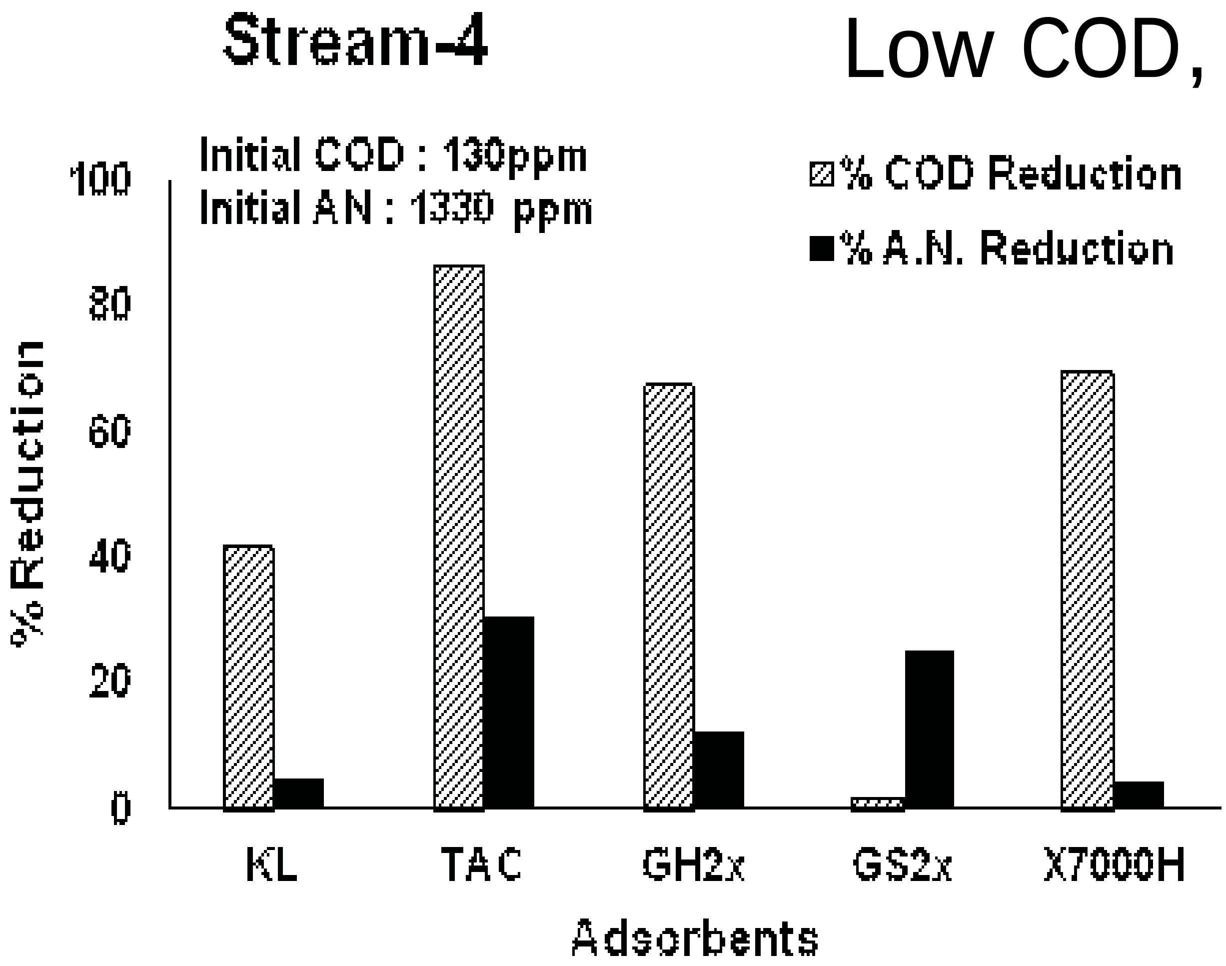


COD reduction of 80% can be obtained using GS2x while ~80% reduction in AN can be obtained using TAC adsorbent.

All adsorbents show more or less satisfactory removal of COD and AN for this stream.

Key Results - Fertilizer Industry

Industrial effluent treatment using Adsorption



Low COD, Very high AN Stream

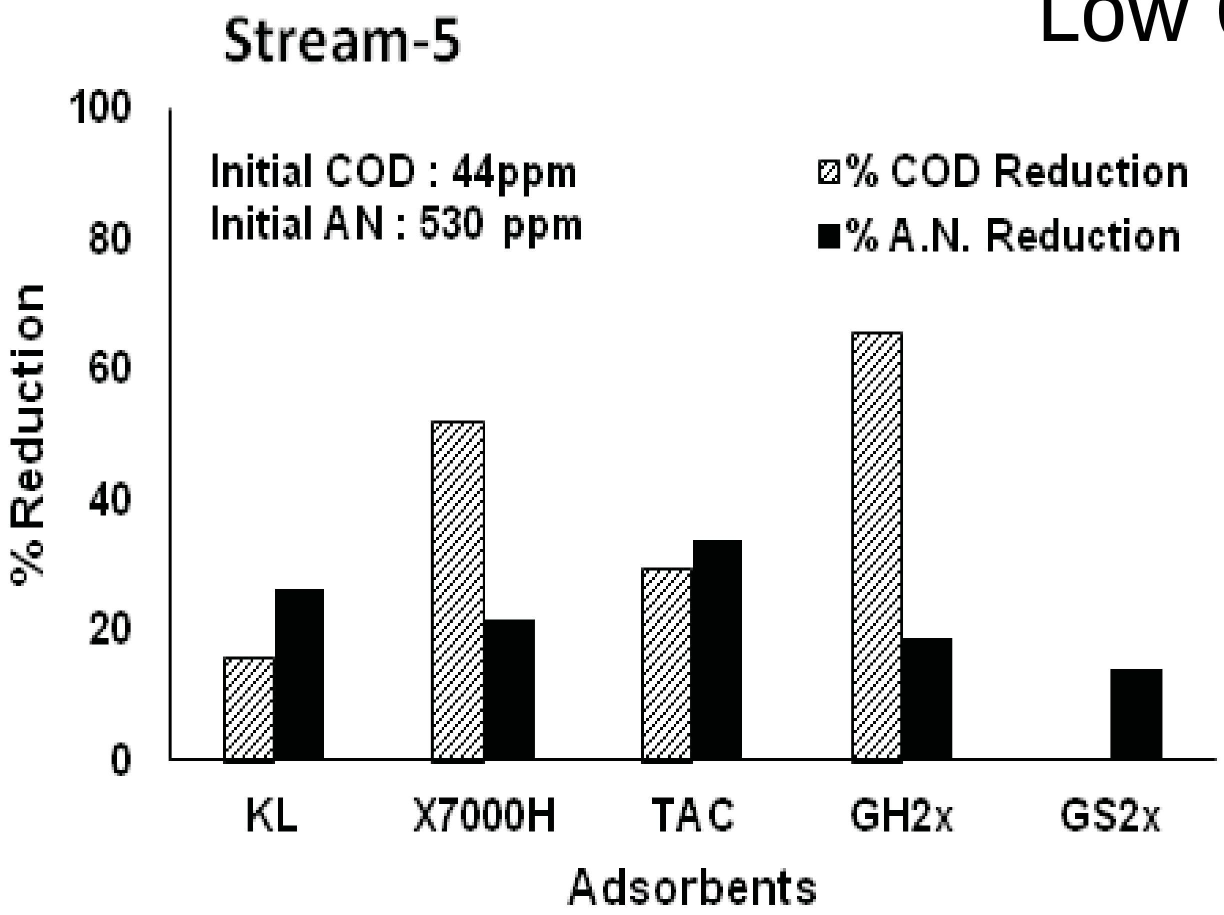
COD reduction of 80% can be obtained using TAC while only ~30% reduction in AN can be obtained using TAC adsorbent.

All adsorbents show less satisfactory removal of AN for this stream.

Key Results - Fertilizer Industry

Industrial effluent treatment using Adsorption

Low COD, High AN Stream



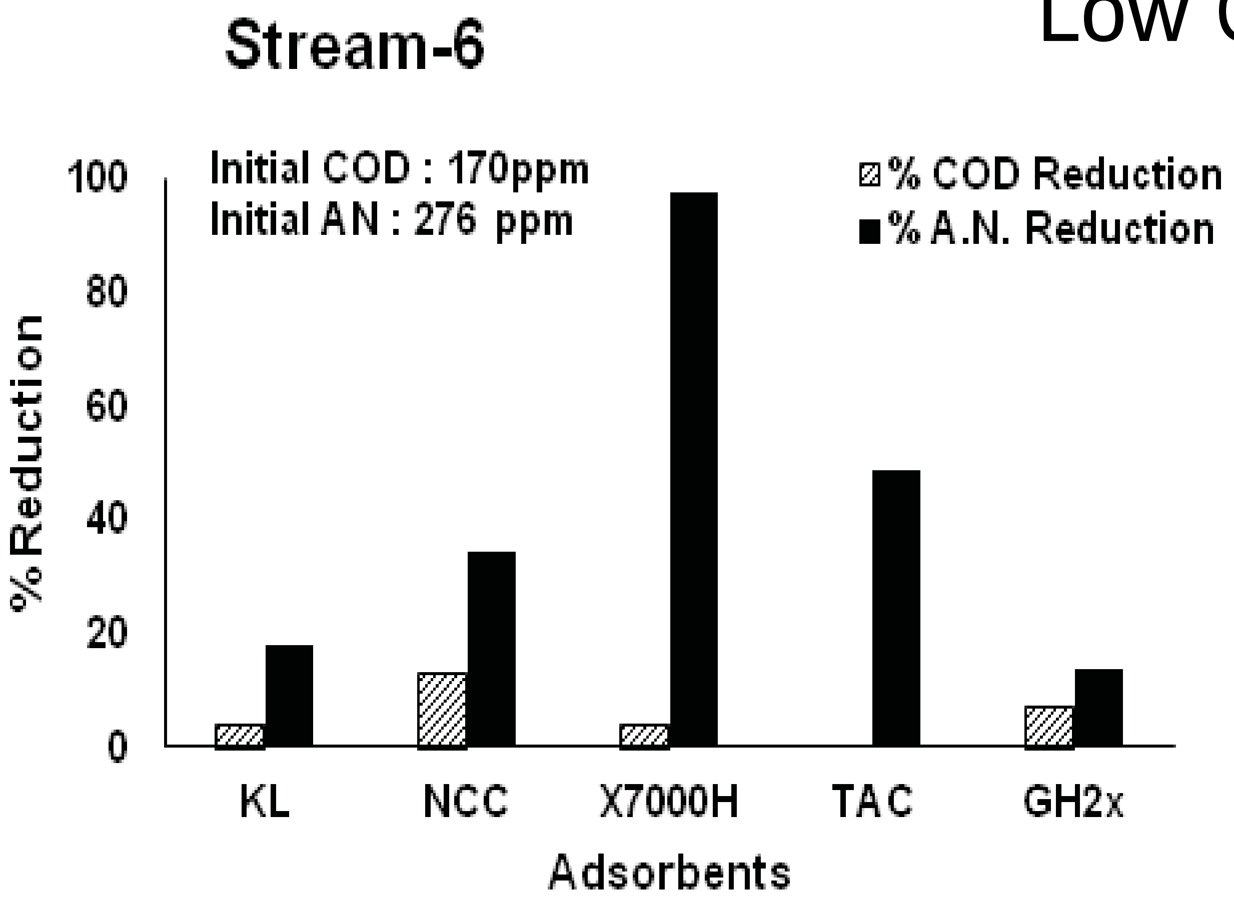
COD reduction of 80% can be obtained using TAC while only ~35% reduction in AN can be obtained using TAC adsorbent.

All adsorbents show less satisfactory removal of AN for this stream.

Key Results - **Fertilizer Industry**

Industrial effluent treatment using Adsorption

Low COD, High AN Stream

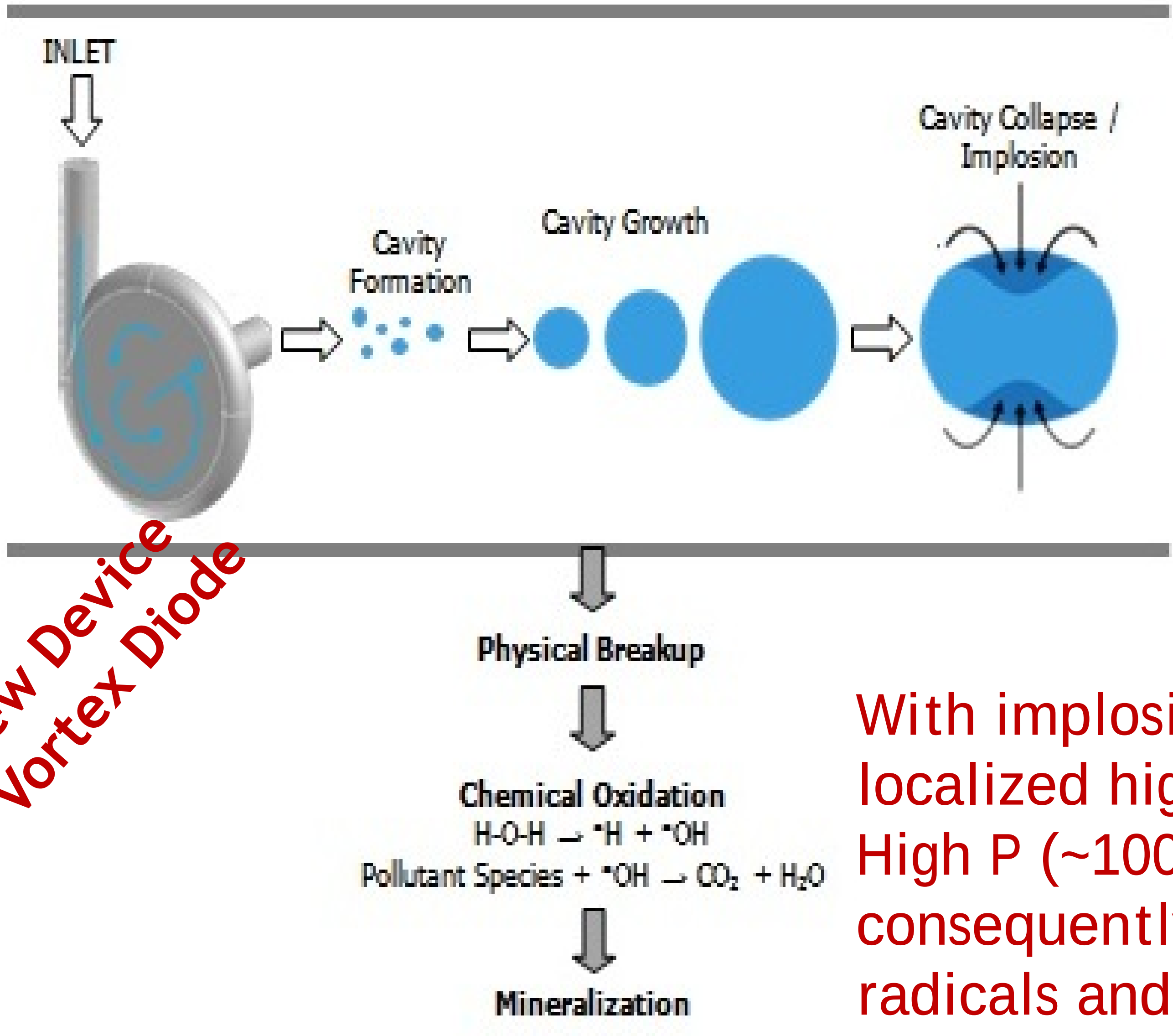


Near complete AN removal (~98%) with X7000H and ~50% reduction with TAC.

Selection of adsorbent is most crucial.

Interestingly, cavitation using vortex diode also yields 87% removal of AN similar to adsorption.

Cavitation? Progress of Cavitation Process



New Device
Vortex Diode

Cavitation Involves:

1. **Formation of cavities**
2. **Growth of cavities**
3. **Implosion of cavities**

With implosion of cavities, localized high T (~10000 K) and High P (~1000 atm) are created, consequently generating OH radicals and subsequent oxidation reactions

Experimental

Pilot Plant Facility at CSIR-NCL, Pune (1 m^3/h capacity)

Cavitation Devices

- Orifice/ ventury
- Diode: CSIR – NCL technology

1st Hour: Pressure drop- 0.5 kg/cm^2 (flow rate of 380 LPH)

After 1 hr: **2.0 kg/cm^2** (flow rate of 780 LPH)

Comparison of adsorption and Cavitation for Different effluent streams

Effluent Stream	Initial COD (ppm)	Initial NH_3-N (ppm)	% Reduction COD Adsorption	% Reduction COD Cavitation	% Reduction NH_3-N Adsorption	% Reduction NH_3-N Cavitation
1	125000	2	--	85	NA	NA
2	946	1710	--	76	--	60
3	460	86	80	<10	80	41
4	130	1330	86	<10	30	36
5	44	530	65	<10	35	37
6	170	276	10	<10	98	87

Conclusions...

- Hydrodynamic cavitation using vortex diode appears to be an effective method for the treatment of industrial wastewaters.
- A very high removal of COD and AN can be obtained using adsorption and hydrodynamic cavitation-vortex diode.
- Adsorption, though effective for removal of both COD and AN, selection of adsorbent is most crucial.
- Where, hydrodynamic cavitation, alone, is not satisfactory for complete treatment, it can be easily combined practically with all other methods of treatment.

Emerging Technologies & Process Integration

- Hybrid technologies
  - **Cavitation + Adsorption**
  - **Cavitation + Coagulation**
  - **Cavitation + Oxidation**
  - **Cavitation + Biological treatment**
  - **Cavitation + Membrane separation**

Effluent before treatment

Effluent after treatment

Cavitation + Ion exchange

Summary

- Ready solutions available only in few cases
- Process integration required :
  - Continuous improvements in
    - Process Separations
      - (New processes/ process modifications/ Materials/ Material modifications /Devices/ Engineering Designs/ Hybrid systems)
    - Industrial wastewater treatment, recycle & reuse
      - (Laboratory studies, pilot plant experiments on real effluents)
      - Need to work on industrial effluents
      - Required- COD reduction, colour reduction and reduction in ammoniacal nitrogen
  - The findings here are expected to be useful not just for fertilizer industry wastewater streams but also for chemical industry effluents, in general….