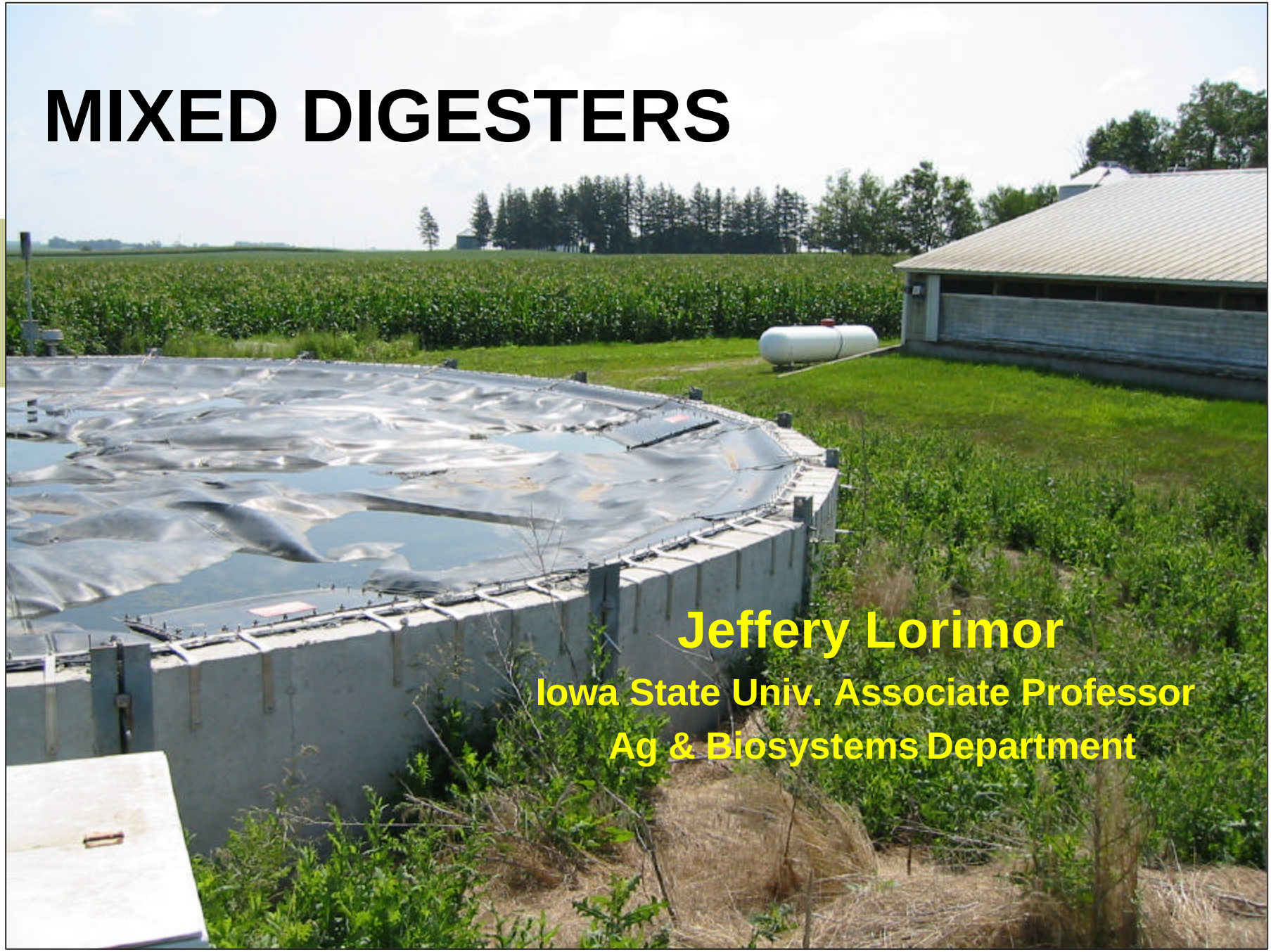
MIXED DIGESTERS



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Mixed Digesters

- Completely Stirred Tank Reactor (CSTR)
  - Continuous flow/stir process
- Sequencing Batch Reactor (SBR)
  - Batch reactor
    - Feed
    - Stir
    - Settle
    - Decant

Stirred Ag Reactors in the U.S.

- 15 mixed digesters*
  - 10 dairy
  - 3 swine
  - 1 caged layers
  - 1 ducks

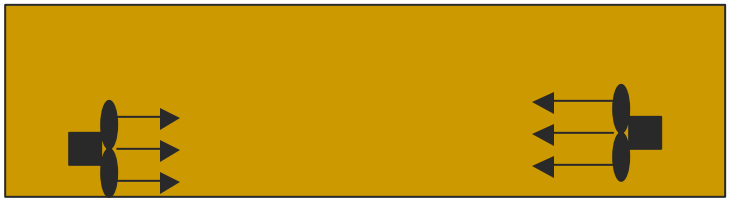
*Per Agstar database Oct. 2002

Mixed Digesters

- CSTR…HRT = SRT
  - Generally design for long detention times
    - 20-30 days
    - Means relatively large volume required…more $$
    - Theoretically fresh manure is discharged if mixing is thorough
- SBR…HRT>SRT
  - HRT may be very short…days or even hours
  - SRT is very long…provides more thorough digestion

Mixed Digesters

- Must have some type of mechanical system for agitating the manure
  - Mechanical propellers
    - Submerged motors
    - Exposed motors with shafts extending into the manure
  - Pumps
    - Recirculate liquid
    - Recirculate gas



Manure Thickness

- **Mixed reactors are good for manures too thin for plug flow and too thick for lagoons**
  - **Plug flow: 10 - 13% TS (dairy)**
  - **Lagoons: 0.1 – 2% TS (flush sys)**
  - **Mixed: 2 – 5% TS (swine)**

Manure Thickness

- Swine manure
  - Farrowing/gestation: 3.0-5.0% TS
  - Finishing houses: 4.0-9.0% TS
    - May have to be diluted if too thick
- Dairy manure
  - Typically 10-13% undiluted
    - Bedding may thicken it
    - Works best undiluted in plug flow digester
    - Sand and digesters don’t go together

Construction

- Mixed digesters may be either “hard top” or “soft top”
- Shape can be rectangular or circular
  - Round designs may be easier to mix
  - Rectangular don’t need special length/width ratio like plug flows
- Concrete or steel
  - Must be insulated in cold climates

Mixing

- Ideally mixing would be continuous
  - Keeps microbes into contact with nutrients
  - Requires a lot of energy
- Periodic mixing
  - Digesters respond quickly after mixing or feeding
  - Over-designed mixers provide safety factor against solids settling

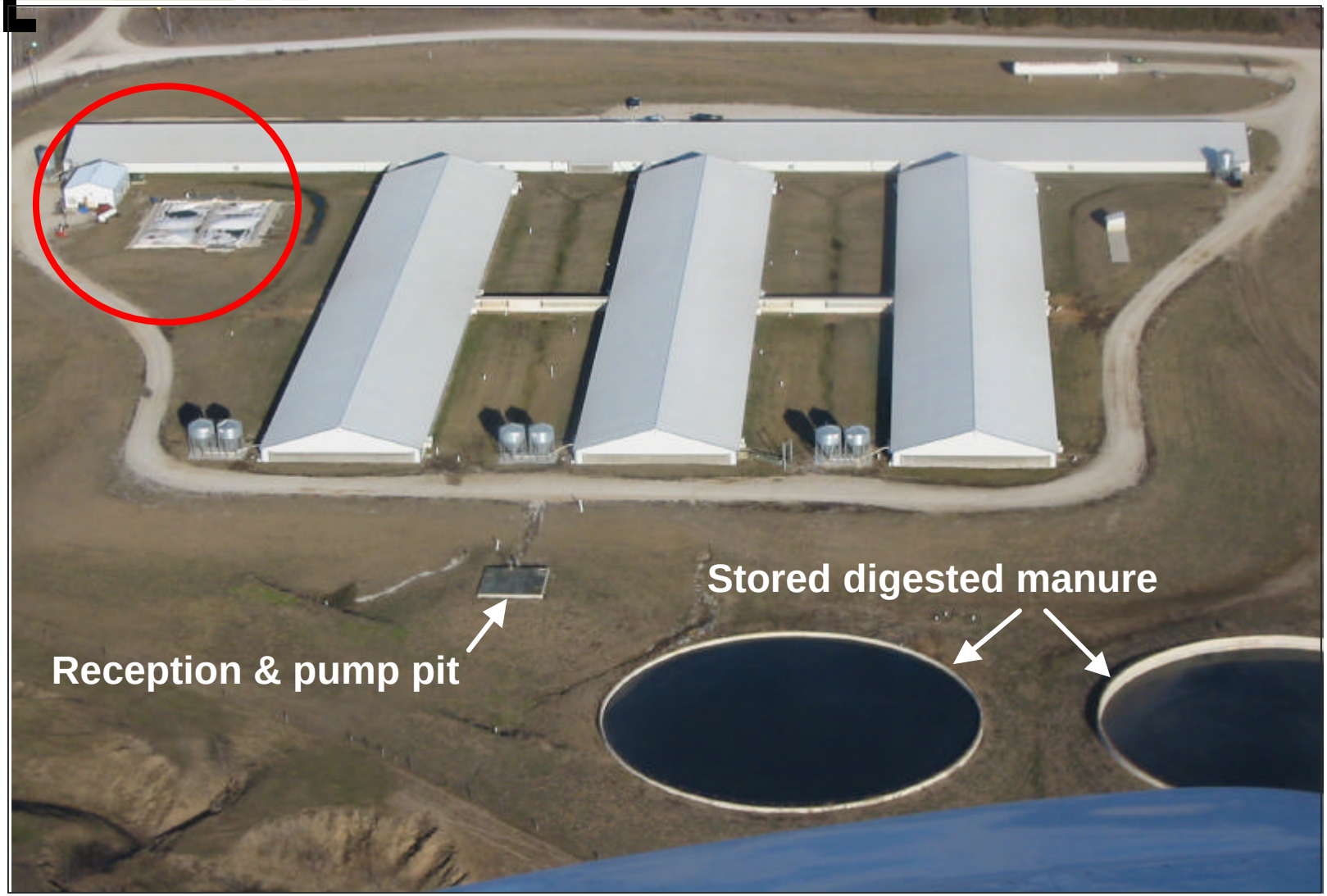
Primary Concerns

- Additional mechanical equipment required for mixing
  - More $$ to construct
  - More maintenance/management requirements
- Solids accumulation if mixing or discharge designa are inadequate
- Struvite accumulations
  - Foul pumps & pipes

Heating

- **Uniform heat is necessary throughout digester volume**
  - **Preheat not necessary or advantageous as it is for plug flow**
  - **Mixing while feeding is good management practice to rapidly warm incoming manure**

Iowa Mixed Digester



Iowa Mixed Digester

- Iowa swine digester
  - Mixed morning and night for ~ 1 hour each time
  - Fed in the morning during the mixing cycle
  - Manually activated pumps to provide feed

Performance

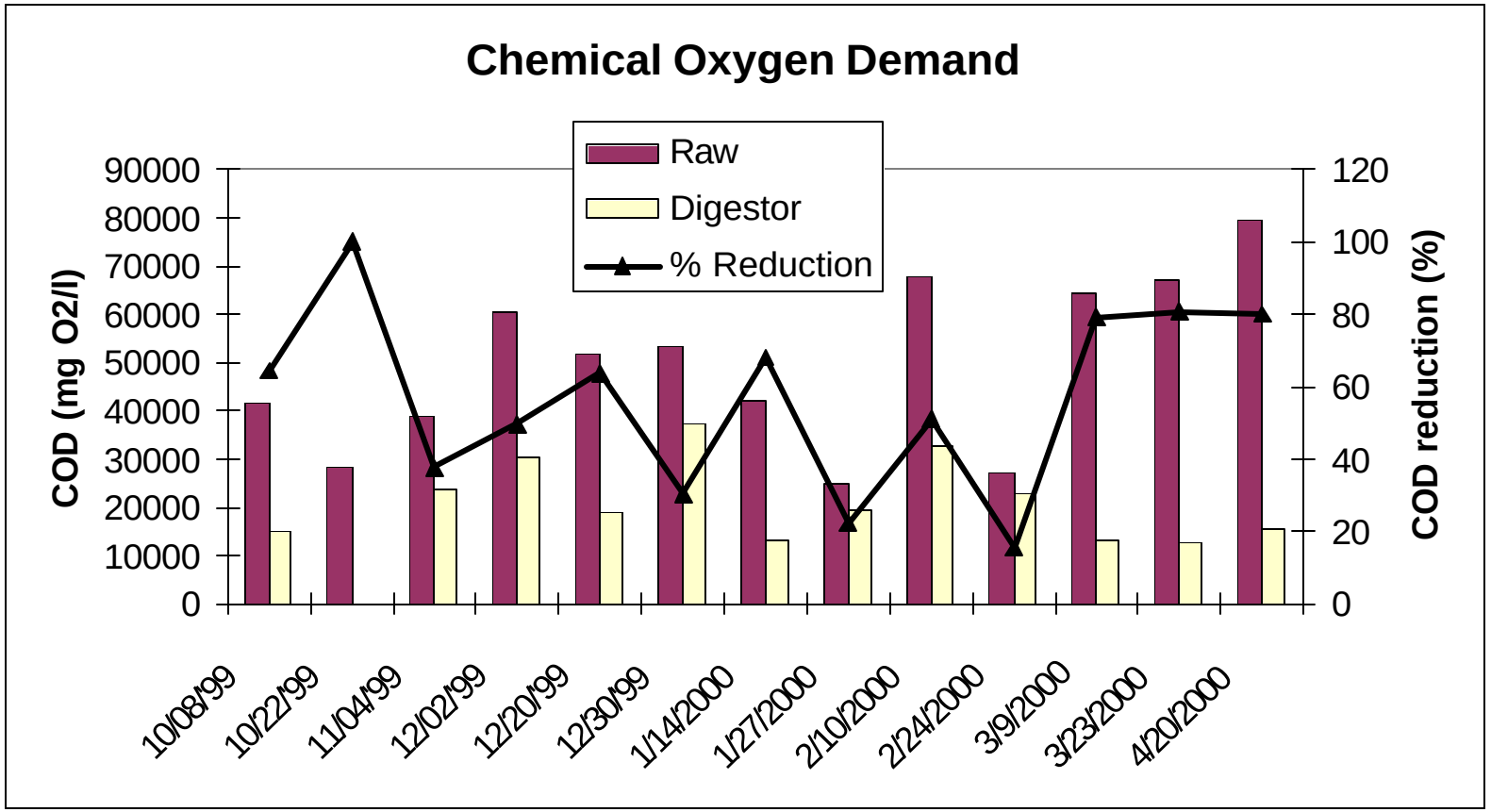
- Loading rate
  - **Gal manure fed = 540,000 gal/mo.**
    - **18,000 gal/day**
    - **3.6 gal/sow-day**
    - **1.5 kg VS/M^3-day**
      - **90 lb VS/1000 ft^3 (~10X lagoon loading rate)**

Performance

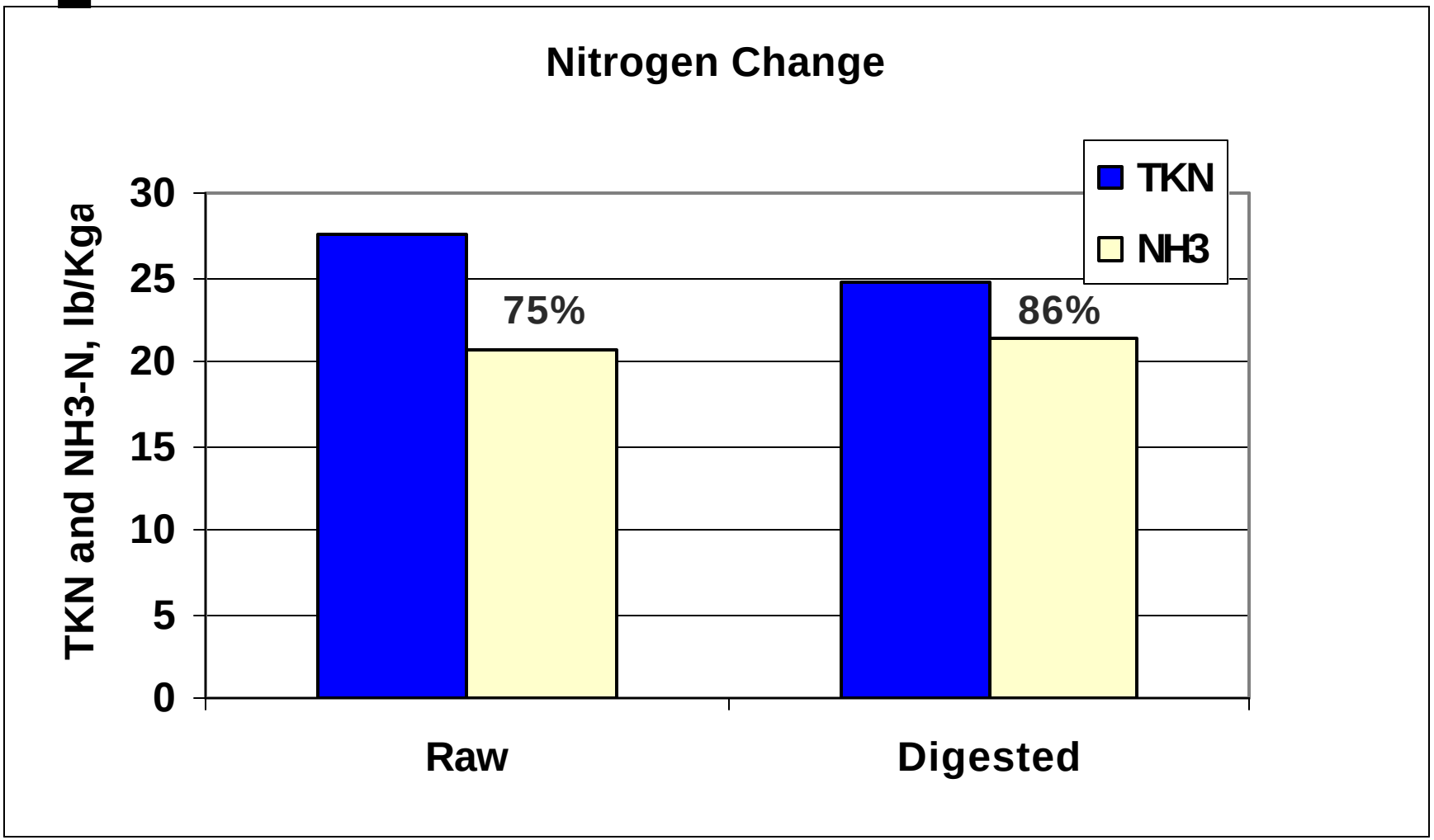
- Energy production
  - Biogas generated = 588,000 cu ft/mo.
    - 19,600 cu ft/day (70% methane)
    - 3.9 cu ft/sow-day
  - Electricity = 24,500 Kwh/mo.
    - 816 kwh/day
    - 163 watt-hr/sow-day
    - 6.8 watts/sow
  - Generator run time 80% first 6 months

Performance - COD

- Average COD reduction for Iowa CSTR = 60%

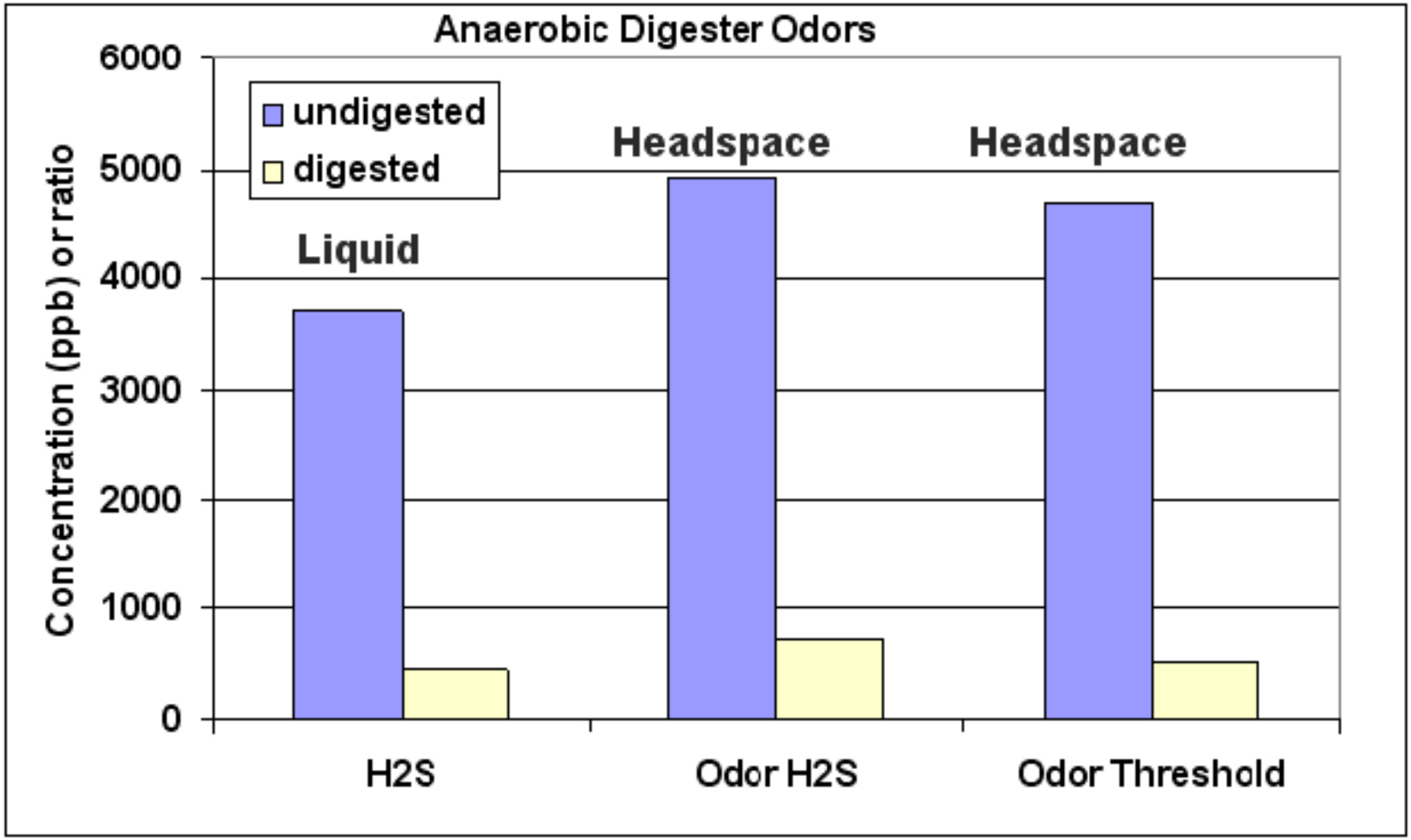


Performance – N Change



Performance – Odor Reduction

- Odors reduced ~ 90%



Summary – Mixed Digesters

- Useful for moderately thick manure
  - Use if manure's not thick enough for plug flow
- Additional mechanical requirements
  - maintenance and good management very critical
  - Iowa unit has been challenging to maintain
- Good COD & VS reductions
- Odor concentrations are reduced
- Manure is still not "releasable" quality