The Unintended Energy Impacts of Increased Nitrate Contamination from Biofuels Production

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Key issues I will address

• How will current policy influence the future expansion of biofuels?

• How will this expansion of biofuels impact the environment?

• What are the unintended consequences of these environmental impacts in the energy sector?
The production of biofuels has implications “downstream”…
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Biofuels for more energy

fertilizers contaminate water
The production of biofuels has implications “downstream”...

Biofuels for more energy

Fertilizers contaminate water

Polluted water raises health concerns
The production of biofuels has implications “downstream”...

- Biofuels for more energy
- Fertilizers contaminate water
- Polluted water raises health concerns
- Advanced water treatments purify water

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The production of biofuels has implications “downstream”...

- More energy is consumed in water treatment.
- Biofuels for more energy.
- Advanced water treatments purify water.
- Fertilizers contaminate water.
- Polluted water raises health concerns.

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Current U.S. policy promotes the future expansion of biofuels
The Energy Independence and Security Act of 2007 implemented a nationwide RFS

- Corn-starch based ethanol production likely to increase to 15 billion gallons per year by 2022
- Advanced biofuels will contribute an additional 21 billion gallons per year
- Total 2022 target: 36 billion gallons of biofuels
EISA 2007 will significantly increase the production of biofuels in the future.
Corn-starch based ethanol production has well-cited water quality implications.
Corn starch based ethanol production has well-cited water quality implications

↑ Corn production

↑ Fertilizer use

↑ Runoff/nutrient loading to downstream water bodies

↑ Increased nitrate contamination in water sources
Analyses predict significant increases in nitrogen loading in water due to EISA 2007

- 37% increase in N loading nationally (Simpson et al., 2008)
- 10-34% increase average annual flux of dissolved inorganic N to the Mississippi-Atchafalaya River Basin by 2022 (Donner and Kucharik, 2008)
- 24% increase in riverine N export to the Lake Michigan basin by 2017 (Han et al., 2009)
Nitrate contamination in drinking water has well-cited health implications.

- Biofuels for more energy
- Fertilizers contaminate water
- Polluted water raises health concerns
Nitrate contamination in drinking water has well-cited health implications

• Confirmed link to methemoglobinemia aka “Blue Baby Syndrome”

• Confirmed link to esophagus, stomach, colon, bladder, lymphatic, and hematopoietic system cancer in animals (Ward et al., 2005)

• Confirmed link to Alzheimer’s, Diabetes Mellitus, and Parkinson's Disease (Monte et al., 2009)

• Potential link to cancer in humans (Ward et al., 2005)
Removing contaminants from water requires advanced water treatment processes.
Water treatment processes are selected based on raw water quality

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Advanced water treatment processes might be necessary to clean degraded water

• Membrane Treatments
  – High pressure gradients push water through very small membranes to remove contaminants

• Ion Exchange Methods
  – Negatively or positively charged ions are exchanged to remove ionic contaminants

• Electrochemical Methods
  – Electric currents are passed through water to kill microorganisms/dissolve contaminants
Advanced water treatment processes have substantial energy costs.

- Biofuels for more energy
- Fertilizers contaminate water
- Polluted water raises health concerns
- Advanced water treatments purify water
- More energy is consumed in water treatment

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Water treatment processes effective for nitrate removal are very energy intensive. Current methods of water treatment consume 9-200 kWh of energy per million gallons.
Water treatment processes effective for nitrate removal are very energy intensive.

Advanced treatment might consume 3,000-30,000 kWh per million gallons depending on source water quality.

- Average Groundwater Treatment
- Average Surface Water Treatment
- Electrodialysis*
- Reverse Osmosis (Brackish Water)*
- Reverse Osmosis (Sea Water)*
Surface water treatment is not likely to be significantly affected by EISA 2007

Surface water sources serve an average of 12,500 people per system
- Mainly serve city populations
- Large water volumes are harder to contaminate

(www.drinking-water.org)
Groundwater contamination is likely to increase as agricultural activity increases

Groundwater sources serve an average of 700 people per system
- Supply 98% of non-community public systems
- Small volumes are most susceptible to contamination
- 24% of shallow (<5 m) groundwater wells in agricultural areas are already contaminated

(www.cwac.net)
The majority of high risk groundwater wells are concentrated in the Corn Belt.

Our analysis estimates the energy that would be required to treat baseline nitrate contamination in the public water supply

- Scenario 1: All water delivered to affected population is treated at the public water treatment facility with advanced nitrate-removal processes
- Scenario 2: Only a portion of the water delivered to the affected population is treated for nitrate removal at the point-of-use

\(^a\) 12.4 million people were supplied nitrate contaminated water from public water systems between 1998-2003 according to the Environmental Working Group’s National Tap Water Quality Database.
Results suggest a dramatic increase in energy requirements for nitrate removal

Scenario 1:
- 12.4 million people are delivered nitrate contaminated water in public water systems
- 634 billion gallons of contaminated water per year treated (assumes 140 gallons/person/day)

Standard SW treatment (baseline):
- 111 million kWh per year

RO treatment for Nitrate Removal (advanced):
- 2,500 million kWh per year
- Increase of 2100% over baseline
Treatment for nitrate contaminated drinking water at the home offers savings

Scenario 2:

- 12.4 million people are delivered nitrate contaminated water in public water systems
- Point-of-use systems are used to treat drinking water only
- 57 billion gallons of contaminated drinking water per year treated (assumes 12 gallons/person/day)

Standard SW treatment (baseline):
- 10 million kWh per year

RO treatment for Nitrate Removal (advanced):
- 221 million kWh per year
Conclusions

- There will be water quality consequences as a result of EISA 2007
- Groundwater wells are more likely to be affected than surface water supplies
- Treating baseline nitrate contamination in the public water supply would elicit substantial increases in energy consumption to meet acceptable MCL
- Point-of-use treatment systems offer potential energy savings for treating small volumes of contaminated water (although they require more energy per volume of water treated)
Questions?
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