Implications of bioethanol production on water quality in Nebraska

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Introduction

In this literature review, we analyze:

- Bioethanol production and water quality in the United States especially Nebraska.
- Essential figures and data, including the scope of the issue or problem identified.
- Potential impacts on the water quality issues caused by water consumption and water waste discharge.

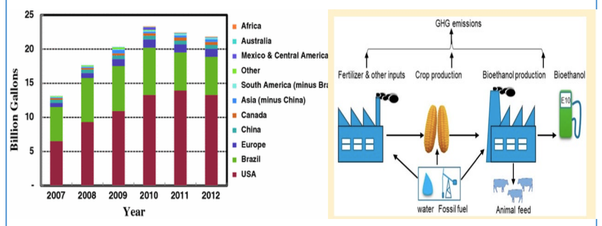
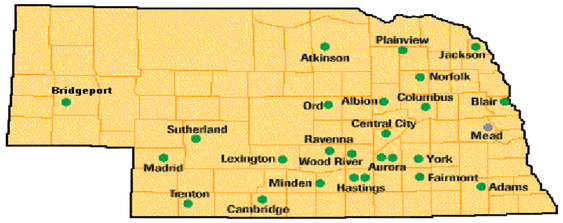


Fig.1 Major bioethanol producers in the world

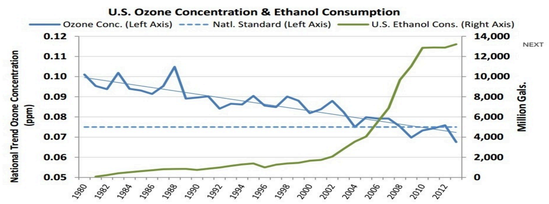
Background

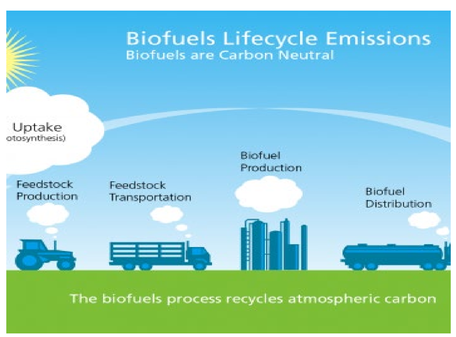
Bioethanol production in Nebraska

- Bioethanol plants in Nebraska



- Ethanol is a non-toxic source of energy hence reducing GHG by 46%.
- 43% GHGs on average are reduced by using corn ethanol.
- 38 million metric gallons of road GHG was reduced by 13.3 billion gallons of ethanol produced.

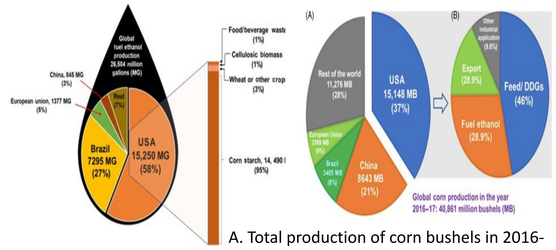




Biofuel as Carbon Neutral scheme

Bioethanol production in Nebraska Vs other states

- Dominant feedstock is corn. Others include sorghum, cellulosic biomass, water, sugars, alcohol, and tobacco.
- According to the Nebraska Corn Board (2019), they use about seven hundred million bushels of corn annually.



A. Total production of corn bushels in 2016-2017 in a million bushels of major corn produces Vs global production in % share.
B. Application of corn in the USA in different sectors

Largest plant "Archer Daniels Midland Co." In Columbus. 313M gallons/year.

	Existing Production Capacity	Capacity Under Constr./ Expansion	Installed Ethanol Biorefineries	Biorefineries Under Constr./ Expansion
Iowa	4,593	-	43	-
Nebraska	2,296	-	26	-
Illinois	1,867	-	14	-
Minnesota	1,384	-	19	-
Indiana	1,337	-	15	-
South Dakota	1,223	-	16	-
Ohio	676	-	7	-
Kansas	615	-	14	-
Wisconsin	603	-	9	-
North Dakota	542	16	6	1
Texas	395	-	4	-
Michigan	350	-	5	-
Missouri	287	-	6	-
Tennessee	237	-	5	-
California	217	-	5	-
New York	165	-	2	-
Colorado	143	-	4	-
Georgia	120	-	1	-
Pennsylvania	120	-	1	-
Idaho	60	-	1	-
North Carolina	57	-	1	-
Arizona	55	-	1	-
Kentucky	50	-	2	-
Oregon	42	-	2	-
Virginia	2	-	1	-
TOTAL U.S.	17,436	16	208	1

- Nebraska 2296M gallons/year, Illinois 1867M gallons/year(Renewable Fuels Association (2021)

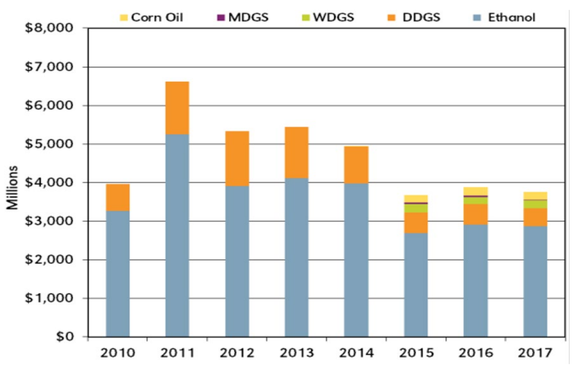


Figure 1: Ethanol Production in Nebraska from 2010-2019
University of Nebraska. (2020). *The Impact of the Covid-19 Crisis on Nebraska's Ethanol*

❖ In this figure, University of Nebraska indicates that decline in ethanol production in USA as well as Nebraska is due to the reduction of energy production worldwide. There has been 58% reduction in profit margins in the industry plus 81% reduction in returns over variable costs.

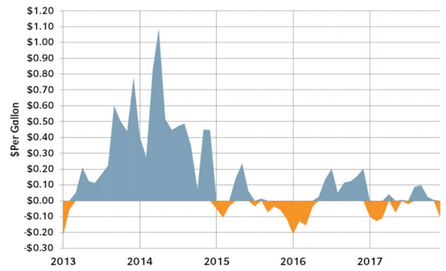


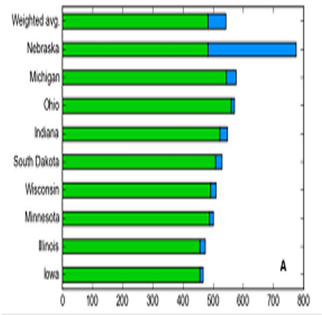
Figure 3. Net Returns for Ethanol January 2013 to December 2017

Measures taken

- Reducing environmental protection is the key to scale up
- Ethanol production in Nebraska requires expenditure of land and water resources.
- Increasing land for corn production and water resources.

Bioethanol production and water quality in USA and Nebraska

The weighted average WF of maize-ethanol in the US is 1220 litre/litre.



- Blue water(water used in irrigation from evapotranspiration)
- Green water(rainwater consumed through crop evapotranspiration during growth stage)

Figure 4: Green and Blue Water Footprint in Bioethanol Production in the Different States (Source: Mekonnen et al., 2018) y 2013 to December 2017

Table 1 Watershed responses of various cellulosic feedstock production and climate change scenarios

	Watershed responses								Reference
	Nitrogen loss	Phosphorus loss	Sediment loss	Soil water	Stream flow	Surface runoff	ET	WUE	
1. Agricultural residue harvest									
Stover removal >24 %	↓	↓	↑	↓	↓	↓	↑	↑	14, 19, 20,
Stover removal with winter cover crop	↓	↓	↓				↑	↑	32
Stover removal with no-till	↓	↓	↓						14, 21,
2. Land conversion to perennials									
From native grass	↑		↓		↓				14, 21
From pasture	↓	↓	↓		↓	↓	↑		20
From row crop	↓	↓	↓	↓[a]			↑	↑	31, 32
3. Mixed feedstock landscape converted from cropland									
Agricultural crop dominant with a fraction of perennial grass	↓	↓↑	↓↑	↓	↓	↓	↑		20, 22
Perennial grass dominant with SRWC	↓	↓	↓		↑↓		↑↓		23, 32
4. Climate changes									
Increased CO_2	↑			↑	↑		↓		27, 28
Increased ozone							↑	↑	52
Increased temperature and decreased precipitation	↓[b]			↓	↓		↑		27

[a] Decreased in summer and increased in spring
[b] Nitrogen concentration in the stream increases
SRWC=short rotation woody crop

- Cropping systems and farming practices affect sediment loading in watershed
- Minimal tillage reduce sediment loading .
- Watershed loading and nutrient eroding are affected by the slope, soil type, fertilizer input rate and farming practices. (M. Wu, 2014)

❖ Fertilizers and pesticides are mostly used in agriculture practices. The latter if not applied in right amounts wash into water bodies and affect water quality. For instance, excess nitrogen in Mississippi River causing a dead zone in the Gulf of Mexico. This affects water quality. *Water Implications of Biofuels Production in the United States*. (2007).

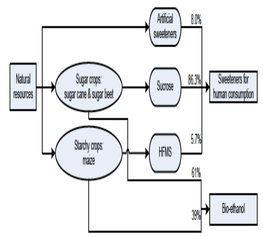
Comparison between USA bioethanol production and Brazil

Today, Brazil is the second largest producer of bioethanol in the world. Before 2006, Brazil was the first major bioethanol producer in the world, but USA surpassed it. The feedstock that is commonly used in Brazil is sugar cane.

Table 1: Global production of sugar cane, raw cane sugar and bio-ethanol over the period 2001-2006 (Source: FAO, 2006c).

Country	Contribution to global sugar cane production (%)	Contribution to global cane sugar production (%)	Contribution to global bio-ethanol production (%)	Main feedstock ethanol
Brazil	30	24	32	Sugar cane
India	21	17	1	Sugar cane
China	7	9	3	Maize, sugar crops, maize
Thailand	4	6	1	Sugar cane
Pakistan	4	3	-	-
Mexico	4	5	-	-
Colombia	3	2	-	-
Australia	3	5	-	-
US	2	3	43	Maize
Indonesia	2	2	-	-

- less than 1%



❖ The total consumptive WF of bioethanol from Brazil's sugarcane is 1.4 times larger than that of bioethanol from Nebraska's corn.

Recommendations

- Supporting areas with smaller energy and water footprints
- Mitigating the energy and water environmental impact rather than cutting back on production levels.
- Mekonnen et al. (2018) add that since most of the total water footprint of bioethanol production in Nebraska and the US occurs at the agricultural stage, policies should target this stage to minimize the industry's impact on the water systems of corn growing areas for biofuel production.
- Conservation tillage
- To ensure that technical assistance in water quality while growing feedstocks. Manochioa, Andradea, Rodrigueza, and Moraes (2017) suggest that there should be measures to promote the diffusion of technologies for early adoption and implementation.
- Currently, there are measures to transition from first-generation (1G) biofuels to second-generation (2G) ones. First-generation biofuels are those feedstocks obtained from food crops while second-generation ones include industrial waste, residue streams, non-food crops, and lignocellulosic feedstocks (Susmozas et al., 2020). Susmozas et al. (2020) propose that a transition from 1G to 2G feedstocks is an urgent concern for sustainability in the biofuel industry since it could lead to better water and natural resources management.

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