

Topic 24: Anthropogenic Changes: Pollution

Coal-fired Gavin Power Plant, Cheshire, OH




image: Wikipedia

test 8: today; includes questions for HW6!
test 9: next Monday (incl HW 7)

Homework 8 due tomorrow 5 pm;
absolutely no late submissions past midnight


Today 4 pm : discussion session; York 3030
Today 5 pm: zoom office hour
no class Wednesday

please participate in SET course evaluation by 12/7

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

1

5-9 Dec 1952 "Great London Smog"



source: Wikipedia

short video 19 (acid rain)

- ✧ cold wave
- ✧ temperature inversion
- > polluted stagnant air
- ✧ "pea soup" fog


- SO_2 from coal burning + H_2O
-> sulfuric acid -> acid rain
- instances of poor air since 1200s
- worsened in 1600s
- Great London Smog worst ever
- 1956: UK Clean Air Act

4000 fatalities by 12/8 (later update: 12,000)
100,000 ill

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

3


Acid Rain and Coal Burning short video 19



statues at the Cologne/D
cathedral (1248)

Image: "Understanding Earth" by Press/Siever

- After coal-firing powerplants increased smokestack height
- massive fish kills in freshwater lakes (Scandinavia, Canada, NE U.S.)
- mountain forests damaged, particular at higher elevations
- \$1 billion damage each year to buildings and monuments



➤ 75% of lakes
➤ 50% of streams acidified

pH < 5.5 affects fish


2023 - EPA
clean rain: 5.6
normal rain: 5.0-5.5
acid rain: < 4.5

Image: wikipedia

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

4

Acid Rain and Coal Burning – U.S. short video 19



*Harvard marble and copper statues
Wrapped for protection every winter
against acid rain and snow*

source: wikipedia

- about 50% of Canada's fallout has U.S. source
- **relationship between acid rain and coal burning firmly established**
- > Clean Air Act in 1991 (1963) (EPA): reduce SO₂ and NO₂ production!
- last administration: "get rid of Clean Air Act" and EPA

N₂O greenhouse gas
NO₂ pollutant

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

5

Coal – The Dirtiest Fossil Fuel

Coal burning emits:

CO₂
CH₄
SO₂
Hg

Newspaper 22 Nov 2016

CANADA TO ELIMINATE COAL-FIRED PLANTS

TORONTO
Canada announced Monday it plans phase out the use of coal-fired electricity by 2030.

The move is in stark contrast to President-elect Donald Trump's vow to revive the American coal industry.

Environment Minister Kathleen McKenna said the goal is to make sure 90 per-

cent of Canada's electricity

comes from sustainable

sources by 2030.

Prime Minister Justin

Trudeau's Liberal govern-

ment is rolling out as part of

a broader climate change

plan. Trudeau also has plans

to implement a carbon tax.

Trump, in contrast, has

also said he would "cancel"

the Paris Agreement.

Barack Obama told President

Trump he would miss

working with him because

he shared so many values.

France, Britain, the

Netherlands, Austria and

Denmark have all announced

accelerated coal phase outs, McKenna said.

ASSOCIATED PRESS

Canada to phase out coal electricity by 2030

Europe:
virtually all countries
moving/moved away from
coal

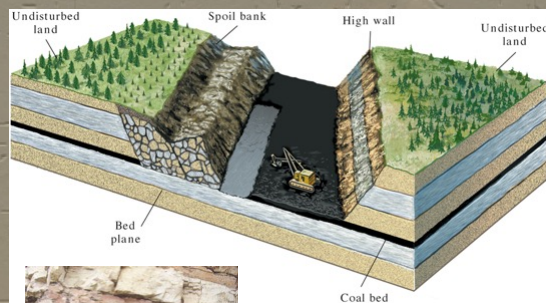
After expiration of Kyoto Protocol, 2011
Fukushima and 2022 Ukraine war:
Germany increased low-grade coal
plants instead of extending nuclear
power plants

last U.S. administration:
➢ bring coal power back
➢ abolish/weaken EPA

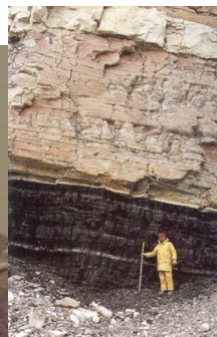
SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

6

Mining Coal



- strip mining (open pit)
- underground mining
- coal mining releases CH₄



coal seam

open pit mining:

- most economic but leaves scars
- acid mine run-off

underground mining:

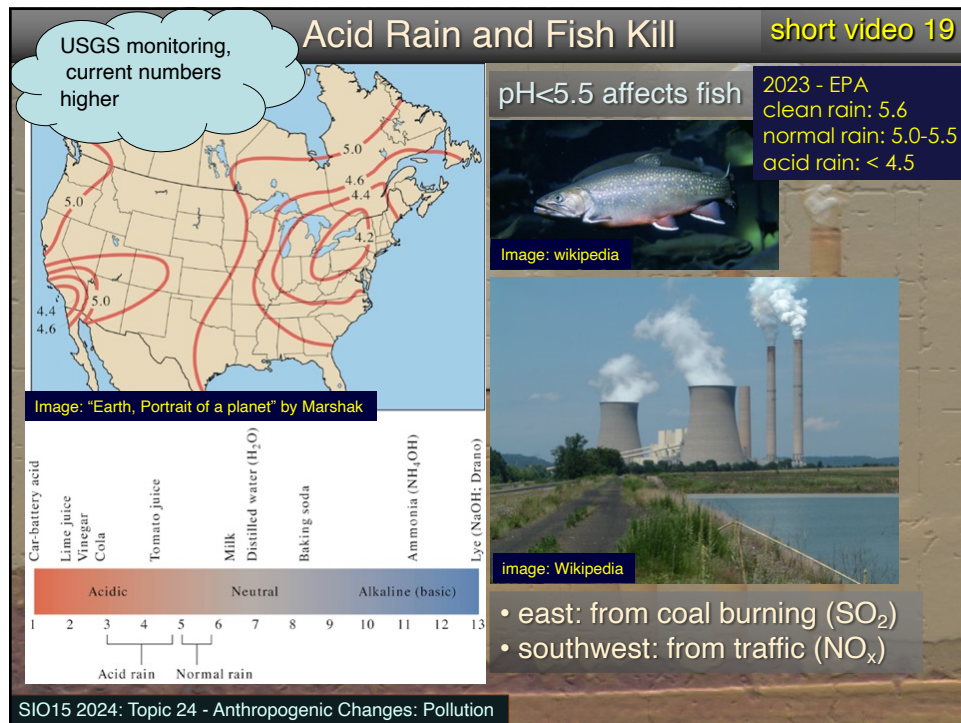
- dig shafts (can collapse)
- mine gas can explode
- miners get black-lung disease



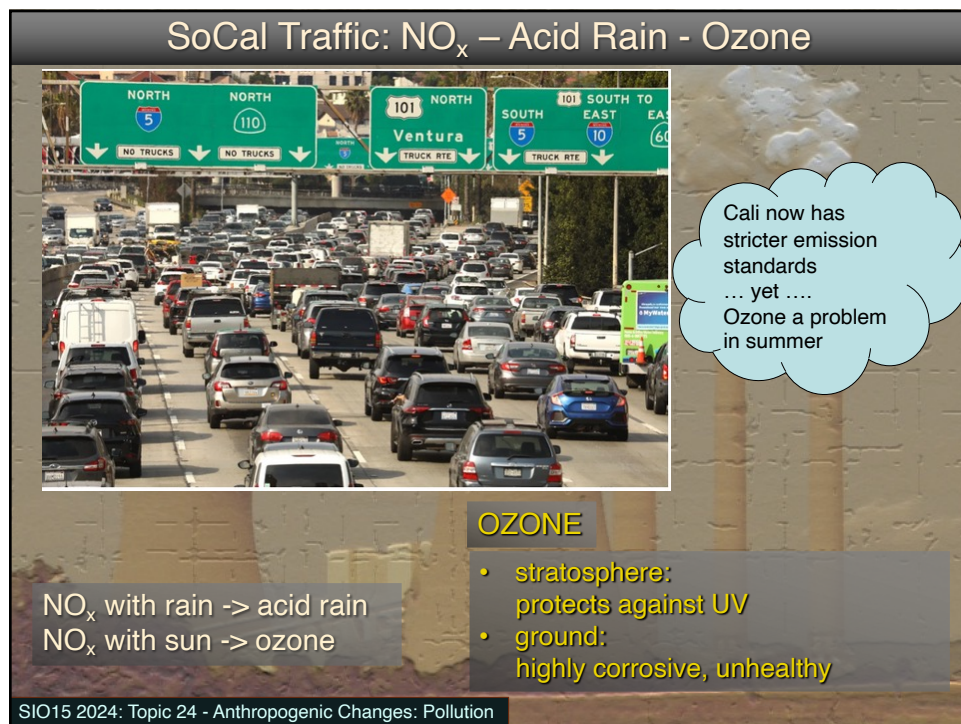
acid streams

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

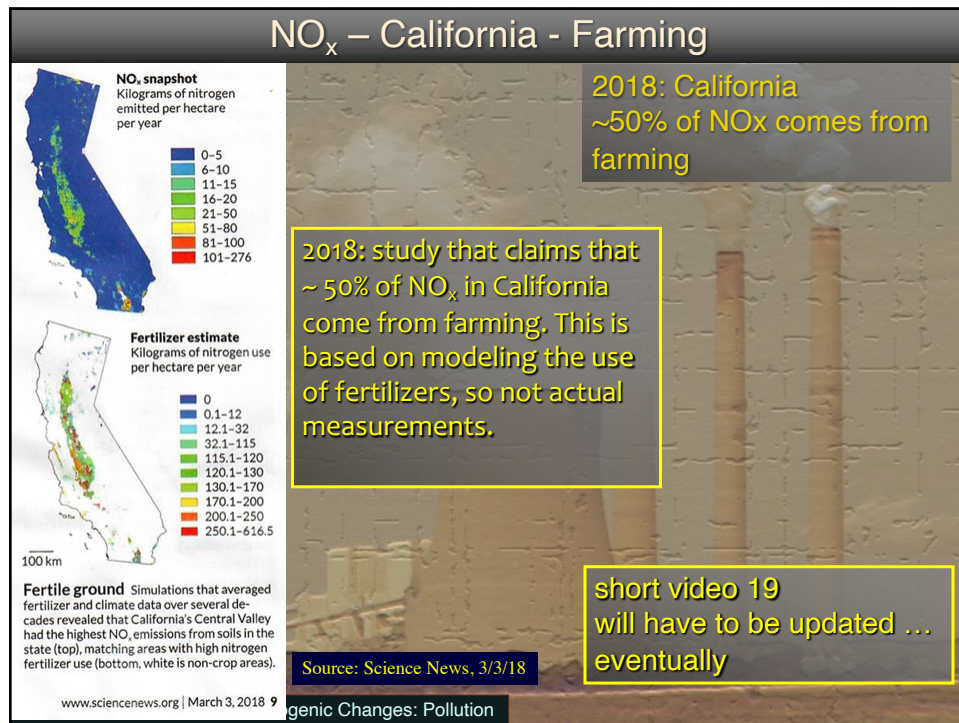
10



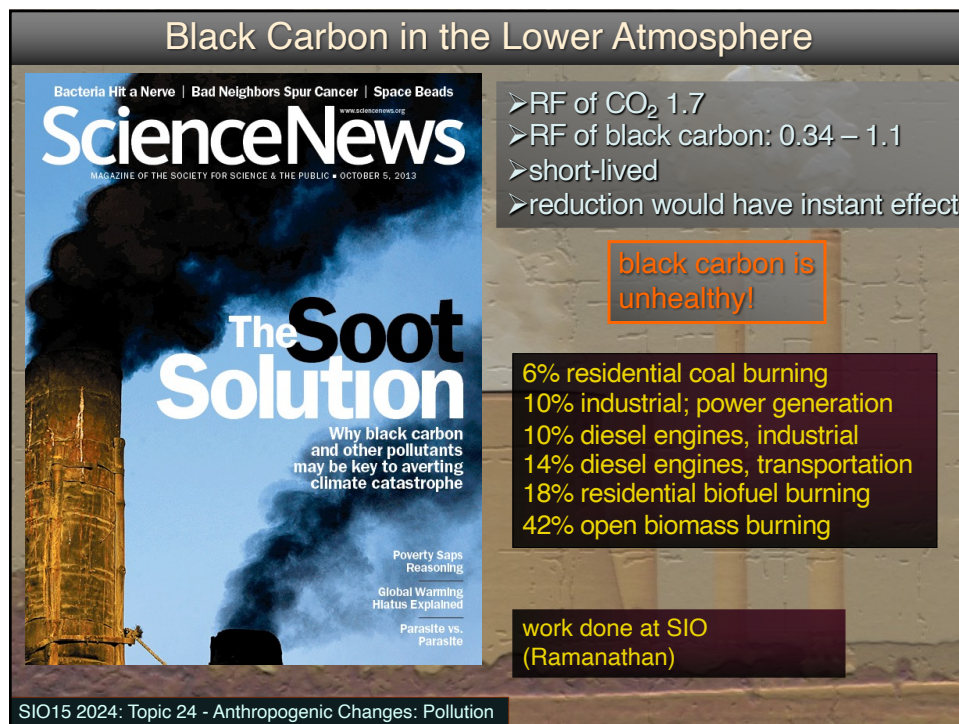
12



13



14



15


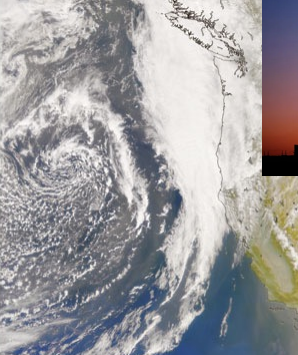

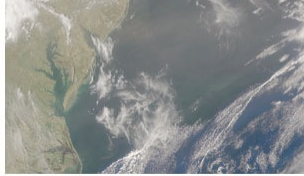
Particulate Matter

tiny pieces of solid or liquid matter in atmosphere suspended in air - > **aerosol**

Radiative forcing:
lower atm: positive
upper atm: negative

Science News: 11/23/19
offset in global warming
1940s-1970s due to
global dimming by pollution
(before Clean Air act)

it takes 2 days for dust
from Gobi desert to
reach U.S. West Coast

Source: Griffin et al. 2001

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

16

Particulate Matter: PM₁₀; PM_{2.5}

source: wikipedia

PM ₁₀ ($\mu\text{g}/\text{m}^3$) (2008-2013) annual mean	PM _{2.5} ($\mu\text{g}/\text{m}^3$) (2008-2013) annual mean
540 Peshawar, Pakistan	153 Delhi, India
448 Rawalpindi, Pakistan	149 Patna, India
334 Mazar-i-Sharif, Afghanistan	144 Gwalior, India
329 Gwalior, India	134 Paipur, India
320 Ahvaz, Iran	117 Karachi, Pakistan
318 Hamad Town, Bahrain	111 Peshawar, Pakistan
305 Raipur, India	107 Rawalpindi, Pakistan
286 Delhi, India	102 Khoramabad, Iran
273 Karachi, Pakistan	100 Ahmedabad, India
260 Kabul, Afghanistan	96 Lucknow, India

desert areas

mainly anthropogenic

China:
101 Shenyang
121 Beijing
124 Xining
126 Xi'an
133 Ürümqi
155 Lanzhou

EU PM₁₀ legislation limits:
yearly average: $20\mu\text{g}/\text{m}^3$
daily average: $50\mu\text{g}/\text{m}^3$
days: 7

China:
55 Yanan
56 Beijing
57 Xining
58 Xi'an
61 Ürümqi
71 Lanzhou

smaller particles more
dangerous than larger ones
smog: PM_{2.5}

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

17

Delhi, India 11/04/2019






Image: NASA Earth Observatory



Air quality index: 900!
2-week driving ban
100s flights cancelled

Air Quality Index (AQI) Values	Levels of Health Concern
When the AQI is in this range:	...air quality conditions are:
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for Sensitive Groups
151 to 200	Unhealthy
201 to 300	Very Unhealthy
301 to 500	Hazardous


SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

18

Mining and the Environment

- * open-pit mining leaves landscape scars
- * mining leaves waste rock in tailings piles (e.g. pile in Moab, UT uranium!)
- * acid/toxic mine runoff (e.g. sulfides released in ore-mining; **mercury** in gold mining; some is radioactive!)
- * rare-earth mining very problematic
- * smelting in ore-processing creates acidic air and rain



SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

20


Mine Reclamation – In Response to a Student Question

check out on Wikipedia:
land rehabilitation
mine reclamation


it may take less than a “couple decades” ... but it depends on toxins

open pit mine in Britain before/during reclamation

2006



2008



can also be done after agriculture, e.g. to restore wetlands

some issues:


- regrade to avoid erosion
- remove sulfides, toxins
- secure tailings dams
- costs

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

21

Mine Reclamation – In Response to a Student Question

Reclaimed strip mines in southwestern Pennsylvania



U.S. has invested \$7.2 B by 2011 to reclaim 295,000 acres

source: wikipedia

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

22

Mercury


- heavy metal; liquid at room T; vapor highly toxic
- USE:
 - * electrical switches
 - * dental fillings
 - * extract gold and silver from dirt
- HOW DOES IT GET INTO ENVIRONMENT?
 - * **unregulated burning of coal (and oil); above all in U.S.**
 - * incineration of waste (batteries!)
 - * gold (and silver) mining runoff
- can be stored in bones instead of Calcium
- not broken down in metabolism; accumulated in food chain
- damages brain and nervous system

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution


24

Mercury and PCB in the Oceans

Eating fish during pregnancy: How to avoid mercury and still get your omega-3s



PCB:
pesticides
paints
plastics
flame retardant
transformers
causes
cancer!



-PCB (phased out in 1970s but long-lived)
(polychlorinated biphenyl)

Mercury (Hg) in tuna:
tuna is a predator/high on food chain
accumulated Hg
attacks nervous system

25

The California Brown Pelican – An Unlikely Victim?



California Brown Pelican
- shells too thin for chicks to hatch
- close to extinction 1980s

DDT
(dichloro-diphenyl-trichloroethane)

1. modern insecticide
(malaria, typhus)
also used in agriculture
2. "safe in humans"
.... but
3. DISASTROUS TO BIRDS

phased out in 1970s but still used
(Bald Eagle also threatened)

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

26

Farming, Fertilizers and Groundwater

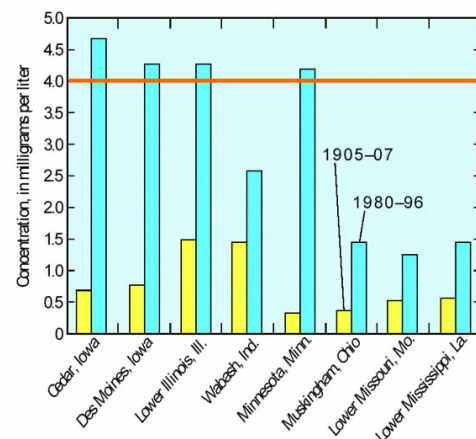
- blue baby syndrome due to **nitrate** in drinking water (> 10 mg/l)
- nitrate \rightarrow nitrite (particularly babies and sick)
- lack of oxygen in blood
- levels in Europe so high that bottled water recommended

current EPA threshold for infants:
10 mg/l (but should be 4 mg/l?)

Other thresholds:
Germany: 50mg/l
Switzerland: 25mg/l

20mg/l bad for cows

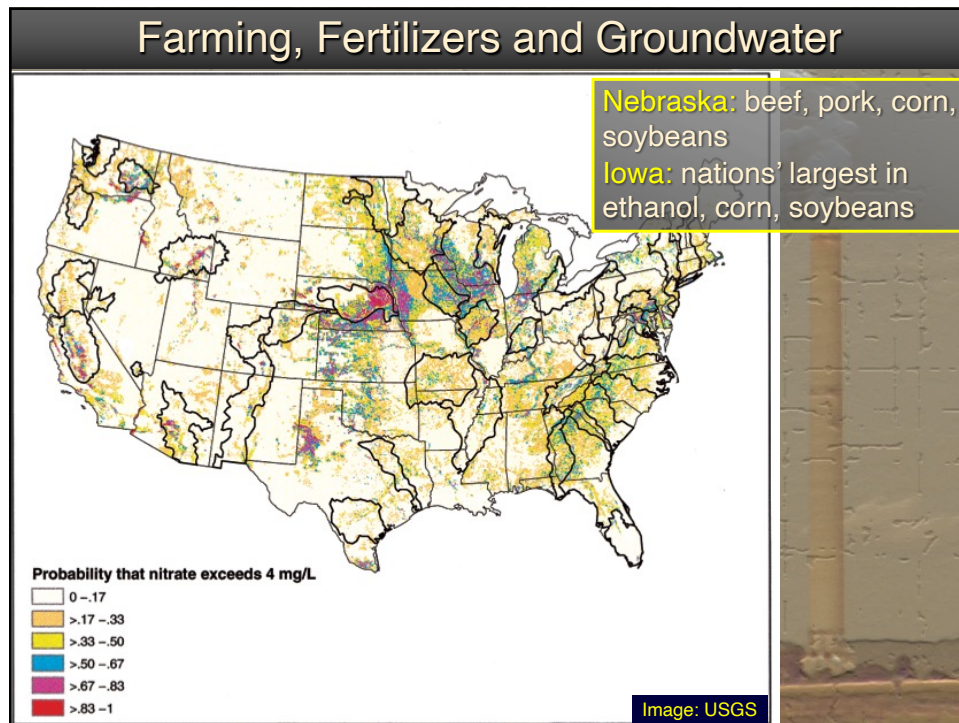
U.S.
some areas 10-fold
increase in last century
... and counting



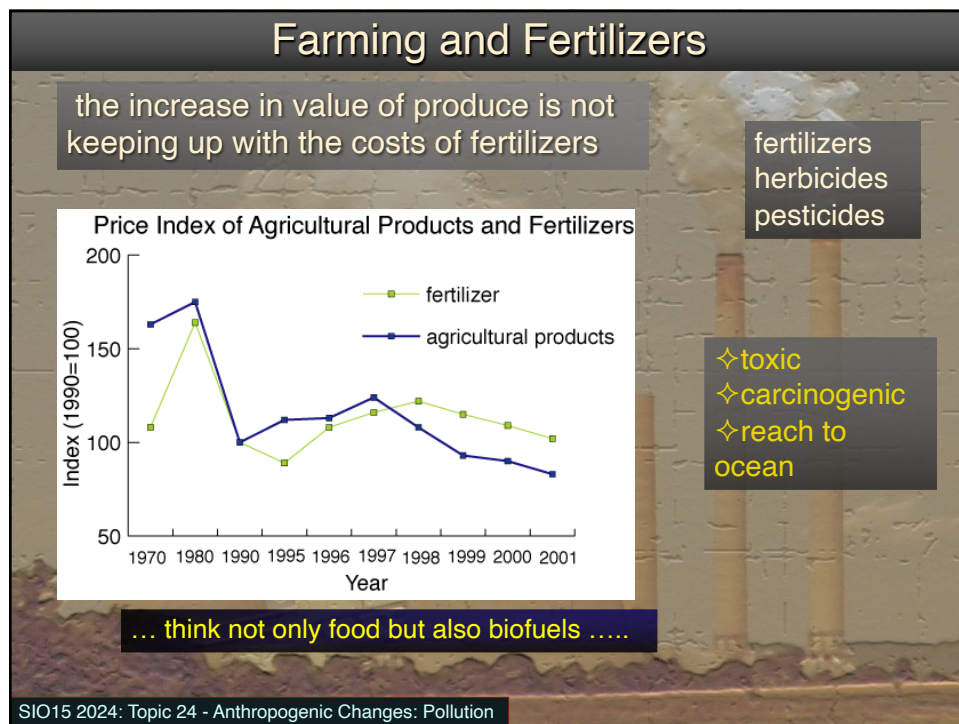
SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

Image: USGS

27



28

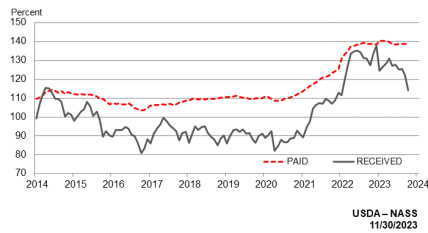


29

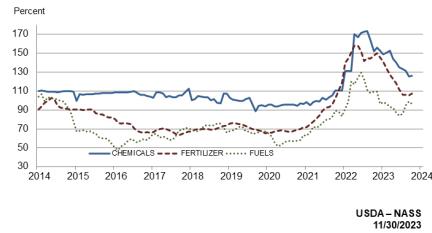
Farming and Fertilizers

update: the increase in value of produce is not keeping up with the costs of fertilizers

Received and Paid Indexes,
All Items by Month –
United States: 2011=100



Paid Indexes by Non-farm Origin and Month,
Chemicals, Fertilizer, and Fuels –
United States: 2011=100



SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

30

Assault on Coasts from far Inland

deforestation



- soil erosion
- increased runoff
- > sedimentation along coast
- choking habitat (coral reefs!)

agriculture



fertilizer, pesticides,
herbicides, fungicides,
other chemicals

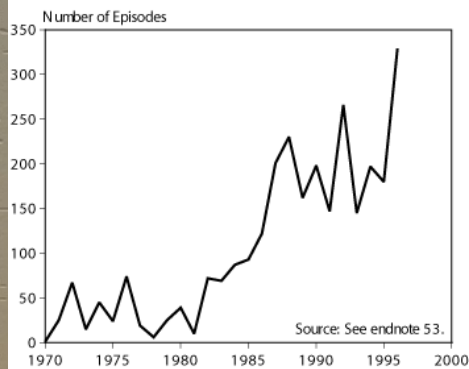
SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

31

Consequences of Overfertilization - Oceans

FIGURE 4

Harmful Algal Blooms in the West Central Atlantic, 1970-96



- harmful algal blooms/red tides
- toxic domoic acid
- > shellfish poisoning
- number of incidents increased 7-fold in last 20 years
- relationship to warming ocean not clear

diatoms vs dinoflagellates



dinoflagellate

research
done at SIO

Nov 21, 2015: CA, WA, OR delay
crab season b/c toxic red tide

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

32

Local Red Tide -> Bioluminescence

Mar 4, 2022: San Diego

Source: SD Union Tribune



dinoflagellates



dinoflagellate

Bioluminescence is lighting up the surf at La Jolla Shores beach. The fleeting glow is seen at night, especially in breaking surf. Scripps Institution of Oceanography scientists say previous episodes have lasted anywhere from one week to a month or more.

LOCAL SURF TAKES ON A GLOW

Quick flashes of bioluminescent light caused by chemical reaction seen at La Jolla Shores and coastal Del Mar

SIO15 2024: Topic 24 - Anthropogenic Changes: Pollution

33