Digging Up the Truth About Chemical Fertilizers

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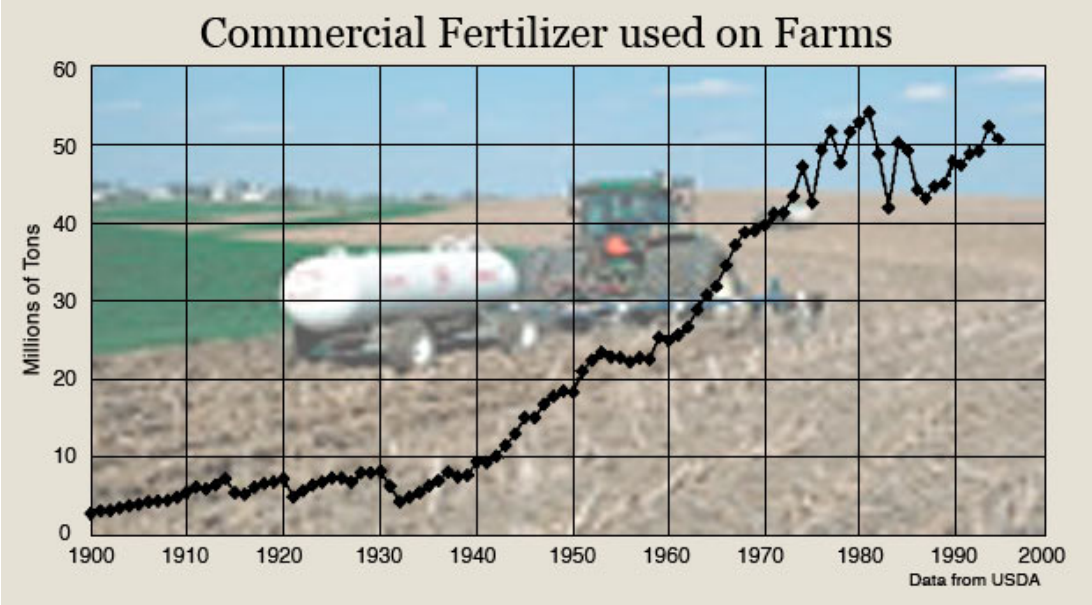
By Heir Dakota Peebler, 13 yrs, May 2019

Since October 2017, Florida has suffered from the devastating impacts of a harmful algal bloom that is creeping up its coast. Florida's pristine, blue waters have turned into a toxic, brown sludge. Going to the beach is now a threat to human health; once full, the beaches are now empty. To

[1] https://greentumble.com/pros-and-cons-of-using-agricultural-fertilizers/ Greentumble

date, the toxic algae's victims include manatees[2], dolphins, many different species of fish[3], sea turtles[4] and even whale sharks[5] . The beaches once visited by beachgoers enjoying a day at the beach have now been replaced by decaying fish and crustaceans. This phenomenon has been ranked the *worst* Florida red tide event in more than a decade.[6]

How did we get here?



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[2] TheGuardian, "Toxic "Red Tide" Blamed for Rise of Manatee Deaths in Florida" https://www.theguardian.com/us-news/2018/aug/20/manatee-deaths-toxic-red-tide-algae-bloom-florida

[3] KQED, "After 16 Months Of Dead Fish, Manatees And Dolphins, Florida's Red Tide Ebbs" https://www.npr.org/2019/02/14/694479180/after-16-months-of-dead-fish-manatees-and-dolphins-floridas-red-tide-ebbs

[4] Herald Tribune, "Red Tide Episode Kills Record Number of Sea Turtles" https://www.heraldtribune.com/news/20190115/red-tide-episode-kills-record-number-of-sea-turtles

[5] SunSentinel, "Did red tide kill this 26 foot whale shark in Florida?" https://www.sun-sentinel.com/news/florida/fl-reg-whale-shark-washed-up-florida-beach-20180809-story.html

[6] Miami Herald, "Florida's Red Tide takes on a mounting toll. And it's not just on the fish." https://www.miamiherald.com/news/local/environment/article216316295.html

[7] https://livinghistoryfarm.org/farminginthe50s/crops_06.html Farming in the 1960s (data from the USDA.)

To understand, let's dig deeper into a major contributor to this problem, chemical fertilizer. This paper covers the history of chemical fertilizers, the threats they pose to our environment and to us, and also takes a look at various solutions to these problems.

In 1918 a German chemist known as Fritz Haber was awarded a Nobel Prize for his invention that synthesized ammonia (NH3) from nitrogen in the air.[8] Ammonia is a key component of chemical fertilizer. Chemical fertilizers have three main elements: nitrogen, phosphorus, and potassium or NPK. Before the Industrial Revolution, when the global population was significantly lower leading to a lower demand for crops, farming methods relied on compost (decomposing organic/natural material) to fertilize crops, which also contains NPK. It was the tried and true method of traditional farming. While this practice was sustainable it did take time and labor to develop the compost and spread it onto crops, thus the discovery of technological solutions that reduced time and cost associated with crop fertilization captivated the farming industry in many developed nations. This would turn out to have consequences for the health of the waterways around our planet and is now may be considered an environmental crisis.[9]

In the pre-and post-World War II era, chemically synthesized fertilizer became indispensable to the agricultural industry, the military, as well as everyday American citizens. As was mentioned previously, one of the main components of chemical fertilizer is nitrogen. Nitrogen was also a major component of the TNT used in the nitrogen bomb. The development of commercial nitrogen supported the many horrors of war in the 20th century including the Nazi reign. According to *Discover* magazine, "None of this could have come about without the discovery of commercial nitrogen fixation. In trying to save Europe, Fritz Haber came close to destroying it."[10] After the War, numerous plants designed for the production of nitrogen for explosives remained. Those

[8] Famous Scientists, "Fritz Haber." https://www.famousscientists.org/fritz-haber/

[9] "Farming in the 1940s." Wessel's Living History Farm, https://livinghistoryfarm.org/farminginthe40s/crops_04.html

[10] James Worrell, David E., Marshall Jon Fisher, "The Nitrogen Bomb." http://discovermagazine.com/2001/apr/featbomb, April 1, 2001

plants were then used later to produce ammonia for fertilizer. The industry continued to grow over time. According to the EPA, “As global demand for grains grew, U.S. consumption of commercial fertilizers peaked at 24 million tons in 1981.”[11]

How are chemical fertilizers used and overused?

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In is not surprising then that American reliance on large amounts of chemical fertilizers first began in the post-WWII era. This stemmed from the post-war boom and the new idea of perfection that developed into over-consumption. It became the “new and improved” American way. Now, not only is chemical fertilizer heavily used in agriculture, it is also utilized in public places such as golf courses and for household purposes, particularly to fertilize lawns. It is used throughout our society and if we are to truly address this problem of the overuse of fertilizer, we must recognize the part that many of us in society can play. If many people who have the capacity and resources to take action and stop using chemical fertilizers in their lawns and gardens as well as pressure legislators to decrease or eliminate the agricultural and commercial use of these chemical fertilizers we can reverse the destruction it has had in our environment.

[11] “Agricultural Fertilizer.” EPA, https://cfpub.epa.gov/roe/indicator_pdf.cfm?i=55

[12] Fertilizer Machinery https://fertilizer-machinery.com/

Agriculture

Although chemical fertilizers can help create a bountiful harvest, there is a major downside. Fertilizers are used to enhance the soil and/or replace chemical elements depleted by previous crops.[13] Chemical fertilizer is known to be detrimental to human health and marine ecosystems and also diminishes soil fertility. Chemical fertilizers strip the soil of important natural nutrients, causing the soil to be less fertile, which in turn results in the use of more chemical fertilizer.[14] Chemical fertilizers are used around the world to create more abundant crops for the growing population and have come to be the norm. Fertilizer consists of the nutrients NPK* which are critical for plant health. Although these nutrients occur naturally in soil, chemical fertilizer is synthetically manufactured and contain pure NPK without other associated compounds found in organic compost. Thus chemical fertilizers act differently in the soil than organic compost changing the chemical nature of the soil that isn't found in nature. Similar to genetically modified crops we just don't know how these synthesized chemicals are interacting with the complex soil ecosystem and changing the adaptability of the soil.

Golf Courses

For some, golfing on perfectly trimmed, bright green grass is a great way to spend a sunny afternoon, but we must be aware of the detrimental impact golfing has on our planet including our oceans. Would the thousands of people who play golf still participate in this sport if they stopped to consider the horrific problem it is causing to the ocean we depend upon? Out of the 34,011 golf courses in the world, 45 percent are in the United States.[15] An 18-

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[13] Adam Augustyn, Patricia Bauer, Brian Duignan, Alison Eldridge, Erik Gregersen, J.E. Luebering, Amy McKenna, Melissa Petruzzello, John P. Rafferty, Michael Ray, Kara Rogers, Amy Tikkanen, Jeff Wallenfeldt, Adam Zeidan, and Alicja Zelazko. "Fertilizer Agriculture." Britannica, https://www.britannica.com/topic/fertilizer

[14] Irum Sarfaraz, "The Effects of Chemical Fertilizer on Soil Health." https://www.hunker.com/13427782/the-effects-of-chemical-fertilizers-on-soil

*Nitrogen, Phosphorus, Potassium

[15] "U.S. Golf courses in steady decline." ESPN, http://www.espn.com/golf/story/_/id/12461331/number-us-golf-courses-steady-decline-says-report Mar, 11, 2015

hole golf course on average consumes, on average: 54 pounds of nitrogen (N), 20.52 pounds of potassium (K), and 10.26 pounds phosphate (P), NKP, in a single 54,000 square foot area per year. Now times these amounts by the 34,011 golf courses using all this fertilizer with almost half of that coming from the United States. This statement from the Global Coral Reef Alliance demonstrates the impact golf course fertilization has on coral reefs. "We studied changes in coastal algae, algae nutrient contents, and health of adjacent coral reefs, before and after construction of Bakers Bay Golf Course on Guana Cay, Abaco. After construction, new algae blooms appeared along shorelines nearest to golf course greens, smothering corals in adjacent reefs, along with sharply increased coral diseases."[16] If golf courses reduced or eliminated their use of chemical fertilizers this would help dramatically improve the health of our waterways and oceans. Golf was invented in Scotland where many of the grounds are made of natural grasses and not chemically modified thus testing the golfers skill on a natural surface.

Household Purposes

Thousands of household chemicals that can end up in places where they disturb the ecosystem, not just harming marine species, but also human health. Many households harbor harmful chemicals, including chemical fertilizers made for home gardening and lawn care.[17] These fertilizers are used to make lawns green and lush. In many suburban neighborhoods a well-kept lawn is a source of pride. Fertilizer is also used to make bountiful gardens that overflow with unblemished fruits and vegetables, similar to those you'd find selling well in grocery stores. These excess and synthetic chemical eventually find their way int o our waterways and ocean causing the harmful algae blooms that kill marine life as well as disrupting the functioning marine ecosystem that we all care for and rely upon for our health.

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[16] Tom Goreau, "Golf course fertilizer runoff causes nutrient enrichment leading to harmful algae blooms on a Bahamian coral reef." Global Coral Reef Alliance, http://www.globalcoral.org/golf-course-fertilizer-runoff-causes-nutrient-enrichment-leading-to-harmful-algae-blooms-on-a-bahamian-coral-reef/, March 5, 2013

[17] "Household Pollutants." Pollution Issues, http://www.pollutionissues.com/Ho-Li/Household-Pollutants.html

Our society blithely idealizes perfection. But, what is perfection? Does it mean having an over-abundance of perfect fruits and vegetables that could cause an algae bloom that affects marine life? How can those in developed, privileged areas of the world stand by and watch as the consequences of our actions decimate vulnerable ecosystem and communities.[18]

Overuse

More is better. That's how contemporary American society has operated for a long time. More happiness, more sleep, more food, more makeup, more money, more, more, more. This way of living can be unhealthy, especially when it comes to the overuse of chemical fertilizer.

In big agriculture, overusing chemical fertilizers is prevalent. This culture of farming continues to lead to the destruction of marine ecosystems.[19] The current degradation of The Gulf of Mexico is a prime example of how detrimental overusing chemical fertilizer is. Harmful nutrients (NPK) from agriculture in the central U.S. agricultural zones are leaching into the Mississippi, which runs directly into the Gulf Of Mexico. These nutrients cause what is called eutrophication, or too much nutrients, that cause algae blooms that eventually die and decay stripping the water of oxygen which eventually leads to a dead zone. A dead zone is an area of low oxygen and little marine life.[20]

[18] "How Fertilizers Harm Earth More Than Help Your Lawn.", Scientific American, https://www.scientificamerican.com/article/how-fertilizers-harm-earth/

[19] Steven Godschall, "The Overuse of Inorganic Fertilizers in Modern Agriculture." https://sites.psu.edu/godshallcivicissue/2016/02/11/the-overuse-of-inorganic-fertilizers-in-modern-agriculture/

[20] The Nature Conservancy, https://www.nature.org/en-us/about-us/where-we-work/priority-landscapes/gulf-of-mexico/stories-in-the-gulf-of-mexico/gulf-of-mexico-dead-zone/

What impacts do chemical fertilizers have on the environment?

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The overuse of harmful nutrients causes an imbalance in the natural co-existence of life in marine ecosystems. Chemical fertilizers have left their poisonous touch on water ecosystems across the world in many different ways. In this section we will take a deeper look at the many impacts that our oceans face due to these harmful nutrients, largely from the overuse of chemical fertilizer. These include harmful algal blooms (HABs), domoic acid, and hypoxia.

Eutrophication

Eutrophication is the process by which a body of water becomes oversaturated with nutrients commonly nitrogen (N) and phosphorus (P); two of the main elements in fertilizer. Ecosystems are damaged through an increase of algal growth, which when they die and decay strip waters of

[21] https://blogs.umass.edu/natsci397a-eross/fertilizers-are-doing-more-than-you-think/ Debating Science-- EPA Photo credit

oxygen, depleting the populations of many species, and ultimately leading to an unhealthy environment. According to the *Survey of the State of the World's Lakes,* created by the International Lake Environment Committee, 48 percent of North America's lakes have been impacted by eutrophication. Eutrophication can lead to many other impacts that affect the environment. Some are even dangerous to human health.[22]

Harmful Algal Blooms

When an overload of nutrients enters a body of water, large and harmful algae blooms (HAB)s may occur. According to the National Oceanic and Atmospheric Administration (NOAA) "Every U.S. coastal and Great Lakes state experiences HABs." Not only do these algal blooms affect the health of our planet, they also affect the health of our economy. According to LG Sonic, a producer of environmentally friendly solutions to harmful algal blooms: "In the fishing industry, fish farms have incurred losses of up to US $24 million after large-scale fish deaths as a consequence of an outbreak of toxic algae growth."[23]

In California the Dungeness crab industry has repeatedly been shut down due to Harmful Algal Blooms.[24] In 2015-2016 California suffered from a terrible HAB that stretched from central California all the way up to Alaska. The diatom that bloomed in this specific case is called *pseudo-nitzschia* which produces a neurotoxin when stimulated called domoic acid. In Florida, the harmful algae that is wreaking havoc in the water there is known as *karenia brevis*. *Cyanobacteria* can also cause HABs. *Cyanobacteria* are single celled bacterium that when triggered will bloom in large amounts. When *cyanobacteria* blooms it takes on a greenish hue, which is why *cyanobacteria* is often known as blue-green algae. These blooms will release *microcystins,* toxins

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[22] "What is Eutrophication? Causes, effects, control." http://www.eniscuola.net/en/2016/11/03/what-is-eutrophication-causes-effects-and-control/, November 3, 2016

[23] "Economic Impact of Algae Blooms." LG Sonic, https://www.lgsonic.com/blogs/economic-impact-algae-blooms/, December 18, 2015

[25] Jim Malewitz, "Lake Erie's algae bloom is growing again after paralyzing Toledo water system." Bridge, https://www.bridgemi.com/michigan-environment-watch/lake-eries-algae-bloom-growing-again-after-paralyzing-toledo-water-system, August 22, 2018

that are incredibly harmful to humans and to organisms that live in that body of water. These blue-green algal blooms generally occur in fresh bodies of water.

According to an article posted in 2011 by *The Bridge*, one of Michigan's non-partisan, nonprofit news sources:

> GIBRALTAR ISLAND, Ohio — Four years ago, 400,000 residents of Ohio and Southeast Michigan learned the green muck infesting Lake Erie each summer is not only a nuisance but can also wreak havoc. Though not always toxic, the eyesores gunk up beaches, choke marine life, and became far more serious in August 2014. That's when Toledo's water system sucked up *cyanobacteria* and contaminated drinking water with microcystin, a toxin that can cause liver and kidney damage. The scare prompted residents to rely on bottled water for three days and cost about $65 million, mostly in lost tax revenue and tourism. Though there's been no repeat water emergency, the blooms continue to grow and climate change may make them more frequent and intense.[25]

This is one of the many examples of lakes that have been affected by *cyanobacteria* blooms. Lake Okeechobee[26], Lake Champlain[27], Keuka Lake[28], and Lake Erie[29]have also been impacted by cyanobacteria blooms. According to Dr. Samantha Joye, "There is hardly a place on the planet that has not been affected by the algal problem."[30] Humans need clean water to survive without

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[25] Jim Malewitz, "Lake Erie's algae bloom is growing again after paralyzing Toledo water system." Bridge, https://www.bridgemi.com/michigan-environment-watch/lake-eries-algae-bloom-growing-again-after-paralyzing-toledo-water-system, August 22, 2018

[26] Adrienne Cutway,"Blue-green algae: An explainer on the sludge blanketing Lake Okeechobee." https://www.clickorlando.com/water/blue-green-algae-what-is-the-thick-sludge-blanketing-lake-okeechobee, August 15, 2018

[27] "Cyanobacteria (Blue-Green Algae) Conditions." http://www.healthvermont.gov/health-environment/recreational-water/lake-conditions

[28] Julie Sherwood, "Blue green algae closes swim beaches on Keuka Lake." Daily Messenger, https://www.mpnnow.com/news/20170806/blue-green-algae-closes-swim-beaches-on-keuka-lake August 6, 2017

[29] Pam Wright, Harmful Lake Erie Algae Bloom Expected This Summer, The Weather Channel, https://weather.com/science/environment/news/2018-07-13-lake-erie-harmful-algal-bloom, July 13, 2018

[30] Interview with Dr. Samantha Joye, May 19 2018

water yet people continually make decisions such as the overuse of chemical fertilizers that negatively impact the water planet we depend upon.

Domoic Acid

In California, marine life suffers from the effects of a specific diatom known as *Pseudo-nitzschia.* When the conditions are right, such as warmer waters and an influx of nutrients, the algae *pseudo-nitzschia* will bloom in harmful amounts. This particular algae releases a neurotoxin called domoic acid. Domoic acid accumulates in shellfish, crustaceans, and sometimes fish, which are eaten by many marine mammals, and humans. In California the Dungeness crab industry has repeatedly been shut down due to HABs linked to domoic acid.[31] The most recent was in 2015-2016 when California suffered from a terrible HAB that stretched from central California all the way up to Alaska.

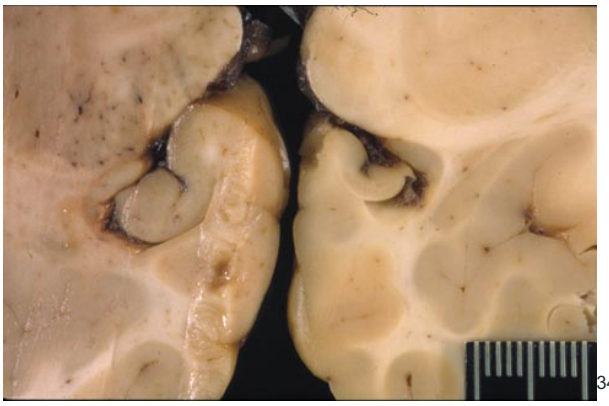
Domoic Acid first became known in 1987 when the toxins were found in shellfish from Prince Edward Island, Canada, that had been consumed by humans. Three people died, and 100 people developed toxic symptoms. According to the National Oceanic and Atmospheric Administration:

> In 1991, along the beaches of Monterey Bay, CA, dead and dying seabirds were observed—many of the sick birds displayed unusual symptoms suggesting a neurological toxin. Examination of the contents of the dead birds' stomachs revealed high levels of domoic acid. Furthermore, the birds had been eating anchovies from the bay. In turn, examination of the anchovy gut contents showed that these fish had been consuming the diatom called *Pseudo-nitzschia australis*. Quick action by state health departments along

[31] Tara Duggan, "Dungeness Crab Season nears in California, but toxins pose a familiar threat." San Francisco Chronicle, https://www.sfchronicle.com/food/article/Dungeness-crab-season-nears-in-California-but-13327955.php, October 25, 2018

the west coast of the United States prevented human illnesses by closures of both recreational and commercial shellfisheries.[32]

The Marine Mammal Center did a study in which they took a photo of a healthy sea lion's brain and a sea lion's brain that was infected with domoic acid. The hippocampus, which is the part of the brain that determines perception, emotion, navigation and memory, was significantly smaller in the infected sea lion's brain than it was in the healthy sea lion's brain.[33]

 [34]

As of August 2017, a total of 89 animals were treated by the Marine Mammal Center in Northern California compared to 70 last year. In years with the biggest algae blooms, such as 2014–2015, numbers of affected animals were well above 200.[35] When marine mammals and other oceanic life are poisoned with this toxin, the symptoms are neurological. They involve, disorientation, lethargy, tremors and convulsions.

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[32] "Domoic Acid Poisoning." NOAA, https://www.nwfsc.noaa.gov/research/divisions/efs/microbes/hab/habs_toxins/marine_biotoxins/da/index.cfm

[33] "Red Tides and Domoic Acid Toxicity." Marine Mammal Center, http://www.marinemammalcenter.org/science/top-research-projects/domoic-acid-toxicity.html

[34] http://www.marinemammalcenter.org/science/top-research-projects/domoic-acid-toxicity.html Marine Mammal Center

[36] "Dead zone formation." Virginia Institute of Marine Science, http://www.vims.edu/research/topics/dead_zones/formation/index.php

Dead Zones

Harmful Algal Blooms have a major negative impact on the water systems we depend upon. What happens after one of these algal blooms? After a large algal bloom occurs, the algae sink to the bottom of the ocean where they decompose. The decomposition process of this algae deprive the area of oxygen. This phenomenon is called hypoxia. These lifeless, oxygen-less areas are known as dead zones.[36] Dead zones occur globally, impacting the health of marine life, humans, and the economy. In 2017 the Gulf of Mexico suffered from a dead zone roughly the size of New Jersey (8,776 square miles). It was the largest dead zone ever recorded. This dead zone occurs almost every summer, decreasing the biodiversity and productivity and leaving behind a trail of devastating impacts.[37]

In the summer of 2017, Chesapeake Bay experienced a dead zone nearly the volume of 3.2 million Olympic-size swimming pools.[38] These dead zones also affect developing nations: According to the University of California: "Smaller, artisanal fisheries may be unable to relocate when low oxygen destroys their harvests or forces fish to move elsewhere. In the Philippines, fish kills in a single town's aquaculture pens cost more than $10 million."[39] Globally, there are more than 400 dead zones, impacting marine life, impacting the state of the economy, and impacting the planet. Baltic sea, Rhine River, Oregon, Hudson River, Virginia, South America, China.[40]

America is known for its large-scale agricultural industry, especially in the middle of the country. Although states such as Indiana and Nebraska are not coastal like California, they still have an impact on the oceans by overusing chemical fertilizers. Streams and rivers connect all land to the

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[36] "Dead zone formation." Virginia Institute of Marine Science, http://www.vims.edu/research/topics/dead_zones/formation/index.php

[37] "Gulf of Mexico 'dead zone' is the largest ever measured--June outlook foretold New Jersey-sized area of low oxygen." NOAA, https://www.noaa.gov/media-release/gulf-of-mexico-dead-zone-is-largest-ever-measured, August 2, 2017

[38] "NOAA, USGS and partners predict larger summer 'dead zone' for Chesapeake Bay." NOAA, https://www.noaa.gov/media-release/noaa-usgs-and-partners-predict-larger-summer-dead-zone-for-chesapeake-bay

[39] Lauren Fimbres Wood, UC San Diego, "The ocean is losing its breath." University of California, https://www.universityofcalifornia.edu/news/ocean-losing-its-breath, January 11, 2018

[40] "What causes ocean dead zones?" Scientific American, https://www.scientificamerican.com/article/ocean-dead-zones/

ocean. The ocean is downhill to everything. Many people tend to dismiss this important fact. Some may believe the health of the ocean won't affect the population of Arkansas, for example. This is not true. The health of the ocean affects everyone and will continue to do so unless we do something about this problem.

Coral Death

Fertilizer overuse is also a large problem in coral reef systems such as the Caribbean. When major fertilizer runoff occurs, the nitrogen in the fertilizer causes an important symbiotic algae that lives in coral, called *zooxanthellae*, to leave the coral. The *zooxanthellae* exits the coral as it no longer needs the coral animal polyps as a nutrient producer because there is already enough nitrogen for the *zooxanthellae* in the surrounding waters from the excess fertilizer. This is detrimental to the health of the coral because when the *zooxanthellae* leaves, that coral no longer has the sugar the zooxanthellae produces which is one of the corals main food source. The zooxanthellae leaving the coral also causes the coral to bleach and may eventually cause it to die. Another issue with an influx of nutrients happens when other non-symbiotic algae is stimulated and grows on and around coral structures suffocating the coral polyps. This also can lead to coral bleaching and death as well.[41]

According to NOAA:

> Pollution from land-based sources is a primary cause of coral reef degradation throughout the world. In the Caribbean, for example, approximately 80 percent of ocean pollution originates from activities on land. As human populations expand in coastal areas, development alters the landscape, increasing runoff from land. Runoff often carries large quantities of sediment from land-clearing, high levels of nutrients from agricultural areas

[41] Interview with Dr. Gary Ray, August 2017

and sewage outflows, and pollutants such as petroleum products and pesticides. These land-based sources of pollution threaten coral reef health.[42]

Coral reefs are a crucial ocean ecosystem that support 25 percent of all known marine fish. Without coral reefs, hundreds of species would not be able survive. Coral reefs face many challenges including warming waters, ocean acidification, habitat destruction and unsustainable fishing practices such as bottom trawling.

What impacts does overusing chemical fertilizers have on human health?

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The previous sections have focused mainly on how chemical fertilizers are impacting the health of marine ecosystems, but how are these fertilizers impacting human health? How can it be safe if the same chemicals we spray on our fruits and vegetables can cause cancer? We can no longer overlook these problems because it is inconvenient to do something about it.

[42] "How pollution affects coral reefs." NOAA, https://celebrating200years.noaa.gov/visions/coral/side.html

[43] https://www.accountingweb.com/practice/practice-excellence/case-study-how-experience-and-need-for-diversity-grew-a-vibrant-cpa Accounting Web

Groundwater Contamination

According to the Groundwater Foundation, "Groundwater supplies drinking water for 51% of the total U.S. population and 99% of the rural population.[44] Groundwater is an important source of drinking water for many U.S. citizens and yet many groundwater sources are contaminated by pollutants including nitrates (a form on Nitrogen, N) that commonly leach through soil. The extra fertilizer that is not taken up by plants is carried away by surface runoff and leaches into the groundwater in nitrate form.

According to UC Davis' 2016 California Nitrogen Assessment, that looked at a seven-year period, each year 419,000 tons of nitrogen leach into groundwater. Also according to UC Davis nitrate is California's most widespread groundwater contaminant.[45] The sources of nitrate pollution in groundwater include increased urbanization, cultivation of crops, over fertilization, thin soil, and poor nutrient buffering.[46]

One of the most disturbing problems of nitrate contamination is that many schools across the country do not have access to clean drinking water due to this issue. According to a Community Water Center report, "between 500,000 to over a million California students attend schools whose water systems don't meet primary safe drinking water standards."[47]

The Water Education Foundation mentioned in a recent report that 680 community water systems that serve 21 million people in California had contaminated groundwater that included nitrate. According to the report, most contaminated schools are in the Eastern San Joaquin Valley, and

[44] "What is groundwater?" Groundwater Foundation, https://www.groundwater.org/get-informed/basics/groundwater.html

[45] Amy Quinton, "California Agriculture is the Largest Source of Nitrogen Pollution in the State." North State Public Radio, https://www.mynspr.org/post/california-agriculture-largest-source-nitrogen-pollution-state#stream/0, August 10, 2016

[46] "Nitrates in groundwater." Lenntech, https://www.lenntech.com/groundwater/nitrates.htm#ixzz5hEaT4obr

[47] Kimberly Beltran, "Contaminated Drinking Water Threatens California Schools." Community Water Center. https://www.communitywatercenter.org/cabinetreportschools June 6, 2016

in Kern, Madera, and Tulare counties. Rural, economically disadvantaged communities are the most impacted by drinking water contamination.[48]

In 2019, 14 year old Shay Barton, Pescadero Heirs To Our Oceans Chapter Youth Leader, explains the issue of groundwater contamination in her school.

> The town in which I live, Pescadero, California, is a tiny area on the California Coast. We have been an agricultural town for many years. Lately, the agricultural practices have been improving in their sustainability, but for many years, chemical fertilizers were common on local farms. Nitrates from these practices gradually accumulated in local groundwater, and as a result, there is currently a serious issue with access to potable water in Pescadero. Many local ranches have unclean water pipes, and my high school has had no clean tap water for years. The fertilizer runoff issue is not an abstract speculation but a reality of life to residents of the town I have grown up in.[49]

Ingesting large amounts of nitrates can result in blue baby syndrome or methomeglobia, which is mostly an issue for infants but can also occur in some adults. When a baby consumes a formula with nitrate-rich water, the body converts those nitrates into nitrites. Those nitrites then bind to hemoglobin (an oxygen carrying blood protein) to form methemoglobin which cannot carry oxygen.[50] This is just one of the many costs of overusing chemical fertilizers. It is now affecting the wellbeing of our children. This generation is innocent of the issues that face our planet. How much longer are people willing to ignore these issues that the next generation will inherit?

Nitrate contamination has also been linked to cancer. Dr. Mary. H. Ward states that “A study in Hungary /20/ found elevated rates of stomach cancer in areas with nitrate levels above 18 mg/L

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[48] “Nitrate Contamination.” Water Education Foundation, https://www.watereducation.org/aquapedia/nitrate-contamination

[49] April 16, 2019 Interview with Shay Barton

[50] Nicole Galan, “What is Blue Baby Syndrome.” Medical News Today, https://www.medicalnewstoday.com/articles/321955.php May 29, 2018

nitrate-N compared to background exposure levels. A study in 258 municipalities in Valencia, Spain found elevated stomach cancer mortality at nitrate levels over about 11 mg/L nitrate-N /21/." (2008) Dr. Ward also brings up the issue in Iowa: "A cohort study of older women in Iowa (U.S.) /22/ found an increased risk of bladder and ovarian cancers associated with higher long-term average nitrate levels in public drinking water supplies used by the women."[51] This problem is dire, and yet effective change has not been made to tackle the issue. This can no longer be the case.

Amnesic Shellfish Poisoning

Amnesic shellfish poisoning occurs when shellfish is consumed with high levels of domoic acid. This illness can range from mild, to severe, and very rarely, can cause death. Mild symptoms include headache, disorientation, dizziness, abdominal cramps, diarrhea, and vomiting. The severe symptoms include difficulty breathing, confusion, irregular heartbeat, seizures, coma, and short-term memory loss.[52] From oxygen loss in infants, to cancer in women, to short term memory loss the problem of chemical fertilizer runoff has been proven to be a problem that we can't overlook.

[51] Dr. Mary H. Ward, "Too Much of a Good Thing? Nitrogen from Nitrogen Fertilizers and Cancer." US National Library of Medicine National Institutes of Health, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3068045/ October 21, 2018

[52] "Domoic Acid and Amnesic Shellfish Poisoning." California Department of Public Health, https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/Domoic-Acid-and-Amnesic-Shellfish-Poisoning.aspx

What impacts does chemical fertilizer have on our economy?

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We have looked at the impacts of chemical fertilizer on our environment and on human health, but what is the impact financially? What are the hidden threats to the health of global economies?

Fishery Closures

In the section about Domoic Acid we discussed the issue of crabs becoming contaminated with this neurotoxin. What happens to the fishing industry when these crustaceans become toxic? According to SeafoodSource, “In a notice published 2 February 2017, the state closed the Dungeness crab fishery to commercial fishing beginning on Friday, 10 February from Coos Bay to Heceta Head, a stretch of coastline approximately 65 miles in length.[54] This specific example was in Oregon but the Domoic Acid issue isn't just in one area. According to Los Angeles Times: “One of the largest toxic algae blooms seen off California has shut down recreational and

[53] https://www.videoblocks.com/video/green-dollar-money-currency-sign-made-from-leaves-on-the-green-ground-included-alpha-ejlypwk26xim5yroy5 Storyblocks

[54] Cliff White, “Domoic acid once again forces closure of some West Coast Dungeness crab fishing areas.” SeaFood Source, https://www.seafoodsource.com/news/supply-trade/domoic-acid-once-again-forces-closure-of-some-west-coast-dungeness-crab-fishing-areas Febuary 6, 2017

commercial fishing along the West Coast and could be contributing to a host of sea lion strandings in the Bay Area, scientists said this week."[55]

In 2015 and 2016, California suffered from a horrendous algal bloom that stretched across the U.S. West Coast. During the two-year span crab boats only caught 12.3 million pounds, a 48 percent drop from the previous five-year average, at a value of about $39 million.[56] Overall, the U.S. has lost too much money due to algal blooms. In 2011 the United States lost $900 million in the fishing industry due to algal blooms.[57]

Increased Water Treatment Costs

Not only do algal blooms affect the production of fisheries, it also increases the cost of the water treatment. LG Sonic, an algal control business, gives a good example. "In Sauce Lake in Uruguay, an important lake that supply [SIC] water to the touristic area of Maldonado, experienced a cyanobacteria bloom that deteriorated considerably the water quality of the lake. This forced the water company to exempt users from payment representing a direct loss of US $4 million."[58]

Effects on Tourism

Toxic algal blooms emit toxins into the air which results in scratchy throats, burning eyes, and also a terrible smell. This can make once beautiful beaches attractive to tourists a deserted graveyard. On August 28, 2018, the Washington Post released an article about the impacts of the huge algal bloom destroying the Florida coast. "Business owners in the hardest-hit counties report they have lost nearly $90 million and have laid off about 300 workers because of the red tide and

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[55] Joseph Serna, "Toxic Algae Bloom Shuts Down West Coast Fisheries." Los Angeles Times, https://www.latimes.com/local/lanow/la-me-ln-toxic-algae-bloom-shuts-down-west-coast-fisheries-20150618-story.html June 19, 2015

[56] Tara Duggan, "California Dungeness crab industry bounces back with strong season." San Francisco Chronicle, https://www.sfchronicle.com/food/article/Dungeness-crab-industry-bounces-back-with-strong-11267878.php July 6 2017

[57] "Economic Impact of Algae Blooms." LG Sonic, https://www.lgsonic.com/blogs/economic-impact-algae-blooms/

[58] "Economic Impact of Algae Blooms." LG Sonic, https://www.lgsonic.com/blogs/economic-impact-algae-blooms/

a separate freshwater algal bloom in the state's largest lake. Together, the two blooms have caused a sharp drop in tourism."[59]

Another example of tourism being affected was in the Dominican Republic. "An area of touristic attraction was affected causing beach closures, a reduced number of visitors and consequently people subsisting from touristic activities directly suffered income losses. The situation is aggravated when the negative effects linger on even after having restored the water quality. Visitors tend to avoid areas where algae blooms have occurred as precaution, worsening the economic impact even more."[60]

The issue of chemical fertilizer overuse is one that we can't afford to ignore any longer. The impact is being felt even more as the climate is changing and waters are becoming warmer. All of us have a part to play in solving this problem.

What is the Solution?

[61]

[59] Darryl Fear and Lori Rozsa, "Florida's Unusually Long Red Tide is Killing Wildlife, Tourism and Businesses." The Washington Post, https://www.washingtonpost.com/national/health-science/floridas-unusually-long-red-tide-is-killing-wildlife-tourism-and-businesses/2018/08/28/245fc8da-aad5-11e8-8a0c-70b618c98d3c_story.html?noredirect=on&utm_term=.037f785d2781 August, 28, 2018

[60] "Economic Impact of Algae Blooms." LG Sonic, https://www.lgsonic.com/blogs/economic-impact-algae-blooms/

[61] https://support.ibisos.com/article/378-solution-evaluation Ibis Support Center

Solving this problem means we must enact solutions on both a domestic level and governmental level. We can no longer take the convenient short-term route that is leading to the destruction of our planet. We are out of time and must now take action.

Domestic Responsibility

There are many ways to take action in your own home. Here are some natural alternatives to chemical fertilizers. Use these substitutes in your garden to keep your harvest bountiful!

- Coffee grinds contain calcium, copper, magnesium, phosphorus, and potassium, all of which are important nutrients for plants. Mix the grounds with water and let it sit in the sun before adding it to your soil.[62]
- Egg shells are largely made of calcium carbonate which is very important for plant growth. Air dry the shells and crush them in your blender into a powder, then sprinkle at the base of your plants![63]
- Compost is made of food waste mixed with plants (dried stems and branches), paper, sawdust, and/or wood shavings. Put all items in a compost bin, add water, then mix it regularly. After a few weeks, it will be ready to apply to your garden![64]
- Grow legumes in your garden because they trap nitrogen from the air, which helps the plants grow strong and healthy. Legumes include beans, peas, lentils, and peanuts!

For lawn health there is no need for chemical fertilizers, if you don't want to add compost to your front yard, just water it regularly! Although it is important as well that you do not overuse water.

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[62] "Coffee Grounds and Composting." Oregon State University, https://extension.oregonstate.edu/gardening/techniques/coffee-grounds-composting

[63] Justin Hand "Gardening 101: How to use eggshells in the garden." Gardenista, https://www.gardenista.com/posts/diy-5-ideas-to-use-eggshells-in-the-garden-pest-control-mulch-fertilizer/

[64] "The importance of composting." Glacier Farm Media, https://www.manitobacooperator.ca/country-crossroads/the-importance-of-composting%E2%80%A9/ July 22, 2015

Also, be aware of what growers you are supporting when you purchase your food. Try to shop responsibly by supporting those farmers who do not spray with harmful chemicals and do not overuse chemical fertilizer. If you don't know, do research to find out!

Government-Level Solutions

The government is responsible for the health of the people. A lot of research has been done that shows the connection between the chemicals and overuse of fertilizer in agriculture and how they negatively affect our health. It is our right to demand that the government put legislative solutions in place that protect us and our environment and certainly our food.

One low-cost solution to agricultural runoff is the creation and use of natural buffers such as catch basins that trap the runoff and filter out contaminants. The government should require agricultural production companies to plant, build, and maintain natural buffer areas to protect our rivers, streams, oceans and our ground water. Buffers are barriers of trees, grass, or other permanent vegetation planted along the banks of streams, lakes, and rivers as a border around farms. Buffers filter the water and reduce run-off of agricultural pollutants, that would result in cleaner drinking water. Buffers are a sustainable way to increase water quality, improve the health of the local population, and maintain the quality of the soil.[65]

Conservation tillage is also a solution for large agricultural production. According to ClimateTechWiki (a clean technology platform) "Conservation tillage is any method of soil cultivation that leaves the previous year's crop residue (such as corn stalks or wheat stubble) on fields before and after planting the next crop to reduce soil erosion and runoff, as well as other

[65] "Buffer Strips: Common Sense Conservation." USDA, https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143_023568

benefits such as carbon sequestration (MDA, 2011). With this technique, at least 30% of the soil surface is covered with crop residue/organic residue following planting (Dinnes, 2004)."[66]

Taxing chemical fertilizer is also a potential solution that could reduce the excessive amount used and motivate farmers to adopt better practices. According to Scientific American: "A huge dead zone in the Black Sea largely disappeared in the 1990s following the fall of the Soviet Union, after which there was a huge spike in the cost of chemical fertilizers throughout the region."[67]

Contact your congresspeople and demand bills be introduced to better protect our water and marine protected areas from chemical fertilizer runoff! Your voice matters and is needed, so please speak up for the future of our planet.

Support and advocate for bills such as AB-176 that gives a usage tax exclusion to farmers who use sustainable agricultural practices!

We all share one planet. Planet earth. It provides us with the air we breathe, the food eat, and the water we drink. This is the planet that will be passed on to future generations and generations after. Right now, the planet humanity is preparing to pass on to the next generation is falling apart. The issues facing our planet are ones that can no longer be overlooked. Chemical fertilizer run-off is not a problem of the future, it is a problem that is real and is happening right now. We are at the tipping point of our planet's future, and now it is up to us to decide what we want to do about it.

[66] "Conservation Tilling." ClimateTechWiki, http://www.climatetechwiki.org/technology/conservation-tillage
[67] "What Causes Ocean Dead Zones?" Scientific American, https://www.scientificamerican.com/article/ocean-dead-zones/