One Ocean – Stopping Oceanic Pollution is the biggest challenge of Climate Change

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Abstract

This is the first paper in a series on our oceans. There has been a concentration of climate change solutions on air pollution which ignores one vital factor. That the ocean covers 70 percent of Earth's surface, containing about 1.35 billion cubic kilometres of water, constituting about 97 percent of all water on Earth. The ocean's size means that it plays a key role in determining weather patterns and hence both local and world climatic events. The critical role of the ocean is in balancing global temperatures as water absorbs heat in the summer and releases it in the winter. Without the ocean to help regulate global temperatures, Earth's climate would be bitterly cold. This paper discusses reasons for dramatic changes in weather patterns known as catastrophic events, emphasizing the role of oceanic currents and pollution. The second paper will discuss solutions.

Keywords Climate change, pollution, carbon capture, oceanic biosphere, continental linkages, sewage

I Introduction

Rising amounts of greenhouse gases are preventing heat radiated from Earth's surface from escaping into space as freely as it used to. Most of the excess atmospheric heat is passed back to the ocean. As a result, upper ocean heat content has increased significantly over the past few decades. Upper layers are accumulating heat faster than deeper layers, but averaged over the full depth of the ocean, the 1993–2022 heat-gain rates are 0.64 to 0.83 Watts per square meter averaged over the surface of the Earth[1]. As there is more water than land covering the Earth's surface, it is no surprise that the warming of the oceans has accounted for around 93 % of the warming of the planet since the 1950s. From 1901-2020 the sea surface temperature rose at a rate of 0.14°F per decade. The ocean warming effect is not evenly distributed, having the greatest impact in the Southern Hemisphere. A viscous cycle is generated by increasing temperatures melting polar ice caps so that as the total area of the global ice and snow cover shrink, it reflects less solar energy back into space, further warming the planet. This in turn results in more freshwater entering the oceans, changing the currents further[2].

The effect of increasing oceanic temperatures is deoxygenation and rising sea levels es causing the loss of breeding grounds and mass migrations with consequences for food scarcity and economic challenges. Rising temperatures intensify hurricanes, droughts, and floods.

However, it has been argued that the impact of greenhouse gases in raising ocean temperatures may be far less that the effect of marine pollution from the spreading of harmful substances such as oil, plastic, industrial, sewage, agricultural waste, and chemical particles into the ocean[3]. Apart from causing the ocean to heat, pollution lowers oxygen content and destroys the ocean's ability to capture carbon and help regulate global temperatures. Besides normal environmental solutions to littering, stopping the use of artificial fertilisers and fossil fuels, there has been a distinct lack of attention focussing on improving and preventing using the ocean as a vast sewerage dump.

The world's sewage must go somewhere, and unfortunately 80% of the sewerage produced by the global population makes its way into the world's oceans untreated. An analysis of 135,000 watersheds reveals that copious amounts of key pollutants come from human wastewater, not just agricultural runoff. Individual sites have long been known to be major sources of coastal pollution. "We've never had a global understanding of how big the problem is," says Cascade Tuholske, a geographer at Columbia University's Earth Institute. He and his colleagues took a broad look at the issue by calculating the amounts of faecal pathogens and nitrogen—which can fuel harmful algal blooms and create oxygen-deprived dead zones—flushed into the ocean inhuman wastewater at 135,000 sites around the world[4].

Surprisedly, they found that they could attribute about half of the nitrogen pollution to just twenty-five locations and the source of around half of the pathogens to twenty-five sources, in some cases the same ones. Sewage pollution of our oceans and other water bodies poses several challenges and has myriad impacts, as discussed in the article. Sewage is the single biggest factor causing coastal pollution. A worldwide estimate shows that 104 of 112 coral reefs are impacted by sewage directly or indirectly. Over 60% of bays in the US Atlantic suffer from seagrass decline, while saltmarshes, mangroves, and fisheries are also heavily impacted. Hence, steps need to be taken to mitigate this problem for the betterment of society and the environment, but it may be beyond by both individuals and governments and require a new regulatory model and agency to enforce the spirit of the 2023 UN Treaty on the Seas. Reasons for such a request range from -

1. Inadequate and Obsolete Infrastructure
2. Dumping by Cruise Ships and leisure craft of considerable sewage into the oceans.
3. Flooding and Improper Treatment at the Sewerage Treatment Plants
4. Lack of sanitation facilities in developing nations.

Sewage and wastewater pollution of the ocean is ignored during allocation of finances by governments and environmental philanthropists. Although a pillar of climate regulation, oceanic pollution due to these causes is absent from the initial key messages of the Global Stocktake of COP 28, which ignored this factor in only considering mangrove and corals, tourism, food, transport, and energy. More research on sewage pollution in the ocean needs to be done to inform international collaborations and help policy makers choose the most effective sewage treatment strategies for contaminated areas. Fixing sewerage problems in the twenty-five trouble spots appears a vastly simpler, cheaper, and faster solution to capturing carbon giving us time to develop new energy source. Focussing on greenhouse gas emissions has costly side effects, such as loss of strategic land and waterways, while concentration on Solar and Electric Vehicles assumes the availability of rare minerals. It also ignores a simpler solution of making our one ocean do its original job of carbon capture and heat distribution while improving the standard of living in developing countries.

This paper is an introduction to a second paper which looks at the current regulatory solution embodied in the 2023 UN Treaty on the High Seas and its limitations, proposing an alternative regulatory model.

II. The link between the oceans, seas, waterways and the climate, oxygen production and carbon capture [5]

A waterbody is the accumulation of water on the earth's surface. The term usually refers to oceans, rivers, and lakes. It is essential to understand the difference between different water bodies to know how they all work. Oceans are large bodies of saltwater surrounding a continent. A river is a large flowing water body that empties itself into seas or oceans. Lakes are large water bodies that are surrounded by land on all sides. Seas have land around them but are not surrounded except for the Sargassos Sea which has no landed boundaries but contains a complete circular current. The majority of the Earth's water is stored in its oceans, seas, and bays which make up 96.5% of the 1.36 billion tons of water.

Oceans are also the deepest water bodies on the planet. For instance, the Pacific Ocean is the largest and deepest ocean in the world, with an average depth of 4,028 meters and a total area of 60 million square miles.[6] Geographically, the oceans cover about 71% of the Earth's surface.

The world's oceans play a crucial role in sustaining life on our planet. Not only do they provide a habitat for countless species, but they also contribute significantly to the amount of **oxygen** in the atmosphere, producing over half.[7] Photosynthesis is the primary process responsible for oxygen production in the oceans when tiny plants called phytoplankton convert carbon dioxide and sunlight into energy.

There are many diverse types of phytoplankton, each with their own unique characteristics and ecological roles. Some common types of phytoplankton include diatoms, dinoflagellates, and cyanobacteria. According to researchers with MIT, there are a "billion phytoplankton in the world's ocean."[8] However the amount of oxygen produced by the oceans varies depending on several factors. One of the most significant factors is the temperature of the water. Colder water holds more dissolved oxygen, which means that areas with colder water tend to have higher oxygen concentrations. Conversely, warmer water holds less dissolved oxygen, which can lead to areas of low oxygen known as hypoxic zones. As the world's oceans warm due to climate change, this will adversely affect the ability of the planet's largest source of water to hold oxygen.

Another factor that can affect oxygen production in the oceans is nutrient availability. Phytoplankton require certain nutrients, such as nitrogen and phosphorus, to grow and photosynthesize. If these nutrients are in short supply, phytoplankton growth and oxygen production can be limited. On the other end of the spectrum, excessive nutrient input, often caused by agricultural runoff or wastewater discharge, can lead to algal blooms and oxygen depletion in certain areas (which can lead to dead zones). Cyanobacteria, also known as blue-green algae, are a type of phytoplankton which can fix atmospheric nitrogen, which means they can convert nitrogen gas into a form that is usable by other organisms. Cyanobacteria can form large blooms, which can have harmful effects on aquatic ecosystem.

Oceans also influence the Earth's climate through a constant transfer of heat from the Equator towards the poles. [9] Evaporation from the ocean's surface brings rain to much of the Earth's land surfaces. In fact, all rain that falls on land starts off in the ocean. The tropics are particularly rainy because heat absorption, and thus ocean evaporation, is highest in this area. In fact, all rain that falls on land starts off in the ocean. The tropics are particularly rainy because heat absorption, and thus ocean evaporation, is highest in this area.

Most of the radiation from the Sun is absorbed by the ocean, particularly in tropical waters around the equator, where the ocean acts like a massive, heat-retaining solar panel. Land areas also absorb some sunlight, and the atmosphere helps to retain heat that would otherwise quickly radiate into space after sunset. The ocean does not just store solar radiation — it also helps to distribute heat around the globe. Ocean water is constantly evaporating, increasing the temperature and humidity of the surrounding air to form rain and storms that are then carried by trade winds.

Outside of Earth's equatorial areas, weather patterns are driven largely by ocean currents**.** Currents are movements of ocean water in a continuous flow, created by surface winds but also partly by temperature and salinity gradients, Earth's rotation, and tides. Major current systems typically flow clockwise in the northern hemisphere and counterclockwise in the southern hemisphere, in circular patterns that often trace the coastlines.

Ocean currents act much like a conveyor belt, transporting warm water and precipitation from the equator toward the poles and freezing water from the poles back to the tropics. Thus, ocean currents regulate global climate, helping to counteract the uneven distribution of solar radiation reaching Earth's surface. Without currents in the ocean, regional temperatures would be more extreme — super hot at the equator and frigid toward the poles — and much less of Earth's land would be habitable.

However, the most crucial factor presently which is being distorted is the ability of the oceans to function as a natural and huge **carbon sink**. "It is difficult to determine the quantity of carbon stored by these mechanisms, but it is estimated that the ocean concentrates 50 times more carbon than the atmosphere".[10] This is discussed further in Section III.

III. The Deep Sea and its water column may be the largest carbon sink on Earth[11].

A carbon sink is a natural or artificial reservoir that absorbs and stores the atmosphere's carbon with physical and biological mechanisms. Coal, oil, natural gases, methane hydrate and limestone are all examples of carbon sinks. After long processes and under certain conditions, these sinks have stored carbon for millennia. On the contrary, the use of these resources, considered as fossil, re-injects the carbon they hold into the atmosphere. Nowadays, other carbon sinks come into play: humus storing soils (such as peatlands), some vegetizing environments (such as forming forests) and of course some biological and physical processes which take place in a marine environment[12].

These processes form the well-known « ocean carbon pump ». It is composed of two compartments: a biological pump* which transfers surface carbon towards the seabed via the food web (it is stored there in the long term), and the physical pump* which results from ocean circulation. In the Polar Regions, more dense water flows towards the Deep Sea dragging down dissolved carbon. In high latitudes water stores CO2, more easily because low temperatures facilitate atmospheric CO2 dissolution (hence the importance of Polar Regions in the carbon cycle).

For some scientists, the Deep Sea and its water column may be the largest carbon sink on Earth but its large-scale future is still unknown. Also, with ocean acidification, this process could become less efficient because of a lack of available carbonates. When talking about carbon storage, the notion of time is crucial. The biological pump is sensitive to disturbances. Consequently, it can be destabilized and re-emit carbon into the atmosphere.

The physical pump acts on another timescale. It is less sensitive to disturbances, but it is affected on a long-term basis. Once the machine is activated, it will be difficult to stop it. The carbon, transferred to the Deep Sea due to ocean circulation, is temporarily removed from the surface cycle but this process is poorly quantified. Also, after a journey of several hundred years, what will this carbon become when these waters resurface?

The biological pump is easier to assess. In the high seas for instance, the planktonic ecosystem is a major player. All organic materials that reach the bottom participate in the biological pump and when conditions permit it, they also participate in oil formation. Calcium-containing materials such as coccolithophore, a microscopic one-celled alga, participate in subtracting carbon from the natural cycle. When they die, they generate a vertical net flux of carbon. This carbon can then be stored in the Deep Sea for long geological periods. These processes can leave traces. For instance, chalk cliffs are an accumulation of coccolithophores (micro algae covered with plating made of limestone) on the ocean seabed, which have later resurfaced to the continent due to geological movement.

Healthy coastal ecosystems play a mitigation role against climate change, especially by capturing carbon for their development. For instance, mangroves, seagrass beds and salt marshes are significant carbon sinks. These last three examples, store at least ten times more carbon than continental forests. However, these coastal ecosystems cover little surface on a global planet scale. Also, these ecosystems are weakened by coastal urbanization and coastal economic activities. Ecosystem restoration remains a priority to improve storage of carbon excessively released into the atmosphere and requires ambitious policies.

To combat climate change, geoengineering techniques to store CO2 artificially in the ocean carbon sink are under consideration. The scientific community is concerned because negative consequences of potential disequilibrium have not been explored yet. The carbon cycle is complex as it is associated with other cycles which favour global warming. Consequently, storing CO2 also releases steam water, which plays an important part in the greenhouse effect. In addition, because of the increase in greenhouse gas concentration, the water temperature and its acidity are changing. This modifies physical, chemical, and biological equilibriums and may affect the ocean pump. All this data should encourage us to be more careful and to preserve marine ecosystems.

The depth of the ocean is on average four thousand metres. In this area also known as "deep sea" there is no light, extremely high pressure, and temperatures that are much more stable than at the surface. The Deep Sea plays a key role in climate change mitigation. By storing a large part of the CO2 produced by human activities and by absorbing the heat accumulated by greenhouse effect, the Deep Sea slows down the warming of surface waters and land. Thanks to this immense mass of water, climate change is still “bearable” for most species on Earth.

In addition, Deep Sea ecosystems capture huge quantities of carbon. For instance, on the continental shelf, microorganisms play a key role in sustainable storage of carbon produced by phytoplankton but are also filters for methane formed by burning fossilized matter. By using methane as energy, these microorganisms transform this greenhouse gas, which is much more powerful than CO2, into minerals. This process prevents greenhouse gases from resurfacing and accelerating climate change. However recently it has been estimated that bottom trawling released 8.5 to 9.2bn tonnes of carbon dioxide into the ocean (equal annually to the entire aviation industry) which otherwise would be safely stored for millennia in the ocean floor, but the fate of the carbon remains an unknown, although it is claimed over half will go into the atmosphere[13].

Life and services provided by Deep Sea organisms depend very much on atmosphere and surface activity. As they are deprived of light, Deep-Sea ecosystems are highly connected to food produced at the surface of the ocean, on which they depend greatly. Marine snow, a rain of organic matters, which drops from the surface, is often the base of the food web. Surface waters also provide oxygen for the deep abysses when they move down to the Deep Sea in the Pole Regions.

Consequently, modifications taking place at the surface, such as oxygen exhaustion or a decrease in phytoplankton, have impacts on life in the Deep Sea and can affect ecosystem functioning. According to observations, there are significant changes of food type and quantity originating from the surface and shifting to the abysses, several thousand metres deep. Are those “natural” events or the first signs of disturbances of the global water column from surface waters to the abyssal plains? 15 to 25 years observation series are still too short to conclude, but they confirm that Deep Sea biodiversity changes very quickly as soon as available resources are modified.

These ecosystems are dependent on many on-going changes. Concurrently with climate change, resource exploitation (minerals, hydrocarbons, fisheries) is spreading to the Deep Sea and brings its share of disruptions in fragile environments.

One point needs particular attention. When surface waters are warmer, they do not mix as well with deep waters. By reducing Deep Sea “ventilation,” warming reduces the already low oxygen content, which naturally affects “intermediate” waters (several hundred meters deep) over wide regions of the tropical ocean. In some very productive regions, north of the Indian Ocean, the West Coast of the United States or even Peru, Chile or Namibia, observations show that less oxygenated waters or waters deprived of oxygen spread and greatly reduce habitat spaces for certain species, like Tuna or Marlin, in favour of other species capable of tolerating these conditions, such as calamari which can affect the entire ecosystem by proliferating.

Other more subtle modifications can have drastic impacts on ecosystems. The increase in water temperature, even by a 10th of a degree every 10 years in certain Polar Regions, enables some predator crabs to expand their territory and decimate species until then protected by extremely freezing waters (-1.5°C).

In other regions, there are concerns regarding the acidification effect of waters, which have absorbed great quantities of CO2, and can cause the deterioration of deep coral reefs, while many fish and shellfish species depend on them. Lab studies show that a combination of this phenomenon with deoxygenation of waters, like in the Gulf of Mexico, where the warming of deep waters is particularly critical.

As deep biodiversity reacts rapidly to change, it is crucial to consider these risks to avoid jeopardizing the mitigation capacity of oceans toward climate disruption and other services provided by the Deep Sea’s biodiversity. Scientific research shows that climate change impacts on the ocean have already affected fisheries. While abundance of several cold-water species is reducing, some tropical species are appearing on our coasts. In future decades ocean warming and acidification can affect growth and reproduction processes of many marine organisms, which may reduce stocks available for many significant commercial species. For instance, shellfish (such as oysters, and mussels) are especially sensitive to acidification. Also, while they are crucial for the economy of small islands and human nutrition, all coral ecosystems in tropical areas are expected to disappear by 2050. Climate change is also going to impact bacterial and phytoplankton communities, which are key to the marine food web. Consequently, if we keep on producing greenhouse gases at the current pace, while simultaneously reducing the ocean’s role as a carbon sink, changes expected before the end of the century in terms of biodiversity could be like those that occurred during the prior 20 or 30 million years.

Fishers will have to adapt to climate change impacts on fish stocks and their geographical distribution, by changing their modes of exploitation, sometimes ships, calendars and fishing areas. Public policies in management, control and governance will also need some redesigning to avoid reconsidering all efforts undertaken to resupply fish stocks for over several decades. For example, the cod stock in the Gulf of Maine has recently dropped because fish quotas had been determined without taking global warming into consideration. Consequently, it is important to learn how to constantly evolve, and this adaptation has a cost and will not happen without difficulty.

Limiting CO_2 emissions is a major issue, not only to mitigate current changes but also to slow them down and give ecosystems a chance to adapt. On the contrary, if changes occur too quickly, the implementation of all adaptation processes by humans might be more difficult or even inefficient for them and the ecosystem. Chaotic situations or extreme crisis situations are expected, in particular in the field of fisheries.

IV. Is Pollution of Oceans still a problem?[14]

The grisly matter of raw sewage entering natural water bodies was a massive ocean issue in the 1980s and 1990s until new laws were introduced, enforcing the treatment of wastewater before its release into the environment. It seems astonishing that these laws were only implemented in the UK 30 years ago and prior to that, our oceans were seen as a vast expanse which could dilute and make disappear our waste. Today, talk of sewage in ocean conservation circles seems to have fallen a little quieter as we focus on the newer issues of plastic pollution, overfishing and warming seas but does this mean that the problem of sewage has been solved?

Unfortunately, the answer is a resounding no as multiple wastewater spills occur in our oceans around the world every day. In fact, sewage is one of the biggest contributors to ocean pollution, with more than 80% of global sewage flowing into our seas untreated. What is running into our oceans is a more complex cocktail than just sewage however, as untreated wastewater contains a plethora of substances harmful to both the environment and humans.

There are three types of wastewater, or sewage: domestic sewage, industrial sewage, and storm sewage. Domestic sewage carries used water from houses and apartments; it is also called sanitary sewage. Industrial sewage is used water from manufacturing or chemical processes. Storm sewage, or storm water, is runoff from precipitation that is collected in a system of pipes or open channels.

Domestic sewage is slightly more than 99.9 percent water by weight. The rest, less than 0.1 percent, contains a wide variety of dissolved and suspended impurities. Although amounting to an exceedingly small fraction of the sewage by weight, the nature of these impurities and the large volumes of sewage in which they are carried make disposal of domestic wastewater a significant technical problem. The principal impurities are putrescible organic materials and plant nutrients, but domestic sewage is also highly likely to contain disease-causing microbes. Industrial wastewater usually contains specific and readily identifiable chemical compounds, depending on the nature of the industrial process. Storm sewage carries organic materials, suspended and dissolved solids, and other substances picked up as it travels over the ground.

The amount of putrescible organic material in sewage is indicated by the biochemical oxygen demand, or BOD; the more organic material there is in the sewage, the higher the BOD, which is the amount of oxygen required by microorganisms to decompose the organic substances in sewage. It is among the most important parameters for the design and operation of sewage treatment plants. Industrial sewage may have BOD levels many times that of domestic sewage. The BOD of storm sewage is of particular concern when it is mixed with domestic sewage in combined sewerage systems (*see below*).

Dissolved oxygen is an important water quality factor for lakes and rivers. The higher the concentration of dissolved oxygen, the better the water quality. When sewage enters a lake or stream, decomposition of the organic materials begins. Oxygen is consumed as microorganisms use it in their metabolism. This can quickly deplete the available oxygen in the water. When the dissolved oxygen levels drop too low, trout and other aquatic species soon perish. In fact, if the oxygen level drops to zero, the water will become septic. Decomposition of organic compounds without oxygen causes the undesirable odours usually associated with septic or putrid conditions.

Another important characteristic of sewage is suspended solids. The volume of sludge produced in a treatment plant is directly related to the total suspended solids present in the sewage. Industrial and storm sewage may contain higher concentrations of suspended solids than domestic sewage. The extent to which a treatment plant removes suspended solids, as well as BOD, determines the efficiency of the treatment process.

Domestic sewage contains compounds of nitrogen and phosphorus, two elements that are basic nutrients essential for the growth of plants. In lakes, excessive amounts of nitrates and phosphates can cause the rapid growth of algae. Algal blooms, often caused by sewage discharges, accelerate the natural aging of lakes in a process called eutrophication.

Domestic sewage contains many millions of microorganisms per gallon. Most are coliform bacteria from the human intestinal tract, and domestic sewage is also likely to carry other microbes. Coliforms are used as indicators of sewage pollution. A high coliform count usually indicates recent sewage pollution.

Problems with wastewater is that it is made up of sewage as well as grey water which runs away from our houses; this could include water used for showering, washing dishes, or watering the garden. Industrial water is also included, which could contain chemicals, acids, and heavy metals, as well as surface run off which is water running off the ground, collecting substances such as animal faeces, agricultural fertilisers, and car oil along the way. All this water is collected in sewage systems and when the system gets overwhelmed, many authorities release this untreated chemical concoction into rivers and oceans to stop the dirty water flowing back up our drains. This has devasting impacts on our natural environments. Coral reefs are a notable example highlighting the impacts of all these harmful substances on the natural world.

Sewage attracts bacteria which then break down the waste and, in the process, use up copious amounts of oxygen which can leave that local path of ocean lacking oxygen. When this happens, fish and other creatures struggle to thrive and in some extreme cases can cause a 'dead zone' where little is able to grow or survive. Even more shockingly, drugs consumed by humans can still be contained in our waste, meaning substances like antibiotics and hormones are floating around in the sea. Antibiotics cause a problem for corals as they attack the natural community of bacteria which live in a mucus layer on the surface of the corals. These bacteria are healthy ones which work in the same way microbes do in our gut. With these bacteria suffering attack, corals may lose their natural protection and be left open to disease. In fact, in Florida around 20 years ago, there was an outbreak of white pox disease which caused the death of 70% of rare elkhorn corals in the area. This was attributed to viruses present in human sewage which was dumped untreated into the ocean.

Agricultural fertilisers are another major component of wastewater and can have detrimental effects in the ocean. Fertilisers are composed of nitrogen and phosphorous which do an excellent job of making plants grow faster, exactly what we want on land but unfortunately, they also have the same effect in the water. The elevated level of nutrients in fertilisers causes algae to blossom and bloom and as a result, the new clouds of algae block sunlight from marine plants which leaves them struggling to grow. When the algae die, it takes with it a lot of the oxygen in the water, leaving marine animals struggling too and this can also lead to dead zones, such as the 7728 square mile area of the Gulf of Mexico which is now largely devoid of life.

Wastewater also contains industrial chemicals and heavy metals which can cause coral bleaching whilst also causing diseases and reduced reproductive success in both corals and other marine creatures. These toxic substances can also be stored in the tissues of fish, polluting the seafood we enjoy consuming. Endocrine disruptors are chemicals which are found in plastic, detergents, and cosmetics, meaning they easily enter the oceans from our own houses as we wash synthetic clothes with chemical washing powders and pour colourful shampoos and soaps down the drain. These chemicals are known to disrupt hormones in both animals and humans.

V. Studies on Waste Disposal into waterways that end up in the Ocean[15]

Though little talked about, our species has a monumental problem disposing of its human waste. Recent modelling studies[16] find that wastewater adds around 6.2 million tons of nitrogen to coastal waters worldwide per year, contributing significantly to harmful algal blooms, eutrophication, and ocean dead zones.

- The Tuholske study mapped 135,000 watersheds planetwide and found that just twenty-five of them account for almost half the nitrogen pollution contributed by human waste. Those twenty-five were pinpointed in both the developing world and developed world and include the vast Mississippi River watershed in the United States.
- Human waste — including pharmaceuticals and even microplastics contained in faeces and urine — is a major public health hazard, causing disease outbreaks, and putting biodiversity at risk. Sewage is impacting estuary fish nurseries, coral reefs, and seagrasses, a habitat that stores CO2, acting as a buffer against climate change.
- Waste is often perceived as mostly a developing world problem, but the developed world is as responsible — due to antiquated municipal sewage systems that combine rainwater and wastewater in the same pipes. As a result, intense precipitation events regularly flush raw sewage into waterways in the U.S., U.K., and EU.

The food we eat, fluids we drink, and medicines we take, once expelled from our bodies, must end up somewhere. Thanks to the recently published scientific Tuholske model and highlighted by Ogasa, (see endnote 16), the destination of a global flood of human waste into coastal areas has at last been tracked for all to see. According to the Tuholske new model, wastewater adds around 6.2 million tons of nitrogen to coastal waters worldwide annually; equivalent to around 40% of the amount emitted by agricultural runoff. Nitrogen is one of the worst pollutants of our planet's oceans, causing toxic algal blooms, eutrophication and dead zones. The study mapped 135,000 watersheds planetwide and found that just twenty-five of them account for almost half the nitrogen "inputs from wastewater into the ocean."

"The sheer scale of wastewater impacts on coastal ecosystems, especially in terms of nitrogen inputs, was pretty surprising," said Cascade Tuholske, a postdoctoral researcher at the Columbia Climate School, who was part of the interdisciplinary team that created the model.

In assessing direct and septic coastal wastewater releases, the study found that the worst nitrogen-polluting watersheds are "concentrated in India, [South] Korea and China, but are also found in other continents, and a single watershed — the Chang Jiang (Yangtze) River in northern China — account[s] for (11%) of global wastewater [nitrogen]." In another finding, South America and Africa account for much higher nitrogen levels than previously thought, while a U.S. watershed, the Mississippi, figures among the major offenders.

Nitrogen release is just one problem caused by human wastewater. Tuholske and his team also tracked faecal indicator organisms. They found that the twenty-five most polluted watersheds —" located on almost every continent" — emit 51% of these organisms, "in particular in densely-populated deltas and estuaries in Southern and Eastern Asia, as well as in Africa."

The global study does not claim to be comprehensive: "Our paper does not look at heavy metals, phosphorus, plastics. I mean there's pharmaceutical products [too]," Tuholske said. "The list goes on and on for what we put into our watersheds that are hitting coastal areas."

VI. How pollution breaks down this link between the ocean, the climate and carbon capture - A 'toxic cocktail' poisoning the world's waters.

Human waste is a fact of life, and our wholesale failure to dispose of it properly is contributing to intense pressures being placed on Earth's "safe operating space." This safe operating zone was first defined in 2009 by a team of international scientists who recognized nine planetary boundaries — limits beyond which humanity cannot go without destabilizing and threatening life on Earth as we know it. Inadequate wastewater disposal is impacting a range of these boundaries. "There's more in there than just poop and pee," Stephanie Wear, senior scientist, and strategy adviser at The Nature Conservancy (TNC), told Mongabay. She defines the sewage pollution problem as an "intersectional threat," with waste representing a "toxic cocktail" for the environment now adversely impacting at least five of the nine planetary boundaries — contributing to nitrogen nutrient pollution, biodiversity degradation, freshwater systems harm, novel chemical entity pollution, and climate change[17].

Globally, human inputs of nitrogen and phosphorus due to agricultural synthetic fertilizer runoff and human waste have already pushed us beyond the safe planetary boundary set by scientists. On our coasts, this excess of nutrients increases eutrophication risk, posing a threat to a range of aquatic ecosystems by causing toxic algae blooms, red tides, and anoxia. Tuholske and his team overlaid their wastewater pollution map atop coral and seagrass areas around the world. They found that 56% of the planet's coral reefs and 88% of its seagrass meadows are exposed to nitrogen in wastewater, predominantly due to direct and septic wastewater inputs.[18] However, there are some practical effects on our ability to survive apart from the destruction of the role of the ocean as a carbon sink, such as,

1. Effect of Toxic Wastes on Marine Animals

The oil spill is dangerous to marine life in several ways. The oil spilled in the ocean could get on to the gills and feathers of marine animals, which makes it difficult for them to move or fly properly or feed their children. The long-term effect on marine life can include cancer, failure in the reproductive system, behavioural changes, and even death.

2. Disruption to the Cycle of Coral Reefs

Oil spill floats on the surface of the water and prevents sunlight from reaching to marine plants and affects the process of photosynthesis. Skin irritation, eye irritation, lung and liver problems can impact marine life over a prolonged period.

3. Depletes Oxygen Content in Water

Most of the debris in the ocean does not decompose and remain in the ocean for years. It uses oxygen as it degrades. As a result of this, oxygen levels go down. When oxygen levels go down, the chances of survival of marine animals like whales, turtles, sharks, dolphins, penguins for a long time also goes down.

4. Failure in the Reproductive System of Sea Animals

Industrial and agricultural wastes include various poisonous chemicals that are considered hazardous for marine life. Chemicals from pesticides can accumulate in the fatty tissue of animals, leading to failure in their reproductive system.

5. Effect on Food Chain

Chemicals used in industries and agriculture get washed into the rivers and from there are carried into the oceans. These chemicals do not get dissolved and sink at the bottom of the ocean. Small animals ingest these chemicals and are later eaten by large animals, which then affects the whole food chain.

6. Affects Human Health

Animals from impacted food chain are then eaten by humans, which affects their health as toxins from these contaminated animals get deposited in the tissues of people and can lead to cancer, birth defects or long-term health problems.

The most severe effect that leads to the destruction of the oceans role in mitigating climate change is thermal pollution, as the dumping of toxic liquids in the ocean directly raises the temperature of the ocean, as the temperature of these liquids is quite high. Also raising the oceanic temperature are discharges of wastewater used for industrial cooling. Thermal pollution can also happen when something affects a body of water's ability to cool off naturally.

VII. Thermal Pollution[19]

Many industrial processes produce a lot of heat. One major example is power generation from fossil fuels, biomass, or nuclear energy. These types of power plants work by heating water to make steam, which turns a turbine to produce power. They are often built near a natural body of water so they can convert that water to steam.

The power plants also use this water for cooling. They pull in freezing water and run it over the machinery to absorb excess heat. Some of this water evaporates, but the rest gets dumped back into the body of water it came from. This heated water raises the temperature of the body of water.

Other industries also generate a lot of waste heat. These include oil refining, pulp and paper mills, steel mills, chemical plants, and desalination plants. All these use water to cool their machinery and then dump it back into natural bodies of water. This process is called "once-through" cooling because chilly water passes through the plant once and leaves as heated wastewater. But there are other factors that cause thermal pollution - soil erosion, which exposes more area to sunlight, which heats up the water; deforestation which removes shade from lake shores and riverbanks. This exposes the water to more sunlight, causing it to heat up; urban runoff and use of flood retention ponds which are wide and shallow, so they heat up quickly in the sun. If water spills out of them, all that hot water runs off into natural bodies of water nearby. And of course, some causes of thermal pollution are natural. Heat from wildfires, volcanoes, and underwater thermal vents can all cause sudden spikes in water temperature. Lightning strikes are also a source of natural heat.

However, in some cases, these natural causes also have a human element. For instance, wildfires today are more frequent and more severe due to human-caused climate change and mismanagement of forests. Climate change can also lead to cold-water thermal pollution because it causes glaciers to melt faster. The net result of thermal pollution is decrease in dissolved oxygen, algal blooms which absorb oxygen, making dissolved oxygen levels even lower. It can choke out other animals and plants. And it absorbs sunlight, making the water even warmer, so the problem grows worse over time. Eventually, it can create "dead zones" where oxygen levels are too low for aquatic creatures to survive.

Thermal pollution often comes with a side dose of other pollution. Industrial cooling water often contains fuel oil, solvents, heavy metals. And cooling water from nuclear plants can be faintly radioactive. All these pollutants can poison plants and animals or cause them to become sterile, having a detrimental impact to biodiversity. Given these adverse effects, and given impending water resource shortages, power plant designers will need to become more resourceful in designing cooling systems. Many innovative and hybrid technologies have been implemented already, and we expect many new applications will evolve in the coming years[20]. However more urgent is to fix the wastewater and sewerage problems that are destroying the ocean's ability to function as a carbon sink.

VIII. How to dispose of Wastewater and Sewerage[21]

A sewerage system, or wastewater collection system, is a network of pipes, pumping stations, and appurtenances that convey sewage from its points of origin to a point of treatment and disposal. There are combined systems and separate ones. Systems that carry a mixture of both domestic sewage and storm sewage are called combined sewers. Combined sewers typically consist of large-diameter pipes or tunnels, because of the large volumes of storm water that must be carried during wet-weather periods. They are quite common in older cities but are no longer designed and built as part of new sewerage facilities. Because wastewater treatment plants cannot handle large volumes of storm water, sewage must bypass the treatment plants during wet weather and be discharged directly into the receiving water. These combined sewer overflows, containing untreated domestic sewage, cause recurring water pollution problems and are very troublesome sources of pollution.

In some large cities the combined sewer overflow problem has been reduced by diverting the first flush of combined sewage into a large basin or underground tunnel. After temporary storage, it can be treated by settling and disinfection before being discharged into a receiving body of water, or it can be treated in a nearby wastewater treatment plant at a rate that will not overload the facility. Another method for controlling combined sewage involves the use of swirl concentrators. These direct sewage through cylindrically shaped devices that create a vortex, or whirlpool, effect. The vortex helps concentrate impurities in a much smaller volume of water for treatment.

New wastewater collection facilities are designed as separate systems, carrying either domestic sewage or storm sewage but not both. Storm sewers usually carry surface runoff to a point of disposal in a stream or river. Small detention basins may be built as part of the system, storing storm water temporarily and reducing the magnitude of the peak flow rate. Sanitary sewers, on the other hand, carry domestic wastewater to a sewage treatment plant. Pretreated industrial wastewater may be allowed into municipal sanitary sewerage systems, but storm water is excluded.

Storm sewers are usually built with sections of reinforced concrete pipe. Corrugated metal pipes may be used in some cases. Storm water inlets or catch basins are located at suitable intervals in a street right-of-way or in easements across private property. The pipelines are usually located to allow downhill gravity flow to a nearby stream or to a detention basin. Storm water pumping stations are avoided, if possible, because of the very large pump capacities that would be needed to handle the intermittent flows.

A sanitary sewerage system includes laterals, submains, and interceptors. Except for individual house connections, laterals are the smallest sewers in the network. They usually are not less than 200 mm (8 inches) in diameter and carry sewage by gravity into larger submains, or collector sewers. The collector sewers tie into a main interceptor, or trunk line, which carries the sewage to a treatment plant. Interceptors are usually built with precast sections of reinforced concrete pipe, up to five metres (15 feet) in diameter. Other materials used for sanitary sewers include vitrified clay, asbestos cement, plastic, steel, or ductile iron. The use of plastic for laterals is increasing because of its lightness and ease of installation. Iron and steel pipes are used for force mains or in pumping stations. Force mains are pipelines that carry sewage under pressure when it must be pumped.

Sometimes the cost of conventional gravity sewers can be prohibitively high because of low population densities or site conditions such as a high water table or bedrock. Three alternative wastewater collection systems that may be used under these circumstances include small-diameter gravity sewers, pressure sewers, and vacuum sewers. In small-diameter gravity systems, septic tanks are first used to remove settleable and floating solids from the wastewater from each house before it flows into a network of collector mains (typically 100 mm, or 4 inches, in diameter); these systems are most suitable for small rural communities. Because they do not carry grease, grit and sewage solids, the pipes can be of smaller diameter and placed at reduced slopes or gradients to minimize trench excavation costs. Pressure sewers are best used in flat areas or where expensive rock excavation would be required. Grinder pumps discharge wastewater from each home into the main pressure sewer, which can follow the slope of the ground. In a vacuum sewerage system, sewage from one or more buildings flows by gravity into a sump or tank from which it is pulled out by vacuum pumps located at a central vacuum station and then flows into a collection tank. From the vacuum collection tank, the sewage is pumped to a treatment plant.

Pumping stations are built when sewage must be raised from a low point to a point of higher elevation or where the topography prevents downhill gravity flow. Special non clogging pumps are available to manage raw sewage. They are installed in structures called lift stations. There are two basic types of lift stations: dry well and wet well. A wet-well installation has only one chamber or tank to receive and hold the sewage until it is pumped out. Specially designed submersible pumps and motors can be located at the bottom of the chamber, completely below the water level. Dry-well installations have two separate chambers, one to receive the wastewater and one to enclose and protect the pumps and controls. The protective dry chamber allows easy access for inspection and maintenance. All sewage lifts stations, whether of the wet-well or dry-well type, should include at least two pumps. One pump can operate while the other is removed for repair.

There is a wide variation in sewage flow rates over the course of a day. A sewerage system must accommodate this variation. In most cities domestic sewage flow rates are highest in the morning and evening hours. They are lowest during the middle of the night. Flow quantities depend upon population density, water consumption, and the extent of commercial or industrial activity in the community. The average sewage flow rate is usually about the same as the average water use in the community. In a lateral sewer, short-term peak flow rates can be roughly four times the average flow rate. In a trunk sewer, peak flow rates may be two-and-a-half times the average.

Although sewage flows depend upon residential, commercial, and industrial connections, sewage flow rates potentially can become higher because of inflows and infiltration (I&I) into the sanitary sewer system. Inflows correspond to storm water entering sewers from inappropriate connections, such as roof drains, storm drains, downspouts, and sump pumps. High amounts of rainwater runoff can reach the sewer system during precipitation and stormflow events or during seasonal spring flooding of rivers inundated with melting ice. Infiltration refers to the groundwater entering sewers via defective or broken pipes. In both these cases, downstream utilities and treatment plants may experience flows higher than anticipated and can become hydraulically overloaded. During such overloads, utilities may ask residents connected to the system to refrain from using dishwashers and washing machines and may even limit toilet flushing and the use of showers to lessen the strain. Such I&I issues can be especially severe in old and aging water infrastructures.

The size and capacity of wastewater treatment systems are determined by the estimated volume of sewage generated from residences, businesses, and industries connected to sewer systems as well as the anticipated inflows and infiltration (I&I). The selection of specific on-lot, clustered, or centralized treatment plant configurations depends upon factors such as the number of customers being served, the geographical scenario, site constraints, sewer connections, average and peak flows, influent wastewater characteristics, regulatory effluent limits, technological feasibility, energy consumption, and the operations and maintenance costs involved.

The predominant method of wastewater disposal in large cities and towns is discharge into a body of surface water. Suburban and rural areas rely more on subsurface disposal. In either case, wastewater must be purified or treated to some degree to protect both public health and water quality. Suspended particulates and biodegradable organics must be removed to varying extents. Pathogenic bacteria must be destroyed. It may also be necessary to remove nitrates and phosphates (plant nutrients) and to neutralize or remove industrial wastes and toxic chemicals.

The degree to which wastewater must be treated varies, depending on local environmental conditions and governmental standards. Two pertinent types of standards are stream standards and effluent standards. Stream standards, designed to prevent the deterioration of existing water quality, set limits on the amounts of specific pollutants allowed in streams, rivers, and lakes. The limits depend on a classification of the "maximum beneficial use" of the water. Water quality parameters that are regulated by stream standards include dissolved oxygen, coliforms, turbidity, acidity, and toxic substances. Effluent standards, on the other hand, pertain directly to the quality of the treated wastewater discharged from a sewage treatment plant. The factors controlled under these standards usually include biochemical oxygen demand (BOD), suspended solids, acidity, and coliforms.

There are three levels of wastewater treatment: primary, secondary, and tertiary (or advanced). Primary treatment removes about 60 percent of total suspended solids and about 35 percent of BOD; dissolved impurities are not removed. It is usually used as a first step before secondary treatment. Secondary treatment removes more than 85 percent of both suspended solids and BOD. A minimum level of secondary treatment is usually required in the United States and other developed countries. When more than 85 percent of total solids and BOD must be removed, or when dissolved nitrate and phosphate levels must be reduced, tertiary treatment methods are used. Tertiary processes can remove more than 99 percent of all the impurities from sewage, producing an effluent of almost drinking-water quality. Tertiary treatment can be expensive, often doubling the cost of secondary treatment. It is used only under exceptional circumstances.

For all levels of wastewater treatment, the last step prior to discharge of the sewage effluent into a body of surface water is disinfection, which destroys any remaining pathogens in the effluent and protects public health. Disinfection is usually accomplished by mixing the effluent with chlorine gas or with liquid solutions of hypochlorite chemicals in a contact tank for at least 15 minutes. Because chlorine residuals in the effluent may have adverse effects on aquatic life, an additional chemical may be added to dechlorinate the effluent. Ultraviolet radiation, which can disinfect without leaving any residual in the effluent, is becoming more competitive with chlorine as a wastewater disinfectant.

IX. Offsetting Revenues from Alternative Uses of Wastewaters

Obviously Less Developed Countries have allocated low priorities to the effects of sewerage on the ocean – however there are ways in which costs of the above-described expensive systems can be offset**.** Wastewater can be used for nutrient farming and making fertilisers. Australia has proven it can use convert human waste into fertilisers.[22]

Given that wastewater is rich in nutrients and other chemicals, sewage treatment facilities have gained recognition as resource recovery facilities, overcoming their former reputation as mere pollution mitigation entities. Newer technologies and approaches have continued to improve the efficiency by which energy, nutrients, and other chemicals are recovered from treatment plants, helping create a sustainable market and becoming a revenue generation source for wastewater processing facilities.

Concepts such as nutrient trading have also emerged. The intention of such initiatives is to control and meet overall pollution load targets for a given watershed by trading nutrient reduction credits between point and non-point source dischargers. Such programs can help to minimize nutrient pollution effects as well as reduce financial burdens on societies for costly treatment plant upgrades.

Wastewater can also be used for Land Treatment. In some locations, secondary effluent can be applied directly to the ground and a polished effluent obtained by natural processes as the wastewater flows over vegetation and percolates through the soil. There are three types of land treatment: slow-rate, rapid infiltration, and overland flow.

In the slow-rate, or irrigation, method, effluent is applied onto the land by ridge-and-furrow spreading (in ditches) or by sprinkler systems. Most of the water and nutrients are absorbed by the roots of growing vegetation. In the rapid infiltration method, the wastewater is stored in large ponds called recharge basins. Most of it percolates to the groundwater, and very little is absorbed by vegetation. For this method to work, soils must be highly permeable. In overland flow, wastewater is sprayed onto an inclined vegetated terrace and slowly flows to a collection ditch. Purification is achieved by physical, chemical, and biological processes, and the collected water is usually discharged into a nearby stream.

Land treatment of sewage can provide moisture and nutrients for the growth of vegetation, such as corn or grain for animal feed. It also can recharge, or replenish, groundwater aquifers. Land treatment, in effect, allows sewage to be recycled for beneficial use. Large land areas are required, however, and the feasibility of this kind of treatment may be limited further by soil texture and climate.

Wastewater can be a valuable resource in cities or towns where population is growing, and water supplies are limited. In addition to easing the strain on limited freshwater supplies, the reuse of wastewater can improve the quality of streams and lakes by reducing the effluent discharges that they receive. Wastewater may be reclaimed and reused for crop and landscape irrigation, groundwater recharge, or recreational purposes. Reclamation for drinking is technically possible, but this reuse faces significant public resistance.

There are two types of wastewater reuse: direct and indirect. In direct reuse, treated wastewater is piped into some type of water system without first being diluted in a natural stream or lake or in groundwater. One example is the irrigation of a golf course with effluent from a municipal wastewater treatment plant. Indirect reuse involves the mixing of reclaimed wastewater with another body of water before reuse. In effect, any community that uses a surface water supply downstream from the treatment plant discharge pipe of another community is indirectly reusing wastewater. Indirect reuse is also accomplished by discharging reclaimed wastewater into a groundwater aquifer and later withdrawing the water for use. Discharge into an aquifer (called artificial recharge) is done by either deep-well injection or shallow surface spreading.

Quality and treatment requirements for reclaimed wastewater become more stringent as the chances for direct human contact and ingestion increase. The impurities that must be removed depend on the intended use of the water. For example, removal of phosphates or nitrates is not necessary if the intended use is landscape irrigation. If direct reuse as a potable supply is intended, tertiary treatment with multiple barriers against contaminants is required. This may include secondary treatment followed by granular media filtration, ultraviolet radiation, granular activated carbon adsorption, reverse osmosis, air stripping, ozonation, and chlorination.

The use of grey-water recycling systems in new commercial buildings offers a method of saving water and reducing total sewage volumes. These systems filter and chlorinate drainage from tubs and sinks and reuse the water for non-potable purposes (e.g., flushing toilets and urinals). Recycled water can be marked with a blue dye to ensure that it is not used for potable purposes. There are a variety of ways to use heat energy of municipal sewage, the most effective of which is to use sewage. That is, release the excess heat in the building into the city sewage through the unit in summer and extract and release it into the building in winter as done by Huber Technology.

X. Legislation governing Pollution of the oceans.

International ocean governance is about managing the world's oceans and their resources together so that they are healthy and productive, for the benefit of current and future generations. Although pillar of climate regulation, the ocean is still absent from the initial key messages of the Global Stocktake undertaken during COP28. Despite positive signals of better consideration of ocean-based solutions, illustrated both in nations' climate strategies and by the growing mobilisation of non-state actors, the ocean was on the margins of the discussions held during the technical dialogue of the Global Stocktake – and absent from the emerging key messages.

Beyond the conclusions of the Global Stocktake, the resulting political response must imperatively be ambitious. To support and encourage action, the ocean community, united under the Marrakech Partnership for Global Climate Action, with the support of the UN High-Level Climate Champions, launched the Ocean Breakthroughs.

With the ambition to accelerate efforts and investments for ocean-based climate action, they cover five key sectors, ranging from marine conservation to shipping, including coastal tourism, marine renewable energies, and aquatic food. For each sector, quantifiable, science-based targets have been developed, to be achieved by 2030, to ensure a healthy and productive ocean by 2050.

However, none of these plans considered urgent action on sewerage, wastewater, and thermal pollution. The reasons are outlined below.

Around 2/3rds of the oceans are considered international waters beyond the boundaries of any country. The 'high seas' however are not lawless. Seafarers, ships, companies and countries are all subject to maritime law: a system of rules, international agreements and conventions that together govern activities on the high seas. However, countries do have the right to claim 'exclusive economic zones' (EEZs) up to two hundred nautical miles from their coastlines. Within these zones, countries have special rights to explore and exploit natural resources, such as fish, oil and gas. While these laws are meant to ensure that no single nation can lay claim to our ocean, they also come with a problem: if 'no one' owns the ocean, who's responsible for caring for them? Outside of these zones, both vessels and countries are subject to maritime law.

Maritime law is a system of laws, conventions and regulations that govern activities on the seas and oceans. It covers a wide range of issues, from navigation, shipping, seafarer welfare and piracy to fishing, marine pollution and conservation. One of the principles of maritime law is the freedom of the high seas. This principle means that all countries have the right to use the oceans for navigation, fishing, and other activities without interference from others. The ocean is chaotic situation. But there is a counter to this. The United Nations Convention on the Law of the Sea, adopted in 1982, recognises that the ocean is the 'common heritage of humankind', and that 'No State shall claim or exercise sovereignty or sovereign rights over any part of the Area or its resources'. While the ocean is free for all, it should not be *a* free for all, open to exploitation and abuse. Major challenges around ratifying and enforcing the UN Convention on the Law of the Sea remain, and it has limited influence over what individual countries choose to do within their own exclusive economic zones and what occurs beyond.

One potential answer to that question came in 2023 with the passing of the UN High Seas Treaty – officially known as the *International legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*.

This treaty allows for the creation of a network of marine protected areas, designed to 'protect, preserve, restore, and maintain biodiversity and ecosystems. This could aid the campaign to protect 30 per cent of the ocean by 2030, one of the key targets of the UN's 17 Sustainable Development Goals for 2030.The treaty also requires countries to conduct Environmental Impact Assessments (EIAs) on planned marine activities such as deep sea mining before they are authorised. This is designed to lead to better understanding of human impacts on the ocean, and challenge actions 'that may cause substantial pollution of or significant and harmful changes to the marine environment.' The High Seas Treaty has been called a 'breakthrough' for international conservation efforts and marine diversity. But there is still work to be done: countries must first legally adopt the agreement and then work together to implement the treaty's requirements.

However, each country is responsible for its own sewage treatment and wastewater and the performance of our most advanced nations is reviewed below and shown to be flawed. Moreover, the UN Treaty offers no assistance to those Less Developed Countries with flawed methods of treating sewerage and wastewaters.

USA

In October 1972, Congress enacted the Marine Protection, Research and Sanctuaries Act (MPRSA), sometimes referred to as the Ocean Dumping Act, declaring that it is the policy of the United States to regulate the dumping of all materials which would adversely affect human health, welfare or amenities, or the marine environment, ecological systems, or economic potentialities. The MPRSA implements the requirements of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter of 1972, known as the London Convention. The London Convention is one of the first international agreements for the protection of the marine environment from human activities[23].

Under the MPRSA, EPA is responsible for establishing criteria for reviewing and evaluating permit applications. EPA is responsible for issuing ocean dumping permits for materials other than dredged material. In the case of dredged material, the U.S. Army Corps of Engineers (USACE) is responsible for issuing ocean dumping permits, using EPA's environmental criteria. Permits for ocean dumping of dredged material are subject to EPA review and written concurrence. EPA is also responsible for designating and managing ocean disposal sites for all types of materials.

Unregulated disposal of wastes and other materials into the ocean degrades marine and natural resources and poses human health risks. For almost 50 years, EPA's Ocean Dumping Management Program has stopped many harmful materials from being ocean dumped, worked to limit ocean dumping generally, and worked to prevent adverse impacts to human health, the marine environment, and other legitimate uses of the ocean (e.g., navigation, fishing) from pollution caused by ocean dumping. Learn more about how EPA protects the oceans from dumping in the United States on the Protecting Our Oceans from Pollution Web page.

Four federal agencies have responsibilities under the MPRSA: EPA, USACE, the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Coast Guard (USCG). The EPA has primary authority for regulating ocean disposal of all materials except dredged materials. USACE and EPA share responsibility for the regulation of dredged material disposal in ocean. USCG maintains surveillance of ocean dumping. Under Title II of the MPRSA, NOAA is responsible for some long-range research on the effects of human-induced changes to the marine environment. In addition, EPA's Ocean Dumping Management Program coordinates with partners at the international, federal, state, and local levels, and through interagency groups, including National and Regional Dredging Teams, on ocean dumping, dredged material management, pollution prevention and marine protection activities.

The passage of the MPRSA in 1972 marked a major milestone in the protection of the marine environment. Today, the United States is at the forefront of protecting coastal and ocean waters from adverse impacts due to ocean dumping. The ocean is no longer considered an appropriate disposal location for most wastes. Ocean dumping of certain harmful wastes is banned. The Ocean Dumping Ban Act of 1988 amended the MPRSA and now prohibits the ocean dumping of municipal sewage sludge and industrial wastes, such as wastes from plastics and pharmaceutical manufacturing plants and from petrochemical refineries. The 1988 amendment also banned the ocean disposal of "medical waste." Other ocean dumping practices, such as woodburning at sea and the disposal of construction and demolition debris, have stopped as a matter of environmentally sound practice.

UK

The UK's increased dumping of raw sewage in the Channel could be a breach of its post-Brexit trade deal with the EU. It passed laws requiring water companies to reduce the frequency and volume of discharges from storm overflows and to install new monitors to immediately report any sewage discharges in their area. However, the EU has been urged to take legal or political action against the UK, arguing that the sewage dumping was killing fish and damaging the marine environment. Pierre Karleskind, the chairperson of the EU

Parliament's fisheries committee, who was one of the three MEPs, said there was "an alarm bell ringing." "We are directly and immediately concerned by the releasing of untreated sewage into the seas. I know our British neighbours are not particularly happy with it either," he said. Public pressure in the UK is growing for the government to take action to prevent the privatised water companies from dumping sewage. Earlier this week, MEPs debated a draft regulation designed to uphold the EU's rights under both the Withdrawal Agreement and the Trade and Cooperation Agreement that now governs EU-UK trade. The bill, which will include mechanisms to suspend parts of the deal and impose sanctions, is expected to be adopted by the end of the year.

EU

Urban wastewater is one of the main sources of water pollution if it is not collected and treated according to EU rules. It contains organic matter, nitrogen and phosphorous. These are all removed when properly treated, otherwise they can lead to eutrophication. It also can be contaminated with harmful chemicals, bacteria, and viruses which, when untreated and discharged into the environment, affect our health, and damages our rivers, lakes, and coastal water.

The EU's Urban Wastewater Treatment Directive currently in force is more than 30 years old. Since its adoption in 1991, the quality of European rivers, lakes and seas has dramatically improved. Countries have set up collecting systems and wastewater treatment plants with the help of Funding. Yet there is still pollution that needs to be addressed and is not covered by the current rules. To address this, the Commission has proposed an update to the Directive. [24]

In 2022 as a leading global actor, the EU set out an updated agenda for better ocean governance based on a cross-sectoral and rules-based international approach, aiming to further consolidate its role as a global leader in ocean governance. Building on and updating the commitments set out in the 2016 Joint Communication, the EU commits to: strengthening the international ocean governance framework at global, regional and bilateral levels; making ocean sustainability a reality by2030 by taking a coordinated and complementary approach to common challenges and cumulative impacts; continuing to make the ocean a safe and secure space as competition in international waters and challenges to multilateral cooperation are growing; building up international ocean knowledge for evidence-based decision-making to resulting action to protect and sustainably manage the ocean.

However, none of these commitments touch on the most important destructive force affecting oceans – sewerage and wastewater management as well as shipping. None of the scheduled meetings on ocean governance raise these issues in their agendas. Consider the effect of shipping on oceanic health.

A Huge Gap in International Regulation of Shipping

It has been estimated that twenty million people are using leisure ships. There are two main problems with current international sewage regulation. First, ships are allowed to dump *untreated* sewage into the ocean if they are further than twelve nautical miles from the coast. Think about that. Raw sewage can be dumped into most of the ocean[25]

Within three nautical miles of shore, vessels of more than four hundred gross tons and passenger vessels certified to carry fifteen people or more must treat sewage using an approved sewage treatment plant. The plant must meet specific treatment standards for total suspended solids, faecal coliforms (indicator organisms that suggest the presence of other bacteria) and other harmful discharges. When ships are between three and twelve nautical miles from shore, they must—at a minimum —disinfect their sewage using an approved sewage treatment system. While better than no treatment at all, disinfection is outdated and inadequate now that [most] ships can use more advanced and effective sewage treatments.

The second problem with current international sewage regulation is that the approved sewage treatment plants needed to meet these requirements are not actually doing their jobs. A 2017 study concluded that 97 percent of ships evaluated did not meet sewage effluent requirements, despite using approved plants. Not only can ships dump raw sewage outside of twelve nautical miles from shore, but 97% are dumping sewage that does not meet legal requirements within this range. The study revealed that most of these ships did not come remotely close to meeting legal standards, with astronomical levels of dangerous contents like faecal coliforms.

XI. The necessity for a system of Oceanic Governance - Saving our oceans with a new Regulatory Model

As has been pointed out before, but which is still not accepted let alone understood by the vast majority, is that even if we employed techno-fixes such as Bill Gates' *Solar Radiation Management Company*, it would not stop climate change's evil twin, ocean acidification, which is threatening to collapse the entire marine ecosystem. A recent paper by marine biologists and environmental consultants has warned that human society faces extinction if nothing is done to reverse the destruction of the oceans.[26]

As a result of many years of negotiation the gap in regulation will hopefully be remedied from 2023 onwards by The High Seas Treaty, which was signed in New York on 20 September, during the United Nations High Level Week[27]. The treaty started in June 2023 as an agreement under the United Nations

Convention on the Law of the Sea (UNCLOS) on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction. Areas beyond national jurisdiction comprise the high seas and the seabed beyond national jurisdiction. So, although as of 2023 we have a 2023 UN Treaty on the Seas we have no regulatory model to police it.

The second paper in this series reviews the challenges and limitations of this Treaty proposing an alternative governance model, which should be urgently considered in view of the necessity for all signing nations to enact it into their own national legislation for it to become legally binding. Meanwhile we desperately need more research on the effects of pollution and the links to the currents and climatic conditions, in particular mapping severe weather events. The frequency, geographic location, history of such events and their relation to the types of pollution mentioned in this paper would enable governments to pinpoint reasons for such events and take preventive measures. Certainly, improving sewage and wastewater management appears a far simpler and more economical solution that concentrating all our resources on emissions reduction.

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