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Scientific Student Conference Paper

POLLUTIONS IN THE OCEANS

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Contents

1.	Water bodies and importance for life	4
1.1.	Introduction to water bodies.....	4
1.2.	Oceans	4
1.2.1.	Pacific Ocean.....	5
1.2.2.	Atlantic Ocean.....	5
1.2.3.	Indian Ocean	6
1.2.4.	Southern Ocean	6
1.2.5.	Arctic Ocean.....	7
1.2.6.	Marine Life	8
1.2.6.1.	Plankton	8
1.2.6.2.	Nekton	9
1.2.6.3.	Benthos	9
1.3.	Importance of oceans	10
2.	General presentation of water pollution.....	11
2.1.	Cause and source of water pollution.....	11
2.2.	Types of water pollution.....	13
2.2.1.	Physical water pollution.....	13
2.2.2.	Chemical water pollution.....	13
2.2.3.	Biological water pollution	14
2.2.4.	Pollution based on types of pollutants	15
3.	Effects of pollutions in waters	21
3.1.	Effects on oceans	21
3.2.	Effects on marine organisms	22
3.2.1.	Toxic chemicals	23
3.2.2.	Ocean acidification	24
3.2.3.	Marine debris and plastic pollution	25
3.2.4.	Harmful algal blooms.....	29
3.3.	Impacts and effects on oxygen production	31
3.4.	Impacts and effects on human	31

3.4.1.	Effects on human health.....	32
3.4.2.	Effects on economy and society	34
4.	Awareness of people based on quantitative data	36
4.1.	Methodology	36
4.2.	Survey questions.....	36
4.3.	Primary data	37
4.3.1.	Cross tabulation	44
4.3.2.	Group statistics and independent sample t-test	46
4.4.	Results.....	47
5.	Conclusion	48
	References	49
	Appendix A – Cross Tabulations	58
	Appendix B – Group Statistics.....	61
	Appendix C – Independent Samples T-Test	62

1. Water bodies and importance for life

1.1. Introduction to water bodies

It is a fact that most people know that the earth we are living in is covered by water for more than 70% (How Much Water Is There on Earth?, n.d.). Water is indeed very important to all living organisms; it is one of the most important natural resources on earth. Water from natural resources includes saltwater and freshwater and it could be found in different water bodies, in many places. Table 1 (How Much Water Is There on Earth?, n.d.) will show details of water percentage from different types of water bodies, with a note that the percentages are rounded, the numbers may not add up to 100 percent:

Water source	Water volume, in cubic kilometers	Percent of freshwater	Percent of total water
Oceans, seas, and bays	1,338,000,000	-	96.54
Ice caps, glaciers, and permanent snow	24,064,000	68.7	1.74
Groundwater	23,400,000	30.1	1.69
Soil moisture	16,500	0.05	0.001
Lakes	176,400	0.26	0.13
Atmosphere	12,900	0.04	0.001
Swamp water	11,470	0.03	0.0008
Rivers	2,120	0.006	0.0002
Biological water	1,120	0.003	0.0001

Table 1 Water percentage from different sources (How Much Water Is There on Earth?, n.d.)

1.2. Oceans

As mentioned in table 1, the biggest water body is the oceans. Oceans are saltwater bodies that are connected to each other. According to oceanic research, they are generally recognized as five major oceans, which are Pacific, Atlantic, Indian, Southern, and Arctic oceans (Ocean | Definition, Distribution, Map, Formation, & Facts, n.d.).



Picture 1 The oceans

1.2.1. Pacific Ocean

The Pacific Ocean is located between Asia and Australia continents on the west and North America and South America on the east. The Pacific is the deepest and largest ocean on earth (What Is the Largest Ocean Basin on Earth?, n.d.). It also possesses numerous and abundant types of plants, algae, and animals. This is because the temperature, current, and nutrients of the Pacific Ocean permit and drive the intermingling and mixing of the different types of living organisms (Pacific Ocean - Tides, n.d.).

1.2.2. Atlantic Ocean

The Atlantic Ocean is the second largest on earth, covering approximately one-fifth of earth's surface. Atlantic Ocean is located on the point that Europe and Africa continents are the east and North America and South America are the west. Another name of the Atlantic Ocean that is well-known is called the Sea of Atlas. Atlantic Ocean is also known to have plentiful of petroleum and natural gas, it is estimated to be as high as of the projected total for all of the world's recoverable oil and natural gas (Atlantic Ocean | Definition, Temperature, Weather, & Facts, n.d.). Atlantic Ocean is one of the factors that drive the hurricanes that are seen in the US. African Easterly Jet, which is a wind stream formed in the

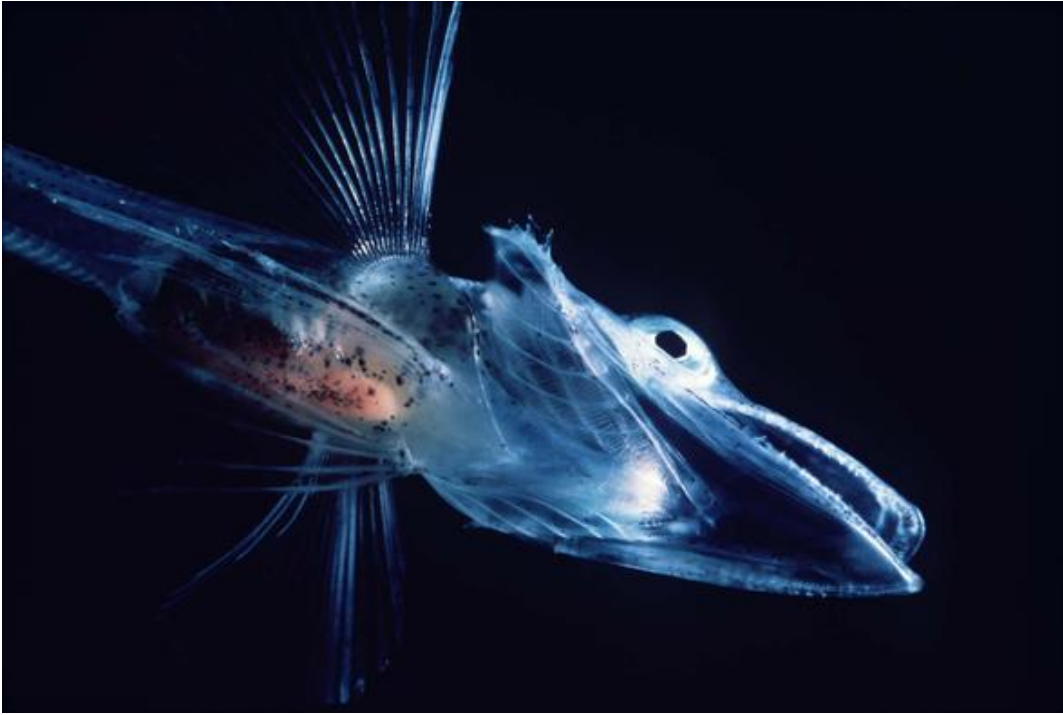
Sahara, travels over to the Africa's west coast, pick up ocean water to form thunderstorm, and continue to travel across the Atlantic Ocean. Then, it is fueled up by warm water off the east coast or in the Gulf of Mexico to form hurricanes (Gibbens, 2021a).

1.2.3. Indian Ocean

Indian Ocean is only smaller than the Pacific and Atlantic Ocean. It stretches from the southern top of Africa and Australia, also touching Asia and Antarctica, covering more than 70,000,000 square kilometers. According to Britannica Encyclopedia, Indian Ocean is geologically youngest and physically most complex compared to the Pacific and Atlantic Oceans (Indian Ocean | History, Map, Depth, Islands, & Facts, n.d.). Most parts of the Indian Oceans are located within the tropics, which makes the Indian Ocean free from ice all year round. With the climate, monsoon, and natural factors across land and sea around the Indian Ocean together, create diversity of species in plants and animals. It is one of the places where the species are more unique and exotic (Description of the Indian Ocean, n.d.).

1.2.4. Southern Ocean

The fourth largest ocean, Southern Ocean, also called Antarctic Ocean, covers one-sixteenth of the earth's total ocean area (Southern Ocean | Location, Map, Depth, & Facts, n.d.). Southern Ocean is the newest ocean to be recognized since the scientists were debating whether it has properties to have its own name. While other oceans' names are based on their locations and continents, the name of the Southern Ocean is slightly different. Southern Ocean is defined by its current, which is roughly established around 34 million years ago. The current is called Antarctic Circumpolar Current (ACC), the water that is flowing in the ACC is colder and less salty compared to the water from the north (Gibbens, 2021b). Due to the fact that ACC keeps Antarctica cold, there are many interesting species to be discovered. One of the most interesting discovery of living organisms is an Antarctic blackfin icefish. The surprising structures of the icefish include but not limited to lack of scales, transparent bones, and white blood, which is the result from not having red blood cell nor hemoglobin pigments for transporting oxygen (Rennie, 2019).



Picture 2 Antarctic blackfin icefish

1.2.5. Arctic Ocean

Arctic Ocean, the smallest ocean in the world, located in the North Pole. Although it is the smallest ocean, it is still five times larger than the Mediterranean, the largest sea. The dominant characterization of the Arctic Ocean is that it is covered by sea ice. Sea ice is frozen seawater that floats on the ocean surface. Sea ice start forming as a tiny ice crystal called frazil, then developed into thin sheets of ice. Over time, the sheets collided and formed thick ridges. Sea ice is an important factor that could help monitoring changes in the environment including ocean circulation, weather, and regional climate. Arctic sea ice reaches its maximum extent during March and its minimum extent during September (Scott & Hansen, 2016).

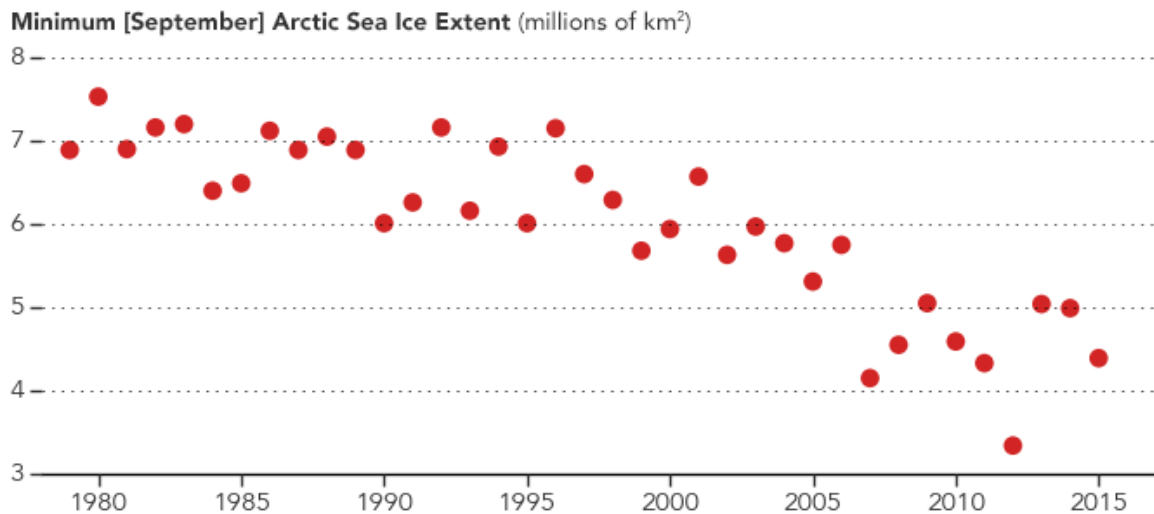


Figure 1 Minimum Arctic Sea ice extent from 1980 to 2015 (Scott & Hansen, 2016)

Figure 1 show that the minimum extent of the Arctic see ice has been declining each decade. This is because of the global warming. As the global getting warmer and the sea ice continue to melt, many species including seals and polar bears will lose their habitat and finally go extinct (Scott & Hansen, 2016).

1.2.6. Marine Life

1.2.6.1.Plankton

Plankton is one of the marine organisms that could weakly swim or could not move by its own. An organism in the ocean is considered as plankton if it is carried by the tide or current. There are two main types of plankton: phytoplankton and zooplankton (What Are Plankton?, n.d.).

1.2.6.1.1. Phytoplankton

Phytoplankton can be bacteria, protist, or plant. It has chlorophyll and could photosynthesize. The factors that affect the growth of the phytoplankton are carbon dioxide, sunlight, salinity, water depth, water temperature, wind, and nutrients. There are some phytoplankton that could fix nitrogen and survive in the area where nitrate concentrations are low. Phytoplankton is the base of food web in the ocean, as it is the primary producer (Lindsey & Scott, 2010).



Picture 3 Examples of phytoplankton

1.2.6.1.2. Zooplankton

Zooplankton are animal-like plankton. It includes microscopic animals, which is usually permanent plankton, and young invertebrates and fish. Zooplankton is not a producer. Zooplankton consumes phytoplankton and is consumed by larger animals. The most well-known predators of the zooplankton are blue whales (What Are Plankton?, n.d.).

1.2.6.2.Nekton

Nekton are living organisms that could swim freely. Marine nekton usually is pelagic, but they could live at all depth of the ocean. Zooplankton has a large size rang, examples of nekton are squid, shrimp, marine retiles, marine mammals, and adult fish (Kress, 2019). There are 20,000 species of fish in the ocean that are discovered, which could make a major segment of the nekton. Even though fish species are very diverse, human can manage to overfish. Measures and policies are needed to stop overfishing and to ensure that fisheries and aquaculture are sustainable (The State of World Fisheries and Aquaculture 2020, n.d.).

1.2.6.3.Benthos

Benthos are organisms that are attached on continental shelf, sediments, ocean floor, or bed of seagrass. Benthic organisms are important to the ecosystem because its structure could reveal organic pollution or contamination. Examples of benthos are polychaeta, mollusks, crustaceans, and echinoderm. Many of benthic organisms had developed to become deposit feeders, suspension feeders, or both (Marine Benthos, n.d.).

1.3. Importance of oceans

Oceans are the most diverse place that provides countless benefits to human beings and other living organisms. First, oceans help regulate the climate, it absorbs carbon dioxide and additional heat to reduce the temperature of the earth, without the oceans, there would be no weather patterns and the temperature would not be stable enough to support lives. There is a report published by World Meteorological Organization that more than 90 percent of the energy trapped by greenhouse gases goes into the oceans. Second, oceans provide food to animals and human. It is an ecosystem that has abundant food for billions of people. Third, it is a way of transportation. Although it might take longer than air or land transportation, but it is more reasonable and affordable when transporting massive merchandise containers in a long distance. Fourth, oceans are economically important. Fisheries, tourism, and other ocean related activities create careers and increase the amount of currency in circulation. Fifth, the ocean is the biggest habitat on earth, it is a home to many organisms (Why Should We Care about the Ocean?, n.d.; 7 Reasons Why We Need to Act Now to #SaveOurOcean, 2017). The benefits of the oceans are not limited to what was mentioned earlier, but those have been studied and are the most well-known to human.

World Employment for Fishers and Fish Farmers, by regions (thousand)						
Regions Year	1995	2000	2005	2010	2015	2020
Africa	2812	3348	3925	4483	5067	5407
Americas	2072	2239	2254	2898	3193	2843
Asia	31632	40434	44716	49427	49969	50385
Europe	476	783	658	648	453	402
Oceania	466	459	466	473	479	473
Total	37456	47683	52019	57930	59161	59509

Table 2 World employment for fishers and fish farmers (The State of World Fisheries and Aquaculture 2020, n.d.)

2. General presentation of water pollution

Water Pollution: Causes, Effects, and Controls defines water pollutant as physical, chemical, or biological factors that cause detriment or damage on aquatic life and on those who consume the water. A factor could be beneficial or harm to the environment depends on the conditions. In some cases, naturally existing chemical elements are essential for the ecosystem, but when they are present in excessive quantity, it leads to water pollution – changing in quality and/or composition to become less suitable for specific purposes (Goel, 2021). Similarly, Modern Treatment Strategies for Marine Pollution (2021) defined marine pollution as “introduction of substances from humans into the marine environment resulting in such harmful effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater and the reduction of facilities” (Kumar & Prasannamedha, 2021).

2.1. Cause and source of water pollution

The cause of pollution in water is mainly from anthropogenic activities. In a day, a human being has several activities from morning to night, from home to workplace, and back at home again. Numerous anthropogenic activities are related to water – whether using it directly or indirectly. At the end of the day, there are end results from those activities that need to be discard – and many of them are being released into the water bodies.

The sources of the water pollution caused from anthropogenic activities could be classified into three major sources, which are domestic, agriculture, and industry (FAO, 2017). Domestic water pollution refers to the discharge of waste and sludge that contain organic matters and soap to the water bodies, usually rivers and seas (Domestic Pollution, n.d.). Agricultural water pollution is generally coming from the leakage or the discharge of water that is already polluted from chemicals, fertilizers, and pesticides. Agricultural pollution is threatening because the pollutants are usually not biodegradable. It stays in the water bodies and soil while destroying and damaging lives and the environment (Agricultural Pollution, n.d.). Agricultural pollution tends to increase as the world’s population increases because the demand of food is higher. Industrial water pollution appears to be the most dangerous

and threatening. Pollutants from industrial origin contain all kinds of substances that are toxic and non-biodegradable. The industrial pollutants are coming from production processes, accidental breaks or leaks of containers containing polluting products, or the pollutants could be carried by rainfall to the water bodies (Industrial Pollution, n.d.).

The cause of marine pollution is definitely from human, as mentioned in the previous paragraph, but the introduction of the substances from human into the marine could be done directly or indirectly. The sources of the pollution in the oceans are mainly land-based, it is said to be 80% of the pollution in the marine environment (What Is the Biggest Source of Pollution in the Ocean?, n.d.).

One of the most threatening pollution in the marine ecosystem is the runoffs. Runoff is a process occur when water, including rainwater, snow melts, and irrigation, flows along and makes its way to rivers, lakes, ponds, seas, and oceans. Polluted runoff is when the runoff is mixed with chemicals, toxic materials, oil and gas, dust, fertilizers, bacteria, salt, heavy metals, and debris. Runoffs are usually coming from agricultural and industrial area when rainwater or irrigation wash of the chemicals and fertilizers in the soil and on the surface to the water bodies (National Geographic Society, 2012).

Meanwhile it does not look related, but atmospheric pollution is one of the sources that harms the oceans. Atmospheric pollution could be simply defined as pollution that is being carried by wind, in this case, to the oceans. Atmospheric pollution includes SO_2 and NO_x from combusting process, greenhouse gases that could increase the temperature of the oceans and contribute to ocean acidification, and light dust and debris that are mixed with toxic materials and heavy metals (What Is Pollution?, n.d.).

Shipping activities are also contributing a significance proportion to the marine pollution. Not only pollute water and harm marine living organisms by releasing carbon dioxide, greenhouse gases, oil spills and discharge, garbage and sewage, and bilge water (bilge water may contain water, oil, urine, detergents, solvents, chemicals, pitch, particles, and other materials) to the oceans (What Is Pollution?, n.d.), shipping activities also cause noise pollution and ship strikes could kill marine mammals in the area too (IMO, n.d.). The other

sources of marine pollution include ocean dumping, deep sea mining, oil spill and gas leakage from oil and gas drilling, and offshore mining.

2.2. Types of water pollution

Water pollution can be identified and classified into many segments, depending on the indicator that are used. It could be classified according to its source: point-source, nonpoint-source, and trans-boundary (Mayer, 2019). It could also be classified according to the properties of water that are being affected: physically, chemically, and biologically.

2.2.1. Physical water pollution

Physical water pollution is the affecting on physical properties of water including color, turbidity, temperature, suspended solids, foam, and radioactivity. Thermal pollution is one form of physical water pollution that is well-known.

Thermal pollution is an emission of excess heat that affect the temperature of the water bodies. Changes in temperature of a water body could lead to declining of water quality, noncyclical nutrient cycle, changes in aquatic food web, and diminishing of biota. Thermal pollution often occurs if released to lakes and rivers. The source of thermal pollution is industrial origin, including discharge of water from cooling towers, power plants, nuclear plants, electric power plants, steel melting factories, crude oil refineries, and ongoing climate changes. Thermal pollution could be reduced if regulations were applied: maximum temperature of water used for cooling, maximum temperature increase in the natural water bodies receiving the thermal influenced, and maximum temperature in the receiving water (Vinnå, 2017; Speight, 2019).

2.2.2. Chemical water pollution

Chemical water pollution is mainly from domestical, agricultural, and industrial origins. Chemical pollution is unnaturally present of chemicals and/or higher chemical amounts that exceed the normality. Common chemical pollutants are ammonium, ammonia, nitrate, nitrite, arsenic, mercury, selenium, lead, crude oil, phosphorus, phosphate, sulphate, hydrocarbon,

pesticides, detergent, and salt (SEPA, n.d.). There are many more chemicals that could make water polluted, but as mentioned before, it all depends on the conditions.

The easiest way to classified chemical pollutants is to classify them by its properties. Inorganic and organic pollutants are the most familiar type of chemical pollutants. Inorganic pollutants include metalloids, heavy metals, halides, oxyanions and cation, radioactive materials and so forth (Srivastav & Ranjan, 2020). Organic pollutants, for instance, are carbon-based chemicals, organic solvents, petroleum, petroleum-based wastage, industrial products, cosmetics, pharmaceutical products, veterinary products, food additives, engineered nanomaterials, pesticides, insecticides, and gas or liquid phase of VOCs (Sharma & Negi, 2020; Brindha & Schneider, 2019).

Another chemical that is creating unsettledness to the water bodies and the environment is persistent organic pollutants (POPs). It is one of the environmental greatest concerns because it is persistent in the environment, meaning it is hard to remove completely from the environment even it has passed through chemical, photochemical, or biological processes. Living organisms, including human and wildlife, could consume it via food web, and the most important is that it is toxic to living organisms (Schwarzenbach et al., 2010).

Chemical water pollution is more concerning in freshwater than in saline water. Freshwater that is being contaminated affects the amount of drinking water that human could consume. It is also the source of waterborne diseases. Knowledge and understanding of type and origin of the chemical pollutants are a great help in assessing any chemical pollution (Schwarzenbach et al., 2010).

2.2.3. Biological water pollution

Biological water pollution is formed from biological pollutants, which means pollution that is emerge from organisms. Biological pollutants refer to viruses, bacteriophage, bacteria, parasites, algae, biological wastes, and invasive species, especially aliens that were just introduced to the environment. Biological water pollution does not only mean declining in water quality and creating waterborne diseases, but it also includes the reducing in fitness of the biological systems for survivals (Elliott, 2003).

Eutrophication is one of the examples of biological water pollution. Although eutrophication is a problem that is caused by changes in amount of nutrients, mostly nitrogen and phosphorus, in the water bodies but it could be view as biological phenomena because it promotes the excessive plants and algal growth and support the growth of decomposer microbes that will use more of the oxygen supply. Eutrophication is naturally occurring as the water bodies aged and are filled with sediments, which usually takes years to occur. Nevertheless, it can be commonly seen because human activities increase the speed, rate, and extent of eutrophication in the aquatic ecosystem. The main source of eutrophication is from agricultural run-off due to the use of fertilizers and animal wastes, follow by wastes from urban and industries (Chislock et al., 2013). The sources of pollution are from one origin, which is the growth of human population and increasing in demands in food, products, and services.

2.2.4. Pollution based on types of pollutants

The types of pollution could be defined based on pollutants and its sources, too. Table 3 (Sources and Effects of Marine Pollution, n.d.) briefly defines the pollutants and its sources.

Type of pollutants	Source
Nutrients	Runoffs, sewage, forestry, agriculture, land use, airborne from power plants, car, et cetera
Sediments	Erosion from mining, forestry, agriculture, and coastal dredging and mining
Pathogens	Runoffs, sewage, and livestock
Alien species	Ballast water, canals linking bodies of water, and fishery
Persistent toxins including PCBs, heavy metals, DDT, et cetera	Industrial discharge, wastewater discharge, land-based sources, pesticides from agricultural activities, forestry, domestic waste, and runoff from landfills
Oil	Cars, heavy machinery, industries, oil tanker operation, shipping activities, accidental spills, and offshore drilling
Plastics	Fishery, cargo and cruise ships, shipping activities, oceans dumping, ocean littering, atmospheric pollution, landfills, and industrial waste
Radioactive substances	Discarded nuclear submarine and military waste, atmospheric pollution, and industrial waste

Thermal	Colling water from power plants and industrial origins
Noise	Shipping activities, supertankers, and large vessels and machinery

Table 3 Type and source of marine pollution (Sources and Effects of Marine Pollution, n.d.), complied by Nadaprapha Binsa Aeteh

One of the most threatening pollutants is plastic. Plastics that are released into the oceans became harmful and toxic to marine organisms and the ocean itself overtime as it does not breakdown easily and release chemicals to the oceans.

Plastics are made up of synthetic polymers, which are chains of atoms that are arranged to be strong, lightweight, and flexible. Plastic was first invented in 1869 by John Wesley Hyatt. Hyatt treated cellulose that was derived from cotton fiber with camphor, (camphor is an aromatic, volatile, terpene ketone derived from the wood of *Cinnamomum camphora* or synthesized from turpentine (Hausner & Poppenga, 2013)), and yield substance that could be shaped and molded into different sizes and shapes and also could create to imitate natural substance like tortoiseshell, linen, horn, and ivory. Plastic was made to protect natural resources from human needs. Then, fully synthetic plastic was created in 1907, by Leo Baekeland. He invented the synthetic plastics called Bakelite to substitute for shellac, a natural resin used as electrical insulator, to meet the needs of people in the United States. Bakelite was a good insulator, durable, heat resistant, suitable for mass production, and could be shaped or molded into anything. Plastics expanded hugely during World War II, nylon and Plexiglas were created then. The plastics were widely used, taken place of steels, glass, paper, and wood, because it was inexpensive, safe, and sanitary (History and Future of Plastics, 2019).



Picture 4 Bakelite rotary telephone

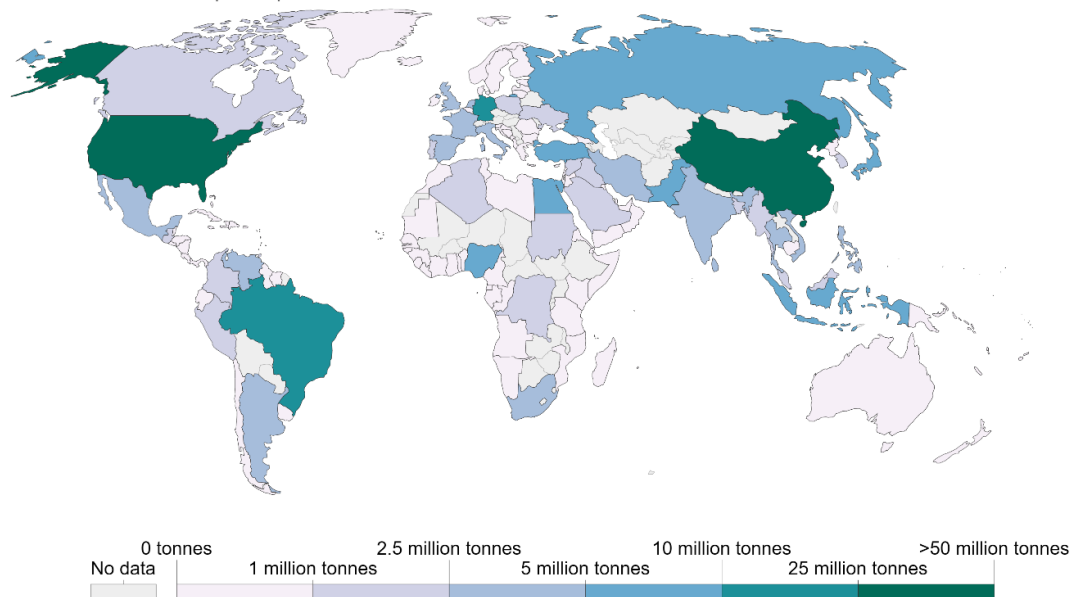
Rapid development and production make it easier and cheaper to consume products made of plastics. The easier it is to get or to consume, the easier it is to dispose. Plastics are becoming pollution because they are nonbiodegradable and persist in the environment, and because the massive amounts of the discarded plastics but few solutions to manage them. Single-used plastics, including straws, takeaway cups and glasses, plastic bags from groceries shopping, candy wrappers, water bottles, and many more, are contributing to the number of plastic wastes that will develop to plastic pollution. Frequently, additives are added into plastics to make them stronger, more flexible, and more durable. Those additives extent the life of the products, which make it more difficult to breakdown, some might take at least 400 years (Parker, 2021a).

United Nations Environment Programme (UNEP) has stated that 300 million tons of plastic waste are produced every year, half of them are from single-used plastics, and more than 99 percent of the plastics are produced from chemicals derived from oil, natural gas, and coal. Only 9 percent of total plastic waste are recycled, while most of the waste ended up in landfill, dumps, and natural environments (UNEP, n.d.).

Data from Our World in Data shows that China produced nearly 60 million tonnes of plastics waste, followed by the United States at 38 million tonnes, Germany at 14.5 million tonnes, and Brazil at 12 million tonnes (Ritchie, 2018). Tonne is a metric unit of mass, which 1 tonne is equivalent to 1.102 tons.

Plastic waste generation, 2010

Total plastic waste generation by country, measured in tonnes per year. This measures total plastic waste generation prior to management and therefore does not represent the quantity of plastic at risk of polluting waterways, rivers and the ocean environment. High-income countries typically have well-managed waste streams and therefore low levels of plastic pollution to external environments.



Source: OWID based on Jambeck et al. (2015) & World Bank

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Figure 2 Total plastic waste generation by country, 2010 (Ritchie, 2018)

Plastic pollution in the oceans was first noticed in the late 1960s by scientists that were studying about planktons. Plastics Europe reported that in 2018, there are between 5.3 million to 14 million tons of plastics discarded into the oceans annually by countries with ocean coastline (Plastic Pollution | Sources & Effects, n.d.). Plastics, especially microplastics, have caused troubles for both human and animals living in the oceans or living with the oceans, not only at the specific area but it could be transported around the world by ocean currents. Microplastics, which are photodegradable from plastics, are bioaccumulated to the food web of human through fish and seafoods and drinking water system.

There are different types of plastic pollution, but studies show that most plastic types that are discovered are polyethylene (PP), polypropylene (PE), nylon 6, polyethylene terephthalate (PET), polyvinylchloride (PVC), and polystyrene (PS) (Lachmann et al., 2017).

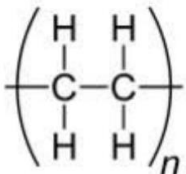
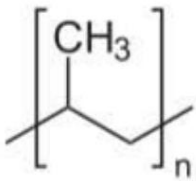
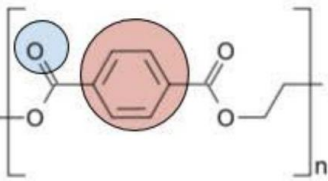
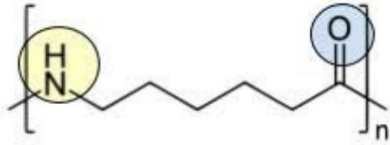
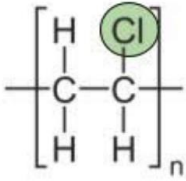
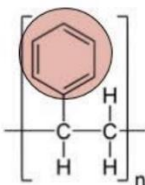
Type	Structure	Source
Polyethylene (PP)		Bottles, food containers, grocery bags, construction film, toys, packaging, and household products
Polypropylene (PP)		Containers, automobile parts, medical components, furniture, luggage, toys, packaging, and household products
Polyethylene terephthalate (PET)		Packaging, PET bottles, carpet, clothing, construction materials, fiber filling for winter clothes and sleeping bags, and rope
Nylon 6		Seatbelts, rope, parachuting material, tubing hose, dental floss, fibers, nets, and tarpaulin
Polyvinylchloride (PVC)		Construction materials, protective clothing, shower curtains, tents, roofing, floor tiles, seat covering, blood storage bags, cable and wire insulation, and clothing
Polystyrene (PS)		Packaging, household products, medical products, construction materials, Styrofoam, disposable cutlery and utensils, and insulation

Table 4 Plastic pollution that are most discovered in the oceans (Lachmann et al., 2017)

Covid-19 has increase significant numbers of plastic waste due to the needs of using surgical masks, latex gloves, PPE, face shield, protective glasses, sanitizer containers, shoe covers, disposable cutlery and utensils, plastic wraps and bags, wet wipes, and so forth. A study of

impact of covid-19 on global plastic waste footprint (Benson et al., 2021) states that the number of plastic wastes generated worldwide is estimated at 1.6 million tonnes per day (1.76 tons). They estimate that Asia would generate the highest quantity, 1.8 billion, of discarded facemasks per capita per day, followed by Europe at 445 million, Africa at 411 million, Latin America and the Caribbean at 380 million, North America at 244 million, and Oceania at 22 million facemasks per day (Benson et al., 2021). These concerning amount are from the facemasks alone, not including other plastic-based biomedical wastes and other plastics wastes. The major challenge of this problem is the effective management systems of the wastes when some recycling programs are suspended because of the concerns of virus spreading, without effective management gigantic amount of plastic-based waste would end up in the ocean (Benson et al., 2021).

3. Effects of pollutions in waters

Water pollution is changes in water or aquatic ecosystems that makes the water unusable or harmful to use for human and/or other living organisms. For example, eutrophication is a form of water pollution which enriched the nutrients in the water to the point that it became excessive to the living organisms. This is considered harmful to the living organisms and could lead to less biodiversity in that aquatic ecosystem. Water pollution affects more than just lives since waters are one of the most important habitats for living organisms and important resource for human.

3.1. Effects on oceans

Oceans are the biggest habitat on earth for the marine organisms. Different organisms live in different zones, which each zone has its properties. A regular person would mention that oceans are composed of saltwater, sands, seabed, or sea floor, and living organisms.

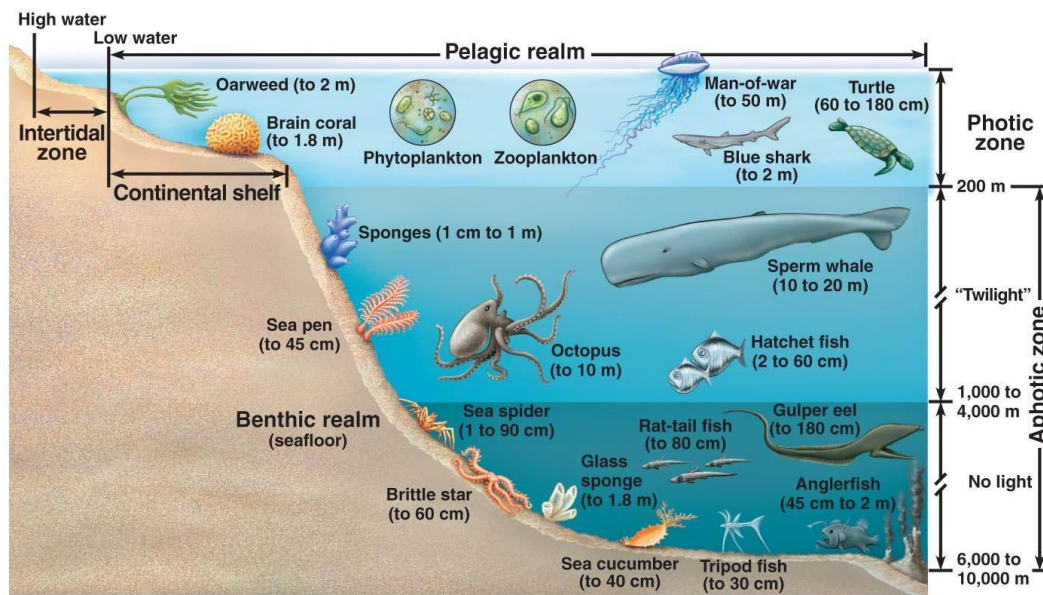


Figure 3 Ocean zones and its living organisms (WNCT, 2016)

Water pollution has impacts on many factors including concentration of dissolved oxygen, levels of chemicals, amount of waste and debris suspended in the water, which result in decreasing of marine water quality. Declining in water quality would have direct effect on

marine organisms, marine ecosystems, and biodiversity. Moreover, water pollution also affects the seabed. Seabed, also known as ocean floor, is an important part of the ocean because it is a habitat for many organisms, and it provides essential minerals.

An example of pollution that is affecting the seabed is plastic pollution, including macroplastics and microplastics. Pohl et al. (2020) mentioned that land-based plastics are introduced to the oceans through rivers, deltas, and beaches, then are transported to continental shelf, which shelf currents move them to submarine canyon. Then, they are being transferred from shallow to deep water by an agent known as turbidity current (Pohl et al., 2020). Plastic pollution and chemical pollution on the seabed will harm the organisms that have seabed as habitat including animals, algae, plants, and bacteria, as it receives and stores pollution.

Furthermore, the pollution in the oceans, which its source is from deep ocean mining and fisheries can also damage the seabed. The damage on the seabed depends on the size of gear of trawls, amount of gear contact, nature of the seabed, and strength of the current (Jones, 1992). Another study of impacts of the fishery on the seabed is a study in La Fonera canyon in the north-western Mediterranean, which has turbidity as a focus of the study. The study reveals that the turbidity on workdays is hundred times higher than the background level. In addition, the effect of fishery changes the natural seasonal patterns of sediment suspended in the water (European Commission, 2013).

Sand is another component of seas and oceans that is possible to be polluted. Although, the real problem of the sand came from sand mining, but it can also be affected by chemical pollution released from land-based sources. If the sand is contaminated, it is very likely to be harmful to human in the area, or if it was flush into the seas and/or oceans, it will probably harm the marine organisms. Further investigation and monitor would be necessary.

3.2. Effects on marine organisms

Pollution has effects on all living organisms, despite its size. From plankton to marine mammals, they are affected by pollution created from human activities. There is news almost every day from around the world that marine organisms are killed from plastic waste, oil,

chemical leakage, and crashed by ships and boats. Different types of pollutants affect living organisms differently. The impacts of pollution in marine organisms are very concerning because marine ecosystems have very complex food chain. If one organism bioaccumulated a pollutant, it could spread to very large area.

3.2.1. Toxic chemicals

Heavy metals are one of the most toxic pollutants to human and animals. It has hazardous effect on health of the contactors. In fish, Zeitoun's study (2014) of heavy metals impacts on fish health states that heavy metals have impacts on fish's gills, skin, kidneys, and brain. The effects on the fish's health are:

It is observed that the external organs are affected due to the toxic chemicals (heavy metals for example), causing loss of equilibrium, increased opercular movement, irregular vertical movements, finally leading to death. Cadmium, lead, mercury, and arsenic cause severe damage to the renal and nervous systems of fish as well as gill damage (Zeitoun, 2014)

Heavy metals could also affect algae community. A study (Han et al., 2020) shows that cadmium has affected seaweed's photosynthesis efficiency, respiratory efficiency, and photosynthetic pigments (Han et al., 2020). Other heavy metals could also affect different algae and sea plants since many scientists used them as bioindicator for levels of heavy metals.

Toxic chemicals, including persistent organic pollutants, paints, oil, pesticides, insecticides, and additives, have threatening effects on marine organisms such as fish, aquatic invertebrates, crustaceans, zooplankton, and marine mammals as it has adverse effects on their reproduction system, growth and development, immune system, endocrine system, nervous system, cellular and DNA damage, survivability rates, and even death. It could have indirect effect as it also affects marine organisms' food sources. Resulting in declining of marine population (IPEN, 2021). In Figure 5 shows the abnormalities in heart, fin, and eyes of the yellowfin tuna larvae that has been exposed to toxic chemical compared to the normal yellowfin tuna larvae.

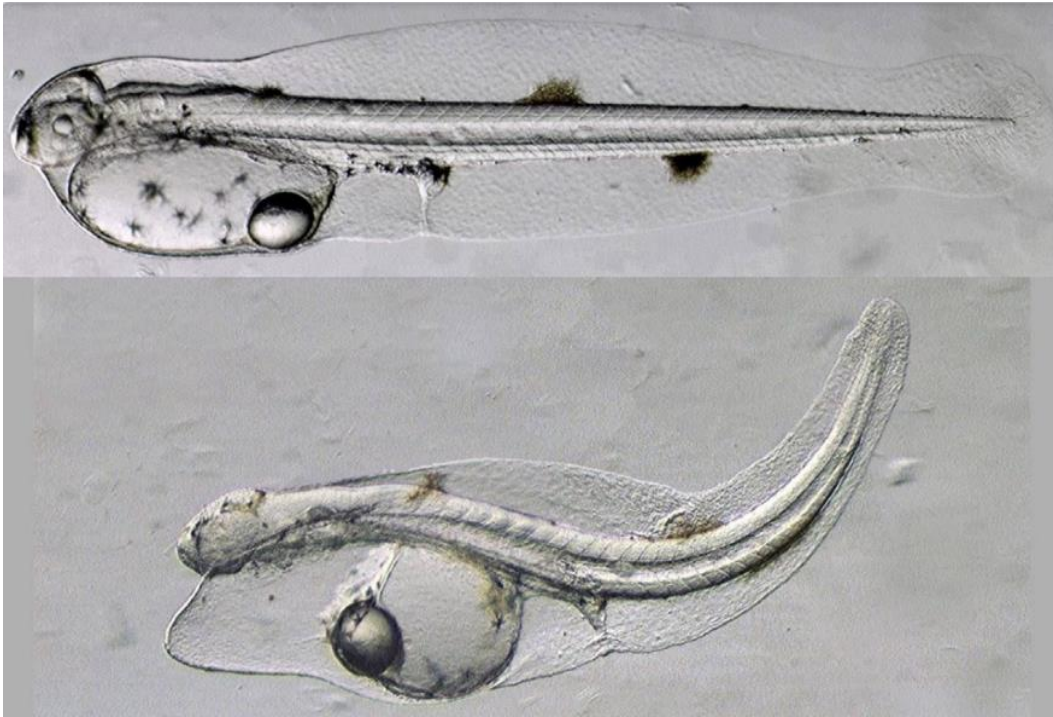


Figure 4 Normal yellowfin tuna larvae (top) and larvae that has been exposed to toxic chemical (bottom) (IPEN, 2021)

3.2.2. Ocean acidification

Ocean acidification is a reduction in pH of seawater process caused by ocean absorption of massive quantity of carbon dioxide that were released into atmosphere from human activities including vehicles, industrial production, and agricultural production. Carbon dioxide that dissolved creates carbonic acid, increasing in acidity and decreasing in carbonate ion concentration (Ocean Acidification | Definition, Causes, Effects, Chemistry, & Facts, n.d.). It is considered as pollution because it damages the marine ecosystem. Guinotte and Fabry (2008) reported that ocean acidification has impacts on coral reef ecosystems and cold-water coral ecosystems as it contributes to coral bleaching, decreasing carbonate saturation, and decreasing aragonite saturation, this could possibly lead to chain effects as many marine organisms rely on these ecosystems as their habitat, protection, and source of nutrition. Ocean acidification also impacts calcifying species of plankton. Pteropods, which is an important plankton prey for juvenile pink salmon, requires supersaturated aragonite habitat to survive, ocean acidification decreases aragonite saturation which means it has restricted

habitat of the pteropods. Further research and studies of the impacts of ocean acidity on marine ecosystem are urgently needed (Guinotte & Fabry, 2008).

The study of Kroeker et al. (2013) support that ocean acidification has adverse effects on marine organisms. They conducted the study based on board range of marine organisms including algae, coral, coccolithophore, mollusk, echinoderm, crustacean, fish, seagrass, and diatom. As a result, “survival and calcification are the responses most affected by acidification, with 27% reduction in both responses, whereas growth and development are reduced by approximately 11 – 19%, respectively, for conditions roughly representing year 2100 scenarios. On average, the abundance is reduced 15%”. Moreover, acidification reduces photosynthesis in calcified algae, abundance in calcified algae and corals, development of early life stage of mollusks and sea urchins, and metabolism among mollusk larvae (Kroeker et al., 2013).

3.2.3. Marine debris and plastic pollution

National Oceanic and Atmospheric Administration (NOAA) gives definition of marine debris as “Marine debris is defined as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment” (What Is Marine Debris?, n.d.). Marine debris has wide variety of types, it can be glass, it can be metal, but most of the marine debris that was found is plastics. In 2015, Laura Parker reported that there are 5.25 trillion pieces of plastic debris alone, floating and sinking in the deep ocean. The number of marine debris was measured by beach surveys, computer models, and estimation of trash entering the oceans (Parker, 2021b).

It can be said that everyone is aware of effects of the marine debris on marine organisms. The effects are threatening to marine biodiversity. Big pieces of marine debris could injure or kill the organisms by entangling in the debris, suffocating, and drowning, or starving to death because they would mistake the debris as food.

S. Gall and Thompson (2015) reveal on the study about the impact of debris on marine life describe that marine debris has destroyed marine organisms’ habitats including shorelines,

estuaries, and surface of the oceans, and it may cause changes to habitats in particular coral reefs. They studied total of 340 research publications, which reveals that there are more than 690 species that have been encountered with marine debris, 92% of the encounters were between organisms and plastics. Most of the incidents were entangled in plastic rope and netting and ingestion of plastic fragments in sea turtles, marine mammals, fish, and sea birds. Besides, 17% of organisms are listed on IUCN Red List as near threaten, vulnerable, endangered, or critically endangered. The listed organisms include Hawaiian monk seal, loggerhead turtle, northern fur seal, and sooty shearwater (S. Gall & Thompson, 2015).



Picture 5 Hawaiian monk seal

Chapter 4: Deleterious Effects of Litter of Marine Life (Kühn et al., 2015) reported that although ingestion is less visible than entanglement, it has been a problem since the 1960s. The organisms might ingest intentionally or unintentionally. Organisms that ingest plastic, it would cause them mortality. The direct mortality is caused by the blockage in the intestines of the organisms. Indirect effects might not be mortality, but it is deleterious. It could decrease their fitness, damage the reproduction system, and decrease survival rates. It could also damage the digestive tract, which contributes to poor nutrition, less energy uptake, or dehydration (Bergmann et al., 2015a). There is much evidence related to marine organisms' mortality and ingestion of marine debris. For example, Carr's study of the impact of marine debris on the survival of sea turtles (1987) shows that many dead turtles that were found on the Florida East Coast have marine debris in their stomachs:

The stomach of the dead ones often contain pellets of tar and the ubiquitous plastic beads that are delivered to the sea by the millions in industry waste water. Both tar pellets and the beads are suggestively similar in size and shape of sargassum floats, and this likeness may account for the turtles' misguided feedings. (Carr, 1987)

Meanwhile, entanglement in debris is a trap to death because the organisms could not acquire or forage food and avoid from predators, or entanglement would cause them injuries or wound, which leads to stress, illness, infection, exhaustion, and reducing in moving efficiency. If an organism is got entangled at young age, it would affect their growth. The debris that cause entanglement are fishing gear, ropes, balloons, plastic bags, sheets, loop-shaped items such as tires and drink holders. Plastic debris may also suffocate organisms if smothered on water surface. Smothering of debris can crush vegetative and lower the light levels that are essential for photosynthesis and organisms' growth (Bergmann et al., 2015a).

Another terrifying pollutant to marine organisms is microplastics. According to chapter 10 in Marine Anthropogenic Litter, microplastic is plastic particles that are less than 5 mm in diameter. Lusher (2015) disclosed that:

Microplastics have been found in almost every marine habitat around the world, with plastic composition and environmental conditions significantly affecting their distribution. Marine biota interact with microplastics including birds, fish, turtles, mammals and invertebrates. The biological repercussions depend on to the size of microplastics encountered, with smaller sizes having greater effects on organisms at the cellular level. In the micrometre range plastics are readily ingested and egested, whereas nanometre-sized plastics can pass through cell membranes. (p. 294)

Microplastics are transported around by ocean currents, it could be suspended in every part and zone of the oceans, including water column, surface waters, coastal waters, estuaries, beaches, and deep-sea sediments (Bergmann et al., 2015b).

Ingestion of microplastics is common in marine organisms because of the microplastics small size or mistaken it as food. Lusher (2015) has reported the results (Table 5) based on many studies, which covers several groups of marine organisms but did not cover all the

species. The results from Table 5 are only from some of the species of organisms that were studied. Some of the effects might not be shown if the same group of marine organisms. Indirect effect on marine organism is that microplastics creates adverse effect on their habitat by increasing the permeability of the sediments and decreasing thermal diffusivity. This would lead to sexual bias in some species of sea turtle as the temperature changed, resulting in longer time of incubation and more male sea turtles (Bergmann et al., 2015b).

Groups of marine organisms	Ingestion method	Types of microplastics	Adverse effects
Planktonic invertebrates	• Absorption	• Nano-polystyrene beads • Pellets	• Inhibit photosynthesis • Cause oxidative stress • Decreased feeding activity • Increased mortality rate
Benthic invertebrates	• Direct ingestion	• Microplastic particles	• Weight loss • Decreased feeding activity • Reduced energy reserves • Retained in digestive tract
Fish	• Direct ingestion	• Fibers • Fragments • Films	• No adverse effects were reported
Sea birds	• Direct ingestion	• Pellets • User-fragments	• Microplastics do not severely harm the sea birds like bigger plastics
Marine mammals	• Inhalation • Direct ingestion • Tropic transfers from preys	• Microplastic particles	• Does not mentioned
Sea turtles	• Direct ingestion • Transfers from preys	• Pellets • Fragments • Beads	• Growth and development

Table 5 Adverse effects on marine organisms that ingest microplastics (Bergmann et al., 2015b)

Many studies show adverse effects in marine organisms as they ingest microplastics into their bodies. Polystyrene microplastics could affect the growth, resulting in reduced of body size and affect severely on reproduction system of water fleas, while increasing mortality rate of mysid shrimps by 30%. Microplastics also have impacts on mollusks, it could damage genetic information, reproduction system, population growth, caused its neurotoxic effects and decreased the survival rates. And the most common marine organism to human – fish, would also be affected if microplastics are ingested. The adverse effects include inflammation, oxidative stress, disrupted energy metabolism, and reproductive system (IPEN, 2021).



Picture 6 Microplastics found in rainbow yellowtail fish

3.2.4. Harmful algal blooms

Harmful algal blooms or HABs refers to rapid grow of algal in which consumes up all oxygen available, leading to low levels of oxygen and death of other organisms in the area and/or creates toxins that harm human, animals, plants, and other organisms. HABs can occur in both freshwater and saltwater. Cause of harmful algal blooms is from human activities, which include increasing nutrient loadings, pollution, introducing alien species, changing in food web, and modification of water flow, that cause a disrupt in an ecosystem. The main cause of HABs is when nutrient, usually from agricultural runoffs, – nitrogen and

phosphorus – exceeds the normal level of needs of the algae in that environment (NOAA, n.d.).



Picture 7 Harmful algal bloom

Since HABs produce toxins to the ecosystem, the organisms in the area are prone to get the adverse effects. Sellner et al. (2003) describe that the toxins produced from HABs event could diarrhetic symptoms to human as one consumes shellfish that was in an area of HAB. It also causes fish lesion, skin and eye irritation, and short-term neurocognitive disorders. “The primary groupings of HAB toxins according to syndrome include paralytic shellfish poisons (PSP), neurotoxic shellfish poisons (NSP), amnesic shellfish poisons (ASP), diarrhetic shellfish poisons (DSP), azaspiracid shellfish poisoning (AZP), ciguatera fish poisoning (CFP), and cyanobacteria toxin poisoning (CTP)” (Sellner et al., 2003).

Karlson et al. (2021) published a study on HABs effects on coastal sea, one of the many effects was related to fish mortality. The study states that fish that was exposed to algal toxin could die from gill irritation and damage and/or asphyxiation from nonfunctional gill or lack of oxygen. Harmful algal blooms also plankton, benthic flora, and benthic fauna. Furthermore, harmful algal blooms are leading to adverse economic changes as HABs have adverse effects on fisheries and seafood industry, tourisms, recreational activities, and public health (Karlson et al., 2021).

3.3. Impacts and effects on oxygen production

As mentioned in the previous section that harmful algal blooms could cause a rapid decrease in oxygen level. Nonetheless, there are many other factors that affect the oxygen production in the oceans. Many marine organisms, including bacteria, plankton, kelp, algal, and so forth, are the primary producers that perform photosynthesis and produce oxygen. Marine pollution – especially chemicals harm and kill sea plants which suggests that oxygen production is going to decline. Besides from oxygen depletion, which will directly affect the marine organisms that require oxygen to live, reduced in amount of oxygen in the oceans could lead to major problems.

In research of Falkowski et al., (2011) shows that oxygen is not only important for living organisms, but also for the environmental processes to properly function:

The potential consequences of ocean oxygen loss are profound. Long-term declines could lead to reduced biological productivity and diversity, altered animal behavior, declines in fisheries, redistributions of communities, and altered biogeochemical cycles. Environmental feedbacks may also result, potentially including increased production of greenhouse gases such as nitrous oxide and methane. In geological past, major shifts in ecosystem structure and even mass extinctions occurred during periods when ocean oxygen content was low. (p. 409)

3.4. Impacts and effects on human

Water pollution does not only affect human health, but it affects other necessary requisites of human beings. Organization of Economic Co-operation and Development (OECD) has made a figure to summarize the impacts that could be caused by water pollution. Other than human health, water pollution also affects use of water in household and commercial use, economy, and productivity of many industries (OECD Water - Water, n.d.). It can be simply explained as water pollution can harm humans directly and indirectly.

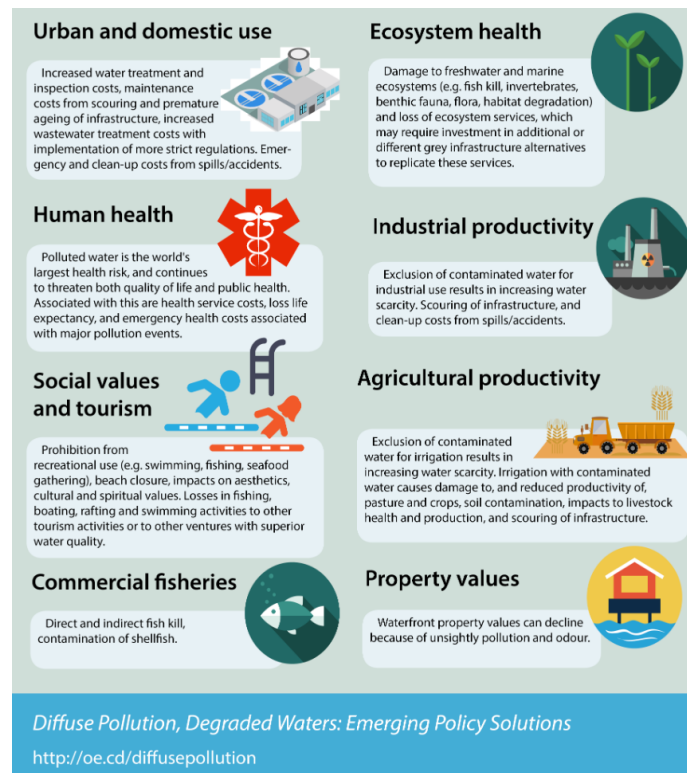


Figure 5 Impacts of water pollution (OECD Water - Water, n.d.)

3.4.1. Effects on human health

No human live without water. Human use water in daily life, to drink, to use in a household, to be used as way of transport, and many other uses. Without treating the waters properly, the waters became polluted, and the adverse effect of water is on human. Water pollution could affect human health directly by drinking water, cooking, showering or indirectly if consumed other products that had interfered with the water pollution such as fish, meat, fruits, and vegetables. Water pollution can bring may diseases and sickness to human according to the type of pollutants – heavy metals, organic substances, bacteria, or viruses. World Health Organization (WHO) states that the common diseases that caused by polluted water re diarrhea, cholera, dysentery, typhoid, and polio (Drinking-Water, 2019).

Sutton et al. (2011) studied about nitrogen as a pollution in water quality of Europe and states that nitrogen could harm human health indirectly. The possibility of nitrogen to affect human health directly via drinking water is low, but still possible. Nitrate could cause blue

baby syndrome and ingesting nitrate, or nitrite is capable to cause cancers to human. Furthermore, N-Nitrosodimethylamine is another carcinogen that should be considered since it might be formed if disinfectants reacted with other compounds in the water (Sutton et al., 2011).

Heavy metals that are found in water and are threatening to human health are lead, mercury, cadmium, and arsenic (Obasi & Akudinobi, 2020). The effects that could occur to human if exposed to heavy metals are headache, irritability, loss of appetite, fatigue, paralysis, vomiting, diarrhea, dizziness, abdominal pain, damage to internal organs, reducing in energy levels and physical progresses, abortion, damage reproductive system, mental and neurological disorders, anemia, brain damage, kidney disfunction, Parkinson disease, death, and other symptoms depends on heavy metal intake. Other heavy metals include zinc, cobalt, selenium, silver, manganese, nickel, chromium, and higher dose of copper (Obasi & Akudinobi, 2020).

Minamata disease is another well-known disease originally from Japan, which is caused by heavy metal – methylmercury poisoning to be exact. Hachiya (2006) states that “Minamata disease is a methylmercury poisoning with neurological symptoms and caused by the daily consumption of large quantities of fish and shellfish that were heavily contaminated with the toxic chemical generated in chemical factories and then discharged into the sea”. He also states that it has caused environmental pollution, conflict in local communities, and political issues (Hachiya, 2006).

Meanwhile, diarrhea is the most common symptom caused by bacterial pollutants. The agents that caused waterborne bacterial diseases include but not limited to vibrio cholerae, campylobacter, salmonella, shigella, and Escherichia coli or also known as E. coli. Dehydration, malnutrition, and infection could be severe and cause death in infants and young children. It is mostly cause from consuming contaminated drinking water (Davis, 2021).

Similar symptoms such as diarrhea, fever, abdominal cramping, and vomiting could also cause by waterborne virus-based diseases. More critical illnesses include inflammation of

heart muscle, meningitis, cancer, and hepatitis. The viruses that cause these symptoms and illnesses are adenovirus, astrovirus, hepatitis A and E viruses, rotavirus, norovirus and other caliciviruses, and enteroviruses. And if the virus contaminated water is being inhaled or contacting with skin and eyes, it could cause respiratory and ocular infections (A. M. Gall et al., 2015).

3.4.2. Effects on economy and society

As shown in Figure 3, water pollution has impact on industrial productivity, agricultural productivity, social values and tourisms, commercial fisheries, and property values, which all of these will lead to an impact on the economy.

Contaminated water that is being used in agriculture or in industrial production could lead to contaminating the products, which could be passing the contaminants to the one consumes or uses them. For example, if contaminated water is used in plants irrigation, the pollutant will be in the food web, and it could cause disease or illness to human and animals. Other case is that the contaminated or polluted water usually is not high on quality, which will result in poor quality of the plants or fruits. This means that the demand and supply of the agricultural and farming products might not be at its equilibrium point and it is why the water pollution could disrupt the economy.

As for social values, tourism, and property values, it is clear that if the water bodies are polluted, it would directly affect the businesses in those areas. People would likely not visit that place again if it was a tourist attraction. Or if water pollutions are near living properties, the price of the properties would drop and probably would have no people buying the properties. In the worst-case scenario, people who are living there would move out as well. Last but not least, water pollution would have impact on aesthetics of the places, making the water quality low – bad smell and unclear, which would make it impossible for leisure activities.

Another important activity that water pollution has impact on is fisheries. Fisheries provide human with abundance of food. According to World Wildlife Fund (WWF, n.d.), approximately three billion people are being fed by wild-caught and farmed seafood (WWF,

n.d.). Overfishing, heavy metals, pesticides and fertilizer, runoffs from industries, oil leakage, and other pollutants have affected on number of fish and seafoods significantly.

Aquatic Pollutants in Oceans and Fisheries (2021) describes that the changes in fishery are caused by pollution:

“Pollution is having deleterious effects on all parts of aquatic food webs. It causes declines in populations of fish and other aquatic organisms by affecting their survival and ability to reproduce. Fishery declines are occurring amid the perfect storm of habitat destruction, loss of healthy food resources within aquatic food webs, draining and damage to nursery areas, as well as the impacts on water quality caused by pollution and climate change”. (p. 10)

4. Awareness of people based on quantitative data

4.1. Methodology

The purpose of the study is to understand people's awareness and understandings of the pollution in the oceans and the marine ecosystems and seek measures to decrease the pollution. To understand people's awareness and understandings, quantitative data was collected using an online survey (Google Form), targeting people from different age groups, locations, and occupations. The 16-questions-survey was created into two version, English and Thai. Then, it was carried out using snowball sample technique, which the participants were asked to send the surveys out to additional participants. After the data was collected, it was analyzed using SPSS 13 software, which is a statistical analysis for social science software. The analysis was made based on a hypothesis that participants who live nearer to the water bodies and/or participants who work or study in a field related to environment will have more understandings and awareness about pollution in the oceans.

4.2. Survey questions

The survey consists of 16 questions, including demographical questions and questions related to ocean pollutions. The questions are as follow:

- What is your age?
- Where is your home located?
- What is your educational background?
- If you are a university student, please specify your major or faculty
- What is your job title?
- Where do you think is the main source of oxygen production?
- How often do you go to lakes, rivers, seas, or oceans per year?
- What was the quality of lakes, rivers, seas, or oceans you visited?
- Do you think oceans are important to human?

- Do you think that humans are responsible for the health of the oceans?
- Do you think that human activities have an impact on the oceans?
- To what extent do you believe that you are informed about local and global problems of the oceans?
- In your opinion, which of the following activities created the most pollution to the oceans?
- Are you willing to change or adjust your lifestyle to be more ocean-friendly and/or eco-friendly?
- Based on your consumption, are you considering on buying sustainable and/or eco-friendly products?
- If you are considering on buying sustainable and/or eco-friendly products, why is that so?

4.3. Primary data

Total responses from the participants are 226 responses, from different age ranges, locations, jobs, and opinion. But these responses do not represent the global population or population, it only represents the understandings and awareness of the participants.

- Age: the largest age group that participated in the survey was 20 – 24 years old (58.4%), followed by 25 – 29 years old (17.7%), 15 – 19 years old (15.5%), 30 – 34 years old (4.9%), 40 – 44 years old (0.9%), 35 – 39 years old (0.9%), 45 – 49 years old (0.4%), 50 – 54 years old (0.4%), 55 – 59 years old (0.4%), and 60+ years old (0.4%). The reason that most of the participants are from age group of 20 – 24 years old is because the snowball sample technique started from a group of university students, who are pursuing bachelor's degree, as a results, most of the participants are from the age group of 20 – 24 years old.

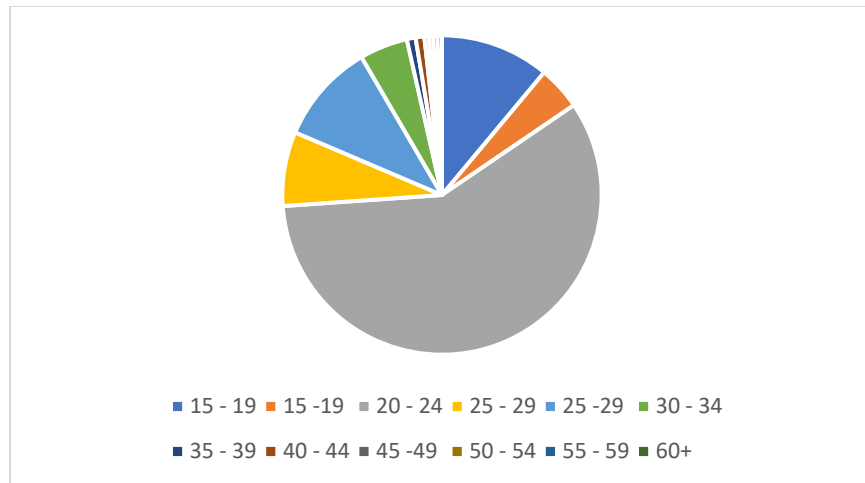


Figure 6 Age range of the participants

- **Location:** the majority of the participants were Asian, 181 participants from 226, which is 80.1%. Followed by 21 participants from Africa (9.3%), 12 participants from North America (5.3%), 9 participants from Europe (4.0%), 2 participants from Australia (0.9%), and 1 participant from South Africa (0.4%). Similar to age group, the majority of the participants are Asians because the snowball sample technique was used the most in Thailand, which is located in Asia. This entails the majority of the participants to be Asians.

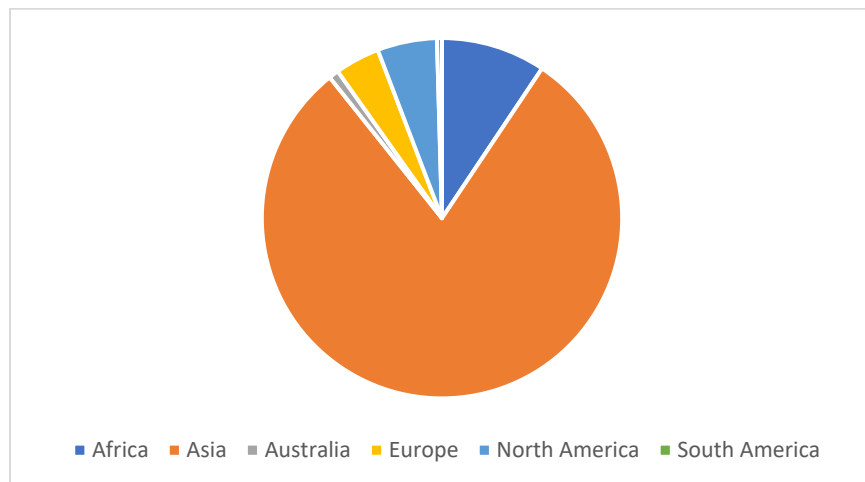


Figure 7 Locations of the participants

- Background education: most of the participants has or are pursuing bachelor's degree (66.8%), high school (20.8%), master's degree (8.9%), Ph.D. (0.9%), and diploma (0.4%). 5 participants (2.2%) prefer not to say their educational background. Background education of the participants was asked to determine the hypothesis, if educational levels are related with understandings and awareness of the pollution.

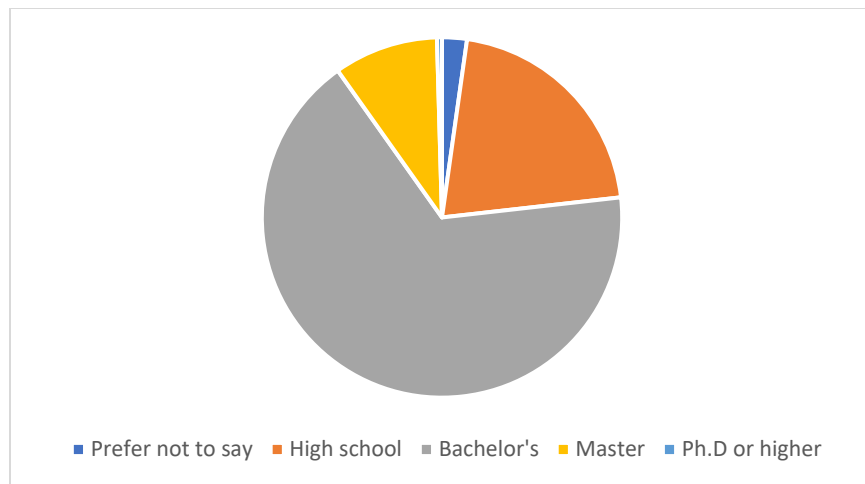


Figure 8 Background education of the participants

- Job: job titles are diverse and have many varieties, which is the reason the data is classified as student and people who work. This question was asked to collect further data about participants' field of studies and/ or work, whether if it is related to the oceans or the environment. This field of data helps to analyze if there are patterns between people who are related to the environment and their understandings and awareness about the pollution. Students were the majority of the participants as the total was 61.5%, while working people are 38.5%.

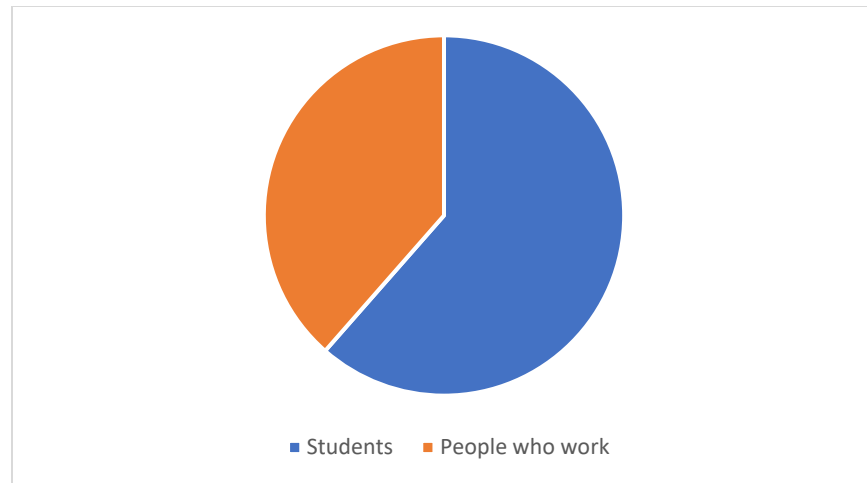


Figure 9 Job titles of the participants

- Faculty and major: this question was asked to determine ration between students who study in field related to environment and ocean and students who study in other fields. This will help to analyze the patter for the hypothesis. The students who study in the related field are calculated as 10.8% and there are 89.2% of students who study in other fields.

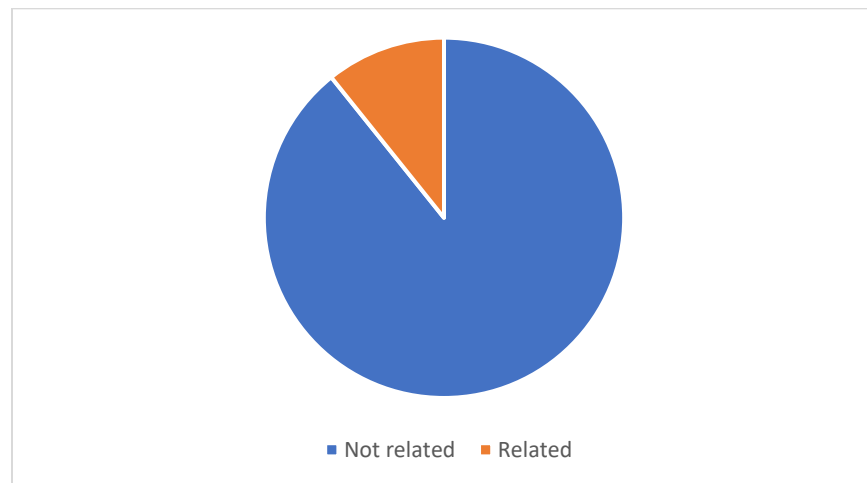


Figure 10 Participants with field of studies that are related with environment and/or oceans

- Source of oxygen production: participants thought that forests are the main source of oxygen production (50.9%), then oceans (30.5%), Amazon rainforest (14.6%), and mountains (3.6%).

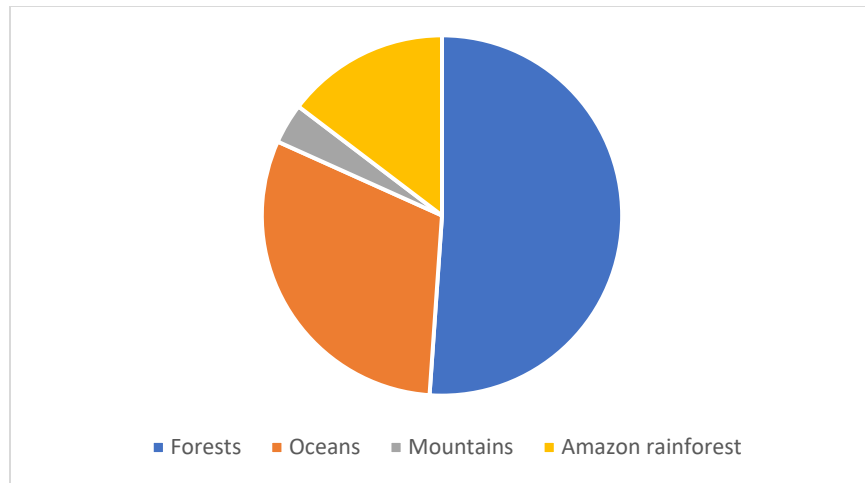


Figure 11 Participants' opinions about source of oxygen production

- Quality of the water bodies: 59.3% of the participants think that the quality of the water bodies that they visited were fair, 33.2% think that it was good in quality, and 7.5% think that it was poor in quality.

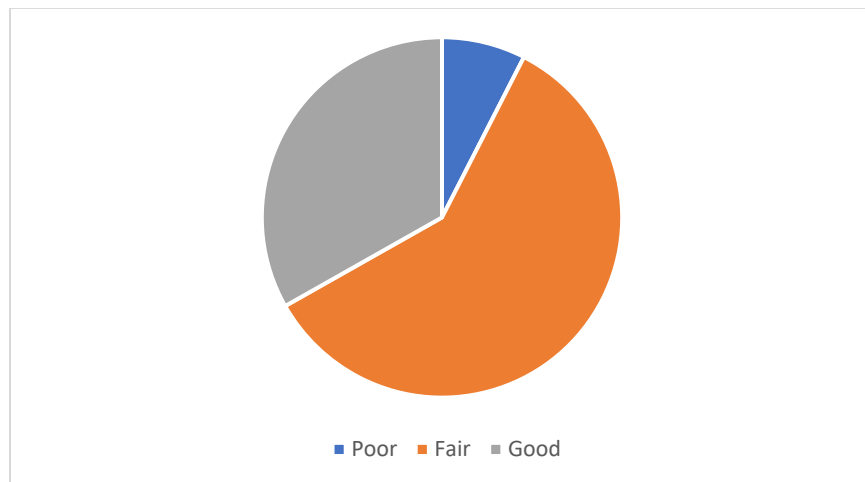


Figure 12 Quality of the water bodies that the participants visited

- Human responsibility: 93.40% of the participants think that humans are responsible for the health of the oceans, while 6.6% think that they do not have anything to do with the health of the oceans.



Figure 13 Participants' opinions about human responsibility toward oceans

- Human activities' impact on the oceans on a scale of 1 to 5, 1 being no impact at all and 5 being huge impact: 66.4% of the participants think that human activities have created huge impact on the oceans, 23.0% on a scale of 4, 10.2% on a scale of 3, and 0.4% on a scale of 2.

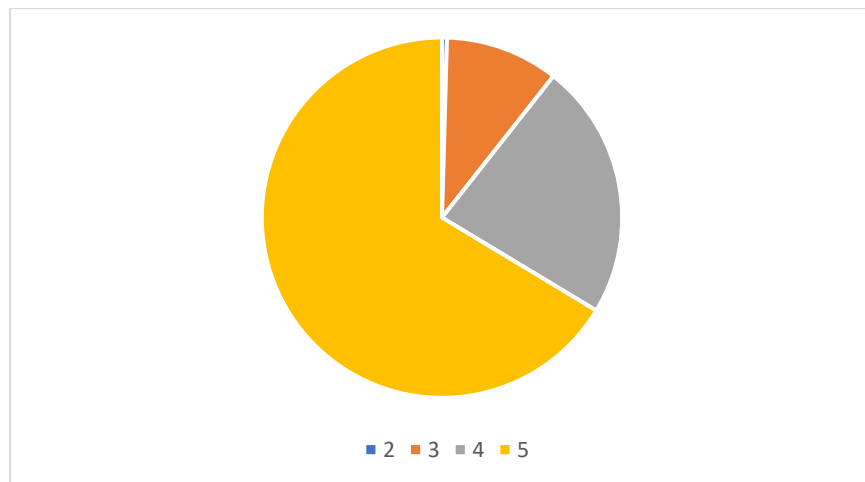


Figure 14 participants' opinions about impact of human activities on the oceans

- Knowledge and understandings on a scale of 1 to 5, 1 being not informed at all and 5 being well informed: 4.0% of the participant think that they are well informed, 34.1% think that they are fairly informed, 43.8% think that they are somewhat informed,

15.0% think that they are slightly informed, and 3.1% think that they are not informed at all.

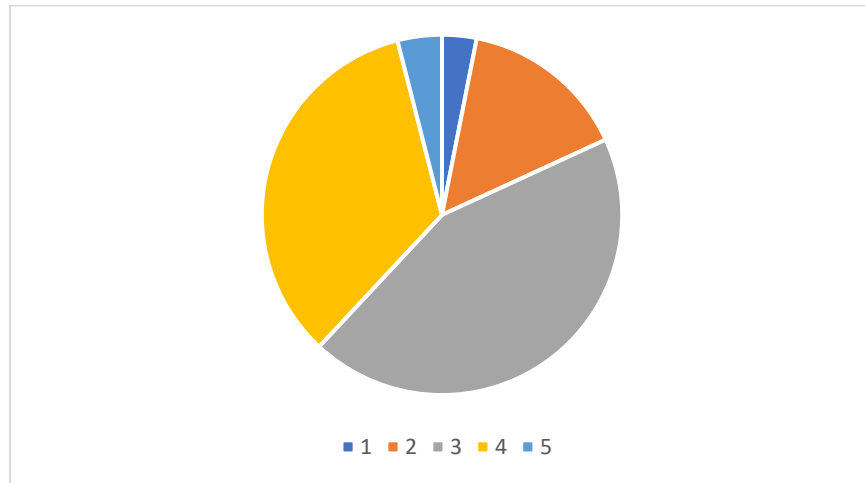


Figure 15 Participants' understandings about marine pollution

- Lifestyle: 82.1% of the participants are willing to change or adjust their lifestyle to be more ocean-friendly and/or eco-friendly, while 17.9% think that they could not do it.

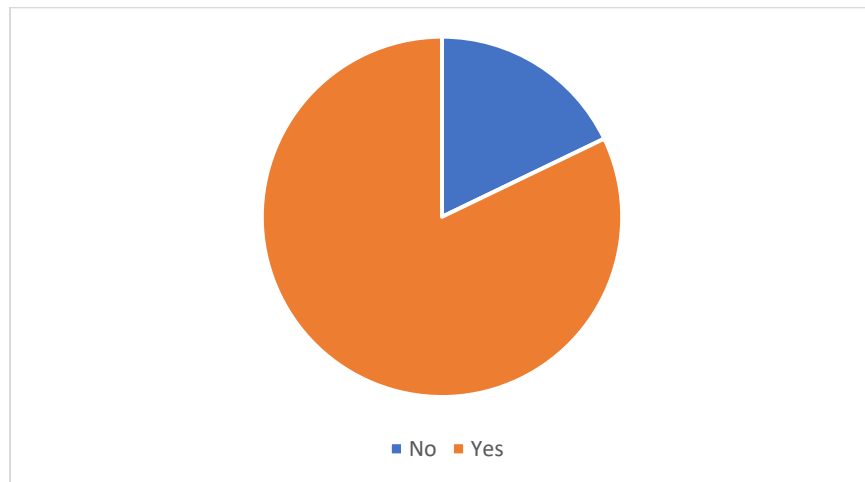


Figure 16 Participants' willingness of lifestyle changing

- Consumption: 86.3% of the participants are considering on buying sustainable and/or eco-friendly products, while 13.7% are not considering so.

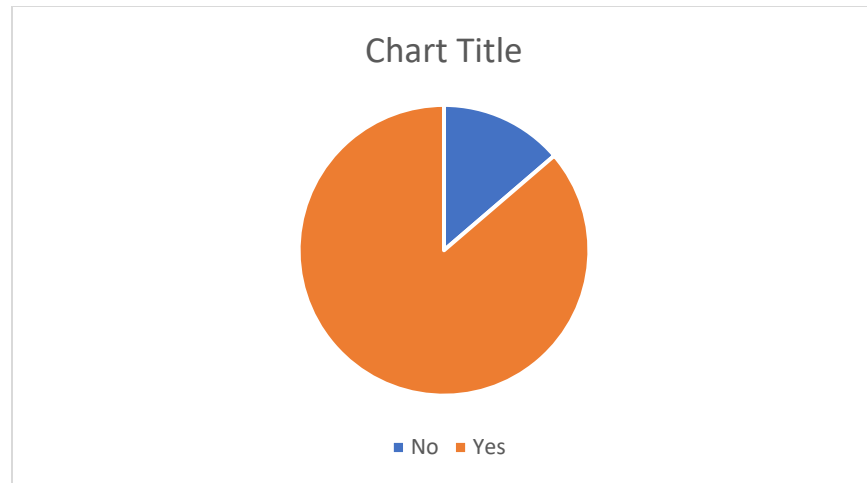


Figure 17 Participants' consideration on sustainable and/or eco-friendly consumption

4.3.1. Cross tabulation

Cross tabulations are made to analyze the relationship between demographic data and the understandings and awareness of the participants. The full analyzation of cross tabulations can be found in Appendix A – Cross Tabulations. Remark that the results of the analyzation do not represent opinion of global population. It only represents opinion of 226 participants.

- Location and responsibility: 20 Africans, 167 Asians, 1 Australian, 8 European, 12 North Americans, and 1 South American think that human are responsible for the health of the oceans, while there are 1 African, 12 Asians, 1 Australian, and 1 European who think that humans are not responsible for the health of the oceans.

		Do you think that humans are responsible for the health of the oceans?		Total
		No	Yes	
Where is your home located?	Africa	1	20	21
	Asia	12	169	181
	Australia	1	1	2
	Europe	1	8	9
	North America	0	12	12
	South America	0	1	1
Total		15	211	226

Table 5 Cross tabulation between locations and human responsibility

- Background education and importance of oceans to human: 36 participants with high school background education, 94 participants with bachelor's degree background education, and 19 participants with master's degree states that oceans are very important to human. 7 participants with high school background education, 42 participants with bachelor's degree background education, and 1 participant with master's degree states that oceans are somewhat important to human. 4 participants with high school background education, 14 participants with bachelor's degree background education, 1 participant with master's degree, and 1 participant with Ph.D. background education states that oceans are important to human. The visualization of the data is shown in Figure 18.

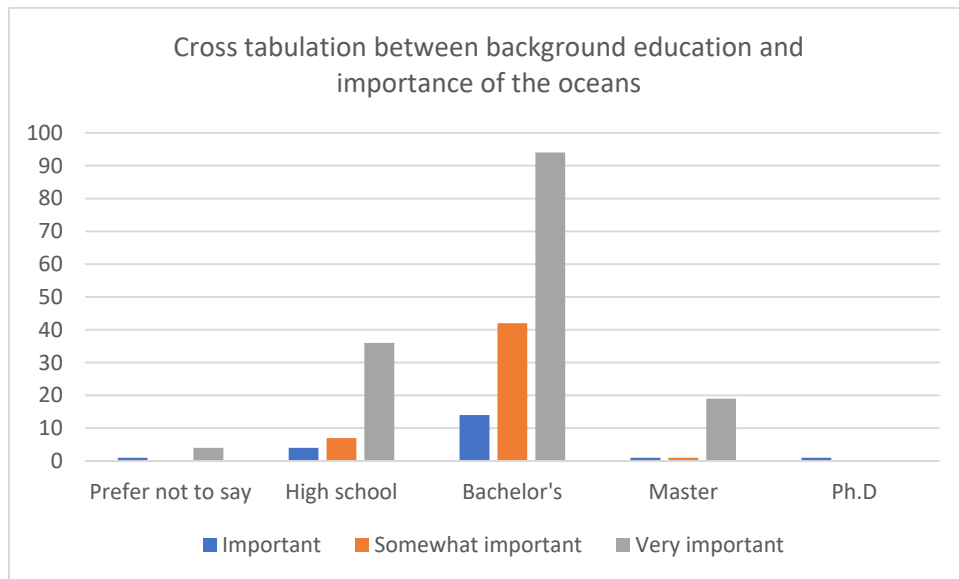


Figure 18 Relationship between background education and importance of oceans

- Job and source of oxygen production: 43 students think that the main source of oxygen production came from the oceans, while 91 students think that the source is from somewhere else. 24 of people who already work think that the main source of the oxygen production is from the oceans, while 90 other people think differently.

		Where do you think is the main source of oxygen production?		Total
		No	Yes	
Job classification	Students	91	43	134
	People who work	60	24	84
Total		151	67	218

Table 6 Cross tabulation between job title and source of oxygen production

- Job and human activities' impact on the ocean on a scale of 1 to 5, 1 being not affecting at all and 5 being create a huge impact: remark that students are marked as 0 and people who work are marked as 1. 92 students and 52 people who already work think that human activities create a huge impact on the oceans 31 students and 20 people who already work think that human activities fairly have an impact on the oceans, 11 students and 11 people who already work think that human activities somewhat have an impact on the oceans, and 1 person who already work think that human activities slightly have an impact on the oceans.

		Do you think that human activities have an impact on the ocean? (5 = very, 1 = not at all)				Total
		2	3	4	5	
Job classification	Students	0	11	31	92	134
	People who work	1	11	20	52	84
Total		1	22	51	144	218

Table 7 Cross tabulation between job title and impact of human activities on oceans

4.3.2. Group statistics and independent sample t-test

The tests were conducted from the data based on the main focus of participants who know that the main oxygen production is from the oceans and the participants who does not know. The level of significance set in this test was 0.05. The only group that has statistically significance difference value is the group of “What was the quality of lakes, rivers, seas, or oceans you visited”. The group has significance value of 0.000, which is less than the level of significance set in the first place. This indicate that the value that we should be dealing with is equal variances assumed and the significance value (2-tailed) is 0.02, which is considered as statistically significance difference. The other groups' values do not indicate

any statistically significance difference. Full analyzation of groups statistics and independent sample t-test can be found in Appendix B – Group Statistics, and Appendix C – Independent Samples T-Test.

4.4. Results

Statistical tests were performed to determine if participants who live nearer to the water bodies and/or participants who work or study in a field related to environment will have more understandings and awareness about pollution in the oceans. The independent samples t-test shows results that there are no significance difference values, which means there is no pattern in the relationship between participants' location and background education with their awareness and understanding about the ocean pollution.

5. Conclusion

Oceans are huge body of saltwater that is a habitat for many lives and provides many benefits to living organisms, include humans. However, human activities for instance, agriculture, industry, fisheries, water transportation, and many more are contributing to pollution in the ocean. The pollution creates many adverse effects to the oceans and living organisms that has symbiotic relationship with it. The effects of the pollution could harm and kill marine organisms, which could lead to major problem such as reduction of oxygen productivity. Marine pollution could also have impacts on human health, economy, and society.

The survey was conducted to understand people's awareness and understanding of the pollution in the oceans and the marine ecosystems. The responses of 226 participants indicate that they are not well aware and understand on how the oceans are important to human and what are the problems oceans are facing. This is a result of 226 participants, and it does not indicate understandings and awareness of global population as a whole.

Marine pollution and any other pollution are created from human. Thus, human should be the one who resolve the problems. Pollution developed to the point that the marine ecosystem is in danger over time, clearly, it would also take time to resolve and restore the oceans to be safe again. The pollution can be reduced starting at one person. Reduce the demand for new things as much as possible, reuse to cut the production, and recycle to lessen the amount of new raw materials. Certainly, one person would not help to resolve the whole problems. The cooperation and participation of government, policy makers, entrepreneurs, researchers, scientists, and every global citizen are needed to make changes happen.

References

- 7 reasons why we need to act now to #SaveOurOcean. (2017, March 27). Food and Agriculture Organization of the United Nations. Retrieved November 4, 2021, from <https://www.fao.org/zhc/detail-events/en/c/846698/>
- Agricultural pollution. (n.d.). Eni School Energy&environment. Retrieved November 4, 2021, from <http://www.eniscuola.net/en/argomento/water-pollution/pollution-sources/industrial-and-agricultural-pollution/>
- Atlantic Ocean | Definition, Temperature, Weather, & Facts. (n.d.). Encyclopedia Britannica. Retrieved November 4, 2021, from <https://www.britannica.com/place/Atlantic-Ocean>
- Benson, N. U., Bassey, D. E., & Palanisami, T. (2021). COVID pollution: impact of COVID-19 pandemic on global plastic waste footprint. *Heliyon*, 7(2). <https://doi.org/10.1016/j.heliyon.2021.e06343>
- Bergmann, M., Gutow, L., & Klages, M. (2015a). *Marine Anthropogenic Litter* (2015th ed.) [E-book]. Springer. <https://doi.org/10.1007/978-3-319-16510-3>
- Bergmann, M., Gutow, L., & Klages, M. (2015b). *Marine Anthropogenic Litter* [E-book]. Springer Publishing.
- Brindha, K., & Schneider, M. (2019). Impact of Urbanization on Groundwater Quality. *GIS and Geostatistical Techniques for Groundwater Science*, 179–196. <https://doi.org/10.1016/b978-0-12-815413-7.00013-4>
- Carr, A. (1987). Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles. *Marine Pollution Bulletin*, 18(6), 352–356. [https://doi.org/10.1016/s0025-326x\(87\)80025-5](https://doi.org/10.1016/s0025-326x(87)80025-5)
- Chislock, M. F., Doster, E., Zitomer, R. A., & Wilson, A. E. (2013). *Eutrophication: Causes, Consequences, and Controls in Aquatic Ecosystems* | Learn Science at Scitable. The Nature Education. <https://www.nature.com/scitable/knowledge/library/eutrophication-causes->

consequences-and-controls-in-aquatic-
102364466/?error=cookies_not_supported&code=075340a0-0dd1-4eb4-a318-
4d6f78215f99

Davis, C. (2021, March 29). Medical Definition of Waterborne bacterial disease. MedicineNet.

https://www.medicinenet.com/waterborne_bacterial_disease/definition.htm

Description of the Indian Ocean. (n.d.). Indian Ocean in World History. Retrieved November 4, 2021, from <https://www.indianoceanhistory.org/Learning-Tools/Historical-Overviews.aspx>

Domestic pollution. (n.d.). Eni School Energy&environment. Retrieved November 4, 2021, from <http://www.eniscuola.net/en/argomento/water-pollution/pollution-sources/water-alterations/>

Drinking-water. (2019, June 15). World Health Organization. <https://www.who.int/news-room/fact-sheets/detail/drinking-water#:~:text=Globally%2C%20at%20least%20%20billion,000%20diarrhoeal%20deaths%20each%20year.>

Elliott, M. (2003). Biological pollutants and biological pollution—an increasing cause for concern. *Marine Pollution Bulletin*, 46(3). [https://doi.org/10.1016/s0025-326x\(02\)00423-x](https://doi.org/10.1016/s0025-326x(02)00423-x)

European Commission. (2013, December). Seafloor Damage. https://ec.europa.eu/environment/integration/research/newsalert/pdf/45si_en.pdf

Falkowski, P. G., Algeo, T., Codispoti, L., Deutsch, C., Emerson, S., Hales, B., Huey, R. B., Jenkins, W. J., Kump, L. R., Levin, L. A., Lyons, T. W., Nelson, N. B., Schofield, O. S., Summons, R., Talley, L. D., Thomas, E., Whitney, F., & Pilcher, C. B. (2011). Ocean deoxygenation: Past, present, and future. *Eos, Transactions American Geophysical Union*, 92(46). <https://doi.org/10.1029/2011eo460001>

- FAO. (2017). Water pollution from agriculture: a global review. <https://www.fao.org/3/i7754e/i7754e.pdf>
- Gall, A. M., Mariñas, B. J., Lu, Y., & Shisler, J. L. (2015). Waterborne Viruses: A Barrier to Safe Drinking Water. *PLOS Pathogens*, 11(6). <https://doi.org/10.1371/journal.ppat.1004867>
- Gall, S., & Thompson, R. (2015). The impact of debris on marine life. *Marine Pollution Bulletin*, 92(1–2), 170–179. <https://doi.org/10.1016/j.marpolbul.2014.12.041>
- Gibbens, S. (2021a, May 4). The Atlantic Ocean, explained. NATIONAL GEOGRAPHIC. Retrieved November 4, 2021, from <https://www.nationalgeographic.com/environment/article/atlantic-ocean>
- Gibbens, S. (2021b, September 23). There's a new ocean now—can you name all 5? NATIONAL GEOGRAPHIC. Retrieved November 4, 2021, from <https://www.nationalgeographic.com/environment/article/theres-a-new-ocean-now-can-you-name-all-five-southern-ocean>
- Goel, P. K. (2021). *Water Pollution: Causes, Effects and Control* [E-book]. New Age International Publisher.
- Guinotte, J. M., & Fabry, V. J. (2008). Ocean Acidification and Its Potential Effects on Marine Ecosystems. *Annals of the New York Academy of Sciences*, 1134(1), 320–342. <https://doi.org/10.1196/annals.1439.013>
- Hachiya, N. (2006). The history and the present of Minamata disease - entering a second half a century. *JMAJ*, 49(3). https://www.med.or.jp/english/pdf/2006_03/112_118.pdf
- Han, T. W., Tseng, C. C., Cai, M., Chen, K., Cheng, S. Y., & Wang, J. (2020). Effects of Cadmium on Bioaccumulation, Bioabsorption, and Photosynthesis in *Sarcodia suiae*. *International Journal of Environmental Research and Public Health*, 17(4). <https://doi.org/10.3390/ijerph17041294>

- Hausner, E. A., & Poppenga, R. H. (2013). Hazards Associated with the Use of Herbal and Other Natural Products. *Small Animal Toxicology*. Published. <https://doi.org/10.1016/b978-1-4557-0717-1.00026-0>
- History and Future of Plastics. (2019, November 20). Science History Institute. <https://www.sciencehistory.org/the-history-and-future-of-plastics>
- How Much Water is There on Earth? (n.d.). USGS. Retrieved November 4, 2021, from https://www.usgs.gov/special-topic/water-science-school/science/how-much-water-there-earth?qt-science_center_objects=0#qt-science_center_objects
- IMO. (n.d.). IMO and its role in protecting the world's oceans. IMO. <https://www.imo.org/en/MediaCentre/HotTopics/Pages/oceans-default.aspx>
- Indian Ocean | History, Map, Depth, Islands, & Facts. (n.d.). Encyclopedia Britannica. Retrieved November 4, 2021, from <https://www.britannica.com/place/Indian-Ocean>
- Industrial pollution. (n.d.). Eni School Energy&environment. Retrieved November 4, 2021, from <http://www.eniscuola.net/en/argomento/water-pollution/pollution-sources/household-pollution/>
- IPEN. (2021, April). AQUATIC POLLUTANTS IN OCEANS AND FISHERIES. https://ipen.org/transfer/embargo/aquatic_pollutants_in_oceans_and_fisheries_ipen-en.pdf
- Jones, J. B. (1992). Environmental impact of trawling on the seabed: A review. *New Zealand Journal of Marine and Freshwater Research*, 26(1), 59–67. <https://doi.org/10.1080/00288330.1992.9516500>
- Karlson, B., Andersen, P., Arneborg, L., Cembella, A., Eikrem, W., John, U., West, J. J., Klemm, K., Kobos, J., Lehtinen, S., Lundholm, N., Mazur-Marzec, H., Naustvoll, L., Poelman, M., Provoost, P., de Rijcke, M., & Suikkanen, S. (2021). Harmful algal blooms and their effects in coastal seas of Northern Europe. *Harmful Algae*, 102. <https://doi.org/10.1016/j.hal.2021.101989>

- Kress, N. (2019, January 1). Seawater Quality for Desalination Plants. ScienceDirect. Retrieved November 4, 2021, from <https://www.sciencedirect.com/science/article/pii/B9780128119532000037>
- Kroeker, K. J., Kordas, R. L., Crim, R., Hendriks, I. E., Ramajo, L., Singh, G. S., Duarte, C. M., & Gattuso, J. (2013). Impacts of ocean acidification on marine organisms: quantifying sensitivities and interaction with warming. *Global Change Biology*, 19(6), 1884–1896. <https://doi.org/10.1111/gcb.12179>
- Kumar, P. S., & Prasannamedha, G. (2021). Biological and chemical impacts on marine biology. *Modern Treatment Strategies for Marine Pollution*, 11–27. <https://doi.org/10.1016/b978-0-12-822279-9.00006-3>
- Lachmann, F., Almroth, B. C., Baumann, H., Broström, G., Corvellec, Hervé, H., Gipperth, L., Hassellöv, M., Karlsson, T., & Nilsson, P. (2017). Marine plastic litter on Small Island Developing States (SIDS): Impacts and measures. *Marine Plastic Litter on Small Island Developing States (SIDS): Impacts and Measures*. Published. <https://doi.org/10.13140/RG.2.2.16168.37121>.
- Lindsey, R., & Scott, M. (2010, July 13). What are Phytoplankton? Earth Observatory. Retrieved November 4, 2021, from <https://earthobservatory.nasa.gov/features/Phytoplankton>
- Marine Benthos. (n.d.). Biologica. Retrieved November 4, 2021, from <https://biologica.ca/organisms-we-identify/marine-benthos/>
- Mayer, M. (2019, March 2). The Three Types of Water Pollution. Sciencing. Retrieved November 4, 2021, from <https://sciencing.com/three-types-water-pollution-8171278.html>
- National Geographic Society. (2012, October 9). runoff. <https://www.nationalgeographic.org/encyclopedia/runoff/>

- NOAA. (n.d.). What is a harmful algal bloom? | National Oceanic and Atmospheric Administration. NOAA National Ocean Service. <https://www.noaa.gov/what-is-harmful-algal-bloom>
- Obasi, P. N., & Akudinobi, B. B. (2020). Potential health risk and levels of heavy metals in water resources of lead–zinc mining communities of Abakaliki, southeast Nigeria. *Applied Water Science*, 10(7). <https://doi.org/10.1007/s13201-020-01233-z>
- ocean | Definition, Distribution, Map, Formation, & Facts. (n.d.). Encyclopedia Britannica. Retrieved November 4, 2021, from <https://www.britannica.com/science/ocean>
- ocean acidification | Definition, Causes, Effects, Chemistry, & Facts. (n.d.). Encyclopedia Britannica. <https://www.britannica.com/science/ocean-acidification#ref301066>
- OECD Water - water. (n.d.). OECD. <https://www.oecd.org/fr/sites/oecdwater/infographic-impacts-of-water-pollution.htm>
- Pacific Ocean - Tides. (n.d.). Encyclopedia Britannica. Retrieved November 4, 2021, from <https://www.britannica.com/place/Pacific-Ocean/Tides#ref36098>
- Parker, L. (2021a, May 3). The world’s plastic pollution crisis explained. National Geographic. <https://www.nationalgeographic.com/environment/article/plastic-pollution>
- Parker, L. (2021b, May 4). Ocean Trash: 5.25 Trillion Pieces and Counting, but Big Questions Remain. National Geographic. <https://www.nationalgeographic.com/science/article/150109-oceans-plastic-sea-trash-science-marine-debris>
- plastic pollution | Sources & Effects. (n.d.). Encyclopedia Britannica. <https://www.britannica.com/science/plastic-pollution>
- Pohl, F., Eggenhuisen, J. T., Kane, I. A., & Clare, M. A. (2020). Transport and Burial of Microplastics in Deep-Marine Sediments by Turbidity Currents. *Environmental Science & Technology*, 54(7), 4180–4189. <https://doi.org/10.1021/acs.est.9b07527>

- Rennie, J. Q. M. (2019, May 6). Icefish Study Adds Another Color to the Story of Blood. *Scientific American*. Retrieved November 4, 2021, from <https://www.scientificamerican.com/article/icefish-study-adds-another-color-to-the-story-of-blood/>
- Ritchie, H. (2018, September 1). Plastic Pollution. *Our World in Data*. <https://ourworldindata.org/plastic-pollution>
- Schwarzenbach, R. P., Egli, T., Hofstetter, T. B., von Gunten, U., & Wehrli, B. (2010). Global Water Pollution and Human Health. *Annual Review of Environment and Resources*, 35(1). <https://doi.org/10.1146/annurev-environ-100809-125342>
- Scott, M., & Hansen, K. (2016, September 16). Sea Ice. *Earth Observatory*. Retrieved November 4, 2021, from <https://earthobservatory.nasa.gov/features/SeaIce>
- Sellner, K. G., Doucette, G. J., & Kirkpatrick, G. J. (2003). Harmful algal blooms: causes, impacts and detection. *Journal of Industrial Microbiology and Biotechnology*, 30(7), 383–406. <https://doi.org/10.1007/s10295-003-0074-9>
- SEPA. (n.d.). The chemistry of water pollution. <https://www.sepa.org.uk/media/120299/chemistry-of-water-pollution.pdf>
- Sharma, C., & Negi, Y. S. (2020). Methods of inorganic pollutants detection in water. *Inorganic Pollutants in Water*, 115–134. <https://doi.org/10.1016/b978-0-12-818965-8.00007-x>
- Sources and Effects of Marine Pollution. (n.d.). *Gdrc.Org*. <https://www.gdrc.org/oceans/marine-pollution.html>
- Southern Ocean | Location, Map, Depth, & Facts. (n.d.). *Encyclopedia Britannica*. Retrieved November 4, 2021, from <https://www.britannica.com/place/Southern-Ocean>
- Speight, J. (2019, August 30). Sources of water pollution. *ScienceDirect*. <https://www.sciencedirect.com/science/article/pii/B978012803810900005X>
- Srivastav, A. L., & Ranjan, M. (2020). Inorganic water pollutants. *Inorganic Pollutants in Water*. Published. <https://doi.org/10.1016/b978-0-12-818965-8.00001-9>

- The State of World Fisheries and Aquaculture 2020. (n.d.). FAO. Retrieved November 4, 2021, from <https://www.fao.org/state-of-fisheries-aquaculture>
- Sutton, M. A., Howard, C. M., Erisman, J. W., Billen, G., Bleeker, A., Grennfelt, P., van Grinsven, H., Grizzetti, B., & van Grinsven, H. (2011). *The European Nitrogen Assessment* [E-book]. Cambridge University Press.
- UNEP. (n.d.). #BeatPlasticPollution. <https://www.unep.org/interactive/beat-plastic-pollution/>
- Vinnå, L. R. (2017, May 1). Physical effects of thermal pollution in lakes. AGU. <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016WR019686>
- What are plankton? (n.d.). NAOO National Ocean Service. Retrieved November 4, 2021, from <https://oceanservice.noaa.gov/facts/plankton.html>
- What is marine debris? (n.d.). NOAA National Ocean Service. <https://oceanservice.noaa.gov/facts/marinedebris.html>
- What is pollution? (n.d.). Islamic University of Gaza. http://site.iugaza.edu.ps/elnabris/files/2015/09/1_What-is-pollution.pdf
- What is the biggest source of pollution in the ocean? (n.d.). NOAA National Ocean Service. <https://oceanservice.noaa.gov/facts/pollution.html>
- What is the largest ocean basin on Earth? (n.d.). NOAA National Ocean Service. Retrieved November 4, 2021, from <https://oceanservice.noaa.gov/facts/biggestocean.html#:~:text=The%20Pacific%20Ocean%20is%20the,of%20the%20world%20ocean%20basins.&text=Covering%20approximately%2063%20million%20square,fit%20into%20the%20Pacific%20basin.>
- Why should we care about the ocean? (n.d.). NOAA National Ocean Service. Retrieved November 4, 2021, from <https://oceanservice.noaa.gov/facts/why-care-about-ocean.html>

- WNCT. (2016, February 26). Ocean zones and what creatures live in them.
<https://www.wnct.com/news/ocean-zones-and-what-creatures-live-in-them/>
- WWF. (n.d.). Sustainable Seafood | Industries | WWF. World Wildlife Fund.
<https://www.worldwildlife.org/industries/sustainable-seafood>
- Zeitoun, M. (2014). Impact of Water Pollution with Heavy Metals on Fish Health: Overview and Updates. Global Veterinaria. Published.
<https://doi.org/10.5829/idosi.gv.2014.12.02.82219>

Appendix A – Cross Tabulations

		Where do you think is the main source of oxygen production?		Total
		0	1	
Where is your home located?	Africa	17	4	21
	Asia	123	56	179
	Australia	1	1	2
	Europe	7	2	9
	North America	8	4	12
	South America	0	1	1
Total		156	68	224

Table 1: Cross tabulation between location and source of oxygen production.

		Do you think oceans are important to human?			Total
		1	2	3	
Where is your home located?	Africa	3	1	17	21
	Asia	17	48	114	179
	Australia	1	0	1	2
	Europe	0	1	8	9
	North America	0	0	12	12
	South America	0	0	1	1
Total		21	50	153	224

Table 2: Cross tabulation between location and importance of oceans.

		Do you think that humans are responsible for the health of the oceans?		Total
		0	1	
Where is your home located?	Africa	1	20	21
	Asia	12	167	179
	Australia	1	1	2
	Europe	1	8	9
	North America	0	12	12
	South America	0	1	1
Total		15	209	224

Table 3: Cross tabulation between location and human responsibility.

		Do you think that human activities have an impact on the ocean? (5 = very, 1 = not at all)				Total
		2	3	4	5	

Where is your home located?	Africa	0	1	5	15	21
	Asia	1	20	43	115	179
	Australia	0	1	0	1	2
	Europe	0	1	2	6	9
	North America	0	0	2	10	12
	South America	0	0	0	1	1
Total		1	23	52	148	224

Table 4: Cross tabulation between location and impact of human activities.

		Where do you think is the main source of oxygen production?		Total
		0	1	
What is your educational background?	0	4	1	5
	1	33	14	47
	2	107	43	150
	3	12	9	21
	4	0	1	1
Total		156	68	224

Table 5: Cross tabulation between educational background and source of oxygen production.

		Do you think oceans are important to human?			Total
		1	2	3	
What is your educational background?	0	1	0	4	5
	1	4	7	36	47
	2	14	42	94	150
	3	1	1	19	21
	4	1	0	0	1
Total		21	50	153	224

Table 6: Cross tabulation between educational background and importance of oceans.

		Do you think that humans are responsible for the health of the oceans?		Total
		0	1	
What is your educational background?	0	1	4	5
	1	3	44	47
	2	9	141	150
	3	1	20	21
	4	1	0	1

Total	15	209	224
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Table 7: Cross tabulation between educational background and responsibility.

		Do you think that human activities have an impact on the ocean? (5 = very, 1 = not at all)				Total
		2	3	4	5	
What is your educational background?	0	1	3	0	1	5
	1	0	4	7	36	47
	2	0	14	42	94	150
	3	0	1	3	17	21
	4	0	1	0	0	1
Total		1	23	52	148	224

Table 8: Cross tabulation between educational background and impact of human activities.

		Where do you think is the main source of oxygen production?		Total
		0	1	
What is your job title?	0	91	43	134
	1	60	24	84
Total		151	67	218

Table 9: Cross tabulation between job and source of oxygen production.

		Do you think oceans are important to human?			Total
		1	2	3	
What is your job title?	0	11	29	94	134
	1	9	20	55	84
Total		20	49	149	218

Table 10: Cross tabulation between job and importance of oceans.

		Do you think that humans are responsible for the health of the oceans?		Total
		0	1	
What is your job title?	0	6	128	134
	1	8	76	84
Total		14	204	218

Table 11: Cross tabulation between job and human responsibility.

		Do you think that human activities have an impact on the ocean? (5 = very, 1 = not at all)				Total
		2	3	4	5	
What is your job title?	0	0	11	31	92	134
	1	1	11	20	52	84

Total	1	22	51	144	218
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Table 12: Cross tabulation between job and impact of human activities.

Appendix B – Group Statistics

Where do you think is the main source of oxygen production?		N	Mean	Std. Deviation	Std. Error Mean
What is your educational background?	0	156	1.81	.599	.048
	1	68	1.93	.676	.082
What is your job title?	0	151	.40	.491	.040
	1	67	.36	.483	.059
How often do you go to lakes, rivers, seas, oceans per year?	0	154	3.10	2.610	.210
	1	65	2.83	2.643	.328
What was the quality of lakes, rivers, seas, oceans you visited?	0	157	2.34	.583	.047
	1	69	2.07	.551	.066
Do you think oceans are important to human?	0	157	2.54	.684	.055
	1	69	2.71	.571	.069
Do you think that humans are responsible for the health of the oceans?	0	157	.92	.267	.021
	1	69	.96	.205	.025
Do you think that human activities have an impact on the ocean? (5 = very, 1 = not at all)	0	157	4.52	.722	.058
	1	69	4.64	.618	.074
To what extent do you believe that you are informed about local and global problems of the oceans?	0	157	3.10	.975	.078
	1	69	3.35	.872	.105
Agriculture	0	157	.17	.379	.030
	1	69	.14	.355	.043
Commercial fisheries	0	157	.01	.080	.006
	1	69	0.00	0.000	0.000
If you are a university student, please specify your major or faculty	0	105	.10	.308	.030
	1	53	.11	.320	.044
Domestic waste	0	157	.49	.502	.040
	1	69	.38	.488	.059
Human	0	157	.01	.113	.009
	1	69	.01	.120	.014
Industries	0	157	.78	.413	.033
	1	69	.75	.434	.052

Military	0	157	.01	.080	.006
	1	69	.01	.120	.014
Oil leakage	0	154	.51	.501	.040
	1	69	.59	.495	.060
Radiation	0	157	.01	.080	.006
	1	69	0.00	0.000	0.000
Suburban development	0	157	.26	.441	.035
	1	69	.25	.434	.052
Thermal pollution	0	157	.01	.080	.006
	1	69	.01	.120	.014
Tourism	0	157	.01	.080	.006
	1	69	0.00	0.000	0.000
Waste	0	157	.01	.080	.006
	1	69	.01	.120	.014
Wastewater treatment plants	0	157	.40	.492	.039
	1	68	.34	.477	.058
Are you willing to change or adjust your lifestyle to be more ocean-friendly / eco-friendly?	0	155	.82	.386	.031
	1	69	.83	.382	.046
Based on your consumption, are you considering on buying sustainable and/or eco-friendly products?	0	157	.87	.341	.027
	1	69	.86	.355	.043

Table 1: Group statistics.

Appendix C – Independent Samples T-Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
What is your educational background?	Equal variances assumed	.000	.991	-1.241	222	.216	-.112	.091	-.291	.066
	Equal variances not assumed			-1.183	114.865	.239	-.112	.095	-.301	.076

What is your job title?	Equal variance s assumed	1.329	.250	.546	216	.586	.039	.072	-.102	.181
	Equal variance s not assumed			.549	128.486	.584	.039	.071	-.102	.180
How often do you go to lakes, rivers, seas, oceans per year?	Equal variance s assumed	.272	.603	.705	217	.482	.273	.388	-.491	1.037
	Equal variance s not assumed			.701	119.085	.485	.273	.390	-.498	1.044
What was the quality of lakes, rivers, seas, oceans you visited?	Equal variance s assumed	14.496	.000	3.199	224	.002	.265	.083	.102	.428
	Equal variance s not assumed			3.272	137.053	.001	.265	.081	.105	.425
Do you think oceans are important to human?	Equal variance s assumed	9.893	.002	-1.859	224	.064	-.175	.094	-.361	.011
	Equal variance s not assumed			-1.994	154.064	.048	-.175	.088	-.349	-.002
Do you think that humans are responsible for the health of the oceans?	Equal variance s assumed	3.492	.063	-.914	224	.362	-.033	.036	-.104	.038
	Equal variance s not assumed			-1.010	166.193	.314	-.033	.033	-.097	.031
Do you think that human activities have an	Equal variance s assumed	4.495	.035	-1.219	224	.224	-.122	.100	-.319	.075

impact on the ocean? (5 = very, 1 = not at all)	Equal variance s not assumed			- 1.295	150.43 3	.197	-.122	.094	-.308	.064
To what extent do you believe that you are informed about local and global problems of the oceans?	Equal variance s assumed	.010	.92 2	- 1.802	224	.073	-.246	.136	-.515	.023
Agriculture	Equal variance s not assumed			- 1.882	144.37 4	.062	-.246	.131	-.504	.012
	Equal variance s assumed	1.052	.30 6	.504	224	.615	.027	.054	-.079	.133
	Equal variance s not assumed			.517	138.08 0	.606	.027	.052	-.076	.130
Commercial fisheries	Equal variance s assumed	1.776	.18 4	.662	224	.509	.006	.010	-.013	.025
	Equal variance s not assumed			1.000	156.00 0	.319	.006	.006	-.006	.019
If you are a university student, please specify your major or faculty	Equal variance s assumed	.103	.74 9	-.161	156	.873	-.008	.053	-.112	.095
	Equal variance s not assumed			-.159	100.91 5	.874	-.008	.053	-.114	.097
Domestic waste	Equal variance s assumed	9.793	.00 2	1.581	224	.115	.114	.072	-.028	.255
	Equal variance s not assumed			1.598	133.22 6	.112	.114	.071	-.027	.254
Human	Equal variance s	.045	.83 3	-.106	224	.916	-.002	.017	-.034	.031

	assumed									
	Equal variance s not assumed			-.103	122.36 1	.918	-.002	.017	-.036	.032
Industries	Equal variance s assumed	.929	.33 6	.492	224	.623	.030	.061	-.090	.149
	Equal variance s not assumed			.483	124.35 8	.630	.030	.062	-.092	.152
Military	Equal variance s assumed	1.432	.23 3	-.598	224	.550	-.008	.014	-.035	.019
	Equal variance s not assumed			-.513	95.256	.609	-.008	.016	-.040	.023
Oil leakage	Equal variance s assumed	5.178	.02 4	- 1.123	221	.263	-.081	.072	-.224	.061
	Equal variance s not assumed			- 1.129	132.55 4	.261	-.081	.072	-.224	.061
Radiation	Equal variance s assumed	1.776	.18 4	.662	224	.509	.006	.010	-.013	.025
	Equal variance s not assumed			1.000	156.00 0	.319	.006	.006	-.006	.019
Suburban development	Equal variance s assumed	.223	.63 8	.233	224	.816	.015	.063	-.110	.140
	Equal variance s not assumed			.234	131.77 1	.815	.015	.063	-.110	.139

Thermal pollution	Equal variance s assumed	1.432	.23 3	-.598	224	.550	-.008	.014	-.035	.019
	Equal variance s not assumed			-.513	95.256	.609	-.008	.016	-.040	.023
Tourism	Equal variance s assumed	1.776	.18 4	.662	224	.509	.006	.010	-.013	.025
	Equal variance s not assumed			1.000	156.00 0	.319	.006	.006	-.006	.019
Waste	Equal variance s assumed	1.432	.23 3	-.598	224	.550	-.008	.014	-.035	.019
	Equal variance s not assumed			-.513	95.256	.609	-.008	.016	-.040	.023
Wastewater treatment plants	Equal variance s assumed	3.725	.05 5	.891	223	.374	.063	.071	-.076	.202
	Equal variance s not assumed			.902	131.05 1	.369	.063	.070	-.075	.201
Are you willing to change or adjust your lifestyle to be more ocean- friendly / eco- friendly? Based on your consumption, are you considering	Equal variance s assumed	.059	.80 8	-.121	222	.904	-.007	.056	-.116	.103
	Equal variance s not assumed			-.121	131.88 9	.904	-.007	.055	-.116	.103
	Equal variance s assumed	.198	.65 7	.224	224	.823	.011	.050	-.087	.110

on buying sustainable and/or eco-friendly products?	Equal variance's not assumed			.221	125.627	.826	.011	.051	-.089	.111
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Table 1: Independent samples t-test results.