**Introduction**

**Where does oil come from?** Pollution of our oceans has become a major problem. With a heightened demand for oil, the spills are more frequent and the quantity spilled is larger. However, this is only a small part of the problem. Oil pollution from large tanker accidents only comprises 5% of the oil polluting our waterways (Chart 1). The largest contributors are ourselves. It is estimated that 363 million gallons of oil dumped into the ocean, is a result of the many cars on our roadways. Most of this comes from oil dumped down drains or otherwise improperly disposed of (NASA). The rest comes from leaking cars. Many people do not see this as a problem because oil leaks very slowly. However, the amount of oil lost every year by one car, multiplied by the millions of cars leaking oil, will give you a large number. This oil sits on roadways and in driveways and parking lots until rain comes and washes into the ocean. Less than 33% of used motor oil generated by people who change oil themselves is disposed of properly.

*Chart 1. Sources of marine oil pollution, measured in millions of gallons (*[*NASA*](http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/peril_oil_pollution.html)*).*

There are two main reasons why oil should be conserves. Motor oil is a non-renewable resource. Luckily, oil is easily recycled. Forty-two gallons of crude oil can make 2.5 quarts of lubricant (motor oil), while 1 gallon of recycled oil will make the same 2.5 quarts while using less energy. Oil, regardless of where it is spilled, is very destructive. One gallon of oil spilled on water can create a one acre oil slick. Because of this, spills spread rapidly and pollute waters hundreds of miles away if untreated. One gallon of oil spilled on land can pollute up to 1 million gallon of drinking water - or a 1 year supply for 50 people.

**Oil and Water don't mix.** When oil mixes with water, it is not a pretty sight. In areas of high turbulence and wave action oil can quickly become emulsified, forming a sticky "chocolate mousse" on the surface, up to 6 inches thick. Although it is much harder to clean up the oil when it becomes emulsified, it does disappear fairly quickly. When the oil is emulsified, the surface area to volume ratio is greatly increase, allowing bacteria to break down the hydrocarbons in oil much quicker. (Clark) Oil and water generally do not mix, but some toxins and small portions of the oil are soluble. Two Canadian scientists found the aqueous solubility of used motor oil in salt water to be 12.83 mg/L at 20� C (Environment Technology Center).

*Chart 2. Different oil products and their hydrocarbon compounds. (*[*Oppenheimer Biotechnology, Inc.*](http://www.obio.com/hydrocar.htm)*)*

**Hydrocarbons.** Oil is a general classification for a group of compounds whose main components are hydrocarbons - organic compounds which consist of only carbon and hydrogen. Crude oil is a mixture of hydrocarbons of different molecular weights; those with higher molecular weight have more carbon and hydrogen atoms per molecule. During the process of refining, hydrocarbons are separated by weight. Different types of oils are comprised of different ranges of hydrocarbons (Chart 2; Table 1). These ranges of hydrocarbons define what the oil is used for, and how destructive it is when spilled. Oils containing "middle" molecular weight hydrocarbons or polycyclic aromatic hydrocarbons are the most harmful. Heavier oils attach to sediments and sink to the bottom after a few weeks, although they are still dangerous. Lighter molecular weight hydrocarbon oils have a higher percentage that evaporates; between 20 and 40%. (Clark)

|  |  |  |  |
| --- | --- | --- | --- |
| **Product** | **Carbon Chain Range** | **Boiling Point Range (Deg. C) or State** | **Uses** |
| Gases | C1 - C4 | -164 to +30 | Fuel, carbon black, gasoline |
| Petroleum Ether | C6 - C7 | 30 - 90 | Solvent, dry cleaning, refrigerant |
| Straight-Run Gasoline | C6 - C12 | 40 - 200 | Motor fuel |
| Kerosene | C12 - C16 | 200 - 315 | Lighting and oil stove fuels, diesel engines |
| Fuel Oil | C15 - C18 | Up to 375 | Furnace oils, diesel |
| Lubricating Oils | C16 - C20 | 350 up | Lubrication |
| Grease, Vaseline | C20 & up | Semisolid | Lubrication, sizing paper |
| Paraffin - Wax | C26 & up | Melts 51 - 55 | Candles, match sticks, household canning |
| Pitch & Tar | C26 & up | Residue | Roofing, paving, rubber |
| Petroleum Coke | C26 & up | Residue | Fuel, carbon electrodes |

*Table 1. Hydrocarbon compounds and chains. (*[*OBI*](http://www.obio.com/hydrocar.htm)*)*

**What is in motor oil?** Used motor oil contains a mixture of hydrocarbons - 80% by volume - in the range of 18 to 26 carbon chains. However, new oil contains shorter and lighter carbon chains. During its use, the hydrocarbons are altered so that they have more carbon chains; many of these wind up turning into polycyclic aromatic hydrocarbons or PAHs, a more toxic group of hydrocarbons (National Park Service). In addition, many metals are added to the oil from wear and tear of the engine. Mostly just lead, but in smaller amounts zinc, chromium, barium, and arsenic (NPS). The changes that occur in the carbon chains and the addition of metals affect some of the properties of the motor oil as well. For example, there is a huge increase in water solubility as well as the toxicity (ETC).

**Phytoplankton.** More than 2/3 of the surface of the earth is cover with oceans, all of which is inhibited by phytoplankton. Phytoplankton is a general term for microscopic, photosynthetic organisms floating freely in oceans. Algae of several different phyla are part of the phytoplankton family (Dawson). Phytoplankton occupy the top 100 meters of the ocean, known as the epipelagic zone. Any further down and not enough light energy penetrates the water to sustain life. Because different species of phytoplankton absorb different spectra of light and different light spectra have varying amounts of energy, there is a stratification of phytoplankton type. The more energy present in one photon of light, the further it will penetrate into water. Green algae, which absorbs red light, lives closest to the surface, normally in the top 10 meters. In the upper 50 meters are plankton which absorb blue light, and below that is plankton that absorbs violet and ultra-violet light. (Dawson)

Higher concentrations of phytoplankton are found in higher latitude. Cooler waters have higher dissolved gas capacity, longer hours of sunlight, and many "upwelling" spots. These upwellings bring nitrogen and phosphorus produced by decomposers to the surface where the phytoplankton can access them. (Davis) In addition to nutrients, phytoplankton needs carbon dioxide in order to carry out photosynthesis (Diagram 1). Most of this carbon dioxide comes from the atmosphere, into which roughly 6 billion tons of carbon dioxide is released annually. It is estimated that half of this is converted into oxygen, by way of photosynthesis, by phytoplankton. (Barss)

CO2 + H2O + energy (light) = O2 + C6H12O6

*Diagram 1. Reactants and products of photosynthesis.*

"Phytoplankton are the foundation of the marine food chain and they can influence the Earth's climate" (Earth Observatory). Phytoplankton serve as the primary source of food in the oceans; when phytoplankton populations decrease, so do those of the organisms that feed on phytoplankton. However, populations of phytoplankton will rebound rapidly once the conditions are optimal again. Phytoplankton grow fast enough that the population can double in numbers in one day. (Earth Observatory)

Although phytoplankton is very important to out ecosystem, limited research has been done on oil pollution. Most research on the environmental aspects of oil spills are field studies of actual spills. It is very easy to count the number of dead seagulls, otters, or other larger animals. Phytoplankton, on the other hand, is much harder to study. Besides their small size, phytoplankton reproduce at a rapid rate and have a short life span - only 2 days on average. Some laboratory studies have been conducted on phytoplankton. These suggest that oil can cause death as well as a variety of sub-lethal effects (Burger). Phytoplankton are more susceptible to toxic water-soluble elements leaching form oil and emulsified oil because they live so close to the surface and are exposed to higher concentrations (Clark).

In depth studies on oil effects were done on small aquatic animals who share some habitats with phytoplankton; Daphnia magna (a small crustacean) and Artemia (newly hatched brine shrimp) were tested. Both were tested to find the toxicity of water-soluble components of used motor oil. They were tested in 2 different ranges; one found the concentration at which half the population died (LC 50), the other found the concentration at which half were affected, but not killed (EC 50). Two groups conducted these tests, however they used different methods, so their results are different (Table 2). (Environmental Technology Center)

|  |  |  |  |
| --- | --- | --- | --- |
| **Organism** | **Endpoint** | **Toxicity (mg/L)** | **Method** |
| Daphnia magna | EC 50 | 4.65 | a |
| Daphnia magna | EC 50 | 0.15 | b |
| Daphnia magna | LC 50 | 4.87 | a |
| Daphnia magna | LC 50 | 0.16 | b |
| Artemia | EC 50 | 12.8 | a |
| Artemia | EC 50 | 0.48 | b |
| Artemia | LC 50 | 12.8 | a |
| Artemia | LC 50 | 0.48 | b |

*Table 2. Acute Toxicity of Water Soluble Fraction. Method a used flourescence spectroscopy. Method b used GC purge-and-trap analysis. (*[*Environmental Technology Center*](http://www.etcentre.org/cgi-win/oil_prop_cgi.exe?Path=%5CWebsite%5Criver%5C)*)*

**What this project is all about.** With the knowledge that oil is a toxic substance to some organisms, I set out to find a way to test its effects on phytoplankton. Because living phytoplankton uses carbon dioxide and produce oxygen, measuring the change in gas volume (measured in parts per million) would give me an idea of whether or not the oil was harming the phytoplankton. If the oil was damaging the phytoplankton, then there would be a significantly smaller change in the oxygen in a bottle with oil than a bottle without oil.

This page (and the ones to follow) are best viewed with Internet Explorer.

[[Project Creek Watch](http://www.pleasanton.k12.ca.us/amador/Creek/index.html)][[Mr. Thiel](http://www.pleasanton.k12.ca.us/amador/faculty/science/thiel.html)][[1998 Projects](http://www.pleasanton.k12.ca.us/amador/Creek/AP98/AP98.html)][[1999 Projects](http://www.pleasanton.k12.ca.us/amador/Creek/AP99/AP99.html)][[2000 Projects](http://www.pleasanton.k12.ca.us/amador/Creek/AP2000/AP2000.html)][[2001 Projects](http://www.pleasanton.k12.ca.us/amador/Creek/AP2001/AP2001.html)]