# carbon dioxide (CO2)

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Colorless, odorless, non-combustible greenhouse-gas that [contributes](http://www.businessdictionary.com/definition/contribute.html) to [global warming](http://www.businessdictionary.com/definition/global-warming.html). Formed by complete combustion of [fossil fuels](http://www.businessdictionary.com/definition/fossil-fuel.html) ([coal](http://www.businessdictionary.com/definition/coal.html), charcoal, [natural gas](http://www.businessdictionary.com/definition/natural-gas.html), [petroleum](http://www.businessdictionary.com/definition/petroleum.html)) and [carbon](http://www.businessdictionary.com/definition/carbon.html) [containing](http://www.businessdictionary.com/definition/container.html) [products](http://www.businessdictionary.com/definition/product.html) (such as wood), it is released also through respiration by living organisms and by the gradual [oxidation](http://www.businessdictionary.com/definition/oxidation.html) of [organic](http://www.businessdictionary.com/definition/organic.html) matter in [soil](http://www.businessdictionary.com/definition/soil.html). Although relatively non-hazardous, it can [create](http://www.businessdictionary.com/definition/create.html) lethal oxygen-deficient[environments](http://www.businessdictionary.com/definition/environment.html) in [high](http://www.businessdictionary.com/definition/high.html) [concentrations](http://www.businessdictionary.com/definition/concentration.html) (specially in [confined spaces](http://www.businessdictionary.com/definition/confined-space.html)). It is one of the [greenhouse gases](http://www.businessdictionary.com/definition/greenhouse-gases.html) and, since over the [last](http://www.businessdictionary.com/definition/Last.html) 200 years its concentration in upper [atmosphere](http://www.businessdictionary.com/definition/atmosphere.html) has increased from 270 [parts per million (PPM)](http://www.businessdictionary.com/definition/parts-per-million-PPM.html) to 350 [ppm](http://www.businessdictionary.com/definition/pages-per-minute-PPM.html), it is said to be the cause of [changes](http://www.businessdictionary.com/definition/changes.html) in [global](http://www.businessdictionary.com/definition/global.html) climatic [patterns](http://www.businessdictionary.com/definition/pattern.html). Discovered in 1754 by the Scottish scientist Joseph Black (1727-1799). See also [carbon monoxide](http://www.businessdictionary.com/definition/carbon-monoxide-CO.html).

Read more: <http://www.businessdictionary.com/definition/carbon-dioxide-CO2.html#ixzz3jL7UaZ53>

**Oxygen and Carbon Dioxide in Aquatic Ecosystems**

September 19, 2012  
  
   Oxygen and carbon dioxide both have very specific roles in an aquatic ecosystem, from providing a safe healthy environment that the fish can breath in, to possibly making it impossible for the fish to live efficiently. Oxygen levels in the water can rise and fall by the change in temperature. The increase in temperatures can cause more oxygen to be dissolved within the water, and that will lower the levels of oxygen provided for the aquatic animals. Even though water is constantly in contact with oxygen only the waters surface is being saturated with water, therefor by means of a bubbler in an aquarium or fish tank or other forms of "forcing"oxygen through the water, is the only way to fully saturate your tank with the correct amounts of oxygen needed to keep your fish alive and well. Carbon dioxide in water can become accesive without the use of aquatic plants to help filter out the carbon and replenish with oxygen. Too much carbon dioxide buildup within your aquatic ecosystem can become extremely harmful to your fish or other aquatic animals, because it can act as poison, and kill them. For every one pound of oxygen inhaled by the fish, they exale more than one pound of carbon dioxide into water, automatically causing levels to rise, so monitoring carbondioxide levels in the water is a smart idea!

# Oxygen and Carbon Dioxide

**Carbon Dioxide in the Water**  
Carbon dioxide, also called CO2, is found in water as a dissolved gas. It can dissolve in water 200 times more easily than oxygen. Aquatic plants depend on carbon dioxide for life and growth, just as fish depend on oxygen. Plants use carbon dioxide during the process of photosynthesis.

Sometimes carbon dioxide levels in water become too high. Pollution can produce too much carbon dioxide. In these conditions, fish have a hard time getting the oxygen they need from the water. They can even suffocate and die.

Keeping a good balance of carbon dioxide and oxygen is one reason why plants and animals are both valuable in a lake. Each makes what the other uses.

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the causes and effects of climate change have been widely discussed and debated for decades. Most scientists agree that increased carbon dioxide (CO2) in the atmosphere resulting from the burning of fossil fuels is causing global warming, at least in part. However, global warming is not the only effect of CO2 emissions.

In recent months, the media have begun to focus on another effect of rising atmospheric CO2 concentrations: the effect of increasing CO2 levels on marine life. The oceans absorb 22 million tons of carbon dioxide every day, writes **Richard Feely**, a scientist with the National Oceanic and Atmospheric Administration (NOAA) in a 2006 science brief, "[Carbon Dioxide and Our Ocean Legacy](http://www.pmel.noaa.gov/pubs/PDF/feel2899/feel2899.pdf)" (100 KB PDF). Although this absorption is said to significantly reduce atmospheric greenhouse-gas levels, some scientists have observed that such an excess of CO2 may be altering the chemistry and biology of the world's oceans.

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When the oceans absorb CO2, the chemical reaction that takes place produces carbonic acid (H2CO3), which increases the acidity (lowers the pH) of seawater. Many scientists believe that decreasing pH in the oceans interferes with the ability of certain marine animals, such as corals and other calcifying marine organisms, to make their skeletons and shells from calcium carbonate minerals. Other marine species that may be affected include lobsters, snails, starfish, oysters, clams, and various species of phytoplankton, which are all species that occupy vital spots in the global-ocean food web. These environmental impacts would reverberate through economies everywhere; various industries, including tourism and fisheries, would likely suffer if the ecology of our oceans were to be altered.

In the past year, numerous agencies and organizations have contributed time, money, research, and insight with the aim of better understanding the impact of carbon dioxide on life in our oceans. The U.S. Geological Survey (USGS) contributes substantially to this effort by conducting research and sharing knowledge with such partners as NOAA, the National Science Foundation (NSF), and the National Center for Atmospheric Research (NCAR).

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First of all, what is photosynthesis? Well, it's how plants get their food. When you get hungry you probably just sit down and have something to eat. Plants, however, don't have it so easy, they have to make their own food. Plants use water (H2O), carbon dioxide (CO2), and sunlight to make glucose (C6H12O6), also known as sugar. The process follows the chemical equation: 6CO2 + 6H2O+light -> C6H12O6. The light has a special role. Just like your car needs gas in order for it to run, photosynthesis needs some kind of energy source for the reaction to occur, because the product has more energy than the starting materials. That fuel is sunlight. Plants have special little chemical machines based on the light-absorbing molecule chlorophyll to conduct the photosynthesis. Most plants and many bacteria get their food by photosynthesis.   
  
So chemically, the photosynthetic process that land and aquatic plants use to produce food is identical. Both types of plants require carbon dioxide, water, and energy to produce glucose (their food). The only difference between photosynthesis in aquatic and land plants is where in their environments they get these nutrients. Land plants get water from the ground through their extensive root system, carbon dioxide from the air through their stomata (tiny holes in a plant's leaves), and energy from the sun. Aquatic plants get water and carbon dioxide from their aquatic environment and, like the land plants, light energy from the sun. Even though the plant is underwater, it still gets its energy from the sun because sunlight can pass through water.   
  
To understand where aquatic plants find this CO2 think about your favorite kind of pop. Those bubbles that give the pop its fizzy nature come from CO2 that's dissolved in the liquid

## Carbon Dioxide

Dissolved Inorganic Carbon (DIC) in freshwater occurs as four different species in equilibrium with one another. The four species of DIC are; carbon dioxide (CO2), carbonic acid (H2CO3), bicarbonate (HCO3-), and carbonate (CO3=). The total amount of DIC largely determines the buffering capacity of freshwater, and the ratio of these species with one another largely determines the pH.

Carbon dioxide dissolves readily in water. At air equilibrium, the concentration of CO2 in air and water is approximately equal at about 0.5 mg/L. Unfortunately, CO2 diffuses about ten thousand times slower in water than in air. This problem is compounded by the relatively thick unstirred layer (or Prandtl boundary) that surrounds aquatic plant leaves. The unstirred layer in aquatic plants is a layer of still water through which gases and nutrients must diffuse to reach the plant leaf. It is about 0.5 mm thick, which is ten times thicker than in terrestrial plants. The result is that approximately 30 mg/L free CO2 is required to saturate photosynthesis in submerged aquatic plants.

The low diffusivity of CO2 in water, the relatively thick unstirred layer and the high CO2 concentration needed to saturate photosynthesis have prompted one scientist to state, "For freshwater submerged aquatic macrophyte plants, the naturally occurring DIC levels impose a major limitation on photosynthesis ... The DIC limitations on aquatic macrophytes and its corollary, the need to conserve carbon, are becoming increasingly apparent as important ecological features of aquatic environments (George Bowes, 'Inorganic Carbon Uptake by Aquatic Photosynthetic Organisms, 1985)."

Aquatic plants have adapted to CO2 limitation in several ways. They have thin, often dissected leaves. This increases the surface to volume ratio and decreases the thickness of the unstirred layer. They have extensive air channels, called aerenchyma, that allow gases to move freely throughout the plants. This allows respired CO2 to be trapped inside the plant and in some species even allows CO2 from the sediment to diffuse into the leaves. Finally, many species of aquatic plants are able to photosynthesize using bicarbonate as well as CO2. This is important, since at pH values between 6.4 and 10.4 the majority of DIC in freshwater exists in the form of bicarbonate.

For the aquarist, the supply of CO2 can be augmented in two ways. Both methods work by increasing the rate of diffusion of CO2 into the plants. First, the rate of water movement in the aquarium can be increased. This will decrease the thickness of the boundary layer and ensure that CO2 levels are at air equilibrium. This method is inexpensive, easy to implement and will produce excellent growth of aquatic plants under most conditions. Secondly, CO2 can be injected into the aquarium. This method can be expensive, and if done improperly, can be lethal to fish. This latter method is only essential, however, if there is a significant daily pH fluctuation in the aquarium, or if the species of plants being cultured are completely unable to use bicarbonate (such as Cabomba sp.).

The Determination of Carbon Dioxide System Parameters in Aquatic Systems Carbon dioxide is the dominant end product of organic carbon degradation in almost all aquatic environments and its variation is often a measure of net ecosystem metabolism [1-3]. Therefore, in aquatic biogeochemical studies, it is desirable to measure parameters that define the carbon dioxide system. CO2 is also the most important green house gas on Earth. Its fluxes across the air-water or sediment-water interface are among the most important concerns in global change studies and are often a measure of the net ecosystem production/metabolism of the aquatic system. There are four readily measurable parameters of the aquatic carbon dioxide system: pH, pCO2, total dissolved inorganic carbon (DIC) and total alkalinity (TA).

Another climate change issue is that the amount of carbon entering streams and rivers is likely tied to the rainfall in a given region, which washes soil carbon into the water. Much research suggests that climate change is altering precipitation patterns, and in areas where rainfall increases this could, in turn, increase the carbon dioxide escape from waterways.  
   
Answering such new questions is part of the team’s ongoing research, which now includes examining ways that changes to surrounding landscapes and to waterway chemistry ultimately affect their carbon cycling roles. “If even 10 percent of this is tied to humans, then perhaps it’s getting large enough to affect the anthropogenic carbon budget,” says Raymond. “We just don’t know yet.”

[Carbon dioxide](http://www.waterencyclopedia.com/knowledge/Carbon_dioxide.html) (CO 2) is considered a trace gas in the atmosphere because it is much less abundant than oxygen or [nitrogen](http://www.waterencyclopedia.com/knowledge/Nitrogen.html). However, this trace gas plays a vital role in sustaining life on Earth and in controlling the Earth's climate by trapping heat in the atmosphere.

**Carbon dioxide** ([chemical formula](https://en.wikipedia.org/wiki/Chemical_formula) **CO2**) is a colorless, odorless [gas](https://en.wikipedia.org/wiki/Gas) vital to [life](https://en.wikipedia.org/wiki/Life) on Earth. This naturally occurring [chemical compound](https://en.wikipedia.org/wiki/Chemical_compound) is composed of a [carbon](https://en.wikipedia.org/wiki/Carbon) atom [covalently](https://en.wikipedia.org/wiki/Covalent_bond) [double bonded](https://en.wikipedia.org/wiki/Double_bond) to two [oxygen](https://en.wikipedia.org/wiki/Oxygen) [atoms](https://en.wikipedia.org/wiki/Atom). Carbon dioxide exists in the [Earth's atmosphere](https://en.wikipedia.org/wiki/Earth%27s_atmosphere) as a [trace gas](https://en.wikipedia.org/wiki/Trace_gas) at a concentration of about 0.04 percent (400 [ppm](https://en.wikipedia.org/wiki/Parts_per_million)) by volume.[[3]](https://en.wikipedia.org/wiki/Carbon_dioxide#cite_note-NOAA-3) Natural sources include [volcanoes](https://en.wikipedia.org/wiki/Volcano), [hot springs](https://en.wikipedia.org/wiki/Hot_spring) and [geysers](https://en.wikipedia.org/wiki/Geyser) and it is freed from [carbonate rocks](https://en.wikipedia.org/wiki/Carbonate_rock) by [dissolution](https://en.wikipedia.org/wiki/Dissolution_(chemistry)) in water and acids. Since carbon dioxide is [soluble](https://en.wikipedia.org/wiki/Soluble) in water, it occurs naturally in [groundwater](https://en.wikipedia.org/wiki/Groundwater), [rivers](https://en.wikipedia.org/wiki/Rivers) and [lakes](https://en.wikipedia.org/wiki/Lakes), in [ice caps](https://en.wikipedia.org/wiki/Ice_caps) and [glaciers](https://en.wikipedia.org/wiki/Glaciers) and in seawater. It is present in deposits of [petroleum](https://en.wikipedia.org/wiki/Petroleum) and[natural gas](https://en.wikipedia.org/wiki/Natural_gas).[[4]](https://en.wikipedia.org/wiki/Carbon_dioxide#cite_note-4)

Atmospheric carbon dioxide is the primary source of carbon in life on Earth and its concentration in Earth's pre-industrial atmosphere since late in the [Precambrian](https://en.wikipedia.org/wiki/Precambrian) was regulated by [photosynthetic](https://en.wikipedia.org/wiki/Photosynthesis) organisms. As part of the [carbon cycle](https://en.wikipedia.org/wiki/Carbon_cycle), [plants](https://en.wikipedia.org/wiki/Plant), [algae](https://en.wikipedia.org/wiki/Algae), and [cyanobacteria](https://en.wikipedia.org/wiki/Cyanobacteria) use [light](https://en.wikipedia.org/wiki/Light) [energy](https://en.wikipedia.org/wiki/Energy) to [photosynthesize](https://en.wikipedia.org/wiki/Photosynthesis) [carbohydrate](https://en.wikipedia.org/wiki/Carbohydrate) from carbon dioxide and water, with oxygen produced as a waste product.[[5]](https://en.wikipedia.org/wiki/Carbon_dioxide#cite_note-5) Carbon dioxide is produced by plants during [respiration](https://en.wikipedia.org/wiki/Cellular_respiration).[[6]](https://en.wikipedia.org/wiki/Carbon_dioxide#cite_note-6)

Carbon dioxide (CO2) is a product of respiration of all [aerobic organisms](https://en.wikipedia.org/wiki/Aerobic_organisms). It is returned to water via the [gills of fish](https://en.wikipedia.org/wiki/Fish_physiology#Respiration) and to the air via the lungs of air-breathing land animals, including humans. Carbon dioxide is produced during the processes of [decay](https://en.wikipedia.org/wiki/Decomposition) of organic materials and the [fermentation](https://en.wikipedia.org/wiki/Fermentation) of sugars in [bread](https://en.wikipedia.org/wiki/Bread), [beer](https://en.wikipedia.org/wiki/Beer) and [winemaking](https://en.wikipedia.org/wiki/Wine). It is produced by combustion of [wood](https://en.wikipedia.org/wiki/Wood), [carbohydrates](https://en.wikipedia.org/wiki/Carbohydrate) and [fossil fuels](https://en.wikipedia.org/wiki/Fossil_fuel) such as coal, [peat](https://en.wikipedia.org/wiki/Peat), petroleum and natural gas.

It is a versatile industrial material, used, for example, as an inert gas in welding and fire extinguishers, as a pressurizing gas in air guns and oil recovery, as a chemical feedstock and in liquid form as a solvent in decaffeination of coffee and [supercritical drying](https://en.wikipedia.org/wiki/Supercritical_drying). It is added to drinking water and [carbonated beverages](https://en.wikipedia.org/wiki/Carbonated_beverage) including [beer](https://en.wikipedia.org/wiki/Beer) and [champagne](https://en.wikipedia.org/wiki/Champagne) to add sparkle. The frozen solid form of CO2, known as "[dry ice](https://en.wikipedia.org/wiki/Dry_ice)" is used as a refrigerant and as an abrasive in [dry-ice blasting](https://en.wikipedia.org/wiki/Dry-ice_blasting).

Carbon dioxide is an important [greenhouse gas](https://en.wikipedia.org/wiki/Greenhouse_gas). Burning of carbon-based fuels since the [industrial revolution](https://en.wikipedia.org/wiki/Industrial_revolution) has rapidly increased its concentration in the atmosphere, leading to [global warming](https://en.wikipedia.org/wiki/Global_warming). It is also a major cause of[ocean acidification](https://en.wikipedia.org/wiki/Ocean_acidification) since it dissolves in water to form [carbonic acid](https://en.wikipedia.org/wiki/Carbonic_acid).[[7]](https://en.wikipedia.org/wiki/Carbon_dioxide#cite_note-7)

# Water Analysis: Dissolved Carbon Dioxide (CO2)

Carbon Dioxide is present in water in the form of a dissolved gas. Surface waters normally contain less than 10 ppm free carbon dioxide, while some ground waters may easily exceed that concentration. Carbon dioxide is readily soluble in water. Over the ordinary temperature range (0-30 C) the solubility is about 200 times that of oxygen. Calcium and magnesium combine with carbon dioxide to form carbonates and bicarbonates.

Aquatic plant life depends upon carbon dioxide and bicarbonates in water for growth. Microscopic plant life suspended in the water, phytoplankton, as well as large rooted plants, utilize carbon dioxide in the photosynthesis of plant materials; starches, sugars, oils, proteins. The carbon in all these materials comes from the carbon dioxide in water.

When the oxygen concentration in waters containing organic matter is reduced, the carbon dioxide concentration rises. The rise in carbon dioxide makes it more difficult for fish to use the limited amount of oxygen present. To take on fresh oxygen, fish must first discharge the carbon dioxide in their blood streams and this is a much slower process when there are high concentration of carbon dioxide in the water itself.

# There are, however, circumstances when carbon dioxide levels can be relatively high and there is an increasing body of evidence to suggest that there are a number of ways in which CO2 can have an adverse effect on fish health.  Carbon dioxide levels of below 10mg/l are thought to be well tolerated by fish, although sensitivity to the gas varies between species. The level of CO2 in the water varies with the respiratory and photosynthetic activity of animals and plants in incoming water, the level of decomposition of organic material in that water (a very significant contributor to CO2 levels in some nutrient-rich waters), and the respiration of the fish themselves. CO2 can build up to significantly high levels in systems with large numbers of fish and relatively slow water turnover.  The effect of increased CO2 in water is to reduce the rate at which CO2 from the fish's own metabolism can be released from the blood through the gills, thus the CO2 in the blood also increases - this is known as hypercapnia - resulting in a drop in the blood pH, an acidosis. At the same time the oxygen-carrying ability of the haemoglobin in the blood is reduced.  So, what is the effect of this hypercapnia? In the short term the physiology of the fish can counteract the effect by balancing the acidosis with an exchange of ions such as increasing the uptake of bicarbonate and losing hydrogen and phosphate ions and little harm is done. In the long term this balancing act can have a more profound effect on the health of the fish.  Nephrocalcinosis in salmonids has long been recognised as a pathological entity related to high dissolved CO2, eventually leading to the formation of large mineralised deposits within the excretory tissue of the kidney and associated kidney pathology. The condition can result in poor condition and performance and occasional fish loss, particularly if other 'stressors' are present. The relationship between nephrocalcinosis and high CO2 is still not completely understood, but is likely to involve the excretion of minerals, particularly phosphorus and calcium, when compensating for blood acidosis.  Some of the work presented most elegantly at recent Alpharma conferences would also suggest that poor water quality in hatcheries and smolt units, particularly high CO2 and hypercapnia, may lead to an increased susceptibility of fish to pathogens which later leads to clinical disease with, for example, IPN. By paying appropriate attention to this aspect of water quality in the early rearing stages, this may reduce vulnerability to clinical disease.  Tony Wall, in a recent Fish Farming Today article (A is for Deformity) highlighted issues relating to spinal abnormalities. It has been postulated that bone demineralisation associated with hypercapnia may be playing a role in this and it is an area which needs to be rigorously investigated.  As mentioned earlier, CO2 is not the easiest of gases to monitor, standard laboratory methods are pretty complex, although there is a relatively easy titration method which is fairly accurate and could be carried out on the farm. CO2 meters tend to be costly and temperamental (insert wife joke here).  Do try to consider the effect of CO2 on your fish stocks. Remember that high levels of oxygen may not help either as the fish respiratory rate is governed by levels of oxygen, high O2 can slow the rate of elimination of CO2 from the blood, thus increasing the hypercapnia. By increasing levels of oxygen, you may just make things worse.  - See more at: http://www.thefishsite.com/articles/103/the-importance-of-measuring-carbon-dioxide-in-aquaculture/#sthash.1Bv7JNbY.dpufCarbon Dioxide

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| Carbon Dioxide exists in most natural waters. Carbon dioxide content is closely related to pH. PH decreases as carbon dioxide content increases and pH goes up as carbonate alkalinity goes up.  Carbon Dioxide exists at pH levels between 3.6 and 8.4. Carbon Dioxide cannot be found in water with a pH of 8.5 or higher. "The pH value is not a measurement of the amount of carbon dioxide in the water, but rather the relationship of carbon dioxide and bicarbonate alkalinity." (Enting Engineering Handbook.)  Carbon dioxide can be used as a means of controlling the pH of swimming pools, by continuously adding gas to the water, thus keeping the pH level from rising. Among the advantages of this is the avoidance of handling (more hazardous) acids. (Wikipedia.) |
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| Although carbon dioxide mainly consists in the gaseous form, it also has a solid and a liquid form. It can only be solid when temperatures are below -78 oC. Liquid carbon dioxide mainly exists when carbon dioxide is dissolved in water. Carbon dioxide is only water-soluble, when pressure is maintained. After pressure drops the CO2 gas will try to escape to air. This event is characterized by the CO2 bubbles forming into water. (Lenntech.)  Carbon dioxide is essential for internal respiration in a human body. Internal respiration is a process by which oxygen is transported to body tissues and carbon dioxide is carried away from them.  Carbon dioxide is a guardian of the pH of the blood, which is essential for survival. The buffer system in which carbon dioxide plays an important role is called the carbonate buffer. It is made up of bicarbonate ions and dissolved carbon dioxide, with carbonic acid. The carbonic acid can neutralize hydroxide ions, which would increase the pH of the blood when added. The bicarbonate ion can neutralize hydrogen ions, which would cause a decrease in the pH of the blood when added. Both increasing and decreasing pH is life threatening. (Lenntech.) |

**What are the main sources of carbon dioxide emissions?**

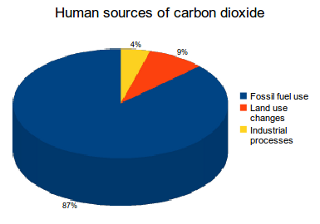
There are both natural and human sources of carbon dioxide emissions. Natural sources include decomposition, ocean release and respiration. Human sources come from activities like cement production, deforestation as well as the burning of fossil fuels like coal, oil and natural gas.

Due to human activities, the atmospheric concentration of carbon dioxide has been rising extensively since the Industrial Revolution and has now reached dangerous levels not seen in the last 3 million years.[1](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote1_drszohw) [2](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote2_4fmcx10) [3](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote3_3xj8rir) Human sources of carbon dioxide emissions are much smaller than natural emissions but they have upset the natural balance that existed for many thousands of years before the influence of humans.

**Human Sources**

Since the Industrial Revolution, human sources of carbon dioxide emissions have been growing. Human activities such as the burning of oil, coal and gas, as well as deforestation are the primary cause of the increased carbon dioxide concentrations in the atmosphere.

87 percent of all human-produced carbon dioxide emissions come from the burning of fossil fuels like coal, natural gas and oil. The remainder results from the clearing of forests and other land use changes (9%), as well as some industrial processes such as cement manufacturing (4%).[1](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote1_drszohw)

**Figure 1:****Source:**Le Quéré, C. et al. (2013). The global carbon budget 1959-2011.

**Fossil fuel combustion/use**

The largest human source of carbon dioxide emissions is from the combustion of fossil fuels. This produces 87% of human carbon dioxide emissions. Burning these fuels releases energy which is most commonly turned into heat, electricity or power for transportation. Some examples of where they are used are in power plants, cars, planes and industrial facilities. In 2011, fossil fuel use created 33.2 billion tonnes of carbon dioxide emissions worldwide.[1](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote1_drszohw)

The 3 types of fossil fuels that are used the most are coal, natural gas and oil. Coal is responsible for 43% of carbon dioxide emissions from fuel combustion, 36% is produced by oil and 20% from natural gas.[5](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote5_71aymju)

**Electricity/Heat sector**

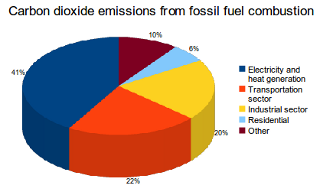
Electricity and heat generation is the economic sector that produces the largest amount of man-made carbon dioxide emissions. This sector produced 41% of fossil fuel related carbon dioxide emissions in 2010. Around the world, this sector relies heavily on coal, the most carbon-intensive of fossil fuels, explaining this sector giant carbon footprint.[5](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote5_71aymju)

**Transportation sector**

The transportation sector is the second largest source of anthropogenic carbon dioxide emissions. Transporting goods and people around the world produced 22% of fossil fuel related carbon dioxide emissions in 2010.[5](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote5_71aymju) This sector is very energy intensive and it uses petroleum based fuels (gasoline, diesel, kerosene, etc.) almost exclusively to meet those needs. Since the 1990s, transport related emissions have grown rapidly, increasing by 45% in less than 2 decades.[8](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote8_biignwr)

Road transport accounts for 72% of this sector's carbon dioxide emissions.[5](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote5_71aymju)Automobiles, freight and light-duty trucks are the main sources of emissions for the whole transport sector and emissions from these three have steadily grown since 1990. Apart from road vehicles, the other important sources of emissions for this sector are marine shipping and global aviation.

Marine shipping produces 14% of all transport carbon dioxide emissions. While there are a lot less ships than road vehicles used in the transportation sector, ships burn the dirtiest fuel on the market, a fuel that is so unrefined that it can be solid enough to be walked across at room temperature.[9](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote9_tdiqooj)Because of this, marine shipping is responsible for over 1 billion tonnes of carbon dioxide emissions.[10](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote10_ow13b4b) This is more than the annual emissions of several industrialized countries (Germany, South Korea, Canada, UK, etc.) and this sector continues to grow rapidly.

**Figure 2:****Source:** CO2 Emissions from Fuel Combustion (2012), International Energy Agency.

**Industrial sector**

The industrial sector is the third largest source of man-made carbon dioxide emissions. This sector produced 20% of fossil fuel related carbon dioxide emissions in 2010.[5](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote5_71aymju) The industrial sector consists of manufacturing, construction, mining, and agriculture. Manufacturing is the largest of the 4 and can be broken down into 5 main categories: paper, food, petroleum refineries, chemicals, and metal/mineral products. These categories account for the vast majority of the fossil fuel use and CO2 emissions by this sector.

**Land use changes**

Land use changes are a substantial source of carbon dioxide emissions globally, accounting for 9% of human carbon dioxide emissions and contributed 3.3 billion tonnes of carbon dioxide emissions in 2011.[1](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote1_drszohw) Land use changes are when the natural environment is converted into areas for human use like agricultural land or settlements. From 1850 to 2000, land use and land use change released an estimated 396-690 billion tonnes of carbon dioxide to the atmosphere, or about 28-40% of total anthropogenic carbon dioxide emissions.[13](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote13_wdqxcxz)

Since deforestation reduces the amount of trees, this also reduces how much carbon dioxide can be removed by the Earth's forests. When deforestation is done to create new agricultural land, the crops that replace the trees also act as a carbon sink, but they are not as effective as forests. When trees are cut for lumber the wood is kept which locks the carbon in it but the carbon sink provided by forests is reduced because of the loss of trees.

Deforestation also causes serious changes in how carbon is stored in the soil. When forested land is cleared, soil disturbance and increased rates of decomposition in converted soils both create carbon dioxide emissions. This also increases soil erosion and nutrient leaching which further reduces the area's ability to act as a carbon sink.

**Industrial processes**

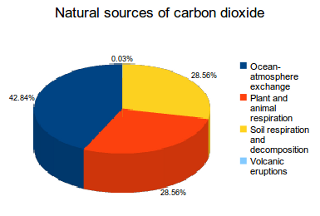
There are many industrial processes that produce significant amounts of carbon dioxide emissions as a by product of chemical reactions needed in their production process. Industrial processes account for 4% of human carbon dioxide emissions and contributed 1.7 billion tonnes of carbon dioxide emissions in 2011.[1](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote1_drszohw)

**Natural Sources**

Apart from being created by human activities, carbon dioxide is also released into the atmosphere by natural processes. The Earth's oceans, soil, plants, animals and volcanoes are all natural sources of carbon dioxide emissions.

Human sources of carbon dioxide are much smaller than natural emissions but they upset the balance in the carbon cycle that existed before the Industrial Revolution. The amount of carbon dioxide produced by natural sources is completely offset by natural carbon sinks and has been for thousands of years. Before the influence of humans, carbon dioxide levels were quite steady because of this natural balance.[4](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote4_at9icdi)

42.84 percent of all naturally produced carbon dioxide emissions come from ocean-atmosphere exchange. Other important natural sources include plant and animal respiration (28.56%) as well as soil respiration and decomposition (28.56%).[4](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote4_at9icdi) [16](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote16_3qnic6a) A minor amount is also created by volcanic eruptions (0.03%).[17](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote17_nxus0q7) [18](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote18_j78dxot)

**Figure 3:****Source:**IPCC Fourth Assessment Report: Climate Change 2007, Intergovernmental Panel on Climate Change.

**Ocean-atmosphere exchange**

The largest natural source of carbon dioxide emissions is from ocean-atmosphere exchange. This produces 42.84% of natural carbon dioxide emissions. The oceans contain dissolved carbon dioxide, which is released into the air at the sea surface. Annually this process creates about 330 billion tonnes of carbon dioxide emissions.[4](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote4_at9icdi) [16](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote16_3qnic6a)

Many molecules move between the ocean and the atmosphere through the process of diffusion, carbon dioxide is one of them. This movement is in both directions, so the oceans release carbon dioxide but they also absorb it. The effects of this movement can be seen quite easily, when water is left to sit in a glass for long enough, gases will be released and create air bubbles. Carbon dioxide is amongst the gases that are in the air bubbles.

**Plant and animal respiration**

An important natural source of carbon dioxide is plant and animal respiration, which accounts for 28.56% of natural emissions. Carbon dioxide is a byproduct of the chemical reaction that plants and animals use to produce the energy they need. Annually this process creates about 220 billion tonnes of carbon dioxide emissions.[4](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote4_at9icdi) [16](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote16_3qnic6a)

Plants and animals use respiration to produce energy, which is used to fuel basic activities like movement and growth. The process uses oxygen to break down nutrients like sugars, proteins and fats. This releases energy that can be used by the organism but also creates water and carbon dioxide as byproducts.

**Soil respiration and decomposition**

Another important natural source of carbon dioxide is soil respiration and decomposition, which accounts for 28.56% of natural emissions. Many organisms that live in the Earth's soil use respiration to produce energy. Amongst them are decomposers who break down dead organic material. Both of these processes releases carbon dioxide as a byproduct. Annually these soil organisms create about 220 billion tonnes of carbon dioxide emissions.[4](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote4_at9icdi) [16](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote16_3qnic6a)

Any respiration that occurs below-ground is considered soil respiration. Plant roots, bacteria, fungi and soil animals use respiration to create the energy they need to survive but this also produces carbon dioxide. Decomposers that work underground breaking down organic matter (like dead trees, leaves and animals) are also included in this. Carbon dioxide is regularly released during decomposition.

**Volcanic eruptions**

A minor amount carbon dioxide is created by volcanic eruptions, which accounts for 0.03% of natural emissions. Volcanic eruptions release magma, ash, dust and gases from deep below the Earth's surface. One of the gases released is carbon dioxide. Annually this process creates about 0.15 to 0.26 billion tonnes of carbon dioxide emissions.[17](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote17_nxus0q7) [18](http://whatsyourimpact.org/greenhouse-gases/carbon-dioxide-sources#footnote18_j78dxot)

- Used to products carbonated soft drinks and soda water.  
- Different candies are made from it.  
- Used as here are several different uses of carbon dioxide such as:

compressed gas for pneumatic systems  
- Used in fire extinguishers  
- Used in welding   
- It acts as a good solvent for lipophilic organic compounds.

The function of CO2 in  our lives is immeasurable:  
  
Humans use carbon dioxide in many different ways. The most familiar example is its use in soft drinks and beer, to make them   fizzy. Carbon dioxide released by baking powder or yeast makes cake batter rise.  
  Some fire extinguishers use carbon dioxide because it is denser than air. Carbon dioxide can blanket a fire, because of its heaviness. It prevents oxygen from getting to the fire and as a result, the burning material is deprived of the oxygen it needs to continue burning.  
  
  Carbon dioxide is also used in a technology called **lipholisation** extraction that is used to decaffeinate coffee. The solid form of carbon dioxide, commonly known as Dry Ice, is used in chemical experiments, etc, to chill usually in an acetone bath.  
Carbon dioxide is one of the most abundant gasses in the atmosphere, around ~21%. Carbon dioxide plays an important part in vital plant and animal process, such as photosynthesis and respiration. These processes will be briefly explained here.  
  Green plants convert carbon dioxide and water into food compounds, such as glucose, and oxygen. This process is called photosynthesis.  
  The reaction of photosynthesis is as follows:  6 CO2 + 6 H2O --> C6H12O6 + 6 O2  
Plants and animals, in turn, convert the food compounds by combining it   
  with oxygen to release energy for growth and other life activities. This   
  is the respiration process, the reverse of photosynthesis.  
  The respiration reaction is as follows: C6H12O6 + 6 O2 --> 6 CO2 + 6 H2O  
  Photosynthesis and respiration play an important role in the carbon cycle   
  and are at equilibrium with one another.