# There is more Oxygen in Dirt than in the Air We Breathe

Soil consists of many diverse elements including mineral particles (sand, silt and clay) that form a framework onto which humus and organic matter are bound. [Refer to http://www.montmorillonite.info/Page%202_abstract_soil.htm]

- These mineral particles of the soil matrix which help to define its structure and texture, constitute about 45% ± of the total soil volume.

- Organic matter makes up from between ½% to 5% as the active portion of the soil. Of this, about 4/5 is life-giving humus.

- The remaining 50% of the soil is occupied by pore spaces between the soil particles. These are filled with water and air.
  - Water and dissolved nutrients take up half of the pore spaces, or 25% of the total soil volume.
  - The remaining half of the pore spaces, or 25% of the soil volume, is actually air space that is filled with diverse gases from root respiration, organic matter decomposition and atmosphere exchange.

The 10 Most Abundant **Elements** in the Earth's Crust

http://education.jlab.org/glossary/abund_ele.html

Source: CRC Handbook of Chemistry and Physics, 77th Edition

| **Element** | Abundance **percent by weight** | Abundance **parts per million by weight** |
|---|---|---|
| **Oxygen**[1] | 46.100% | 461,000 |
| **Silicon** | 28.200% | 282,000 |
| **Aluminum** | 8.230% | 82,300 |
| **Iron** | 5.630% | 56,300 |
| **Calcium** | 4.150% | 41,500 |
| **Sodium** | 2.360% | 23,600 |
| **Magnesium** | 2.330% | 23,300 |
| **Potassium** | 2.090% | 20,900 |
| **Titanium** | 0.565% | 5,650 |
| **Hydrogen** | 0.140% | 1,400 |
| **All others combined** | 0.205% | Trace… |

[1] [Refer to http://www.chelatedtraceminerals.com/montmorillonite_minerals.html]

45% down, 55% to go: While the table above clearly shows Oxygen as the biggest single macro element present in the soil, this fact, however, refers largely to the mineral ingredients comprising the soil matrix itself. Thus, we can see almost half of the elements identified in soil particles are actually oxides—minerals comprised of Oxygen and some other element(s) that have reacted with one another (to form)—heterogeneous substances referred to by chemists as a "salts". Inasmuch as we have only accounted for some 45% of the soil's make-up thus far, let us turn our attention to the remaining 55%

Next 5%: Organic matter is essentially Carbon-based. If it is not Carbon-based what you are looking at is likely a mineral or a gas. At least it is inorganic. Animals and vegetables are made up to a great extent by Carbon, but also by other elements, including gases and mineralized elements. Animal life in the soil (i.e., nematodes, annelids, and insects, for example), also contains a high degree of Oxygen, both as a component of the water it is comprised of--just as human beings, and Oxygen within the further oxides making up the organisms' mineral composition, exclusive of Carbon. This animal life accounts for perhaps **10%** of the organic matter in the soil. [For an interesting breakdown of how much oxygen these creatures might contribute to the soil independently of the soil's mineral particulate matter, refer to http://www.montmorillonite.info/Element%20Table.htm ] Perhaps some **65%**, therefore, of the non-vegetable organisms make-up is accounted for by Oxygen. While the living organisms other than plant roots comprise only a fraction (1/20th) of the soil's organic matter which in turn is only a small fraction of the total make-up of the soil (up to 5%), nevertheless a substantial part of their physical constitution is, in fact once again, Oxygen. Living plant roots make up another $1/20^{th}$ of the organic matter in the soil. As everybody knows, during the day plants take in carbon dioxide (which contains Oxygen) for photosynthesis, but that resides principally in the plant parts above ground [www.wsu.edu/DrUniverse/**plant**2.html ]. In the roots themselves we are again probably looking at a significant amount of Oxygen both as a part of the water they uptake or in transit, and that comprises their flesh as well as the oxidized minerals uptaken and forming a part of plant root tissue.

Another 25%: Keep in mind that the volume of water and air space bear a direct reciprocal relationship with each other. Entrance of water into the soil excludes air, and as water is removed by drainage, evaporation or plant use, pore space that was occupied by water becomes refilled with air. Speaking of the liquid in the soil, besides water it contains particulate matter in suspension and in solution. A lot of this particulate matter whether organic or inorganic will contain Oxygen in the form of oxides. The water itself we know to be good old $H_20$, or two atoms of Hydrogen for every atom of Oxygen. But by volume Oxygen is the biggest component since an Oxygen atom is a little more than 15 times the weight of a Hydrogen atom. So, two thirds of water in the soil is Oxygen, and probably something like 45% of what is in suspension or solution as minerals, is also likely to be Oxygen.

The final 25%: We can probably assume that the gases in between the particles of clay, sand and silt fairly closely model the atmospheric gases of our earthly environment. That is to say, around 21% of the gas trapped in the soils pores is also Oxygen.

Atmosphere may be defined as that mixture of gases surrounding any celestial object that has a gravitational field strong enough to prevent the gases from escaping; especially the gaseous envelope of Earth. The principal constituents of the atmosphere of Earth are Nitrogen (78 percent) and Oxygen (21 percent). The atmospheric gases in the remaining 1 percent are Argon (0.9 percent), carbon dioxide (0.03 percent), varying amounts of water vapor, and trace amounts of Hydrogen, ozone, methane, carbon monoxide, Helium, Neon, Krypton, and Xenon. (Elements are capitalized, compound substances are not.) Note that ozone, carbon monoxide, carbon dioxide, etc., also contain Oxygen, but even with the Oxygen that these gases contain, they make up diminimous amounts of air.

## Major Gases in the Earth's Atmosphere

http://scifun.chem.wisc.edu/CHEMWEEK/Airgases/airgases.html

| Element | Percentage of air |
|---|---|
| **Nitrogen** | 78.00 % |
| **Oxygen** | 21.00 % |
| **Argon** | .90 % |
| **Carbon Dioxide** | .03 % |
| **Water Vapor** | Varies daily |
| **Hydrogen** | Trace |
| **Ozone** | Trace |
| **Carbon Monoxide** | Trace |
| **Helium** | Trace |
| **Neon** | Trace |
| **Krypton** | Trace |
| **Xenon** | Trace |

In conclusion, all the Oxygen deep down in the earth, within its crust or surrounding us in the atmosphere was created, or brought to our environment billions of years ago. It joined with various other elements and became a building block of many diverse substances. Nothing today creates Oxygen, but forces and organisms are at work to release Oxygen from other compounds so that we can enjoy "free" Oxygen, i.e., that not bound up with other substances or gases as in the air we breathe. So, as you can see, there really is more Oxygen in the dirt we walk upon than in the air we breathe. Let's review:

| Make-up of soil class by percentage | | % of Oxygen by class | Net contribution |
|---|---|---|---|
| Inorganic Oxides / minerals | = 45% | x 46% | = 20.70% |
| Organic life in soil | = 5% | x 10% x 65% | = .32% |
| Water in soil pores | = 25% | x 88% (by weight) | = 22.06% |
| Atmospheric air in pores | = 25% | x 21% | = 5.25% |
| **TOTAL** | = 100% | | **48.33%** |

Final Score, Oxygen Totals: **Air 21%** **Dirt 48.33%**

The balance of this article represents quotes and ideas taken from:
http://encarta.msn.com/encyclopedia_761559991/Atmosphere.html

The mixture of gases in the air today has had 4.5 billion years in which to evolve—perhaps not that much younger than the earth itself. Some of these same gases became trapped in minerals due to chemical bonding and the processes of ionization. The earliest atmosphere must have consisted of volcanic emanations alone.

Gases that erupt from volcanoes today, however, are mostly a mixture of water vapor, carbon dioxide, sulfur dioxide, and nitrogen, however with almost no free Oxygen. If this is the same mixture that existed in the early atmosphere, then various processes would have had to operate to produce the mixture we have today. One of these processes was condensation. As it cooled, much of the volcanic water vapor condensed to fill the earliest oceans. Chemical reactions would also have occurred. Some carbon dioxide would have reacted with the rocks of Earth's crust to form carbonate minerals, and some would have become dissolved in the new oceans. Later, as primitive life capable of photosynthesis evolved in the oceans, new marine organisms began producing, perhaps better stated, releasing Oxygen—that is, freeing it from compounds and molecules containing it. Almost all the free Oxygen in the air today is believed to have formed by photosynthetic combination of carbon dioxide with water. About 570 million years ago, the Oxygen content of the atmosphere and oceans became high enough to permit marine life capable of respiration. Later, some 400 million years ago, the atmosphere contained enough Oxygen for the evolution of air-breathing land animals.

The water-vapor content of the air varies considerably, depending on the temperature and relative humidity. With 100 percent relative humidity, the water-vapor content of air varies from 190 parts per million (ppm) at -40°C (-40°F) to 42,000 ppm at 30°C (86°F). Minute quantities of other gases, such as Ammonia, hydrogen sulfide, and oxides of Sulfur and Nitrogen, are temporary constituents of the atmosphere in the vicinity of volcanoes and are washed out of the air by rain or snow. Oxides and other pollutants added to the atmosphere by industrial plants and motor vehicles have become a major concern, however, because of their damaging effects in the form of acid rain. In addition, the strong possibility exists that the steady increase in atmospheric carbon dioxide, mainly as the result of the burning of fossil fuels since the mid-1800s, may affect Earth's climate (*see* Greenhouse Effect).

Similar concerns are posed by the sharp increase in atmospheric methane. Methane levels have risen 11 percent since 1978. About 80 percent of the gas is produced by decomposition in rice paddies, swamps, and the intestines of grazing animals, and by tropical termites. Human activities that tend to accelerate these processes include raising more livestock and growing more rice. Besides adding to the greenhouse effect, methane reduces the volume of atmospheric hydroxyl ions, thereby curtailing the atmosphere's ability to cleanse itself of pollutants. *See also* Air Pollution; Climate; Smog.

See also, article, "There is more Nitrogen in the Air we breathe than in Fertilizer".