SolEco
"Solutions Ecologique"

BioChar, Solutek and Soil Rejuvenation.

"It is impossible to overestimate the importance of microbiological action in soils."

F. B. Smith - Florida Agricultural Experiment Station, Gainesville.

Soil rejuvenation and revival through the addition of organic materials and matter that promotes microbial action within the soil, and further assists with the sequestration of CO_2 in the soil, are now becoming extremely important areas of development of a natural path to soil fertility and increased production of fruit and vegetables.

The use of such organic stimulants may increase the effectiveness of other fertilisers by as much as twenty-five (25) percent but in observations that increase of effectiveness is always at least five to ten percent (5% to 10%).

Solutek is a 100% fully and natural organic solution that massively promotes and causes the rapid growth of, beneficial, naturally occurring bacteria that when added to soil, increases microbial activity; when added to clay soils Solutek helps promote the breakdown of the clay and encourages the formation of friable soil.

The use, in a combination of BioChar and Solutek, acts to increase soil fertility, rejuvenates and revives the soil, to promote a better quality of crops and an increase in crop yield, as well as assisting in the uptake by root systems of man-made fertilisers, thus reducing costs to farmers.

BioChar is charcoal used as a soil amendment. **BioChar** is a stable solid, rich in carbon, and can endure in soil for thousands of years. Like most charcoal, **BioChar** is made from biomass via pyrolysis.

Biochar - Wikipedia

https://en.wikipedia.org/wiki/Biochar

Biochar can be distinguished from charcoal - **used** mainly as a fuel - in that a primary application is use as a soil amendment with the intention to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong

Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com

Phone: +61 3 5221 0779
Soleco-technology.com

[Frequently Asked Questions about Biochar | International Biochar ...]

www.biochar-international.org/biochar/faqs

Soil amendments are materials which are worked into the **soil** to enhance the **soil's** properties. Examples would include organic matter such as compost, manure, bone meal or leaf mould, as well as synthetic fertilisers.

Biochar is a solid material obtained from the carbonisation thermochemical conversion of biomass in an oxygen-limited environment. In more technical terms, biochar is produced by thermal decomposition of organic material (biomass such as wood, manure or leaves) under limited supply of oxygen (O_2), and at relatively low temperatures (<700°C). This process mirrors the production of charcoal, which is perhaps the most ancient industrial technology developed by humankind. Biochar can be distinguished from charcoal - used mainly as a fuel - in that a primary application is use as a soil amendment with the intention to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases.

What can biochar do?

Sustainable biochar is a powerfully simple tool that can 1) fight global warming; 2) produce a soil enhancer that holds carbon and makes soil more fertile; 3) reduce agricultural waste; and 4) produce clean, renewable energy. In some biochar systems, all four objectives can be met, while in others a combination of two or more objectives will be obtained.

How is biochar produced?

Carbonisation is the process of converting a feedstock into biochar through reductive thermal processing. The process involves a combination of time, heat and pressure exposure factors that can vary between processors, equipment, and feedstocks. There are two main processes: pyrolysis or gasification. Energy products in the form of gas or oil are produced along with the biochar. These energy products may be recoverable for another use, or may simply be burned and released as heat. In addition, biochar can be made from a wide variety of biomass feedstocks. As a result, different biochar systems emerge on different scales. These systems may use production technologies that do or do not produce recoverable energy as well as biochar, and range from small household units to large bioenergy power plants.

How do we know that biochar helps increase crop yields?

There is a large body of peer-reviewed literature quantifying and describing the crop yield benefits of biochar-amended soil. Field trials using biochar have been conducted in the tropics over the past several years. Most show positive results on yields when biochar was applied to field soils and nutrients were managed appropriately.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong

Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com

Phone: +61 3 5221 0779
Soleco-technology.com

There is also evidence from thousands of years of traditional use of charcoal in soils. The most well-known example is the fertile *Terra Preta* soils in Brazil, but Japan also has a long tradition of using charcoal in soil; a tradition that is being revived and has been exported over the past 20 years to countries such as Costa Rica. The Brazilian and Japanese traditions together, provide long-term evidence of positive biochar impact on soils.

The larger questions concerning overall biochar benefits to soils and climate have been answered in the affirmative.

How can biochar help farmers?

Biochar provides a unique opportunity to improve soil fertility for the long term using locally available materials. Used alone, or in combinations, compost, manure and / or agrochemicals are added at certain rates every year to soils, in order to realise benefits. Application rates of these can be reduced when nutrients are combined with biochar. Biochar remains in the soil, and single applications can provide benefits over many years.

Farmers can also receive an energy yield when converting organic residues into biochar by capturing energy given off in the biochar production process. In both industrialised and developing countries, soil loss and degradation is occurring at unprecedented rates, with profound consequences for soil ecosystem properties. In many regions, loss in soil productivity occurs despite intensive use of agrochemicals, concurrent with adverse environmental impacts on soil and water resources. Biochar can play a major role in expanding options for sustainable soil management by improving upon existing best management practices, not only to improve soil productivity but also to decrease nutrient loss through leaching by percolating water.

How does biochar affect soil biology?

Decades of research in Japan and recent studies in the U.S., have shown that biochar stimulates the activity of a variety of agriculturally important soil microorganisms and can greatly affect the microbiological properties of soils. The pores in biochar provide a suitable habitat for many microorganisms by protecting them from predation and drying, while providing many of their diverse carbon (C), energy and mineral nutrient needs. With the interest in using biochar for promoting soil fertility, many scientific studies are being conducted to better understand how this affects the physical and chemical properties of soil and its suitability as a microbial habitat. Since soil organisms provide a myriad of ecosystem services, understanding how adding biochar to soil may affect soil ecology is critical for assuring that soil quality and the integrity of the soil subsystem are maintained.

How does biochar affect soil properties like pH and CEC?

Biochar reduces soil acidity which decreases liming needs but, in most cases, does not actually add nutrients in any appreciable amount. Biochar made from manure and bones is the exception; it retains a significant amount of nutrients from its source.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong
Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com
Phone: +61 3 5221 0779
Soleco-technology.com

Because biochar attracts and holds soil nutrients, it potentially reduces fertiliser requirements. As a result, fertilisation costs are minimised and fertiliser (organic or chemical) is retained in the soil for longer. In most agricultural situations worldwide, soil pH (a measure of acidity) is low (a pH below 7 means more acidic soil) and needs to be increased. Biochar retains nutrients in soil directly through the negative charge that develops on its surfaces, and this negative charge can buffer acidity in the soil, as does organic matter in general.

CEC stands for Cation Exchange Capacity, and is one of many factors involved in soil fertility. "Cations" are positively charged ions, in this case we refer specifically to plant nutrients such as calcium (Ca^{2+}), potassium (K^+), magnesium (Mg^{2+}) and others. These simple forms are those in which plants take the nutrients up through their roots. Organic matter and some clays in soil, hold on to these positively charged nutrients because they have negatively charged sites on their surfaces and opposite charges attract. The soil can then "exchange" these nutrients with plant roots. If a soil has a low cation exchange capacity, it is not able to retain such nutrients well, and the nutrients are often washed out with water.

Can you add biochar to alkaline soils?

Most biochar trials have been done on acidic soils, where biochar's with a high pH (e.g. 6 – 10) were used. One study that compared the effect of adding biochar to an acidic and an alkaline soil found greater benefits on crop growth in the acidic soil, while benefits on the alkaline soil were minor. In another study, adding biochar to soil caused increases in pH which had a detrimental effect on yields, because of micronutrient deficiencies which occur at high pH (>6). Care must be taken when adding any material with a liming capacity to alkaline soils; however, it is possible to produce biochar that has little or no liming capacity that is suitable for alkaline soils.

How long does biochar persist in the soil?

Biochar is a spectrum of materials, and its characteristics vary depending upon what it is made from and how it is made. One unifying characteristic of biochars, however, is that it mineralises in soils much more slowly than its uncharred precursor material (feedstock). Most biochars do have a small labile (easily decomposed) fraction of carbon but there is typically a much larger recalcitrant (stable) fraction. Scientists have shown that the mean residence time (the estimated amount of time that biochar carbon will persist in soils) of this recalcitrant fraction ranges from decades to millennia.

Why is biochar persistence in soils important?

The persistence of biochar when incorporated into soils is of fundamental importance in determining the environmental benefits of biochar for two reasons: first, it determines how long carbon in biochar will remain sequestered in soil and contribute to the mitigation of climate change; and second, it determines how long biochar can provide benefits to soil and water quality.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong

Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com

Phone: +61 3 5221 0779
Soleco-technology.com

How much carbon can biochar potentially remove from the atmosphere?

According to one prominent study (Woolf et al, 2010), sustainable biochar implementation could offset a maximum of 12% of anthropogenic GHG emissions on an annual basis. Over the course of 100 years, this amounts to a total of roughly 130 petagrams (106 metric tons) of CO_2-equivalents. The study assessed the maximum sustainable technical potential utilising globally available biomass from agriculture and forestry. The study assumed no land clearance or conversion from food to biomass-crops (though some dedicated biomass-crop production on degraded, abandoned agricultural soils was included), no utilisation of industrially treated waste biomass, and biomass extraction rates that would not result in soil erosion.

How does biochar work to reduce emissions of greenhouse gases other than CO_2?

Recent studies have indicated that incorporating biochar into soil reduces nitrous oxide (N_2O) emissions and increases methane (CH_4) uptake from soil. Methane is over 20 times more effective in trapping heat in the atmosphere than CO_2, while nitrous oxide has a global warming potential that is 310 times greater than CO_2. Although the mechanisms for these reductions are not fully understood, it is likely that a combination of biotic and abiotic factors are involved, and these factors will vary according to soil type, land use, climate and the characteristics of the biochar. An improved understanding of the role of biochar in reducing non-CO_2 greenhouse gas (GHG) emissions will promote its incorporation into climate change mitigation strategies, and ultimately, its commercial availability and application.

Biochar can be a tool for improving soils and sequestering carbon in soil. However, this technology, as any other, must be implemented in a way that respects the land rights of indigenous people and supports the health of natural ecosystems. The goal of biochar technology as IBI envisions it, is to improve soil fertility and sequester carbon, taking into consideration the full life cycle analysis of the technology. Properly implemented, biochar production and use should serve the interests of local people and protect biodiversity.

Can I use biochar immediately after producing it?

Biochar straight out of the pyrolysis unit might take some time to reach its full potential in soil, because it needs its surfaces to "open up", or "weather". This happens naturally in soil, but the process can be sped up by mixing biochar with compost, for example. Nutrient retention with biochar is thought to improve with time, along with crop benefits. Mixing biochar with compost is a great idea, since apart from the ash (and there might only be small amounts of it in biochar), biochar is not a fertiliser in itself so the compost can provide nutrients which the biochar can help retain.

International bio-char organization.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong

Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com

Phone: +61 3 5221 0779
Soleco-technology.com

MICROBIAL ACTION in Soil Rejuvenation.

Key points

- Soil fertility depends on three major interacting components: biological, chemical and physical fertility.
- Soil organisms improve soil fertility by performing a number of functions that are beneficial for plants
- Some management practices may help improve and maintain the biological fertility of soil.

Releasing nutrients from organic matter

Soil microorganisms are responsible for most of the nutrient release from organic matter. When microorganisms decompose organic matter, they use the carbon and nutrients in the organic matter for their own growth. They release excess nutrients into the soil where they can be taken up by plants. If the organic matter has a low nutrient content, micro-organisms will take nutrients from the soil to meet their requirements.

For example, applying organic matter with carbon-to-nitrogen ratios lower than 22:1 to soil, generally increases mineral nitrogen in soil. In contrast, applying organic matter with carbon-to-nitrogen ratios higher than 22:1, generally results in microorganisms taking up mineral nitrogen from soil (Hoyle *et al.* 2011).

Fixing atmospheric nitrogen

Symbiotic nitrogen fixation is a significant source of nitrogen for Australian agriculture and may account for up to 80% of total nitrogen inputs (Unkovich 2003). In the symbiosis, rhizobia or bradyrhizobia fix nitrogen gas from the atmosphere and make it available to the legume. In exchange, they receive carbon from the legume. The symbiosis is highly specific and particular species of rhizobia and bradyrhizobia are required for each legume. For more information see fact sheet "Legumes and Nitrogen Fixation".

Increasing phosphorus availability

Most agricultural plants (except lupins and canola) form a symbiosis with arbuscular mycorrhizal (AM) fungi that can increase phosphorus uptake by the plant. The hyphal strands of AM fungi extend from plant roots into soil and have access to phosphorus that plant roots cannot reach. The AM fungi can provide phosphorus to plants and in return they receive the carbon they need to grow.

Importantly, this symbiosis is only beneficial for plants when available phosphorus in soil is insufficient for the plant's requirements. Increasing phosphorus availability may be especially beneficial on phosphorus fixing soils in Australia, which are widespread and can store 100 kilograms of phosphorus per hectare (Cornish 2009).

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong

Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com

Phone: +61 3 5221 0779
Soleco-technology.com

Degrading pesticides

The degradation of agricultural pesticides in soil is primarily performed by microorganisms. Some microorganisms in soil produce enzymes that can break down agricultural pesticides or other toxic substances added to soil. The length of time these substances remain in soil is related to how easily they are degraded by microbial enzymes.

Controlling pathogens

Some microorganisms and soil animals infect plants and decrease plant yield. However, many organisms in the soil control the spread of pathogens. For example, the occurrence of some pathogenic fungi in soil is decreased by certain protozoa that consume the pathogenic fungi. The soil food web contains many relationships like this that decrease the abundance of plant pathogens.

Improving soil structure

Biological processes in soil can improve soil structure. Some bacteria and fungi produce substances during organic matter decomposition that chemically and physically bind soil particles into micro-aggregates. The hyphal strands of fungi can cross-link soil particles, helping to form and maintain aggregates. A single gram of soil can contain several kilometres of fungal hyphae (Young and Crawford 2007). In addition, soil animals increase pores by tunnelling through soil and increase aggregation by ingesting soil.

Further reading and references

Cornish PS (2009) Phosphorus management on extensive organic and low-input farms. Crop & Pasture Science **60:** 105 – 115.

Young IM and Crawford JW (2004) Interactions and self-organisation in the soil-microbe complex. Science **304:** 1634 – 1637.

Hoyle FC, Baldock JA and Murphy DV (2011) 'Soil organic carbon – Role in rainfed farming systems: with particular reference to Australian conditions', in Rainfed farming systems, Springer Science-Business Media BV, Netherlands.

Unkovich (2003) 'David and Goliath: Symbiotic nitrogen fixation and fertilisers in Australian agriculture', *Proceedings of the 12th Australian nitrogen fixation conference.* Glenelg, SA Sep 2003.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong

Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com

Phone: +61 3 5221 0779
Soleco-technology.com

What beneficial processes do soil microbes carry out?

Soil microbes are of paramount importance in cycling nutrients such as carbon (C), nitrogen (N), phosphorus (P), and sulphur (S). Not only do they control the forms of these elements [e.g. specialized soil bacteria convert ammonium N (NH_4^+) to nitrate N (NO_3^-)], they can regulate the quantities of N available to plants. This is especially critical in systems relying on organic fertilisers. **It is only through the actions of soil microbes that the nutrients in organic fertilisers are liberated for plants and use by other microbes.** Soil microbiologists call this process **mineralisation** [the conversion of organic complexes of the elements to their inorganic forms, e.g., conversion of proteins to carbon dioxide (CO_2), ammonium (NH_4^+) and sulphate ($SO_4^=$)]. It is perhaps the single-most important function of soil microbes as it recycles nutrients tied up in organic materials back into forms useable by plants and other microbes. In fact, the so-called Principle of Microbial Infallibility (popularized by Dr. Martin Alexander of Cornell University) states that for every naturally occurring organic compound there is a microbe or enzyme system that can degrade it. Note that this applies to naturally occurring compounds.

It is obvious that some our persistent pesticides did not conform to this principle and even some naturally occurring compounds are fairly resistant to microbial attack. It is through the process of mineralisation that crop residues, grass clippings, leaves, organic wastes, etc., are decomposed and converted to forms useable for plant growth, as well as converted to stable soil organic matter called **humus**. Herein lies another important role for the larger soil animals like earthworms. The large organisms function as **grinders** in that they reduce the particle size of organic residues, making them more accessible and decomposable by the soil microbes. The soil microbial population also further decomposes the waste products of the larger animals. Thus, the activities of different groups of soil organisms are linked in complex "food webs".

One beneficial process carried out exclusively by soil microbes is called **nitrogen fixation**, the capture of inert N_2 gas (dinitrogen) from the air for incorporation into the bodies of microbial cells. In one well-known form of this process, symbiotic nitrogen fixation, soil bacteria such as Rhizobium and Bradyrhizobium actually inhabit specialised structures on the roots of leguminous plants (soybeans, cowpeas, beans, clovers, etc.) where they fix substantial quantities of nitrogen that becomes available to the host plant. Unfortunately, the root nodule system is not found in the grasses so we cannot rely on it for "free" nitrogen. Nevertheless, free-living (nonsymbiotic) nitrogen-fixing bacteria do associate with roots of grasses where they fix small quantities of nitrogen using carbon compounds (root exudates, sloughed root cells, etc.) produced from the roots as energy sources to drive the energy-expensive nitrogen-fixing enzyme system. Another factor limiting the utility of free-living N_2 fixers is the fact that they will not fix N_2 when exposed to even very low levels of fertiliser nitrogen. Thus, in fertile turfgrass soils this process is of limited importance, whereas in unfertilised prairie soils the 10 to 25 pounds of N fixed per acre per year is ecologically relevant.

SolEco Limited:
1901-2 Park-in Commercial Center
56 Dundas St., Kowloon, Hong Kong
Administration and Sales:
Level 1 - 343 Pakington St., Newtown,
Australia 3220 - info@soleco-technology.com
Phone: +61 3 5221 0779
Soleco-technology.com

Another benefit of soil microbes is their ability to degrade pest control chemicals and other hazardous materials reaching the soil. Thus, through the actions of the soil microflora, pesticides may be degraded or rendered nontoxic, lowering their potential to cause environmental problems such as ground and surface water contamination.

Of course, there is a "downside" to this microbial capability. In some instances, soil microbes have been shown to degrade soil-applied pesticides so rapidly as to reduce the ability of the chemicals to control the target pests. This phenomenon is known as **enhanced degradation** and usually results from repeated applications of a chemical to the soil. One way around this problem is to vary the use of pest control chemicals.

DAVID A. ZUBERER - TEXAS A&M UNIVERSITY

BioChar and **Solutek**, working together where possible, promote increased yields and soil fertility.

Solutek, when added to irrigation water, provides for a massive increase in positive microbial action in any and all soils.

For all enquiries please contact…

U.S.A. enquiries: mark.cohen@soleco-technology.com

Global enquiries: pettman@soleco-technology.com