A simple mixture of organic waste, such as chicken manure and zeolite , a porous volcanic mineral, has been developed into a powerful bio-fertiliser which can also reclaim semi-arid and contaminated land.

Food and biofuel crops can now be grown and sustained in many places where it wasn't previously possible, such as deserts, former mining sites, and marginal land thanks to an inexpensive, non-chemical soil additive that functions biologically.

The additive, a simple mixture of organic waste, such as chicken manure, and natural zeolite, a porous volcanic mineral, can be used to support agriculture in both the developed and developing world, while avoiding the serious environmental consequences associated with the overuse of traditional chemical fertilisers. The mixture permits a controlled slow release of nutrients and the regulation of water, providing an ideal environment for growing crops.

Plant growth experiments have been conducted at the Botanic Garden, University of Cambridge and a new approach to plant nutrition has been developed. Peter J. Leggo , working in the Department of Earth Sciences, University of Cambridge, has together with colleagues demonstrated that with the addition of the bio-fertiliser, biofuel crops can be successfully grown and – more importantly, sustained - even on acid sulphide wine waste , coal waste and metal refinery residues.

The above picture shows Oil Seed Rape (*Brassica napus*) growing in acid sulphide mine waste from a site near Fron Goch in Central Wales. This site is completely barren of vegetation due to the high concentration of base metals and the acidity of the waste pore water. Plants in the left hand pot are growing in un-amended waste and plants in right hand pot are growing in waste amended with the bio-fertilizer. The plants were grown synchronously under identical green-house conditions.

Using coal waste from the site of a demolished colliery at Calverton in Nottinghamshire as a substrate, the researchers grew rapeseed, flax, sugar beet and maize, using the bio-fertilizer as an amendment.

The plants grown in the amended coal waste were found to be very much larger and lusher than those grown in the un-amended coal waste. This difference occurred in all the plant species.

The coal waste contains chemical elements that can be ionised by the bio-fertiliser, making essential nutrients available for uptake by the plants. As the organic waste in the mixture decomposes, it produces ammonium ions which are adsorbed by the zeolite. When the mixture is added to soil, it boosts the population of micro-organisms responsible for nitrification, which is essential for plant nutrition. The bio-fertiliser also helps plants develop dense root systems which stabilise the soil against erosion.

In addition to the coal waste, the team is working with marginal soils, such as those in desert climates, which normally require large amounts of water and chemical fertilisers in order for plants to grow. Control experiments have shown that water held in the zeolite increases the moisture content of soil in desert conditions. After initial watering, early-morning dew is held in the pores of the zeolite and released during the hottest part of the day. Plants grown with the bio-fertiliser achieve greater weight, and in the case of fruits and vegetables, a better taste, than those grown with chemical fertilisers.

Nitrogen is critical for crop development, yet is deficient in many types of soil. Over the past century, chemical fertilisers have been used to increase nitrogen levels and crop yields, helping global food supply keep pace with population growth. However, this has come at a cost as they are detrimental to long-term soil health. Without a regular input of organic matter, soil microbial diversity decreases and the carbon concentration is lowered. The overuse of chemical fertilisers causes the soil to lose both its ability to hold water and its overall structure, leading to greater runoff and groundwater pollution. Nitrogen-rich fertiliser runoff is the primary cause of oxygen depletion in oceans, lakes and rivers, leading to aquatic 'dead zones.'

"The application of the bio-fertilizer is a whole new approach to plant nutrition," says Dr Peter Leggo of the Department of Earth Sciences, who developed the material. "Previously, you'd douse crops with chemicals, and it has caused a huge reduction in soil microbial diversity and a loss of soil organic matter". It has reached the stage that in certain parts of North America enormous dust bowls have developed as a consequence. The material we've developed takes less energy to produce, improves soil structure and enables the growth of crops on almost any type of soil."

The team has plans to commercialise the material where there are large deposits of zeolite, and export it to other markets. There are also plans to collaborate with charities and social enterprises to create sustainable farmland for small hold farmers in the developing world.

The development of the biological fertilizer including a full account of the geological, mineralogical and plant growth experiments are given in "The Properties and Function of the Organo-Zeolitic Bio-fertilizer" published by LAP Lambert Academic Publishing Company, Saarbrücken, Germany.

Dr Peter Leggo
E: leggo@esc.cam.ac.uk