Microbial Balancing in Agriculture

A new direction in soil and water management

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Part A Background

ENVIRONMENTAL RESEARCH & INFORMATION CONSORTIUM

ERIC Background

- ERIC was established in February 1992
- Received numerous honors and awards for R&D and innovation in environmental information technologies
- Australia's leading company in the development and application of remotely sensed data for resource assessment
- Formed Healthy Soils Australia in 2005
- Advocate for biological farming

Presentation Outline

- The secret life of soils
- Microbial balancing described
- Microbe populations
- Microbial balancing in the making
- Microbial balancing in the web of life
- Microbe uses
- Microbial balancing products for agriculture
- Microbial balancing in agriculture
- Microbial balancing in water and waste applications
- Microbial balancing in animal production
- Conclusion

Presentation purpose

- The purpose of this presentation is to outline the reasons and benefits for using microbial balancing: an organic liquid fertiliser to improve soil fertility and plant production
- Microbial balancing is a specific process to provide the necessary microbes and nutrients to restore unhealthy and degraded soils.
- Soil life is a balanced microbial population and complete soil food web that is critical to soil health, resilience in plant production and animal health.

The Secret

Sustainable agriculture

- Agriculture is sustainable when the enterprise is profitable and natural resources of the farm are healthy.
- The secret to sustainable farming is to create and maintain a biologically active, living soil with balanced, abundant and a diverse population of microbes.
- Healthy, living soils provide healthy plants, animals and humans.

Philosophic differences to soils

- Conventional agriculture treats soils as a hydroponic medium
  - provides support for plants and a store for applied water and nutrients
- Deficiencies are addressed in a piecemeal fashion as they arise or are discovered
  - teats soil nutrition similarly to a disease
  - creates a cycle of a need for new inputs to redress adverse impacts of past inputs
- Addressing soil biology seeks to create good soil health
  - good health is more than being free of known diseases
- Uses natural soil processes to improve plant nutrition and control pathogens

The soil environment

- All microbes must have a safe, hydrated and nutritious environment
- Avoid activities that desecrate the soil (eg. tillage, chemical fertilisers, bare soil, compaction, overgrazing, etc
- Keep the microbe *pantry* full of food, eg. organic matter, organic minerals, etc.
- Improve soil structure (friability) to allow oxygen and water infiltration
- Most agricultural soils lack the fungi to produce the fulvic and humic acids that are essential to the life of microbes, water retention and nutrient building

Benefits of soil organic matter

- Increases the aggregation of soil particles
- Greatly increases the stability of soil aggregates
  - increases the permeability to air and water
  - usually increases the available soil water storage
  - decreases water loss through runoff and direct evaporation
- Increases the retention of nutrients
- Improves nutrient availability to plants (buffers a neutral pH)
- Provides food and a favourable environment for microbes
  - increases nutrient recycling
  - provides new nutrients (increases the nutrient supply)
  - protect plants against pathogens

How to create a healthy soil

- Inoculate the soil with a balanced population of microbes
- Increase % volume of soil organic matter to greater than 2% and preferably 4-5%.
- Minimise tillage (ie, minimal till)
- Sustain a perennial grass cover (even on cropping areas) and avoid bare soil
- Avoid excessive use of inorganic or chemical fertilisers and sprays
- Avoid excessive burning of stubble and grasses

Plant health principles

- Plants have evolved to be healthy
  - Genetic variability allows plants to adapt to variability in the environment.
- All components of the plant-soil system are interconnected
  - Anything that affects one part directly or indirectly affects all other parts
- Under natural conditions, plant-soil systems evolve and are self-regulating
- Harmful insects and disease are the result of weak or unbalanced soil-plant systems
- Plants need a continuous flow of balanced nutrients for ideal growth of fruit and seed.
- Energy drives the plant-soil system (ie. sunlight, magnetic and paramagnetic, chemical and biological).

Benefits of biological farming

- More nutritious plants and healthier animals
- Increased profitability and sustained production
- Increased soil hydration or soil water reservoirs
- Less disease in plants and animals
- Improved occupational, health and safety for farm workers
- Lower costs to rectify problems
- Greater drought resilience
- Remediation of soil acidity, salinity, mineral toxicity, compaction and erosion.

Microbial Balancing Described

Microbial balancing formulations

- VRM Microbial balancing products use liquid mixtures of beneficial micro-organisms
- The microbial populations contain four main groups of organisms:
  - Photosynthetic organisms (both anaerobic and aerobic)
  - Lactobacillus (Lactic acid bacteria)
  - Yeasts
  - Specialist organisms with specific functions
- Microbial balancing provides the building blocks for cell development in plants, animals and humans.

Effective Micro-organism (EM) development

- EM was developed by Dr Terou Higa (Professor of Horticulture, University of Ryukyus, Okinawa), Japan in 1980's
- EM is firmly established under an EM licence agreement in Asia, Europe, USA and Australia
- There is ongoing collaborative research by EM Research Organisation (EMRO) in Japan and other collaborators across the globe.
- VRM (www.vrm.com.au) is a world leader with other collaborators in EM research, developments and innovations

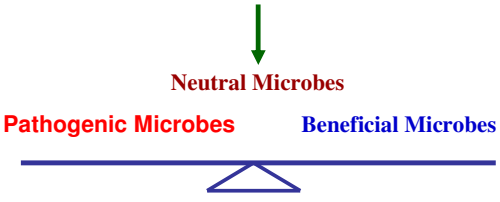
Microbial Populations

The microbial world

- The habitat for micro-organisms is everywhere
  - in the atmosphere (known at 10km high)
  - on the surface of the Earth
  - within the Earth (occurs in rock at 3km depth)
- Everything once living or alive will be consumed by microbial decomposers at some time
- Every kind of microbe occurs where plants, insects, animals and humans exist
- Every surface is a home for microbes

Micro-organisms in soils

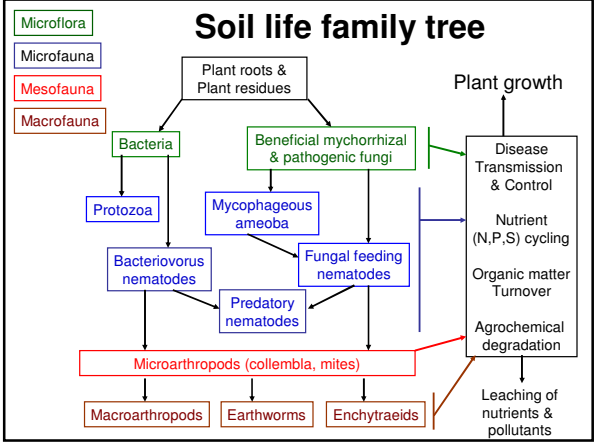
Competitive Exclusion
Natural Control of Disease
Balanced Microbial Ecology



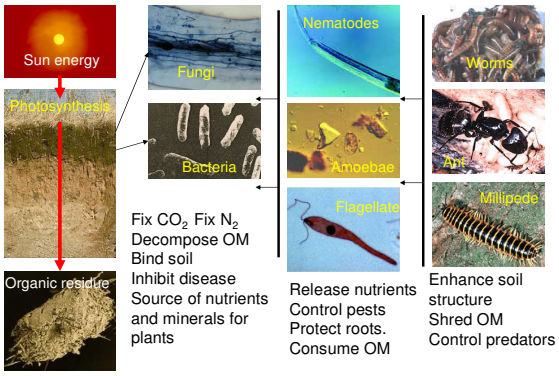
The microbes used in products

- Non harmful, non pathogenic, non genetically modified organism (GMO), not chemically synthesised
- Probiotic: promotes balanced beneficial microbial activity
- Competitively excludes pathogens
- Production and assimilation of nutrients, anti-oxidants, vitamins, minerals and bioactive compounds
- Decomposition, assimilation and neutralisation of oxidative and odour substances

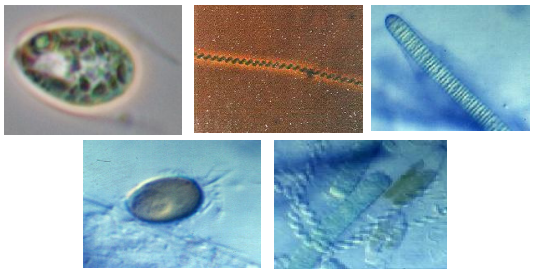
Soil life family tree



Soil food web: life in the soil



Photosynthetic bacteria

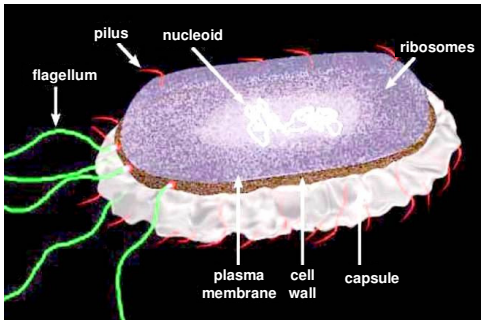


Use sunlight and soil heat as a source of energy.
Synthesise useful substances (eg. amino acids, nucleic acids and sugars) from secretions of roots, organic matter and / or harmful gases (eg. hydrogen sulphide)

Bacteria

Simply stated, bacteria and blue green algae (prokaryotes) are molecules surrounded by a membrane and cell wall.
Prokaryotic cells may have photosynthetic pigments, such as is found in cyanobacteria ("blue bacteria").
Prokaryotic cells come in many shapes: cocci (round), baccilli (rods), and spirilla or spirochetes (helical cells).

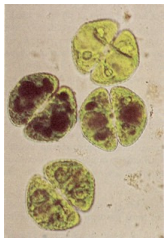
Bacteria cell



Photosynthetic bacteria: Autotrophs

- Autotrophic organisms produce their own food
  - they include phototrophic bacteria that are able to synthesize organic molecules from simple inorganic compounds (use energy to produce food from inorganic material)
- Most autotrophs use energy from sunlight to combine carbon dioxide and water into energy rich chemicals such as glucose via photosynthesis. Some bacteria use energy from nitrogen and sulfur compounds.
- The food made by autotrophs is stored in various organic compounds, primarily the carbohydrate glucose (a six-carbon sugar)
- Without autotrophs all other living things would die. Without these producers you cannot have consumers.

Photosynthesis, light and life

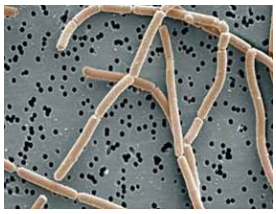


Photosynthesis is the process by which autotrophs convert solar energy into the chemical bond energy of glucose ($C_6H_{12}O_6$)

$6CO_2 + 12H_2O$ + solar energy ---> $C_6H_{12}O_6 + 6H_2O + 6O_2$

Cells of a green algae that live in fresh water. Each cell is an individual, self-sufficient photosynthetic organism. The green colour is due to chlorophyll, in which the radiant energy of sunlight is converted to chemical energy.

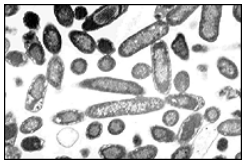
Lactobacillus bacteria



Produce lactic acids from the sugars and other carbohydrates developed by photosynthetic bacteria and yeast. Strong sterilising compound and suppresses harmful micro-organisms and enhances the decomposition of organic matter.

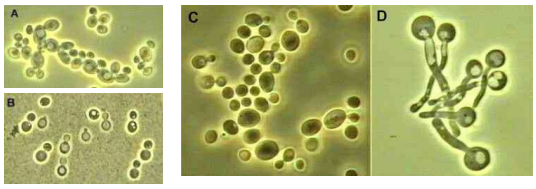
Bacteria and antibiotics

Pseudomonas bacteria



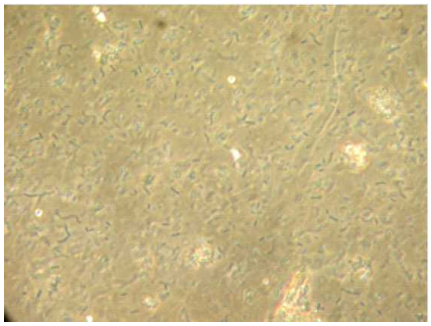
The cell wall is the target for antibiotics, as well as for carbohydrates that our immune system uses to detect infection.
A major threat to humankind is the antibiotic-resistant strains of bacteria that have been selected by the overuse of antibiotics.

Yeast organisms

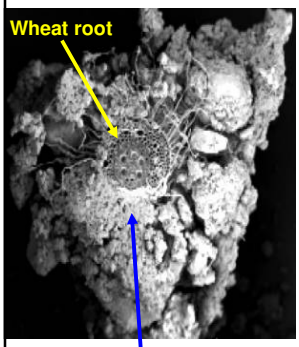


Synthesise anti-microbial and other useful substances required for plant growth from amino acids and sugars secreted by photosynthetic bacteria, organic matter and plant roots. Produce bio-active substances such as hormones and enzymes that promote active cell and root division.

Microbe culture under microscope



The rhizosphere



Rhizosphere: soil particles bound by exudates and root hairs

The rhizosphere is the zone of soil surrounding a plant root where the biology and chemistry of the soil are influenced by the root. It is an area of intense biological and chemical activity where microbes feed of plant exudates (compounds of carbohydrates/simple sugars exuded by plants. This is where soil acids/gels are formed by micro-organisms that hold nutrients and water.

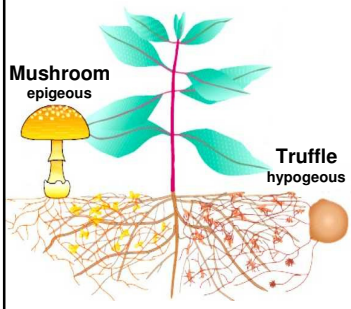
Soil acids/gels (1)

- Humates, primarily as humic acids, can provide the main storage for moisture and nutrients in soils
- The humic compounds are produced by soil microbes
- Suppressing soil microbes reduces humic production which suppresses plants through a decline nutrition and aeration
- A downward spiral develops as plants provide less food for the microbes and the microbes less nutrients for plants.

Soil acids/gels (2)

- Soil acids are mainly lost from the soil by breakdown by microbes (oxidation).
- Excess breakdown of humic substances is caused by:
  - soil disturbance
  - high soil temperatures (exposure of bare soil)
- Poor production of humic substances is caused by:
  - chemical imbalance (over applications of chemical fertilisers)
  - poor plant production

Mychorrhiza

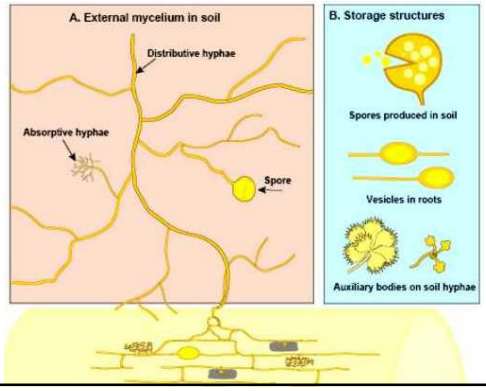


Mychorrhizal fungi are symbiotic with plants. The fungal hyphae grow in plant roots as well as the soil. Collectively the fungal hyphae are called mycelium.
The fungi utilise organic compounds from the host for food.
By breaking down soil organic matter and extracting minerals from the soil the fungus supplies nutrition to the plant.
The fungal hyphae transport nutrients from the soil to the plant. As the proportion of root colonised by fungal hyphae increases the rate of plant growth increases.

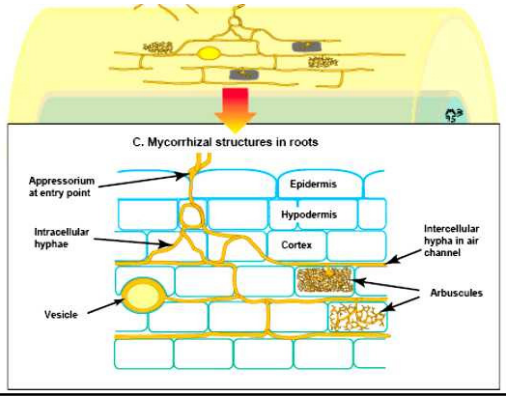
Arbuscular mychorrhizal fungi (glomalin)

- Production of the protein glomalin by mychorrhizal arbuscular fungi is a recent discovery
- Glomalin functions similarly to humic compounds in binding soil particles and storing water and nutrients
- The life span of glomalin is appreciable (years to decades) although shorter than humic compounds (hundreds of years)
- Glomalin can constitute around one third of the soil organic matter

Glomalean mychorrhizal associations 1



Glomalean mychorrhizal associations 2



Increase in carbon, nutrient & water storage with a 2% increase in OM

Carbon	OM (t/ha)	CO2 (t/ha)	
All soils	72	155	
Cation Exchange	**(meq/kg)**	**(eg/m^2)**	**% Increase**
Sand	600	21.6	~2000
'Normal' soil	600	21.6	~400
Reactive clay	600	21.6	~100
Water	**AWHC (kL/ha)**	**Rainfall (mm)**	**% Increase**
Sand	164	16.4	~110
'Normal' soil	164	16.4	~27
Reactive clay	32	3.2	~17

Microbial Formulations

Microbial balancing in Australia

- VRM Pty Ltd is licensed by EMRO (Japan) to produce EM based products in Australia.
- VRM also produces high quality bio-technology formulations for water and soil remediation.
- This includes odour control, compost accelerants, organic bio-fertilisers, waste treatment , bio-conversion of organics and eco-cleaners.
- VRM leads the manufacture and distribution of microbial balancing products in Australia.
- VRM holds patents in Australia and overseas for its innovative microbial balancing technology.

VRM's Bio Fertilisers

Vital Resource Management Pty Ltd

Townsville based and serving Australian markets

The making of core cultures

- Fermentative anaerobic and aerobic micro-organisms co-existing symbiotically
- The EM-1 *mother culture* provides the basis of other stabilised or core cultures
  - Used to produce expanded EM products for specialist applications, eg. water, soil and organic waste treatment, etc.
- Specialist mixtures from PDM-7 are incorporated in a proprietary stabilisation routine process
- VRM's own base cultures are then added and a long-term fermentation process used to produce final core cultures
- Designed to restore and sustain the microbial ecology of the environment for growing a healthy soil biota and plant nutrition.
- Applied as a liquid inoculant of mixed cultures

VRM microbial balancing process

Microbial balancing involves balancing combined multi-cultures

Cultures of EM-1, PDM-7, VRM cultures and specialised yeasts

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VRM Core Cultures

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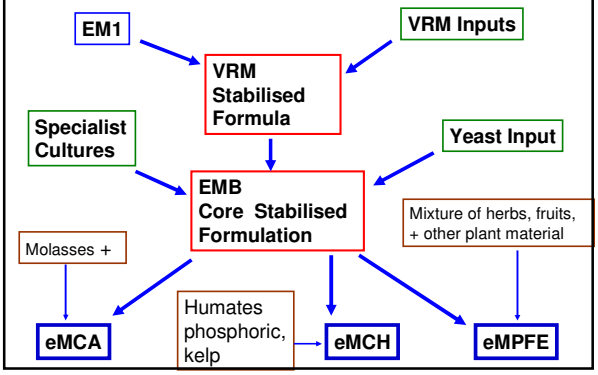
VRM microbial balancing products comprising eMCA, eMCB, eMCH, etc.

VRM Probiotics: family tree 1



VRM Probiotics: family tree 2

eMCA
Used for sugar mills, spray innoculation & seed culture for compost, waste treatment etc

eMCH
Used as a starter culture for septics, treatment plants & feedstock for fertilisers

eMPFE
Fermented mixture based on various herbe/plants
Feedstock for bio-fert products and silage

eMC Cleaners
Cirtus
Lavender
Kitchen (dishes)
Power (commercial)

Bio-fert Concentrates
Cal-Booster
Nitro-Boost
Bio-Base
KS Special

Bio-Fertiliser
Ecothunder range of mixtures
Bio-Base range of products

Etherxylated alcohol
Essential Oils

Trace elements + other supplements

Humates, Molasses, fertiliser blends

Three properties of VRM cultures

- Anaerobic fermentative basis with aerobic microbial action in symbiosis
- Anti-oxidative effect of the microbes
- Magnetic resonance of microbes
  - Phototrophic bacteria can receive and emit resonances, photons of light and energy

The forefront of sustainable living

VRM products are at the forefront of environmental restoration of soils and water systems.
Prevent downstream effects in waterways such as algal booms.
Improve soil health and fertility, ameliorating acidity, salinity, compaction, crop diseases that cause loss of plant productivity.
Prevent odours and supports rapid bioconversion of organic wastes.
In homes, inoculate surfaces and systems, and manage odours through the build up beneficial microbes.

Production of bio-active products

Mother cultures are formulated and fermented to provide the core and stabilised ingredients for each product

Active bio-fertilisers (BioBase)

Cultures used in making VRM products

Is microbial balancing safe ?

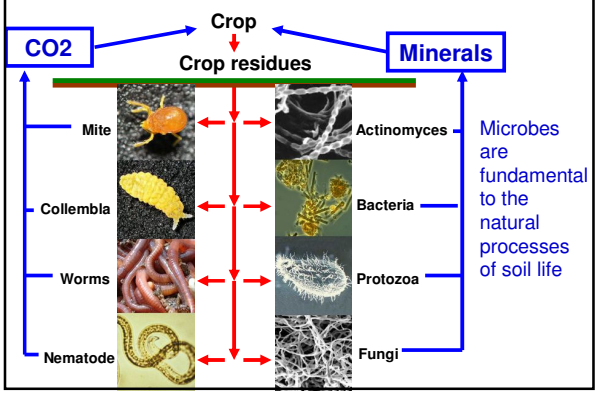
- The micro-organisms in VRM products are not genetically modified
  - mainly gathered from micro-organisms used in the food processing industry.
- The micro-organisms are carefully chosen and pass very strict criteria in terms of no harm to plants, animals, humans and the environment.
- Routine screening and a process of competitive exclusion are used to ensure proportionate levels of included groups in equilibrium.

Ongoing R & D

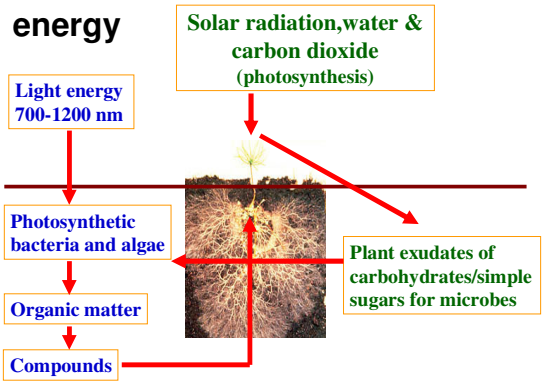
Focussed on the application of microbial balancing, nutrient management, increased crop yields, foliar fertilisers and fungal control.

Microbial balancing and carbon in the soil web of life

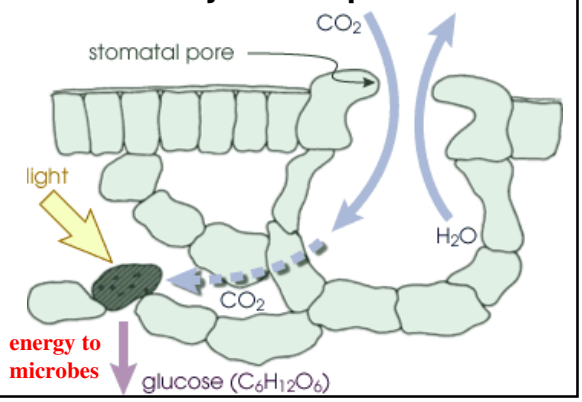
Life in soils



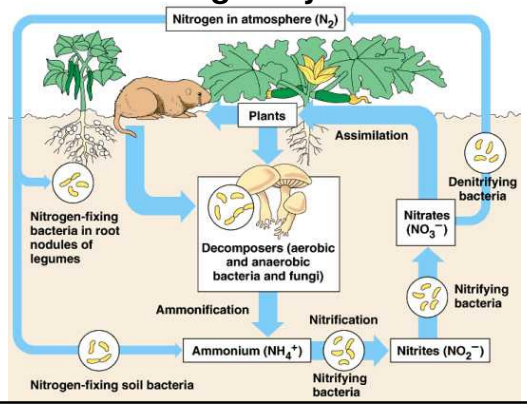
Free energy



Photosynthesis process

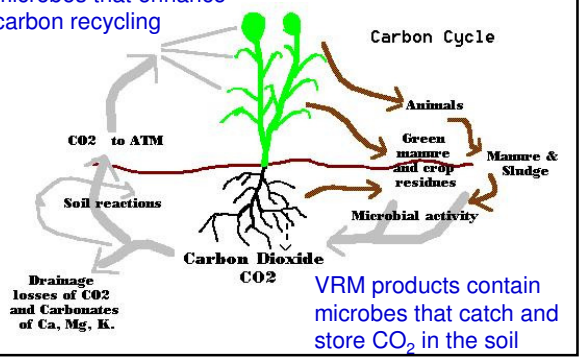


Nitrogen Cycle



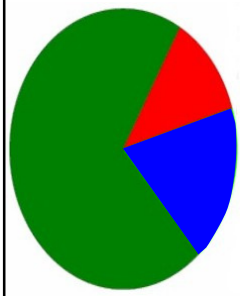
Carbon Cycle

VRM products contain microbes that enhance carbon recycling



VRM products contain microbes that catch and store CO_2 in the soil

Forms of soil organic matter



Living 2-12%
Viruses, Bacteria, Yeasts, Arthropods (e.g. mites, insects), Worms, Plant roots

Dead 8 – 24%
Plant & animal remains
Organic compounds (sugars)

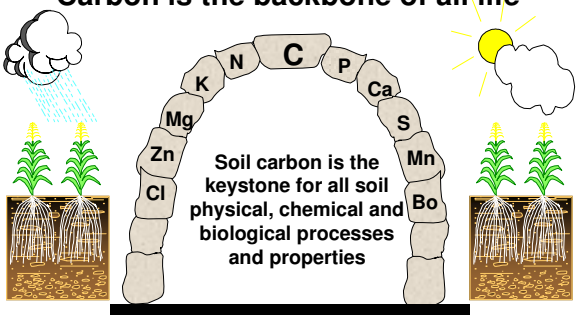
Stable Humus (70 – 90%)
(synthesized by microbes)
Humic compounds
Glomalin, Charcoal

Forms of soil organic matter

Location	Form	Longevity	Abundance*
Soil surface	Litter	days-years	1-10
Below Ground	Roots	days-decades	30-50
	Invertebrates	weeks-months	0.01-10
	Microbes	days-weeks	0.01-100
Soil Organic Matter	Carbohydrates +	days-weeks	0.01-30
	Glomalin	years-decades	0.01-100
	Fulvic acids	years-decades	0.01-100
	Humic acids	100-1000 years	0.01-100
	Humins	100->1000 years	0.01-100

* % of above ground biomass

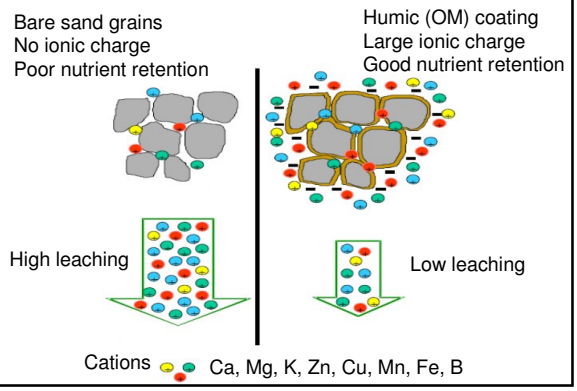
Carbon is the backbone of all life



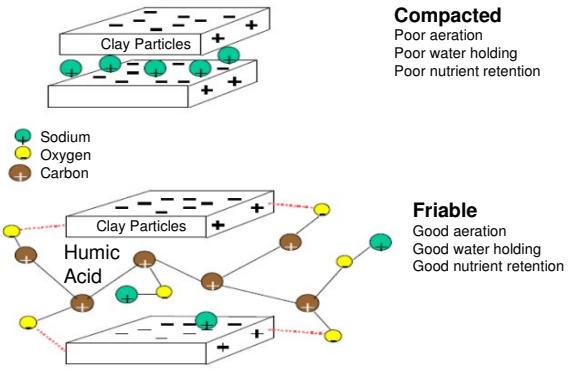
Management platform

fertility, microbe variety and activity, photosynthesis, CO_2 management, tillage techniques, soil and plant health

Cation exchange capacity



Soil structure



Rhizosphere benefits

Coevolution with plant roots to support the production (microbial metabolism) and exchange of:

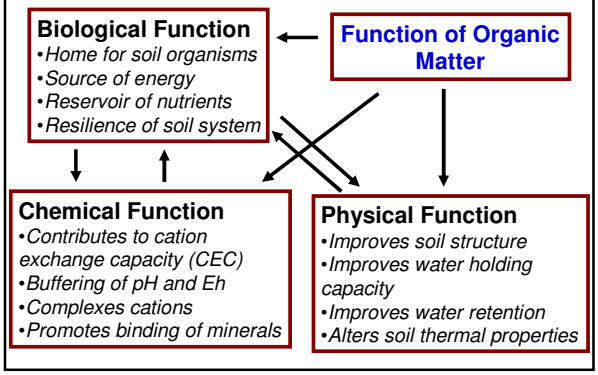
- Carbohydrates (simple sugars from plants)
- Organic, amino and nucleic acids
- Hormones and enzymes
- Nutrients and minerals

VRM: Seeding the reaction for soil and plant health

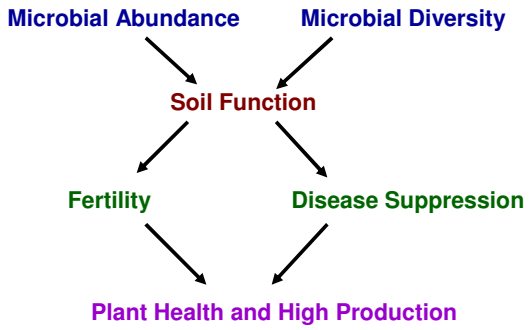
Biology control concepts

- General suppression:
  - Abundance and diversity of micro-organisms results in fertility and biological controls.
- Specific suppression:
  - Specific micro-organisms are antagonistic to certain plant pathogenic or parasitic organisms, eg. bio-pesticides and microbials (eg. root consumers, parasitic nematodes).

Microbe home



Microbial balancing:
basis of fertility and plant health



Contact Details

- www.eric.com.au (access to research papers on soils, soil testing and advice and microbial balancing) or contact Rob Gourlay on 48428182, rob@eric.com.au, 0418 462 443 for supply of VRM products
- www.healthysoils.com.au (join and get access to soil health articles and papers) or contact Rob Gourlay on 48428182, rob@healthysoils.com.au