Vermicast explained, beyond a simple element analysis.

An NPK analysis of vermicast would show something like 1:1:1. Vermicast is produced from organic materials that have taken up minerals in exactly the ratio in which they were needed to produce and sustain growth. Therefore the minerals are contained in castings in a natural balance such as is required for vigorous, healthy growth. In ordinary soil, plants usually have to seek them out but, in vermicast, they are readily available when they are needed. Significantly **in vermicast there is no excess of nitrates and phosphates, which are water soluble and which, when applied in much higher concentrations in manufactured fertilizers, dissolve in run off to pollute our land and waterways.**

The great influencing factor of the NPK of vermicast is, of course, the organic matter ingested by the worms. Worms can't manufacture any nutrients, only liberate them. If the ingested matter is nitrogen rich, then so too will be the castings; but if the matter is nitrogen poor, the castings will be too. However the nutritional value of worm castings is not the point. **The value of vermicast lies in the plant growth stimulants, the cationic exchange rate and the soil benevolent biota.**

One of the great difficulties in promoting vermicast is that growers will frequently request an analysis. Invariably, such a request is made on the basis that vermicast is a fertilizer and not a biological stimulant. These analyses will detail the mineral content, not the important biological content. Therefore vermicast frequently fails the assessment of being able to provide essential minerals to soil. But that is not what it's about.

Applying vermicast instead of fertilizers to soil is like giving a hungry man a fishing line instead of a fish. Once the fish is eaten, it's gone; but with a fishing line, he has the ability to access food far into the future. Vermicast is the fishing line, the bait, and the skill all rolled into one! **The biota introduced to the soil in vermicast (or its derivatives) can work away out of sight, releasing the minerals already there and trapping free nitrogen from the atmosphere.**

Cationic exchange rate

An important and often unrecognized feature of vermicast is its cationic exchange rate. This is the rate at which the cat ionic soil trace elements can attach themselves to vermicast.

Everything in nature has an electrical charge. Some charges are positive, cations, and some are negative, anions. Organic vegetative matter is anionic and, because vermicast is highly vegetative matter, it is strongly anionic. Most trace elements are cationic.

In simple terms this means that trace elements are attracted to vermicast and readily bond to it in the same way that opposite poles of a magnet attract each other. Plants have a stronger pull than the vermicast and can therefore draw the trace elements away from the vermicast and into their roots.

Phosphorous is one of the essential trace elements that are negatively charged, same as the organic matter. P is therefore repelled by vegetative matter and will lie loosely in the soil. When rain comes, because the P is not bonded to anything, it is readily washed away. P is often blamed for stimulating growth of water plants, and of upsetting the ecology of the fish environment. This is because ultimately loose un-bonded P will be washed into the waterways; it can't go anywhere else.

By David Murphy – Organic Growing with worms

Findings from a variety of studies on the efficacies of vermicast and earthworm activity in Agriculture:

Earthworms increase the amount of mineralized nitrogen from organic matter in soil. The microbial composition changes qualitatively and quantitatively during passage through the earthworm intestine (Pedersen and Hendriksen, 1993).

Earthworms not only disperse microorganisms important in food production but also associated with mycorrhizae and other root symbionts, biocontrol agents and microbial antagonists of plant pathogens as well as microorganisms that act as pests (Edwards and Bohlen, 1996).

Several researchers have demonstrated the ability of earthworms to promote the dispersal of beneficial soil microorganisms through castings, including pseudomonads, rhizobia and mycorrhizal fungi (Edwards and Bohlen, 1996; Buckalew et al., 1982; Doube et al., 1994a; Doube et al., 1994b;Madsen and Alexander, 1982; Reddell and Spain, 1991; Rouelle, 1983; Stephens et al., 1994).

During vermicomposting process when organic matter passes through the worm‟ s gut, it undergoes physico-chemical and biochemical changes by the combined effect of earthworm and microbial activities.
Vermicasts are coated with mucopolysaccharides and enriched with nutrients. The cellulolytic, nitrifying and nitrogen fixing microbes are found established in the worm cast (Kale et al., 1988).

Vermicasts are excellent media for harbouring N-fixing bacteria (Bhole, 1992).

Earthworms directly cycle the nitrogen by excretion in the casts, urine and mucoprotein and through the turnover of earthworm tissues (Lee, 1985).

Earthworms have multiple, interactive effects on rates and patterns of nitrogen mineralization and immobilization in natural and managed ecosystems (Edwards and Lofty, 1977; Lee, 1983; Lavelle and Martin, 1992; Blair et al., 1995b).
Earthworm casts are enriched in terms of available nutrients and microbial numbers and biomass, relative to the surrounding soil (Shaw and Pawluk, 1986; Lavelle and Martin, 1992)

Earthworms reject significant amounts of nutrients in their casts. In part these losses result from the intense microbial activity in their gut, and from their own metabolic activity. Eg. The elimination of N due to fast turnover of this element in microbial biomass. A significant proportion of C assimilated by earthworms is secreted as intestinal and cutaneous mucus with greater C:N ratios than those of the resource used (Lavelle et al., 1983; Cortez and Bouche, 1987).

Joshi and Kelkar (1952) **reported that earthworm casts contained greater percentage of finer fractions like silt and clay than in the surrounding soils. This change in mechanical composition of soil was probably due to the grinding action of earthworm gizzard. The chemical analysis of vermicasts revealed that they were richer in soluble salts, neutral or alkaline in reaction and had higher percentage of exchangeable Na, K and Mg but a lower exchangeable Ca than in corresponding soil.**
Earthworm casts also contained greater amounts of Nitrogen (N), Phosphorous (P) and Potassium (K). The vermicasts contained higher amounts of nitrate nitrogen and possessed a greater nitrifying power than the corresponding soils.
Vermicompost also contained Mg, Ca, Fe, B,Mo and Zn in addition to some of the plant growth promoters and beneficial microflora.
Several valuable compounds were also produced through the earthworm – microfloral interaction, which included vitamins such as B12 and plant growth hormones such as gibberellins.

Barois et al., (1987) **observed an activation of N mineralization, with the casts having 270 percent more ammonia than the bulk soil.**
Within a year of application of vermiculture technology to the saline soil, 37 percent more N, 67 percent more P2O5 and 10 percent more K2O were recorded as compared to chemical fertilizer (Phule, 1993).

Kale (1991) **has attributed the improved growth in pastures and in other crops like rye and barley to the chemical exudates of the worms and microbes in association with them.**

Tomati et al., (1983) **related the beneficial influence of worm cast to the biological factors like gibberellins, cytokinins and auxins released due to metabolic activity of the microbes harboured in the cast.**

It has also been indicated that the chemical exudates of worms and those of microbes in the cast, influence the rooting or shoots of layers. In a field trial Kale and Bano (1986) **observed that the seedling growth of rice in nursery increased significantly due to vermicompost application, and transplanting of seedlings could be made one or two days earlier than the usual practice. After transplanting the growth of seedlings in main field was more favourably**

influenced by worm cast than the chemical fertilizer. This was attributed to higher availability of nitrogen for plant growth. The improved growth was also attributed to the release of plant growth promoting compounds from worm cast, which in their opinion could easily replace the chemical fertilizers at nursery level.

Atiyeh et al. (2000) **found that compost was higher in ammonium, while vermicompost tended to be higher in nitrates, which is the more plant-available form of nitrogen.**

Similarly, work at NSAC by Hammermeister et al. (2004) indicated that **"Vermicomposted manure has higher N availability than conventionally composted manure on a weight basis". The latter study also showed that the supply rate of several nutrients, including P, K, S and Mg, were increased by vermicomposting as compared with conventional composting.**

These results are typical of what other researchers have found (e.g., Short et al., 1999; Saradha, 1997, Sudha and Kapoor, 2000). **It appears that the process of vermicomposting tends to result in higher levels of plant-availability of most nutrients than does the conventional composting process.**

The literature has less information on this subject than on nutrient availability, yet **it is widely believed that vermicompost greatly exceeds conventional compost with respect to levels of beneficial microbial activity.**

Much of the work on this subject has been done at Ohio State University, led by Dr. Clive Edwards (Subler et al., 1998). In an interview (Edwards, 1999), he stated that **vermicompost <u>may</u> be as much as 1000 times as microbially active as conventional compost**, although that figure is not always achieved.
Moreover, he went on to say that "…**these are microbes which are much better at transforming nutrients into forms readily taken up by plants than you find in compost – because we're talking about thermophillic microbes in compost – so that the microbial spectrum is quite different and also much more beneficial in a vermicompost.**
I mean, I will stick by what I have said a number of times that a vermicompost is much, much preferable to a compost if you're going in for a plant-growth medium."

Many researchers have found that vermicast stimulates further plant growth even when the plants are already receiving optimal nutrition.

Atiyeh at al (2002) **conducted an extensive review of the literature with regard to this phenomenon. The authors stated that: "These investigations have demonstrated consistently that vermicomposted organic wastes have beneficial effects on plant growth independent of nutritional transformations and availability. Whether they are used as soil additives or as components of horticultural soil less media, vermicomposts have consistently improved seed germination, enhanced seedling growth and development, and increased plant productivity much more than would be possible from the mere conversion of mineral nutrients into more plant-available forms."**

Moreover, the authors go on to state a finding that others have also reported (e.g., Arancon, 2004), **that maximum benefit from vermicompost is obtained when it constitutes between 10 and 40% of the growing medium.**

It appears that levels of vermicompost higher than 40% do not increase benefit and may even result in decreased growth or yield.

Atiyeh et al **further speculate that the growth responses observed may be due to hormone-like activity associated with the high levels of humic acids and humates in vermicomposts: "…there seems a strong possibility that …plant-growth regulators which are relatively transient may become adsorbed on to humates and act in conjunction with them to influence plant growth".**

This important concept, that vermicompost includes plant-growth regulators which increase growth and yield, has been cited and is being further investigated by several researchers (Canellas et al, 2002).

There has been considerable anecdotal evidence in recent years regarding the ability of vermicompost to protect plants against various diseases.
The theory behind this claim is that the high levels of beneficial microorganisms in vermicompost protect plants by out-competing pathogens for available resources (starving them, so to speak), while also blocking their access to plant roots by occupying all the available sites.
This analysis is based on the concept of the "soil foodweb", a soil-ecology-based approach pioneered by Dr. Elaine Ingham of Corvallis, Oregon (see her website at http://www.soilfoodweb.com for more details). Work on this attribute of vermicompost is still in its infancy, but research by both Dr. Ingham's labs and the Ohio State Soil Ecology Laboratory are very promising.

With regard to the latter institution, Edwards and Arancon (2004) **report that "…we have researched the effects of relatively small applications of commercially-produced vermicomposts, on attacks by Pythium on cucumbers, Rhizoctonia on radishes in the greenhouse, and by Verticillium on strawberries and Phomopsis and Sphaerotheca fulginae on grapes in the field. In all of these experiments, the vermicompost applications suppressed the incidence of the disease significantly."**
The authors go on to say that the pathogen suppression disappeared when the vermicompost was sterilized, indicating that the mechanism involved was microbial antagonism.

In recent research, Edwards and Arancon (2004) **report statistically significant decreases in arthropod (aphid, mealy bug, spider mite) populations, and subsequent reductions in plant damage, in tomato, pepper, and cabbage trials with 20% and 40% vermicompost additions to Metro Mix 360 (the control). They also found statistically significant suppression of plant-parasitic nematodes in field trials with peppers, tomatoes, strawberries, and grapes. Much more research is required, however, before vermicompost can be considered as an alternative to pesticides or alternative, non-toxic methods of pest control.**

Case Study

Apple farming at Clan Leslie - take less, waste less, make more
Farmers Weekly 21 October 2010
Hayden Green

By incorporating vermicomposting and worm-casting tea in its apple production system, Clan Leslie Estate has improved its fruit quality, reduced input costs and improved the soil and tree health in its orchards. Hayden Green visited Mike Leslie to find out more.

Mike Leslie farms in partnership with his father Nick and brother Graham on the Clan Leslie Estate near Harrismith in the Free State. Like's farming philosophy is to keep things simple, but pay attention to detail. He's passionate about apple production and about where sustainability is taking the enterprise. He combines technology with applicable management and biological farming techniques to produce fruit that looks good, is healthy and nutritious, and exceeds export quality requirements. To achieve quality and production goals, Mike also partners with nature's prime recycler – the humble earthworm.

Vermiculture – earthworm farming

To branch out into exports, Clan Leslie established its apple production division in 1996. Five years ago, they decided to integrate vermiculture into the operation because of changing export regulations, specifically for chemical residue levels. "Our list of suitable chemicals was and still is shrinking due to global regulations and the green movement," Mike says. "Consumers are looking for residue-free fruit, and we had to find a different way of doing things." Fruit destined for export is batch-tested five days before picking, and Mike felt that moving to natural pest and disease control in the form of "worm tea" would minimise the risk of residue on the fruit, increase its nutritional value, and reduce chemical use and withholding periods. He contacted private consultant Hennie Eksteen for advice on vermiculture, and partnered with vermiculture specialist Poerie Coetzee to manage it. This left Mike himself free to concentrate on orchard management. "I was initially concerned that salmonella and E. coli contamination from feedlot manure and chicken litter we used as compost base came through in the testing," he admits. "But we tried the worm tea in selected apple blocks and the results were perfect. The earthworms destroyed all pathogens in the manure, giving us the confidence to freely use compost tea."

Foliar and soil-feed teas

"Foliar-feed tea requires an anaerobic process," explains Mike. "We mix the earthworm castings with water, molasses, ground lucerne and fishmeal, and brew the mixture in 1 000â„" vats for three weeks. When it's ready, we dilute the tea with water and use it as a foliar feed, sprayed at 80â„"/ha."Likewise, converting the solid material in worm castings into a liquid enables a practical, accurate and uniform application of soil-feed tea throughout the orchard. Soil-feed tea is made aerobically by pumping a large volume of air through it for up to 24 hours. Once the correct microbe population is reached (established by microscopic examination), the tea must be applied undiluted at 200â„"/ha within a few hours before the aerobic bacteria die from a lack of oxygen. Follow-up irrigation further washes the tea into the soil.The total cost of foliar and soil-feed tea production and application is around R12 625/ha per season. This will decline in time as the orchard health improves and less spraying is needed.

Mulching – retaining a natural balance

"In nature, fruiting trees are part of a complicated ecological system, existing in symbiotic relationships with the fauna and other flora to sustain a healthy fruiting cycle," says Mike. He's concerned about the consequences and economic sustainability of a system of constant harvesting, with synthetic chemicals as the only inputs. So, mimicking nature, he scatters tree pruning clippings and other plant residue around the base of the trees to eventually decompose and form mulch. "We use nine 1,5m-diameter round bales of wheat residue to every 200m of tree row," he explains. "This equates to 104 bales, or 26t of dry plant material, per hectare, and lasts for three to four years. Nothing is wasted."The mulch, besides retaining moisture, feeds the bacterial processes stimulated by the soil-feed worm tea. Mike points to the contrast between mineral soil and the rich organic matter resulting from earthworm activity. "The earthworms manage the environment for me," he says. "The soil is moving towards a natural state of balance (homeostasis) without chemical fertiliser." He estimates that this production system needs one-third less irrigation water. "The savings are significant." Mike was astonished when he first saw the increase in root growth as a result of the mulch and soil feed. "This increased nutrient uptake has resulted in healthier, stronger apple trees."

A competitive advantage

"Quality counts. The market is prepared to pay for an apple that tastes better and, more importantly, lasts longer," says Mike. Mulching with worm tea had precisely this effect, increasing demand for Clan Leslie apples from clients in Africa, where the cold supply chain isn't as advanced as other export markets. "The local informal market is massive, and is prepared to pay premium prices for quality fruit that will last," he explains. Although being situated in the south-eastern Free State gives Clan Leslie a three-week harvesting advantage over its Cape competitors, the unseasonal heavy frosts are a problem. Mike warns that worm tea is no silver bullet, and that balancing the soil is a slow process. Over the last five years, he has recorded an average increase from 8 Brix to 12 Brix in his plants, correlating directly to frost resilience. An SMS early warning system notifies him to irrigate when air temperature drops below 5°C. **Incorporating earthworms has increased yields from 50t/ha to 75t/ha in Pink Lady apples, and by 15t/ha in other varieties.**

The path towards more sustainable production on the 66ha apple orchard constantly challenges Mike. "In the future I would define myself increasingly as a carbon farmer who produces apples," he says.

Based on the success of the worm tea in the orchards, he aims to produce low-carbon-footprint apples with a superior nutritional value. Worm tea has been so successful in the apple orchards that he intends to expand it to the other Clan Leslie enterprises.

Contact Mike Leslie on 082 770 0306 or e-mail **mike@clanleslie.co.za.**

LABORATORIUMVERSLAG VIR VERMICAST

MAATSKAPPY: Omnia
ADRES: Posbus 384
ADRES: Sasolburg
POSKODE: 1947

KLIENT NAAM: New Kingstonvale
ADRES: Plaston
BEST: V322105
DATUM: 5/31/2013

Sample#	VERW NO	Produk	N	Ca	Mg	K	Na	S	P	Fe	Mn	Cu	Zn	Mo	B	Al	Vog	As	pH	C	C:N
			%	%	%	%	mg/kg	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%		%	
L43957	Vermikast		1.34	1.00	0.30	0.52	727	0.21	0.29	5814	419	20	134	<0.10	10	5460	60.94	63.27	6.40	21.35	15.94:1

Resultate op 65°C Gedroogde monsters

Davley Organics Vermicast Analysis

Element	Chemical symbol	Results	Units
Nitrogen	N	1.34	%
Calcium	Ca	1	%
Magnesium	Mg	0.3	%
Potassium	K	0.52	%
Sodium	Na	727	mg/kg
Sulphur	S	0.21	%
Phosphorus	P	0.29	%
Iron	Fe	5814	mg/kg
Manganese	Mn	419	mg/kg
Copper	Cu	20	mg/kg
Zinc	Zn	134	mg/kg
Molybdenum	Mo	<0.10	mg/kg
Boron	B	10	mg/kg
Aluminium	Al	5460	mg/kg
	Vog	60.94	%
	As	63.27	%
	pH	6.4	
	C	21.35	%
	C:N	15.94:1	