ORGANIC MATTER AS A RESOURCE FOR SOIL FERTILITY

Uta Lübke & Siegfried Lübke

Group CMC

Untererleinsbach 1, A4722 Peuerbach, Austria, Tel 0043 7276 2762

Introduction

Organic matter has become a scarce and sought after resource. On the one hand, agriculture has `forgotten` about the fact that plant roots are one of the most valuable sources for organic matter in soils and has given up intercropping (green manures, cover crops, etc.) for the benefit of soils. On the other hand - soils have lost their ability to recycle and stabilize organic matter in the form of humus. On top of that, agriculture is at a disadvantage against the `renewable-energy industry`, which can show a more direct financial return from the utilization of our valuable organic matter resources, whereas in agriculture it is much more difficult to show the economical benefits, of soil organic matter, to nature and society.

With this in mind, it is of highest importance to understand what makes the utilization of the little organic matter, that remains available for the benefit of soils, most efficient and sustainable.

This lecture intends to provide a few central points to this globally pressing issue.

Organic matter the most precious resource for agriculture

What do you associate with the term organic matter?

Green manure?
Crop residue?
Manure?
Liquid manure?
Compost?
Humus?

All of the above are forms of organic matter. Yet each one will have a completely different effect on soil fertility.

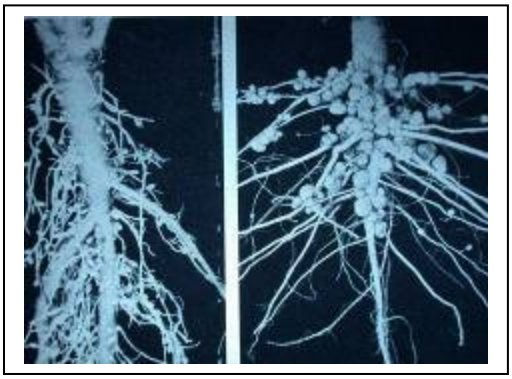
What are the main reasons for the frequent cultivation of green manure in Austria and Central Europe?

Benefits of the cultivation of green manure

1. An improved soil structure, because of the increased rooting.

2. Protection against soil erosion.

3. Crumb structure and the uptake of residual nitrogen of the previous crop to avoid nitrogen leaching.



4. Nitrogen collection through legumes and their nodule bacteria.

Bild 34. *Luzerne* auf Lehm, 3jährig, dichter Bestand. Ernteertrag: 470 dz Grünmasse/ha – Ernterückstände: 69 dz Trs/ha, davon Wurzelrückstände: rd. 45 dz Trs/ha.

5. Breaking open subsoils through the plant`s root systems (e.g. lucerne), which allows for deeper rooting of the following crop.

Incorporation of green manure

A green manure crop must always be disconnected from the roots and cut to small particle size.

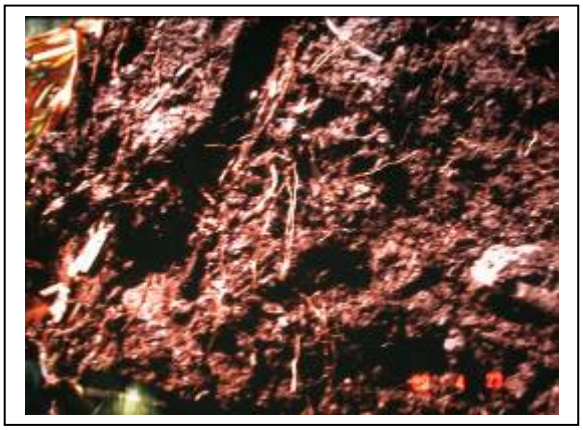
Then it is incorporated into the soil by a rotating spade plough, from Imants in Holland.

According to the CMC-method, which we developed during the past 30 years, we apply the CMC-inoculum to the green manure crop before incorporation. The CMC-inoculum is a microbial preparation, which was developed by Dr. Ehrenfried Pfeiffer 70 years ago. Ever since we have been using this starter preparation, we have had no more problems with the breakdown of organic matter. The increased microbial activity allows for such an efficient breakdown of the green manure, that the following cash crop can be planted right away, without a wait period. Previous to the use of the inoculum, the green manure easily putrefied in our soils, which made the vegetable crops susceptible to diseases, slug attacks and insect problems. As the use of pesticides was unacceptable to us, we needed to ensure soil fertility, so the use of chemicals was not necessary.

It was our aim to build sustainable soil fertility, which would allow us to cultivate healthful and disease resistant plants. Ever since the use of the CMC-inoculum we found exactly that. The biological activity increased the humus content which in turn resulted in healthier plants and higher crop yields. Nowadays, crop yields of organically certified farms, implementing the CMC-method, are comparable to the yields of conventional farming methods, using commercial fertilizers.

Our research has led us to the conclusion, that the minimum organic matter content of a soil needs to be 5%, in order for the soil to grow and sustain plants holistically. This organic matter content can only be achieved sustainably in the form of highest quality humus, which is accumulated through the use of compost and green manuring.

It is very important to incorporate fresh green matter as freshly as possible and evenly throughout the top soil.



Here an example how green manuring can turn into a problem for soils.

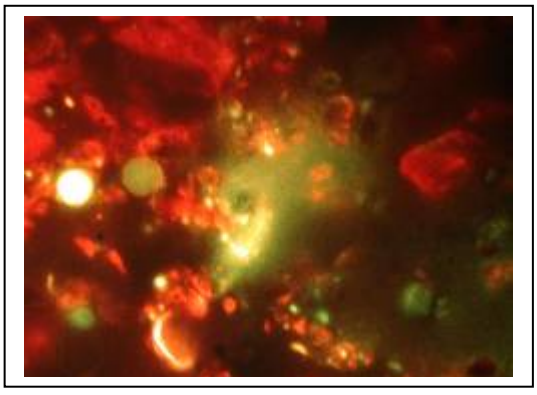
In autumn a tall standing green manure crop was by with a mold board, which caused pocket formation and the green matter was turned under as a thick layer. Because of the winter rains, the oxygen flow was not sufficient for the digestion of the green matter and it putrefied.

“Putrefaction is the worst enemy of soil fertility.”

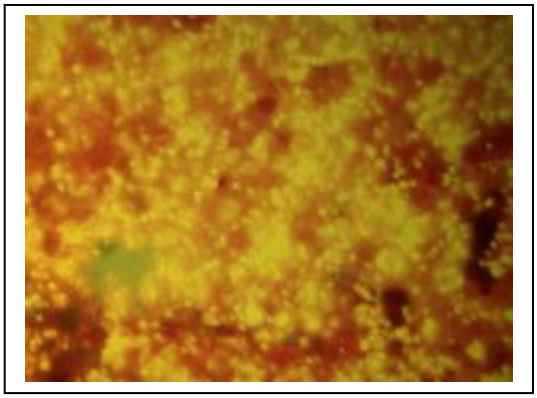
This was the problem for the following crop, which was winter wheat. It turned yellow, which was not caused by a lack of nitrogen, but by a fungal infection.

Straw residue from grain production can cause problems for a following green manure crop, if the residual straw is turned under in pockets, causing putrefied conditions.

The question is, what is the underlying cause for the crop problems after incorporation of raw organic matter into the soil.



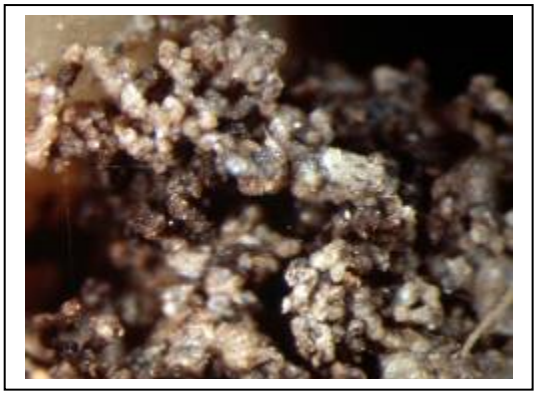
Once one takes a look at the soil under the microscope answers are found.
Many soils show very little microbial life and diversity.

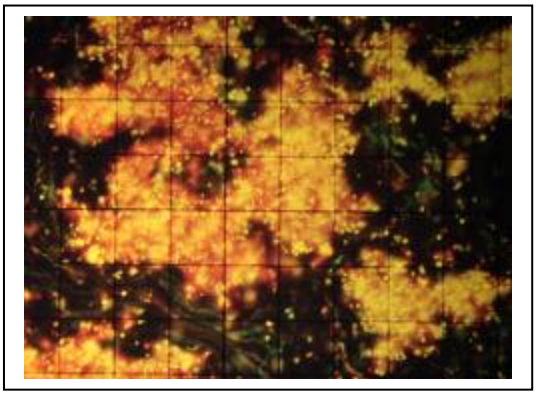


Contrary to the inactive soil on the past image, here a well populated soil. A healthy soil can contain up to 4 billion organisms per gram, which are incredibly efficient in their work. The diversity of the soil life as well as its total numbers determine the speed of digestive processes to humus formation, and the level of overall fertility.

This is the SECRET OF SOIL FERTILITY – to re-establish the needed microlife in a soil and to supply a sufficient amount of fresh organic matter to feed this life.

The image shows a soil profile (→ 0 – 30 cm) with a homogenous crumb formation all the way to 30 cm depth and below.





The magnification clearly shows the air spaces between the soil crumbs.

This allows for the needed oxygen supply to keep the aerobic microflora alive.

Aerobic microorganisms need:

Firstly: oxygen – just like most life forms of life on the surface of the planet.

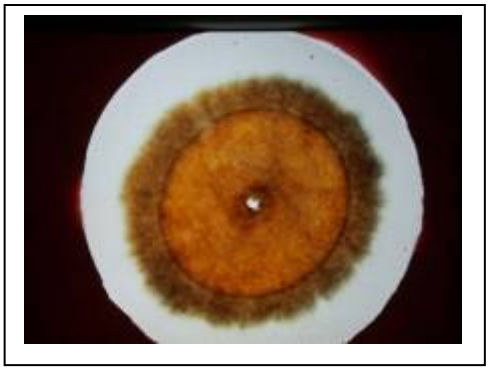
Secondly: moisture – active carbon has the ability to store 4 times it`s own weight in water and to conserve it for the life processes in the soil. Since the utilization of water also becomes more efficient, much irrigation water can be saved (from 30 to 70% in vol.)

Thirdly: food - which can be crop residue, green manure, compost, etc.
Yet it should not be organic matter in a condition of putrefaction.
This means, anything with an offensive odour is a problem to aerobic soil life.
Just like larger life forms like animals and humans have problems with putrefied food, the beneficial soil microlife is harmed by putrefied organic matter.

Fourth: temperature - in cool climates, if the soil temperature approaches 0 Celsius during the night, it is not advisable to incorporate green manure anymore.

Any form of erosion is an indicator for soils in `agony`. In order to understand the biological situation of a soil and its potential for humus formation, Ehrenfried Pfeiffer developed round-filter-paper-chromatography for soil and compost quality assessment.

Soil quality assessement



Chromatograms provide information about the microbial activity of soils and many quality related factors. The above slide for instance displays a soil containing humus, but hardly any microbial activity.

The different zones of a chromatogram provide information about different biological transformations taking place. For example in the outer zone the chromatogram reveals the

quality of protein synthesis, which is either expressed as spikes and spears in case of good microbial turnover, or no visible definition in the case of poor microbial activity.

Another indicator for a fertile soil is a white circle forming the center of the chromatogramm.

Here an example for a chromatogram of a fertile soil. The multitude of colors, the white center, the radial lines, the spikes and spears of the outer zone – they are all indicators of a biologically active soil, which also feeds the plant well.

Even though this is a heavy clay soil, one can easily see the good crumb structure indicating the biological activity, which is also confirmed by the chromatogram.

Whereas the neighbouring soil is compacted and low in oxygen.

The chromatogram reflects the unfertile condition, which is expressed in a missing white center, cog-wheel like definition in the outer zone, etc.

Manure and liquid manure are still considered valuable sources of organic matter and nutrients – even in organic agriculture

Yet, they contain high concentrations of putrefied substances, which have and still are contributing to the loss of microbial diversity of our agriculturally used soils. These liquid manure and manure applications are not only to a disadvantage of soil fertility but also a danger to human health and the environment.

In 1997, a congress took place in Fulda Germany, on human medicine which addressed the application of microbially unsafe organic materials being applied to soils. One of the headlines of the medical press, following the congress, was *deadly dangers from foodstuffs*.

There is a worldwide increase in contaminated foodstuffs endangering the health of people e.g. salmonella, E.coli, BSE, parasites etc.

Experts name intensive livestock keeping as one of the main causes, because it contributes considerably to the release of pathogens into the environment. Especially Salmonella, which populate rapidly with poultry farming. In addition, the immune system of about 20% of the population is already weakened, and not able fight infections properly any more.

It is important, that farmers realize, that putrefied manures, liquid manures and sludges contain and spread these pathogens and in addition cause the release of greenhouse gases like methane. The more putrefied an organic material, the more methane is released from it.

Over time the aerobic microlife is eliminated, because an aerobic flora needs a sufficient supply of oxygen. Obviously the rate at which the aerobic microlife is killed depends on the amount and frequency of the application of manures. There is another factor involved in the application of raw and putrefied organic matter. Once the organic matter is decomposed, the nutrients are washed out to the ground water table, polluting it. The less oxygen, the more an anaerobic putrefying microlife takes foot.

Some examples from our work-practice:

1st example:

One of our students told us, that he keeps 250 head of cattle on 50 ha of land. His reason for attending our program was that he needed to increase the horsepower of his tractors frequently because the soils became more and more compact. Once he was up to a 500hp tractor which was still not ploughing well, he realized he needed to take action to increase

the soil fertility of his land. It was only after he learned to compost properly, according to our controlled composting method, that he was able to improve friability and water holding capacity of his soils.

What had happened, was that aerobic microlife was reapplied to the soils through the CMC-compost and each green manure crop that was incorporated, fed the microlife causing a rapid populating. Frequent aeration through discing etc. helped to uphold the living conditions for the aerobic microlife.

If a soil is continually treated with putrefied organic matter, the products of decay will not only pollute the environment, but also kill the aerobic life and can cause a soil to become compacted and unfertile within only a few years.

2nd example:

An organic farm, specialized on the production of Aloe Vera, which was sold to the pharmaceutical industry in Germany. The aloe plants were fertilized with goat manure. Since the goats had been treated with antibiotics, the plants uptook the residual antibiotics, which were subsequently found in the plant tissue of German Aloe Vera.

Of course it is unacceptable and illegal to apply antibiotic containing manure to medical plants. Had the manure been composted prior to application, the antibiotics would have been broken down, and not taken up by the plants.

In Europe many men and women experience fertility problems, which are directly related to the application of manures, liquid manures and sludges to soils. The residual hormones are either taken up by plants or contaminate the ground water, and become part of the food chain.

3rd example:

In one of the watersheds of Munich the water quality had dropped considerably and the authorities had to either invest into water treatment facilities or improve the soil quality. A ten year program was started where subsidies were paid to the farmers in the watershed area to farm organically and only use compost for fertilization (no raw organic matter like manures etc.). The project has proven to be successful.

This measure could be taken anywhere!

The most important improvement for soils will be to apply no putrefied materials and no more products of decay as they always cause negative consequences for soils and soil-life.

Longterm studies in the United States have shown that more than 80% of the nutrient potential of manures is lost within the first year after application. The same applies to any raw organic matter and to commercial fertilizers.

The less the total numbers and diversity of soil life, the higher the losses of nutrients and carbon.

4th example:

A young farmer and student of ours was ready to take over his fathers farm of 25 years organic farming. Yet the problems with diseases and insects were so massive, that they

had to exchange the soil in the greenhouses on a yearly basis. The insect pressure was still massive and crop yields very low. The young farmer considered denying the inheritance.

We recommended the production of highest quality compost and a humusmanagement program.

Above, the composting facility he built after attending our composting program.

In the green houses a fast growing green manure crop was seeded. Once the compost was ready for application, the green manure was chopped and inoculated with the CMC-inoculum and incorporated into the soil, along with the compost, at a rate of 50 m^3/ha.

A wait period of one week was recommended before planting the next crop. Usually this is not needed, but in that particular situation caution was preferable.

The influence of the plant roots on the microlife is considerable and as long as there is a diverse microlife active in a soil, the needs of the plant are satisfied through an interaction and communication between plant roots and soil life.

5th example:

When we taught composting seminars in California, during the 1980ies, we were called to consult for some farmers regarding composting issues.

I remember well, how 10 to 12 farmers, all with a university education and much farming experience, sat around a table with doleful expressions. Some had tears in their eyes when their soil problems were explained to us.

We were told that 30 years ago the consultants of the fertilizer industry had offered to supply seeds and fertilizers beforehand as well as top yields along guaranteed with

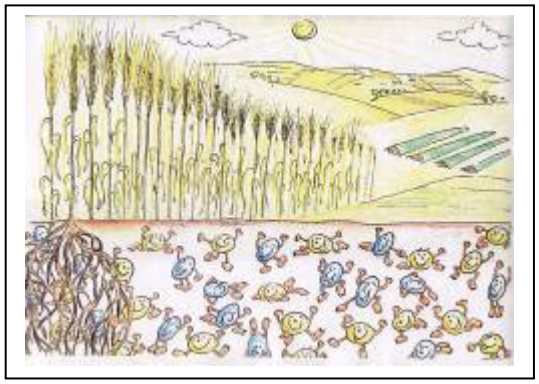
marketing prices. Investment costs only had to be repaid after the harvest. The only condition was, that they were not allowed to apply organic matter to their soils.

So straw was burnt, manures sold off, and long term marketing contracts signed. For years the concept worked and good money was made. However once the authorities outlawed the burning of organic matter, the straw had to be ploughed under, where it didn`t brake down any more. Now the question they addressed to us was: is it possible to compost just straw. Which is not possible, at least not without a lot of losses and environmental pollution.

What this incident showed us, was that even 30 years ago, the research behind the commercial fertilizer industry was aware of the fact that if organic matter doesn`t brake down quickly and properly, it turns putrefied and damages soil life and crops. Therefore the restriction of organic matter use.

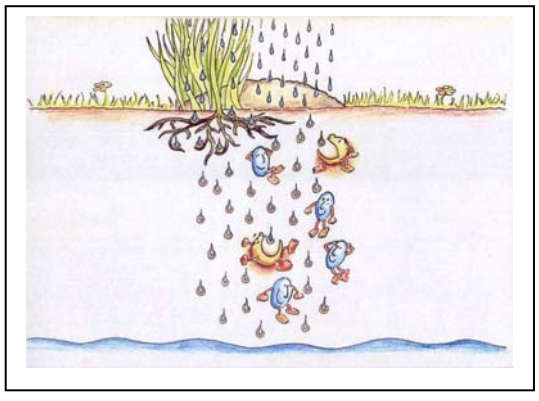
Putrefaction in soils causes poor yields, disease susceptibility of plants – especially towards fungal infections, and insect pressure.

However, if soil life is deprived of organic matter for a long time, it starves until it dies. The use of agro-chemicals and commercial fertilizers added their share.



It is not an easy task to reactivate an infertile soil.

The microworld of our planet evolved long before human life and its most important task is to transform and digest all organic residue as quickly and efficiently as possible and to reintegrate the compounds into stable chemical forms. Since the life, accomplishing this work, consists of unicellular beings, a great diversity of species is needed to meet all the plant`s requirements. This same life also fulfils a cleansing action and has a protective effect towards plants, by eliminating pathogens, e.g. by excretion of antibiotics.



Once a cow-pie is dropped on a pasture, the breakdown products are washed into the ground with rainwater or irrigation. Within the ground, the microlife is ready to take on these nutrients and complex them.

For easier understanding I have split the microlife into two groups. The blue ones are the break-down microflora and the yellow ones are the humifiers.

The blue microorganisms will digest and disintegrate the organic matter.

The yellow microorganisms, which are the humufiers, take the various products of decay and reintegrate them into chemical compounds, thus detoxifying them.

The initial process is considered the formation of nutrient humus, which is an assembly of short chemical chains. When this nutrient humus is not utilized and the proper microlife is present, then permanent humus can be formed over longer periods of time.

Our example picture shows a reduced number of microorganisms, meaning that the total population and the diversity of life is not sufficient to keep the grasses from taking up a surplus of nutrients and consequentially growing tall but unhealthy.

If there were a proper population of humifiers the plant would not be able to take up an excess of nutrients, because the microlife would tie them into the humus before the plants could get to them.

So as in our case, if there is a lack of life in a soil, the plant may grow fast and tall, but with an imbalance in nutrients, uptaking substances that weaken the immune system and decreasing the quality of protein synthesis.

Animals have an instinct towards this imbalance in plants and refuse to graze such pastures.

Humans have a different approach, we are proud to produce much mass, at the expense of quality.

Unfortunately sensitve, old and sick people are adversely affected by the consumption of plants that have taken up the products of decay. Also unhealthy or dangerous substances leach into the ground water table. The proof of that is easily found right across Europe.

This means, in all areas and countries, where ground water cannot be consumed any more, the humifying microlife is missing.

This takes us to a central point regarding soil-fertility. A biologically inactive soil, cannot be brought back to life simply by adding raw organic matter to it – e.g. green manure, manure, liquid manure, crop residue, etc. Fertility is reinstalled in a soil through a combination of the activity of plant roots and microbial life. This is why inoculated, aerobic CMC-compost is so effective.

We will now take a look at the situation in a soil with much anaerobic organic matter. The anaerobic life is represented by little devils, because they create a lot of problems for us.

As mentioned already, putrefied matter can always be detected by an offensive odour. In our case the organic material is manure, which had been ploughed under.

Anaerobic activity produces methane, which rises and at the same time kills off aerobic microlife and causes plant roots to stay to the very top layer of the soil.

As a consequence the plant roots dry up during dry periods.

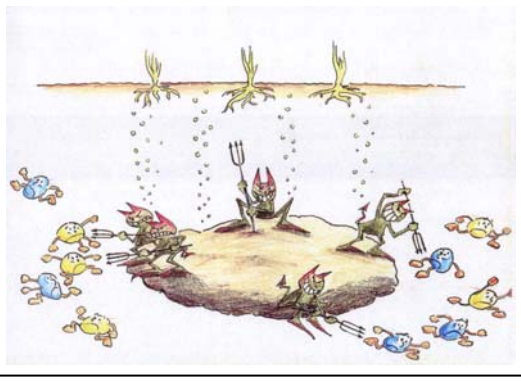
The anaerobic life also excretes metabolites which are toxic (e.g. putrescin and cadaverin) thus harming the immune system of plants, making them susceptible to diseases and insects.

The renown humusresearcher Dr. Gustav Rohde, of the technical university in Berlin said the following:

In an aerobic process oxygen is tied into the materials.
In an anaerobic process oxygen is released from the materials.

In a putrefaction process ptomains like putrescin and cadaverin are being built from the building blocks of protein.

Pathogens need these ptomains for their growth.



The aerobic microlife takes care of the hygienization of the soil. The efficiency of this process depends on the oxygen availability in the soil. In case of an oxygen deficiency the anaerobic flora dominates the soil milieu.

Conclusion

If humans intend to populate this planet much longer, we need to learn to understand natural laws and live by them. Neither genetic engineering nor chemical solutions or clever technological tricks will guarantee soil fertility or food on the long run. The increasing rate of environmental catastrophes shows clearly that we need to pay attention to re-establishing soil fertiliy and stop disturbing the natural balance.

The humus researcher Annie France, who carried out her research on soil life, around the globe, for decades, warned in her book `The last chance` in the 1950ies already that the destruction of humus will lead to incredibly devastating catastrophes.

I am not a pessimist and I believe in the good in people! This is why I am here today.

I would like to encourage you to make others aware of the fact that: anyone who consumes, has a responsibility towards the fertility of ours soils. The only way of re-establishing soil fertility efficiently is to collect organic waste materials and stabilize them in the form of highest quality compost, before returning them to soils. Ours soils do not have the ability any more to digest organic matter properly, and therefore all organic matter must be prestabilized before its incorporation into soils.

Even those of us, who do not deal with soils directly must accept their responsibility.

The Austrian model has shown that it is possible to collect organic waste materials and to process them on decentralized agricultural-municipal composting facilities. Decentralized facilities have many advantages over centralized ones (short transport ways, fresher materials, flow of finances into agriculture, etc) and the compost quality is much higher than on large indoor facilities.

Humus is one of the most precious goods of our time. It guarantees high quality food, healthy plants, and a safe environment.

I can only encourage you to take every measure to increase humus in soils, whether it is by planting a tree in your backyard, by influencing legislation or by producing highest quality compost. Whatever your range of influence.

Generally it is believed that our efforts for soil fertility will guarantee the survival of following generations. However we are at a point of criticality and if we will not be able re-establish humus in soils quickly it will be our own necks at risk, not only those of our children.