COMPOST LEGISLATION:

SANITIZATION VS. BIOLOGICAL QUALITY

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0. Abstract

The presence of different pathogens in organic residuals, by-products and substrates has been extensively proved and studied, as well as its associated risks. “Biowaste and compost” specific legislation as well as “Safety and Health” national regulations, set up control procedures, approved treatment methods and biological compost standards to be achieved.

A review of biological parameters in legislation dealing with organic substrates, compost and fertilisers is performed, including a scientific analysis of its adequacy as indicators. Treatment technologies (as composting, lime stabilisation, thermal..) are also listed with its main pathogen controlling factors and processes.

Very little efforts, (and mainly at scientific level) have been dedicated to study the “positive biology” in these substrates, the compost and organic fertilisers, and its sub-sequent positive and specific effects on soil and crops. So biology and ecology and in general “life in compost and soils” are systematically forgotten or neglected. So many questions still remain unformulated today from the eco-biological standpoint:

- Are the sanitary microbiological indicators adequate from scientific perspective?
- Are the sanitary microbiological indicators a measurement of biological quality of compost?
- Are the sanitization legislative compost standards proportionate to risks?
- Are the harder treatment technologies the better? If not what are the right technologies?
- Are the extreme temperature or pH processes necessary and safer?
- Are the sterilized / pasteurized substrates better for soil and crops or do they pose problems?
- Are there other possible methods of sanitization by biological dynamics enhancement?
- What is the right substrate or compost quality for specific uses, soils and crops?

Maybe, a new approach to compost production, quality assessment and use is needed, considering the users (nurseries, landscapers and farmers) and the specific needs of soil, plants and crops. The Agroecology could offer a friendly (cultural and scientific) frame for this integrated vision where compost is considered a resource for the biological cycling of the nutrients and an element for the balance and health of soils and crops, and the agriculture a practice oriented to produce healthy quality food in harmony with the environment.

1. The question of biology in organic substrates

1.1. Management and treatment for safety: technical and scientific approach

The presence of different pathogens in organic residuals, by-products and substrates has been extensively proved and studied, as well as its associated risks, with the primary purpose of avoiding their direct or indirect transmission. Although there is little evidence of public health problems caused by organics recycling in developed areas, "Biowaste and compost" specific legislation as well as "Safety and Health" national regulations have been set up, with approved treatment methods and biological compost standards to be followed.

When developing these rules and standards, it would be advisable to apply a scientific approach, taking into account the specific conditions of management and use of these materials, not "directly importing sanitary or alimentary standards" that are unrealistic and unnecessary.

The risks for humans, animals and plants from pathogens present in organic residuals, by-products and substrates could be classified as follows (3):

- Occupational risks: collection, transportation, treatment, delivery, distribution
- Food chain risks: transmission of pathogens to man or animal and plants of agricultural importance
- Environmental risks: introduction of pathogens into the environment, water courses or groundwater contamination .

The scientific approach when dealing with hygiene and safety would require the use of risk assessment analysis, measuring the risk for every exposure pathway.

Tens of pathogenic species can be found in sludge and biowaste that should be monitored for measuring the effective sanitization or characterising the compost. However, it is not possible to monitor all these species because their unmanageable variety but also because there are not always specific, homely and fast standards for their quantification and identification.

It becomes therefore important to select some specific micro-organisms. For this purpose, the concepts of "indicator micro-organisms" and "test micro-organisms" have been developed.

<u>Indicators</u>

To be considered as indicator, micro-organisms have to satisfy some criteria:

- Their growth characteristics (temperature, pH, etc) must be similar to those of pathogens which detection and quantification are difficult or sometimes impossible.
- Being determined by simple reliable, precise and inexpensive analytical techniques.
- Presenting similar or greater resistance to treatments than pathogens.
- The concentration and evolution of indicator microorganisms have to be correlated to those of pathogen population.
- To be able to withstand the disinfectant and environmental stresses at the same level as the potentially present pathogens.

As a sole indicator microorganism does not predict the presence of all pathogens, is better to have several indicator microorganisms. Pathogens such as helminths and protozoa are not always found in wastes, virus cultivation is not quite easy, so the best kind of indicator micro-organism seems to be bacteria.

In most of European countries, the selected indicator microorganisms are:

- Coliforms (total and faecal)
- *E. coli*
- *Enterococcus*
- *Clostridium*
- Enterobacteria

Test micro-organisms

A test micro-organism is a non endogenous microorganism introduced in the studied substrate and used to validate the sanitization in the treatment processes. They are dosed in the samples before treatment and after treatment their concentration is measured.

They have to accomplish with some terms:

- To be resistant to physical and chemical conditions of treatment
- To have easy conditions of isolation and culture
- To have low transmission potential and sanitary risk
- Low cost of analyses

The test microorganisms are chosen with some specific growth characteristics, usually resistance to high temperatures. Bacteria of genus *Clostridium* are the most resistant among the bacteria usually present in biowaste and compost, but they are too resistant to be used as test micro-organism because their inactivation rate is not sufficiently important.

There are many types of biowaste: yard or green waste, household wastes, crop residuals and by-products wastes, sewage sludge, drinking water sludge, industrial sludge, manure, agro-industries derivates, etc. The pathogen (and microbiological) composition of these different biowastes and compost in term of amount or species is variable and not always studied.

As an example, sewage sludge pathogens, animal manure and the pathogens from vegetable wastes are listed below (4).

Table 1.- Pathogens and Indicator micro-organisms in sewage sludge

Bacteria	Fungi	Virus	Protozoa	Helminths
Salmonella	*Aspergillus*	Poliovirus	*Cryptosporidium*	*Ascaris*
Shigella	*Candida*	Coxackievirus A, B	*Entamoeba*	*Ancylostoma*
Escherichia coli	*Cryptococcus*	Echovirus	*Giardia*	*Echinococcus*
Campylobacter	*Geotrichum*	Hepatitis A virus	*Sarcocystis*	*Diphyllobothrium*
Bacillus	*Epidermophyton*	Adenovirus	*Toxoplasma*	*Toxocara*
Clostridium	*Phialophora*	Reovirus		*Trichuris*
Enterococcus	*Trichophyton*	Rotavirus		*Taenia*
Leptospira	*Trichosporon*	Astrovirus		
Listeria		Calicivirus		
Mycobacterium		Coronavirus		
Pseudomonas		Norwalk-like viruses		
Staphylococcus				
Vibrio				
Yersinia				

Special attention has to be paid to animal by-products (from slaughterhouse or meat processing facilities) that would contain mostly animal pathogens or zoonotic agents.

Table 2.- Pathogens and Indicator micro-organisms in animal manure

Bacteria	Fungi	Virus	Protozoa	Helminths
Salmonella	Various species	Aphtovirus	*Cryptosporidium*	*Toxocara*
Bacillus		Coronavirus	*Sarcocystis*	*Trichuris*
Brucella		Herpesvirus		*Taenia*
Clostridium		Parvovirus		*Diphyllobothrium*
Campylobacter		Rotavirus		*Echinococcus*
Escherichia coli				
Leptospira				
Yersinia				

If vegetable material (i.e. crop residuals) has been added or used for the compost production, it may contain plant pathogenic viruses, bacteria, fungi and parasites. The major risk that should be addressed in this case would be of phytopathological origin.

Field experience shows that vegetal and mixed vegetal compost (or peat) is a also extraordinary friendly habitat for pathogens and indicators (*Salmonella*, Coliforms, Enterobacteria…), due to its favourable physical-chemical conditions.

Table 3.- Plant pathogens found in crop residuals and vegetable waste

Pathoghen	Host
Bacteria	
Xanthomonas	Cabbage
Pseudomonas	Lettuce, bean, cucumber
Corynebacterium	Tomato, potato
Erwinia	Potato
Agrobacterium	Various
Viruses	
Potato virus X, Y	Potato
Aucuba virus	Potato
Rattle virus	Potato
Tobacco mosaic virus	Tobacco
Pea mosaic virus	Pea
Lettuce mosaic virus	Lettuce
Horse bean mosaic virus	Bean
Yellow bean mosaic virus	Bean
Onion mosaic virus	Onion
Beet mosaic virus	Beet
Fungi	
Alternaria	Carrot, tomato
Fusarium	Tomato
Plasmodiophora	Cabbage
Cladosporium	Cucumber
Phoma	Cabbage
Peronspora	Celery, spinach, onion
Marssonia	Lettuce
Sclerotina	Lettuce
Botrytis	Lettuce, onion
Bremia	Lettuce
Cerspora	Turnip

1.2. Management and treatment for safety: social and political approach

Usually, legislation is only partly founded in scientific evidence. Precautionary principle and not the risk assessment is the inspiring principle of some legislation. In other cases like EPA part 503 sludge rule has been used the risk assessment approach.

Sometimes new alarms ring when new pathogens (organisms, strains) or new transmission vectors or pathways are suspected or proved (Prions in BSE, *Cryptosporidium* (9) in drinking water, *E.coli* O-157 in some animal products) to cause animal or human epidemic outbreaks.

Although these are food or water borne diseases, it is common to produce a direct or indirect impact in compost related legislation.

There are three complementary strategies used as single or combined tools for guaranteeing a reliable degree of sanitary safety in organics management:

- Validation of treatments and regular registration of process parameters
- Test for microbiological (or biological) indicators in the end products (compost)
- Restrictions for the utilisations of the final product

Phyto-pathological microbiological indicators should be advisable, but are missing, when i.e. compost is made from crop by-products and dedicated to plant nurseries or intensive agriculture.

It is important to investigate if with these regulations and with expensive technologies the compost is safer, if it is reached on this way a higher CO_2 fixation rate and stability in soils, if the compost is richer or its nutrients are more available for soil micro-life and if the indicators set up in compost legislation are a valid measurement of its biological quality.

1.3. Management and treatment for specific use or quality (soil, crops, gardens)

Management for quality starts with a good selection and combination raw materials that should be clean from physical impurities and pollutants. Two general types of substrates could be differentiated:

- *C-rich substrates:* crop residuals and by-products, paper sludge, green and forestry and other substrates rich in lignine, cellulose and hemi-cellulose

  These substrates will produce fungal dominated compost. The process of composting will be slower, less thermophilic and with a longer period of maturation needed. The compost pH is usually less than 7.

- *N-rich substrates:* sludge, m.s.w. organic fraction, animal by-products, bio-industries and other residuals (including all those with high contents in protein, lipids and simple sugar)

  These substrates will produce bacterial dominated compost. The process of fermentation will be easy starting with high temperatures due to rapid bacterial growth, release of ammonia and sulphur odour compounds, with a tendency to anaerobic conditions. The compost pH tends to be alkaline.

From biological perspective, this balance of C/N which derives in the balance Bacteria/Fungi in compost is the main issue to address, together with the rest of biological indicators (Protozoa, nematodes, etc) that should also be balanced.

This balance could also be defined in soils, as fungal or bacterial dominated. Every crop has a better response in specific soils regarding its physiological characteristics. The compost biological profile should fit with soil biological profile and crop characteristics for optimum results with minimum use of inputs (agro-chemicals and labours).

End products coming from chemical or physical treatments are difficult to adapt for this specific biological quality purpose for obvious reasons.

Table 4.- Types of raw organic substrates and treated end products

Raw/Fresh	Treated, End / Products
- Sludge	- Treated sludge, Compost, Dry sludge, lime st
- Organic fraction m.s.w.	- Compost
- Bio-industries residuals and by-products	- Compost, lime st
- Crop residuals and by-products	- Compost
- Manure	- Compost, Dry manure
- Forestry green residuals	- Compost
- Biologically enhanced mixed organics	- Bio-fertilisers
- Chemically enhanced mixed organics	- Organic-mineral fertilisers

2. Biological parameters in organics, compost and fertilisers legislation

2.1. References of biological parameters in legislation

Table 5.- Biological parameters in legislation in some countries

Country	*E. coli*	Enterobacteria	Enterococci	*Salmonella*	Others
EC 86 / 278 Sewage sludge	No microbiological limit values				
EC 3[th] Draft sludge	$< 5 \cdot 10^2$	-	-	Absent / 25 g	-
EC 2[nd] Draft biowaste	-	-	-	Absent / 50 g	*C. perfringens* (Absent 1 g)
EC 1774/2002 Regulation Animal by-products	-	< 300 / g (5 samples 25 g)	-	Absent (5 samples 25g)	-
EC 2001/688 Eco-label soil improvers	$< 1 \cdot 10^3$	-	-	Absent / 25 g	-
Spain May 1998 Fertilisers	$< 1 \cdot 10^3$	-	-	Absent / 25 g	-
Spain Draft fertilisers	$< 1 \cdot 10^3$	-	-	Absent / 25 g	*C. perfringens* (Absent 1 g)
Austria Compost ordinance 2001	-	-	-	Absent	*Campylobacter Yersinia Listeria*
Germany Biowaste ordinance 1998	-	-	-	Absent / 50 g	-
Greece Ministerial decision, 2000	-	Absent	-	-	-
Italy Law Fertilisers 748/84 (modified by decree 27/3/98)	$< 1 \cdot 10^3$	$< 1 \cdot 10^3$	-	Absent / 25 g	-
U.S.A. EPA/40 CFR part 503	A: $<1 \cdot 10^3$	-	-	Absent	-
	B: $<2 \cdot 10^6$	-	-	3 / 4 g	-

2.2. Scientific analysis of biological parameters in legislation

i. *Clostridium perfringens*

C. perfringens is an anaerobic, gram-positive, spore-forming rod. It is widely distributed in the environment and frequently occurs in the intestines of humans and many domestic and wild animals. It is found in soils and sewage. Spores of the organism persist in soil, sediments and areas subject to human or animal faecal pollution, but the presence of small numbers of *C. perfringens* is not uncommon in raw meats, poultry, dehydrated soups and sauces, raw vegetables and spices. Because the spores of some strains are resistant to temperatures as high as 100ºC for more than 1 hour, their presence in foods may be unavoidable. The infective dose is greater than 10^8 vegetative cells. So the legal limits in present and future compost legislation seem to be too restrictive, more adequate for food standards.

ii. Enterobacteria

Enterobacteria is a family of gram-negative bacilli that contains more than 100 species of bacteria, including some that can infect the human gastro-intestinal tract, other cause opportunistic infections and some are widely distributed in the environment: soil, water, sewage and decaying matter. Including Enterobacteria as indicator in some legislation has been the consequence of directly adopting sanitary standards, but it is an unrealistic and unachievable requirement.

iii. *Escherichia coli*

E. coli takes part of the "coliforms group". Normally inhabits the intestinal tract of the human and warm blooded animals. *E. coli* is used as an indicator of fecal contamination of water and food.

Certain strains of *E. coli* are pathogenic: enteropathogenic (EPEC), enterohemorragic (EHEC), enteroinvasive (EIEC), enterotoxigenic (ETEC) and verotoxigenic (VTEC, producing verotoxin). The famous outbreaks of *E. coli* 0157:H7 are associated with faecal contaminated meats.

E. coli is widespread in the environment, including soil and surface water bodies. For this reasons its utilization as indicator of faecal contamination is questionable.

iv. *Enterococcus*

Originally classified in the 30´s as Group *D Streptococci, Enterococcus* were officially given genus status in 1.984 after hybridization studies showing the distance with *Streptococci.* They are found as a natural coloniser of the digestive tract in many animals including humans. They are robust microbes, able to tolerate high salts concentrations and low pHs.

Enterococci has been used very frequently as indicator of faecal contamination in microbiological analyses of water and food, but, as commented before for *E. coli*, they are usually found in soil and water.

v. *Salmonella sp*

It is not a bacterium naturally present in soil or natural water, therefore it can be a reliable and adequate parameter to be controlled.

vi. *Salmonella senftenberg*

It is a test micro-organism, artificially introduced in the processing substrate with the purpose of validating the sanitization during the treatment. They are dosed in samples before treatment, their concentration is measured.

Test microorganisms must accomplish some conditions as to be resistant to physical and chemical conditions of treatment; to have easy conditions of isolation and culture; to have low transmission potential and sanitary risk and low cost of analyses.

In composting and other heat treatments test microorganisms must have resistance to high temperatures. For this reason, *Salmonella senftenberg, a thermoresistant bacterium,* the most temperature resistant strain of genus *Salmonella,* has been chosen as test microorganism in last draft of European Directive on sludge.

Among bacteria usually present in soil and biosolids are bacteria of genus *Clostridium*, but they are too resistant to be used as test microorganism, because its inactivation rate is not sufficiently important.

3. Technologies for organics treatment and biology

3.1. List of treatment technologies and control parameters

Table 6.- List of treatment technologies and process control parameters (4)

Treatment technologies	Control parameters
	Process parameters
- Heat treatments (Pasteurization, Sterilization)	– Time, Temperature
- Thermolysis	– Time, Temperature, Pressure
- Thermal drying	– Time, Temperature, H_2O content/activity
- Composting / Aerobic digestion	– Time, Temperature, O_2, H_2O content/activity
- Lime stabilization	– Time, Temperature, pH
- Anaerobic digestion	– Time, Temperature, H_2O content/activity
- Air drying	– Time, H_2O content/activity
- Irradiation	– Time, Dose
- Long term open air storage	– Time
	Biological related quality parameters
	– Pathogens / Indicators
	– Stability AT_4- respiration activity after 4 days, (mg O2 /g dm) DRI- Dynamic respiration index (mg O2 / kg VS/h
	– Maturity
	– Biological test (fields germination)

Biological, chemical, physical and combined systems are applied in order to inactivate pathogens presents when processing organic substrates. Biological and chemical processes have also complementary objectives as organic matter stabilisation, moisture, odour reduction which improves not only the sanitary but the management conditions. The treatments that stabilise the substrate are most efficient to avoid pathogens re-growth, a situation that is very usual and uncontrollable to an important degree.

External factors as direct sun radiation, relative air moisture are also influential in open air biological processes.

Several physical chemical factors as temperature, moisture or pH, can directly influence pathogen reduction, but also other phenomena of biological such as competence, microbial antagonism, antibiosis, etc.

There are not treatment technologies that can selectively operate on pathogens inactivation or reduction, so when extreme conditions are applied the positive biology in substrates and compost is by any means seriously affected, although not measured until today.

As organic substrates and its end products (i.e.-compost) can be defined as “living mediums or even soil like ecosystems” with an incredible biological diversity and complexity, we can imagine that a management of this biological spontaneous processes is possible, including biologically driven pathogens reduction and inactivation compatible with “high biological compost quality”

- *Physical treatments*

  Heat treatments as pasteurization, sterilization: to achieve pathogens inactivation or death through different combinations of time-temperature

- *Chemical treatments*

  pH treatments

  Alkaline stabilisation: with pH rise over 11 or 12 we attempt to suspend microbial activity. With addition of lime, this phenomena is usually accompanied by sudden temperature rising over 60ºC. This combination provides a high degree of sanitization.

- *Biological treatments*

  – *Anaerobic Digestion*: Many pathogens survive during mesophilic anaerobic digestion, but thermophilic anaerobic digestion (at temperatures at least of 55ºCand log retention times) ensures a larger pathogen reduction.

  – *Composting*: The composting process is based on the heat (temperatures recommended between 53 and 68ºC are the common standard) generated during the aerobic decomposition of organic matter by micro-organisms. Competence and antagonism between micro-organisms become a very important factor in pathogen removal.

The treatment processes and its final results in terms of biology are strongly conditioned by a large diversity of factors: type of substrates, mixtures of them, local climatic and ecological conditions, together with the complex non mathematical biological nature of the subject and the serious limits of available laboratory determination methods. Therefore, not very conclusive results can be made, except that a lot of questions remain unformulated and a big field of research and development is still open.

3.2. Practical examples of treatment-sanitization that should make us think

A. *Composting 3 different organic substrates in windrows (over 55 º, more than 6 h)*

(*) Results expressed in CFU/g (1)

		Initial admixture	
	Sludge/Biomass	**M.s.w./Biomass**	**M.s.w./Sludge/Biomass**
Faecal coliforms	5.700	10.100	6.800
Total coliforms	56.400	132.800	69.200
Faecal streptococci	870.000	1.200	95.000
Escherichia coli	Present 0,1g	Present 0,1g	Present 0,g
Salmonella sp.	Absent 25g	Absent 25g	Absent 25 g

		Finished compost	
	Sludge/Biomass	**M.s.w./Biomass**	**M.s.w./Sludge/Biomass**
Faecal coliforms	400	3.200	60
Total coliforms	13.000	680.000	500
Enterococci	5.700	7.900	26.600
Escherichia coli	<1000	<1000	<1000
Salmonella sp.	Absent 25g	Absent 25g	Absent 25 g

		Mature compost	
	Sludge/Biomass	**M.s.w./Biomass**	**M.s.w./Sludge/Biomass**
Faecal coliforms	11.000	15.000	8.000
Total coliforms	50.000	78.000	10.000
Enterococci	2.500	5.700	22.000
Escherichia coli	<1.000	<1.000	<1000
Salmonella sp.	Absent 25g	Absent 25g	Absent 25 g

B. *Windrow composting of Sludge/Yard trimmings (1/3 volume)*

(*) Results expressed as CFU/g dm. Summary of intervals of various determinations

	Before (sludge)	**After composting**
Dry matter (%)	25,0%	60,0%
E. coli	10^3-10^5	0-10^2
Faecal coliforms	10^3-10^5	10^2-10^3
Enterobacteriaceae	10^3-10^5	10^2-10^3
Enterococci	10^4-10^5	10^3-10^4
Salmonella sp	Detected	Absent

C. *Sludge thermal drying (30 min, 92ºC)*

(*) Results expressed as CFU/g dm. At this dry matter content, all the free, colloidal, capillary and most of intracellular water are lacking, so how would you describe biological situation of this product and predict its effects when applied to soil?

	Before	**After drying**
Dry matter (%)	32,3%	97,8% (*)
Total count	$3,5 \times 10^7$	$5,9 \times 10^5$
Aerobic spores	$6,4 \times 10^5$	$1,4 \times 10^5$
Enterococci	$1,4 \times 10^4$	0
Faecal coliforms	$8,0 \times 10^3$	0

D. *Mesophyllic A.D m.s.w. organic fraction (30 days, 37ºC) after pasteurising (70ºC, 1h)*

(*) Results expressed as CFU/ml. Clostridium tyrobutiricum showed an amplification through the A.D. process, as T. crustadeus and T.lanuginosus due to its thermophylli character. All the selected were spore forming species. (7)

Specie	**Before**	**After digestion**
Clostridium tyrobutiricum	inoculum n.d.	$>10^7$
Aspergillus flavus	"	$<10^2$
Aspergillus fumigatus	"	$<10^2$
Penicillium roquefortii	"	$<10^2$
Rizomuccor pusillus	"	$<10^2$
Thermoascus crustadeus	"	$>10^3$ (10^6 19 days, 55ºC)
Thermomyces lanuginosus	"	$>10^3$ (10^6 19 days, 55ºC)

4. Biological quality of compost developments

Organic matter from endogenous or exogenous origin is the source for soil organic matter build up or conservation. As the main food to soil fauna and flora, endogenous and exogenous organic matter quality and quantity added to soils is a key element of biological activity and functionality (as expression of its metabolic capacity) of soils.

The convenient agricultural practices (conservation agriculture practices, rotations, use of cover crops…) can also help keeping or rising organic matter in soils.

It is recognised the principal role of biological activity linked to soil organic matter in the soil fertility in the agro-systems, decisively influencing the main soil processes and characteristics: (mineralization, humification, aggregation, water retention…). This biological activity would be defined by the number and variety (biodiversity) of species colonising the soil. For example, well conserved forest soils are acknowledged as the richer in micro-life (by counts and diversity of species), and by consequence the more stable and resilient soils.

Compost is universally recognized as one of the main sources of organic matter for farms and gardens. It has been traditionally viewed as physical amendment and supply for organic matter and slow release nutrients and oligo-elements. But it could also be considered as a food resource for the soil food web, as biological seedling for soil, as a substrate with disease control properties, and in summary as a good production input for healthy soils and agro-ecosystems. It would be necessary, then to identify its biological profile.

As comparable substrates, the same parameters and indexes can be used for soil and compost biological activity determination:

<u>Indexes for Soil/Compost biological activity</u>

- *Biochemical indexes*

  - Dynamic Respiration Index
  - Substrate induced respiration
  - Enzymatic activity (many enzymes)
  - ATP concentration

Biochemical indexes are a measure of metabolic activity of microbial biomass

- *Biological parameter or indexes*

  - Total heterotrophic micro-organisms
  - Total microbial biomass
  - Total bacterial biomass
  - N microbial biomass
  - C microbial biomass
  - Total fungal biomass
  - Nematodes (species)
  - Protozoa
  - Micro and meso-fauna
  - Macro-fauna (lumbricids)

The interpretation of these parameters would require an ecological assessment, also considering the balance and ratios between different groups and species presents in compost to produce an assessment report identifying the “biological quality of compost”.

This analysis should be complemented with the information of soil characteristics and legacy, farming practices and cultivated crops, so the right compost could be used for the right situation and soil-crop binomial (7).

5. Biological quality of compost and agroecology

There is a traditional although not very extended working line considering cultivated lands as agro-ecosystems (6). From this perspective the main goal is to understand the dynamics of populations and communities. These dynamics obeyed to the soil based food web relationships.

As seen before, it is also possible to extend this eco-biological approach to organic substrates and compost.

Thus, it can be set up a common frame for agro-ecological analysis of organic substrates, compost and soil (and crops).

This is a way of interpreting the agro-ecosystems inside the plans of “The System of systems”, the environment, linking science and practice and yielding many advantages, from cultural side, protecting the biodiversity and the environment and enhancing the quality of the crops and food products. Healthy soils… healthy environment, healthy food.

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