NOSB NATIONAL LIST
FILE CHECKLIST

CROPS

MATERIAL NAME: **#7 Humic acid derivatives**

- ✓ **NOSB Database Form**
- ✓ **References**
- ___ **MSDS (or equivalent)**
- ✓ **TAP Reviews from:** **William Zimmer, James A. Johnson, Paul Sachs**

NOSB/NATIONAL LIST
COMMENT FORM
CROPS

Material Name: #7 Humic acid derivatives

Please use this page to write down comments, questions, and your anticipated vote(s).

COMMENTS/QUESTIONS:

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1. In my opinion, this material is:
_____ Synthetic _____ Non-synthetic.

2. This material should be placed on the proposed National List as:
_____Prohibited Natural _____Allowed Synthetic.

TAP REVIEWER COMMENT FORM for USDA/NOSB

Use this page or an equivalent to write down comments and summarize your evaluation regarding the data presented in the file of this potential National List material. Complete both sides of page. Attach additional sheets if you wish.

This file is due back to us by: Aug. 5, 1996

Name of Material: Humic Acid Derivatives

Reviewer Name: BART HALL

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

GENERALLY NON-SYNTHETIC

If synthetic, how is the material made? (please answer here if our database form is blank)

Derivatives, especially liquid products have been fluxed up w/strong alkali. Natural TRONA flux only permitted.

This material should be added to the National List as:

____ Synthetic Allowed   ____ Prohibited Natural ←

or, ✓ Non-synthetic (This material does not belong on National List)

H.A.D. dissolved in alkali other than natural trona (→ Prohibited Natural)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Permitted only when liquids are dissolved with natural Trona, and then, only if all other ingredients comply.

Please comment on the accuracy of the information in the file:

Any additional comments? (attachments welcomed)

See attachment. Also, some H.A.D. products are definitely bizarre 'soups', containing all sorts of stuff.

Do you have a commercial interest in this material? ____ Yes; ✓ No

Signature Barton M. Hall   **Date** 96.08.06

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

NONE

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment;

generally no problem.

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

Probably minimal in most cases – I believe

(4) the effect of the substance on human health;

Unknown.

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

Too complex and unstudied to determine at this point.

(6) the alternatives to using the substance in terms of practices or other available materials; and

See attachment.

(7) its compatibility with a system of sustainable agriculture.

Generally compatible though not always effective

HUMATES and HUMIC ACID DERIVATIVES

Prepared by Bart Hall, October, 1995

Humates and humic acid derivatives are a diverse family of products, generally obtained (directly or indirectly) from various forms of oxidized coal.

Coal deposits are of three types. Anthracite coal is very dense and hard with quite low sulphur content. Bituminous coal is a softer coal, usually with rather high sulphur levels. Lignite coal is a very soft, coarse coal with highly variable sulphur content and often marginal fuel value. Softer coals, particularly lignite, are (as a result of their more open texture) subject to oxidation, especially if found in a near-surface deposit.

While oxidation decreases the fuel value of lignite coals, it increases the percent of alkaline-extractable humic matter. In the western part of the Dakotas and the eastern part of Montana there are millions of tons of oxidized, near-surface lignite, surrounded by millions of hectares of alkaline soils capable of releasing assorted humic substances from these lignites.

Oxidized-coal-derived (OCD) humus and humic substances are essentially the same as humus extracts from soil (1), but there has been a reluctance to accept OCD humus as a worthwhile soil additive. In part, this stems from the belief (unjustified, in my opinion) that only humus derived from recently-decayed organic matter is beneficial.

Production and recycling of organic matter in the soil cannot be replaced by OCD humus — the sugars, gums, hemi-celluloses and similar materials from fresh organic matter play a vital role in both soil microbiology and structure, but they are not humus. Sod-based rotations, green manures and cover crops, preservation of crop residues and additions of manure or compost remain fundamental elements of any healthy soil management system, but especially *organic* management systems. However, only a small portion of the organic matter added to the soil will ever be converted to humus (most will return to the atmosphere as a result of microbial activity and cultivation), and only then on a time scale greatly exceeding current management frameworks.

The reluctance to accept OCD humus as a worthwhile soil amendment may also arise not only from the plethora of definitions for "humus," but also from the chemical complexity of humus, making it impossible to demonstrate that OCD humus and soil humus are identical. As a result, most of the research with OCD humus has involved indirect field trials and similar "bio-assay" methods. Such studies, by nature, involve many more variables and unknowns than do simple head-to-head chemical comparisons, and are much more subject to uncertainties and variations in their results. Additionally, there is an extensive body of anecdotal and experiential information surrounding OCD humus, arising from studies of varying sophistication and independence by farmers and vendors of the product.

Even determining the most fundamental characteristics of OCD humus can be challenging, especially in the case of farmer or vendor trials, because the degree of oxidation is something of a continuum and the exact origin and/or composition of the tested material has not necessarily been recorded. Many forms of oxidized coal are available, and are generally classified by stages of oxidation eventually ending in the complete humification of the starting material (1). In the case of lignite coal, the apparent end-product of natural oxidation is a soft, loose-textured, almost earthy OCD humus known as **leonardite** (2). Leonardite usually occurs at lignite outcrops, or at the top of very shallow beds of lignite, grading into the parent lignite seam.

Partially-oxidized lignite is called slack lignite and contains far less OCD humus than leonardite, but nevertheless more than lignite. The following table (1) summarizes approximate chemical properties of potential sources of OCD humus:

	LIGNITE	SLACK LIG.	LEONARDITE
Oxygen in source material	20%	25%	30%
Extracted humic acids	5%	30%	85%
Oxygen in extracted humic acids	25%	30%	30%

Summaries of some leonardite studies

For Kennebec potatoes treated with 200 lb./ac. 10-20-10 fertilizer, plots treated with pulverized slack lignite (1 ton/ac.) showed a dry-matter-corrected yield increase of 9% over the control. Plots treated with leonardite (1 ton/ac.) showed a 28% dry-matter-corrected yield increase compared to the control (1).

Soybeans are a difficult crop to grow in the northern Great Plains, due to alkaline soils and short growing seasons, so leonardite was studied in that region to determine if it had significant enough impact on crop yield to make the difference between crop failure and success. The limited study suggests that it does (2). Unfertilized soybeans, both rhizobia-inoculated and uninoculated, were treated with 1 ton/ac. or leonardite *in the row*. Inoculated, untreated soybeans yielded 65% more than the uninoculated, untreated control. Both uninoculated and inoculated leonardite-treated soybeans yielded roughly three times the control, while the treated, inoculated soybeans managed to double the yield of their untreated (but inoculated) counterparts.

Other leonardite research in Illinois (3) on corn and soybeans shows no benefit from the material. In general there have been far more positive results on Western soils, typically high pH soils with low available iron, low organic matter and low extractable humic acids.

With most crops, quality was improved, and yield increases noted for some of the crops normally responsive to additions of organic matter. Humate increased root growth and root formation, deepened the color of the leaves, flowers, and fruits, and at high rates increased branching and reduced terminal extension (4).

Humic acids retain nutrient ions against leaching, yet hold them in a way that they are nevertheless readily available to plants. This results from humic acids' high cation exchange capacity (5).

Humic acids mobilize the phosphate ion. In the presence of humates, plants use phosphate fertilizers much more fully than otherwise. This is probably because the humic molecule and phosphate anions compete almost equally for the anion exchange sites on clays, and for the multivalent cations, such as aluminum (6).

Humic acids appear to chelate certain metallic cations, and may be important for plants growing in alkaline soil by enabling increased uptake of micronutrients (7). Humate fertilizers added to a sandy loam soil had no beneficial effect on plant growth; rather, they decreased soil permeability (5). Humate has also been shown to improve the chipping quality of white potatoes so greatly that chippers pay a premium for such potatoes (8).

Eastern studies (9) suggest that corn yields were best at 5 ppm humic acid and that the addition of humates to a hydroponic solution stimulated both root and shoot development, resulting in an increase of 87%. These studies also show that as soil humic acid levels increased, so did phosphorus in the plant, indicating that humates probably play an important role in plant phosphate utilization. These data also seem to show that if soil humate levels are already high, further additions may not benefit the crop.

Humic acids may protect plants against the harmful effects of aluminum, by preventing phosphorus deficiency in the presence of high aluminum and by suppressing toxie effects of aluminum (10). It has also been suggested that soil aluminum and iron may inactivate humates. This may be one important reason why humate products often generate disappointing results when used on acid soils in humid areas. Such acid soils often contain large amounts of soluble aluminum and iron, and will be problematic (with or without humates) unless limed to optimal levels. Western soils, in contrast, often have high levels of free lime, resulting in very low iron and aluminum levels as calcium tends to precipitate those ions, along with manganese; in such situations, humates seem inherently more effective.

In sum, then, OCD humus has shown very promising results as a natural soil amendment in areas of alkaline, low-organic-matter soils. Such soils are common across a wide range of agricultural production zones in central and western North America. Leonardite and similar products appear to be entirely consistent with organic production practices, given that they are natural products with proven benefit in certain situations.

Citations:

1) Freeman, Philip C. 1970. Technology and Use of Lignite. Proceedings: Bureau of Mines - Univ. North Dakota Symposium, Grand Forks, North Dakota. BOM Circular 8471.

2) Fowkes, W.W. and C.M. Frost. 1960. Leonardite: A lignite byproduct. Bureau of Mines Rept. of Inv. 5611. 12 p.

3) Anonymous. 1976. NCR-103 Committee report.

4) Martin, J.A, et al. 1962. Influence of humic and fulvic acids on the growth, yield, and quality of certain horticultural crops. Clemson Univ. Dept. Hort. Research Series No. 30, May.

5) Acock, B. 1963. Effects of humic acids on the growth of tomato plants and the physical properties of sand and sandy soils. M.Sc. Thesis. Clemson Univ., South Carolina.

6) Bosse, A. 1957. Information supplied to Doggett-Pfeil Co., Springfield, New Jersey Cited in:
   Stearman, R.J., et al. 1989. Characterization of Humic acid from no-tilled and tilled soils using Carbon-13 nuclear magnetic resonance. Jour. Soil Sci. Soc. Am. Vol. 53, p. 744-49.

7) Heintze, S.C., and P.J.G. Mann. 1949. Jour. Agric. Sci. Vol 39, p. 80-95.

8) Moore, M.D. 1964. Unpublished data, Clemson Univ. Dept. Hort. Cited in:
   Stearman, R.J., et al. 1989. Characterization of Humic acid from no-tilled and tilled soils using Carbon-13 nuclear magnetic resonance. Jour. Soil Sci. Soc. Am. Vol. 53, p. 744-49.

9) Lee, Y.S. and R.J. Bartlett. 1976. Stimulation of plant growth by humic substances. Jour. Soil Sci. Soc. Am. Vol. 40, p. 876-79.

10) Tan, K.H. 1985. The effects of humic acid on aluminum toxicity in corn plants. Agronomy Abstracts.

TAP REVIEWER COMMENT FORM for USDA/NOSB

Use this page or an equivalent to write down comments and summarize your evaluation regarding the data presented in the file of this potential National List material. Complete both sides of page. Attach additional sheets if you wish.

This file is due back to us by: Aug. 5, 1996

Name of Material: Humic Acid Derivatives

Reviewer Name: William A. Zimmer D.V.M. RECEIVED JUL 30 1996

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

non-synthetic

If synthetic, how is the material made? (please answer here if our database form is blank)

Generally produced by mining natural deposits of humates or humic substances. These may be extracted using alkalines to produce water soluble derivates of humic acid, fulvic acid.

This material should be added to the National List as:

____ Synthetic Allowed ____ Prohibited Natural

or, X Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Please comment on the accuracy of the information in the file:

minimal information

Any additional comments? (attachments welcomed)

Composition - humic acid, fulvic acid, natural salts of these acids such as calcium humate.
Properties - Dark brown, black granular or powder solid mined from natural humate deposits. OR
How Made Dark brown, black liquid consisting of acids extracted by treatment with weak alkalies. OR
Golden, clear liquid of water extracted humates.
Uses - source of humic acid, fulvic acid, carbon, numerous trace minerals bound as colloids or weak electrostatic bonds. Nutrient for plants, animals.

Do you have a commercial interest in this material? X Yes; ____ No

Signature William A. Zimmer DVM **Date** 7-8-96

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

minimal - naturally occurring, ubiquitous compounds

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment; minimal under practiced use conditions

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

none

(4) the effect of the substance on human health;

positive effects when used as a nutrient source.

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

positive effect on soil organisms activity

(6) the alternatives to using the substance in terms of practices or other available materials; and unknown

(7) its compatibility with a system of sustainable agriculture.

compatible

TAP REVIEWER COMMENT FORM for USDA/NOSB

Use this page or an equivalent to write down comments and summarize your evaluation regarding the data presented in the file of this potential National List material. Complete both sides of page. Attach additional sheets if you wish.

This file is due back to us by: August 5, 1996

RECEIVED AUG 0 5 1996

Name of Material: Humic Acid Derivatives

Reviewer Name: Paul Sachs

Is this substance synthetic or non-synthetic? Explain (if appropriate)

Synthetic; it comes from natural materials but is extracted via chemical reactions.

If synthetic, how is the material made? (please answer here if our database form is blank)

Humic acid derivatives are usually extracted from lignite or leonardite (soft coals) by reactions with potassium hydroxide or ammonia (use of ammonia is very rare). The extract usually contains potassium from the reaction.

This material should be added to the National list as:

☒ ***Synthetic Allowed*** ☐ ***Prohibited Natural, or***

☐ Non-synthetic (This material does not belong on National List

Are there any use restrictions or limitations that should be placed on this material on the National List?

Per Label instructions.

Please comment on the accuracy of the information in the file:

None provided

Any additional comments? (attachments welcomed)

Humic acid derivatives seem to be very helpful in poor soil that are deficient in organic matter or humus. Research indicates, however, that very little benefit is provided in soils that are already rich in organic matter and humic substances.

Do you have a commercial interest in this material Yes ☐ No ☒

Signature Paul D. Sachs ***Date*** 8/5/96

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

1. the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

None that I know of.

2. the toxicity and mode of action of the substance and of its breakdown products of any contaminants, and their persistence and areas of concentration in the environment;

These products are not known for any type of toxicity to plants, soil organisms, or higher animals. Breakdown by soil organisms is near complete.

3. the probability of environmental contamination during manufacture, use, misuse or disposal of such substance:

There is very little waste produced in the manufacturing process. The main by-product is inorganic material similar in analysis to the inorganic component of soil.

4. the effect of the substance on human health;

None that I know of.

5. the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

Beneficial reactions have been recorded in poor soils. Neutral reaction are noted in good soils. I have never seen negative research data.

6. the alternatives to using the substance in terms of practices or other available materials; and

Soil building practices.

7. its compatibility with a system of sustainable agriculture.

Yes.

TAP REVIEWER COMMENT FORM for USDA/NOSB

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This file is due back to us by: Aug. 5, 1996

Name of Material: Humic Acid Derivatives

Reviewer Name: ____________________ RECEIVED JUL 3 0 1996

Is this substance Synthetic or non-synthetic? Explain (if appropriate)

If synthetic, how is the material made? (please answer here if our database form is blank) [illegible] Leonardite [illegible]

This material should be added to the National List as:

____ Synthetic Allowed ____ Prohibited Natural

or, ✓ Non-synthetic (This material does not belong on National List)

Are there any use restrictions or limitations that should be placed on this material on the National List?

Please comment on the accuracy of the information in the file: [illegible] in depth [illegible] [illegible] final [illegible]

Any additional comments? (attachments welcomed)

"Complexation of transition metals, such as Cu, Zn, Fe, Mn & others, by humic [illegible] has been the focus of a large number of [illegible] of humic [illegible] or soil solution [illegible] to improve availability [illegible] elements" ([illegible] 1986. [illegible] (ed.) The role of [illegible] [illegible] 73-[illegible])

Do you have a commercial interest in this material? ____ Yes; ✓ No

Signature James A. Johnson **Date** 7/29/96

Please address the 7 criteria in the Organic Foods Production Act:
(comment in those areas you feel are applicable)

(1) the potential of such substances for detrimental chemical interactions with other materials used in organic farming systems;

none

(2) the toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment; not known

(3) the probability of environmental contamination during manufacture, use, misuse or disposal of such substance;

(4) the effect of the substance on human health; ?

(5) the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock;

[illegible]

(6) the alternatives to using the substance in terms of practices or other available materials; and [illegible]

(7) its compatibility with a system of sustainable agriculture.

Very compatible

NOSB Materials Database

Identification

Common Name Humic Acid Derivatives

Chemical Name

Other Names

Code #: CAS

Code #: Other

N. L. Category unknown

MSDS ○ yes ◉ no

Chemistry

Family

Composition

Properties

How Made

Type of Use Crops

Use/Action

Specific Use(s)

Action

Combinations

Status

OFPA

N. L. Restriction

EPA, FDA, etc

Directions

Safety Guidelines

Historical status

Internationl status

HUMAX™

GENERAL INFORMATION

HUMAX contains humic acids extracted from leonardite. **HUMAX** can be used as soil or foliar application. It may enhance nutrient uptake by plants. It is compatible with most fertilizer solutions and biological or enzymatic formulations. **HUMAX** is not a plant food ingredient.

ACTIVE INGREDIENTS

12% Humic Acids derived from leonardite.

NET CONTENTS: ☒ **1 Gallon** ☐ **5 Gallons**

Lot No. 1604124

Manufactured by:

JH BIOTECH, INC.
P.O. Box 7943
Ventura, CA 93006 USA

DIRECTIONS OF USE

SHAKE WELL BEFORE US

SOIL APPLICATION: apply quarts of **HUMAX in 30** water or liquid fertilizer **per**

FOLIAR APPLICATION: Apply 1.0 quarts of **HUMAX** with folia fertilizer in at least 6 gallons **of wate** per acre. It can also **be applie** pesticides.

HUMAX is **compatible** fertilizer solutions **and pesti** check the compatibility **be**

LIMITED WARRANTY

Manufacturer or seller warranty, whether **expressed** implied, concerning the use **of th** product other than for the **purpo** indicated on the label. manufacturer nor seller **shall** for any injury or **damage** this product due **to** mishandling, or any **appli** specifically described **on the**

JH BIOTECH, INC.

Solid Waste Composting Council. 1991. Technical Information on the use of Organic materials as soil amendments: A Literature Review. Henry, Charles L. (ed.) Washington State Dept of Ecology, Univ of WA.

after an increase and ultimately accounted for 15% of the initial nitrogen. Value for NO_3^--N had doubled by the end of the experiment.

Others suggest other forms of nitrogen as useful. Harada and Inoko (1980) and Harada *et al.* (1981) considered total N as a useful maturity indicator. Raw eucalyptus bark contained more total available N then a pine bark nursery mix and the amount increased after composting (Hardy and Sivasithamparam, 1989). Riffaldi *et al.* (1986) observed that total nitrogen content, expressed as percentage of dry matter and referred to an unchanging base (ash) remained constant during composting. It was considered more useful from a product utilization standpoint as reported on a dry matter basis. The two maturity parameters of hydrolysable nitrogen and C:N ratio demonstrated a high correlation and acted as useful indicators.

Hydrogen ion

The pH of eucalyptus compost increased from 4.0 to 7.5 in 10-12 days, fell to 6.2-6.5 within 65 days, then leveled out (Hardy and Sivasithamparam, 1989). The pH values of two MSW compost piles, one covered and one exposed, were constant for three months, increased by one unit the fourth month and fell the beginning of the fifth (Charpentier and Vassout, 1985). Leachate analysis of cranberry processing wastes during composting showed that an addition of lime provided adequate buffer effect (Blanc and O'Shaughnessy, 1989). In contrast, a pile with natural buffer failed to maintain an optimum pH range. Others dismissed compost pH as a suitable parameter to assess compost maturity because it cannot be described as a monotonic function (de Nobili, 1988).

Organic matter and humification

As ultimately the readily decomposable organics should tend towards humic substances, both organic matter and humification has been suggested as indicators of maturity. Organic matter content cannot be used as a maturity test because its absolute value is dependent on the feedstock composition (de Nobili, 1988). Not surprising, Estrada *et al.* (1987) found that total organic matter decreased during composting. Charpentier and Vassout (1985) also found the amount of total organic matter decreased, from 50-60% at the start of composting to 30% three months later. This trend was similar for two compost piles, one covered and one exposed. Wong (1985) found that organic carbon content reduced from 40% to 30% after 16 weeks.

Increases in CEC, total N, C_{HA}, lignin and methoxyl groups beyond compost stabilization were attributed to decreases in organic matter content (Riffaldi *et al.*, 1986).

Riffaldi *et al.* (1983) suggested that research into numerous samples at different stages of maturity and a comparison of the humification of different materials in soil and their effects on crop growth is needed to determine the most suitable sources for soil amendments. He found in experiments that humic and fulvic acids extracted from different organic wastes varied in chemical composition but generally had high N contents and had characteristics of young humic substances, namely a lower degree of carbonization, lower contents of the main acidic groups and a more complex organic structure than humic compounds taken from soil organic matter.

Humic acid extracts from fresh and aged bark composts differed with increased humic acid yield, total acidity, total N and carboxyl groups in the older compost (Albrecht *et al.*, 1982). Alkaline phosphatase activity held a constant high value at the end of curing under optimal composting conditions but never reached a high value under poor conditions (Godden and Penninck, 1986). Humic acid (HA) increased with a decrease in fulvic acid (FA) as MSW compost stabilized (Sugahara and Inoko, 1981). The shape of infrared (IR) spectra of humic acid, a function of oxidation, became similarly featureless during the curing process, and was suggested to indicate maturity.

Calculations for some parameters have been suggested by Roletto *et al.* (1985). The humification ratio is the percentage on total extracted humic carbon (C-extr) on organic carbon:

$$\text{humification ratio} = (\text{C-extr})(100/\text{C-org})$$

The humification index (HI) is the percentage of humic acid carbon (C_{HA}) in an organic carbon.

$$HI = (C_{HA})(100/\text{C-org})$$

The authors also suggested minimum values for evaluating maturity of compost made from ligno-cellulosic materials as listed in Table 11.

Table 11. Minimum values for evaluating maturity of compost made from ligno-cellulosic materials.

Parameter	Minimum value
C_{HA}:C_{FA}	1.0
Humification ratio %	7.0
HI %	3.5
Total humic carbon %	3.0
Particles with nominal molecular weight ≥ 10,000 %	40

De Nobili and Petrussi (1988) reported a linear decrease with time in the HI during the thermophilic phase. Values dropped after the pile was turned but increased again each time pile temperature reached 65°C. Water extracts of the HI_w decreased hyperbolically with time in the thermophilic stage. Measurement of HI_w was not considered useful for assessing compost maturity; values indicated stabilization while the thermophilic stage was in progress (de Nobili, 1988). The HI was determined for MSW composts at different stages as the ratio of non-humified (non-phenolic) to humified (phenolic) organic carbon after extraction with alkaline sodium pyrophosphate.

Classic analysis of humified organic matter by humic acid (HA) and fulvic acid (FA) contents was not satisfactory for determining humification of organic materials (Riffaldi *et al.*, 1986). The authors cited Sugahara and Inoko (1981) who reported that total humus remained constant while HA increased and FA decreased. Riffaldi *et al.* (1986) examined their procedure and noted that most changes to the humified carbon (C_{HA} + C_{FA}) had occurred within the first 30 days as a 15% increase. The C_{HA} increased considerably up to 60 days and C_{FA} decreased. The C_{HA}:C_{FA} ratio increased by 50% after a two month stabilization period. This indicated an advanced amount of humification. Optical densities increased significantly the first 20 days and continued at a lesser rate. The extinction values of the pyrophosphate extract result correlated with C:N and C_{HA+FA}, demonstrating reliability for maturity testing.

Chemical degradation with potassium persulphate and 13C-NMR magnetic or resonance spectral characteristics showed differences in humic acids of 3 MSW composts (Gonzalez-Vila and Martin, 1985). All three composts were largely aliphatic.

Appendix III

ABSTRACTED ARTICLES

Albrecht, M.L., M.E. Watson, and H.K. Tayama. 1982. Chemical characteristics of composted hardwood bark as they relate to plant nutrition. *J. Amer. Soc. Hort. Sci.* 107(6):1081-1084.

Waste type: bark
Emphasis: compost quality
Plants: *Lolium multiflorum* Lam.
Experimental conditions: laboratory

Abstract: No differences were observed in the level of total acidity, total N and phenolic hydroxyl groups for samples of fresh and aged composted hardwood bark. Humic acid was extracted from both fresh and aged composted hardwood barks. Yield of humic acid was greater for the aged bark, and there was an increase in the reactive functional groups which are involved in micronutrient chelation (carboxyl groups increased from 2.69 to 3.59 meq/g; phenolic hydroxyls increased from 7.82 to 10.29 meq/g). Alcoholic hydroxyl groups in fresh composted hardwood bark decreased from 2.03 to 0.01 meq/g with aging. From leaching studies it was determined that 0.5 meq/g Cu^{+2} was bound per gram of dried, fresh bark. Nutrient uptake studies showed a reduction in the foliar nutrient concentration for *Lolium multiflorum* Lam. with increased cropping time when grown in aged, composted hardwood bark.

Keywords: wood (bark), product, quality, nutrients, pH, organic matter, humic acid

Ashbolt, N.J. and M.A. Line. 1982. A bench-scale system to study the composting of organic wastes. *J. Environ. Qual.* 11(3):405 - 408.

Waste type: bark, fish waste
Emphasis: process
Experimental conditions: laboratory, bench-scale reactor
Location: Tasmania

Abstract: In an investigation of the composting of eucalypt bark, a bench-scale system was designed to provide strict control over air composition, moisture content, temperature, and mixing. The composter consisted of six 4-L capacity gas-tight units of PVC plastic, each of which was provided with a mixing paddle coupled to a common drive. Natural temperature rise was simulated by having the units immersed in a water bath, with the temperature increased at rates consistent with those observed in large-scale compost heaps. This provided a comparatively inexpensive versatile system, with rates of CO_2, NH_3, CH_4, and H_2S production and O_2 consumption manually monitored by gas chromatography. The reproducibility of the system was as good as the best reported.

Keywords: wood, bark, process,bench-scale reactor

Barbera, A. 1987. Extraction and dosage of heavy metals from compost-amended soils. p.598-614. In *Compost: Production, Quality, and Use.* M. de Bertoldi, M.P. Ferranti *et al.* (ed.) London: Elsevier Applied Science. 17-19 April 1986. Udine, Italy.

Waste type: MSW, sewage sludge
Emphasis: compost contaminants - metals
Plants: corn, beet
Soils: sandy-silt calcareous
Experimental conditions: field

Abstract: Short term results of the behavior of heavy metals in compost-amended soils are presented in comparison with manure and mineral fertilization. The application of compost in agriculture increased both the total and the available fraction concentration of some metals in the soil. Significant linear relationships hold among the different analyses performed on metals: total, EDTA, DTPA extractable. Significant uptakes of metals in corn silage and leaf beet were noticed. Generally the uptake variations of metals in plant tissues were related to variations of their available fraction in the soil. In particular a strict linear relationship was found for Zn between its available fraction in the soil and the metal

de Haan, S. 1986a. Nitrogen in drainage water from containers with soils treated with different types of sewage sludge or municipal waste compost, including substrates consisting only of these products. p. 128-141. In *Efficient Land Use of Sludge and Manure.* A.D. Kofoed, J.H. Williams *et al.* (ed.) London: Elsevier Applied Science.

Waste type: MSW
Emphasis: leachate
Soils: sand, clay
Experimental conditions: laboratory, leaching tubes

Abstract: Municipal solid waste composts mixed with a sandy soil and a clay soil in leaching tubes at a rate of 10% compost by volume produced a negligible change in the composition of the leachate. Using 100% municipal waste compost as a plant substrate resulted in a mean N concentration of the drainage water over ten years of 60 mg/L as compared to air dried sewage sludges from various sources which yielded values of 177, 460, 351, 255, 359, and 196 mg/L of N. The N concentrations in the drainage water corresponded rather well with the amounts of N in the substrates at the start of the experiment with the exception of one sludge treatment; the low N concentration in the drainage water from this treatment was probably the result of inhibited mineralization of organic N by high concentrations of heavy metals in this sludge, which also inhibited plant growth. Mineral N in the drainage water was generally in the form of nitrates. Only some of the air-dried sewage sludge treatments released N predominantly in the form of ammonia during the first year. Concentrations of organic N in the drainage water, determined during the first two years of the experiment only, were very low compared with mineral N. Municipal waste compost treatments had a greater organic N concentration than the sewage sludge treatments.

Keywords: MSW, concerns, leachate

de Haan, S. 1986b. Phosphorus in drainage water from containers with soils treated in different ways with sewage sludge or municipal waste compost, including substrates consisting only of these products. p. 142-149. In *Efficient Land Use of Sludge and Manure.* A.D. Kofoed, J.H. Williams *et al.* (ed.) London: Elsevier Applied Science.

Waste type: MSW
Emphasis: leachate
Soils: sand, clay
Experimental conditions: laboratory, leaching tubes

Abstract: Municipal waste compost applied to a sandy soil and a clay soil in leaching tubes at a rate of 10% by volume over a ten year time period did not affect the amount of P in the drainage water. Concentrations of water-soluble P in the soil in 1983 were negatively affected by applications of 100% compost. For the 100% compost treatment, the P concentration in the drainage water was only significantly higher than the control for the first year. This indicates fixation rather than release of P by MSW compost.

Keywords: MSW, concerns, leachate

de Nobili, M. and F. Petrussi. 1988. Humification index (HI) as evaluation of the stabilization degree during composting. *J. Ferment. Technol.* 66(5):577-583.

Waste type: MSW
Emphasis: maturity
Experimental conditions: laboratory
Location: University of Udine, Italy

Abstract: This study investigated the effects of pile temperature, moisture level and oxygen availability on the value of the humification index (HI). The stabilization of a pile of ground urban refuse was monitored during five months. Carbon dioxide evolution, temperature, moisture level, organic matter and pH were measured regularly. The humification index of organic matter extracted by 0.1 M $Na_4P_2O_7$ plus 0.1 M NaOH was found to decrease linearly with time during the thermophilic phase from about 1.4 to 0.4. Turning of the pile caused a drop in the HI values, but the index increased again every time the temperature of the static pile reached a maximum after four days in the superficial layers and after eleven days at a depth of 30 cm. The humification index was also determined in water extracts to test whether this method is more sensitive. Values of the HI on water extracts (HIw) were found to decrease hyperbolically with time during the thermophilic phase. HIw measurements did not appear useful for assessing compost maturity; the composition of water extracts stabilized while the thermophilic phase was still in progress, after about thirty days of composting. Results of the study

Gomez, A. and C. Lejeune. 1987. Comparison of the physical and chemical properties of humic acids extracted from a podzolic soil and a mature city refuse compost. p. 495-500. In *Compost: Production, Quality and Use*. M. de Bertoldi, M.P. Ferranti *et al.* (ed.) London: Elsevier Applied Science. 17-19 April 1986. Udine, Italy.

Waste type: MSW
Emphasis: compost quality
Experimental conditions: operational composting facility

Abstract: Characterization of the humic acids obtained from a four month old city refuse compost and from an organic sandy podzolic soil revealed significant differences in their nature. The humic acids present in the compost were less rich in ashes, had a higher nitrogen and sulphur concentration, and had half the cation exchange capacity of the humic acids found in the podzolic soil. The data from electrophoretical mobility, infrared spectra and respirometric measurements supported the observation of large differences between the two types of organic matter and showed that compost humic acids have an important proteinic content, related to their biological lability.

Keywords: MSW, product, quality, organic matter

Gonzalez-Vila, F.J., C. Saiz-Jimenez, and F. Martin. 1982. Identification of free organic chemicals found in composted municipal refuse. *J. Environ. Qual.* 11(2):251-254.

Waste type: MSW (mainly paper wastes and household garbage)
Emphasis: compost contamination
Experimental conditions: operational composting facilities

Abstract: Three Spanish municipal refuse composts were analyzed to evaluate the qualitative composition of the nonhumified free organic compound fraction. The samples were sequentially extracted with ether and ethanol, which constituted the total lipids extract. The nonsaponifiable fraction was made up of *n*-alkanes, in the range of C_{18} to C_{32}, as well as olefins. The saponifiable fraction contained *n*-fatty acids from C_{14} to C_{26} and some branched fatty acids. The method used for separation and identification of specific organic compounds in sediments was adapted for municipal composts and the resulting methylene chloride extract was subjected to gradient chromatography on alumina. The fractions eluted from the column with pentane and pentane-methanol contained aliphatic hydrocarbons; the benzene fraction was made up of phthalate esters, and the benzene-methanol and methanol fractions contained a mixture of aliphatic hydrocarbons, phthalate esters, *n*-fatty acid methyl esters, and some individual compounds. The presence of aliphatic hydrocarbons and fatty acids in municipal composts suggested a microbial origin, while phthalate esters may arise from the debris of plastic packaging.

Keywords: MSW, product, quality, organic contaminants

Gonzalez-Vila, F.J. and F. Martin. 1985. Chemical structural characteristics of humic acids extracted from composted municipal refuse. *Agric., Ecosystems and Environ.* 14(3/4):267-278.

Waste type: MSW
Emphasis: compost quality
Experimental conditions: operational composting facilities

Abstract: As a continuation of previous work about the characteristics of the organic matter in three Spanish municipal refuse composts (Gonzalez-Vila et al., 1982), the humic fraction of these composts was studied. It was found that techniques such as ^{13}C-NMR magnetic or resonance spectral characterisation and chemical degradation with potassium persulphate revealed the differences between the humic acids (HA) in various composts much better than analytical parameters such as elementary composition, functional group contents and E_4:E_6 ratios. The characteristic shared by the HAs of the three composts was their predominantly aliphatic nature. Potassium permanganate degradation appeared unsuitable for structural studies of compost HAs because of the probable formation of undesirable aromatic artifacts.

Keywords: MSW, product, quality, humic acid

Gonzalez-Vila, F.J. and F. Martin. 1987. Modifications of the humic acid fraction in a soil treated with composted municipal refuse. *Sci. of the Total Environ.* 62:459-466.

Waste type: MSW
Emphasis: effect on soil
Plants: sorghum, wheat
Soils: Xerofluvent
Experimental conditions: field

Abstract: The effects of three years of compost application on the humic acid fraction of a soil was studied in a field experiment. Most of the analytical parameters, such as elementary composition, functional group contents, E_4:E_6 ratios and spectral characteristics seemed inadequate for evaluating differences between the structure of the humic acids isolated from soil before and after the application of compost. Some information was revealed by chemical degradations which indicated that representative components of the organic matter from compost, such as fatty acid series, were retained in loosely linked forms in the humic acid fraction of the soil.

Keywords: MSW, soil, organic matter, humic acid

Gonzalez-Vila, F.J., J.L. Lopez, and F. Martin. 1988. Determination of polynuclear aromatic compounds in composted municipal refuse and compost-amended soils by a simple clean-up procedure. *Biomed. and Environ. Mass Spec.* 16(1-12):423-425.

Waste type: MSW
Emphasis: compost contamination - organic compounds

Abstract: A rapid and reproducible procedure for the analysis of polycyclic aromatic compounds (PACs) in sludges and soil samples was developed. The PACs were isolated by ultrasonic extraction with methyl chloride, redissolution of the crude extract in isooctane and clean-up of the PAC-containing fraction by chromatography on alumina micro-columns. After separation and quantitative determination of the various PACs by capillary gas chromatography/mass spectrometry, more than 50 PAC compounds at various concentrations were detected in the sludge samples. The most abundant compounds were mono-, di-, and trimethyl derivatives of naphthalene, phenanthrene, fluorene, dibenzethiophene and naphthothiophene. No accumulation of PACs was observed in a three year old compost application to agricultural soil.

Keywords: MSW, product, quality, organic contaminants

Gouin, F.R. 1977. Conifer tree seedling response to nursery soil amended with composted sewage sludge. *HortScience* 12(4):341-342.

Waste type: sewage sludge
Emphasis: effect on plants
Plants: Norway spruce, white pine
Soils: Evesboro Loamy Sand
Experimental conditions: field

Abstract: Seedlings of Norway spruce (*Picea abies* (L.) Karst) produced similar stem growth in seedbeds amended with 224 dry t/ha screened composted sewage sludge or top-dressed with 1 t/ha of Osmocote 18-6-12 or 112 dry t/ha of unscreened compost. Screened compost application rates less than 224 t/ha and all rates of unscreened compost application did not produce as much stem growth. More seedlings of white pine (*Pinus strobus* L.) were produced in soils amended with 112 dry t/ha of unscreened composted sewage sludge than in soils amended with 448 dry t/ha of screened composted sewage sludge or the control. Soils amended with composted sewage sludge had higher pH, Mg, and P levels than soils top-dressed with Osmocote 18-6-12 and mulched with pine sawdust.

Keywords: sewage sludge, plant growth, use, horticulture

Ribalta, R., J.C. More, and J. Sana. 1987. The priming effect and the respiratory rate/compost dose ratio as compost ripeness index. p. 328-333. In *Compost: Production, Quality, and Use*. M. De Bertoldi, M.P. Ferranti *et al.* (ed.) London: Elsevier Applied Science. 17-19 April 1986. Udine, Italy.

Waste type: MSW
Emphasis: maturity

Abstract: The priming effect (the increase of soil organic matter mineralization caused by an organic substratum addition) was studied for the addition of different compost samples to different soils. This effect has been indirectly quantified by comparing the respiratory rate of the soil with increasing compost doses. Since the effect is greatest for less mature compost, the resulting respiratory rate/compost dose ratio provides a useful index for compost maturity.

Keywords: MSW, product, quality, maturity

Richard, T. and M. Chadsey. 1989. *Croton Point Compost Site: Environmental Monitoring Program*. Cornell University, Department of Agricultural and Biological Engineering. Final Report. November. 15pp.

Waste type: yard waste
Emphasis: leachate
Experimental conditions: large-scale composting facility

Abstract: The impact of municipal leaf composting on soil, water and compost quality was evaluated in a full-scale composting facility. The environmental monitoring program examined soil samples for changes in heavy metal content, sampled water infiltrating beneath the site for common water pollution indicators and tested the finished compost product for nutrients, heavy metals, and pesticide residues. It was discovered that for leaf composting, the primary concerns were BOD and phenol concentrations found in water runoff and percolation. These products should be pretreated before release from the site with an alternative such as soil treatment, filter strips or recirculation. The leaf composting operation did not generate high levels of nitrates or other nitrogen compounds. The heavy metals content of the leaves was quite low and did not affect the water, soil, or compost quality. Only four pesticides were detected in the finished product, and these were all in the low end of the range for background values in suburban soils.

Keywords: yard waste, operation, concerns, leachate, product, quality, soil, contaminants

Riffaldi, R., R. Levi-Minzi, and A. Saviozzi. 1983. Humic fractions of organic wastes. *Agriculture, Ecosystems and Environment* 10(4):353-359.

Waste type: MSW
Emphasis: compost quality
Experimental conditions: samples from composting facilities

Abstract: The distribution and composition of humic and fulvic acids were investigated in the following organic wastes: straw, sewage sludge, poultry manure, municipal refuse compost, and pig slurry. Of the total organic carbon, the proportion present as humic carbon varied from about 13% in the compost to 50% in the pig slurry; the humic compounds extracted were characterized by a variable chemical composition. As compared to the natural humic substances from soil organic matter, these compounds showed a lower content of acidic functional groups, lower E_4:E_6 and C:H ratios and can be classified as young forms of humic substances

Keywords: MSW, product, quality, organic matter, humic acid

Riffaldi, R., R. Levi-Minzi, A. Pera, and M. De Bertoldi. 1986. Evaluation of compost maturity by means of chemical and microbial analyses.*Waste Management and Research* 4(4):387-396.

Waste type: paper mill sludge, straw
Emphasis: compost maturity
Experimental conditions: test pile

Abstract: Several chemical and microbiological parameters (including percent organic matter, cation exchange capacity, hydrolysable nitrogen content, humified organic matter content, and growth and decay of microbial populations) were tested during a 140 day period to characterize the stabilization process of a paper processing wastewater sludge composted

with straw. The parameters indicate two months as a suitable period for the establishment of an equilibrium in the decay process, although some parameters show that compost reaches an acceptable level of stability in thirty days. Evaluation of stability in the end-product is difficult to define by only one parameter, whether it be chemical or biological.

Keywords: pulp and paper mill sludge, process, product, quality, maturity

Rutili, A., M. Civilini, B. Citterio, S. Frassinetti, and M. De Bertoldi. 1987. Microbial variations in compost amended soils. p. 615-632. In *Compost: Production, Quality and Use.* M. de Bertoldi, M.P. Ferranti *et al.* (ed.) London: Elsevier Applied Science. 17-19 April 1986. Udine, Italy.

Waste type: MSW, sewage sludge
Emphasis: effect on soil
Experimental conditions: field

Abstract: The effect of compost applications on the biological fertility of soil over a number of years was studied on field plots planted with maize. The parameter used for measuring the effect of compost on soil fertility was the evolution of some physiological groups of microorganisms from the maize rhyzosphere during the vegetative cycle of this crop. Three different dosages of a MSW/sewage sludge compost were compared with a control, plots treated with mineral fertilizer, and plots treated with manure. Only three of the five years of work have been concluded, so the data gathered is not conclusive, but a trend seems to be evident towards elevated microbial populations in soil treated with large compost applications.

Keywords: MSW, sludge, sewage, soil, microorganisms

Sanderson, K.C. and W.C. Martin Jr. 1974. Performance of woody ornamentals in municipal compost medium under nine fertilizer regimes. *HortScience* 9(3):242-243.

Waste type: MSW
Emphasis: use in horticulture
Plants: woody ornamentals
Experimental conditions: outside containers

Abstract: Dry weight and total plant height of *Ilex cornuta* Lindl. cv. Burfordii and *Thuja occidentalis* L. were greater in municipal compost amended medium than in sphagnum peat moss-amended medium. *Viburnum burkwoodii* Burkwood did not show any growth differences between the two media.

Keywords: MSW, plant growth

Saviozzi, A., R. Riffaldi, and R. Levi-Minzi. 1987. Compost maturity by water extract analyses. p. 359-367. In *Compost: Production, Quality and Use.* M. de Bertoldi, M.P. Ferranti *et al.* (ed.) London: Elsevier Applied Science. 17-19 April 1986. Udine, Italy.

Waste type: paper mill sludge, straw
Emphasis: compost maturity
Experimental conditions: analyses of water extracts

Abstract: Water extracts of a paper processing wastewater composted with straw were analyzed to investigate the stabilization process. During the composting period, the following findings were obtained: dry matter, carbon, nitrogen, volatile acid and amino acid contents decreased after an initial increase, whereas phenol content decreased only after thirty days; C:N and E_4:E_6 ratios as well as Δlog K values increased clearly. None of the above parameters reached an equilibrium so their relationship to compost maturity is unclear. The parameters that did indicate compost maturity were: 1) the germination index (water extracts are no longer phytotoxic after approximately thirty days) and 2) the disappearance of a relatively low molecular weight component (M.W. < 1500) of the water extracts after twenty days. A definition of the stabilization degree of the material can be reached by taking into account the parameters tested both on the solid (Riffaldi et al., 1986) and on the water soluble phase of the compost.

Keywords: pulp and paper sludge, product, quality, maturity

Strom, P.F. 1985b. Identification of thermophilic bacteria in solid-waste composting. *Appl. Environ. Microbiol.* 50(4):906-913.

Waste type: MSW
Emphasis: microorganisms
Experimental conditions: laboratory
Location: Rutgers University, New Brunswick, NJ

Abstract: The thermophilic microbiota of solid waste composting, with major emphasis on *Bacillus* spp., was examined with Trypticase soy broth (BBL Microbiology Systems) with 2% agar as the initial plating medium. Five 4.5-liter laboratory units at 49 to 69° C were fed a mixture of dried table scraps and shredded newspaper. The composting plants treating refuse at Altoona, PA, and refuse-sludge at Leicester, England, were also sampled. Of 652 randomly picked colonies, 87% were identified as *Bacillus* spp. Other isolates included two genera of unidentified nonsporeforming bacteria (one of gram-negative small rods and the other of gram-variable coccobacilli), the actinomycetes *Streptomyces* spp. and *Thermoactinomyces* sp., and the fungus *Aspergillus fumigatus*. Among the *Bacillus* isolates, the following, in order of decreasing frequency, were observed: *B. circulans* complex, *B. stearothermophilus*, *B. coagulans* types A and B, *B. licheniformis*, *B. brevis*, *B. sphaericus*, *Bacillus* spp. types i and ii, and *B. subtilis*. About 15% of the *Bacillus* isolates could be assigned to species only by allowing for greater variability in one or more characteristics than has been reported by other authors for their strains. In particular, growth at higher temperatures than previously reported was found for strains of several species. A small number of *Bacillus* isolates (less than 2%) could not be assigned to any recognized species.

Keywords: MSW, food, paper, sewage sludge, process, aerobic, microorganisms

Sugahara, K. and A. Inoko. 1981. Composition analysis of humus and characterization of humic acid obtained from city refuse compost. *Soil Sci. Plant Nutr.* 27(2):213-224.

Waste type: MSW
Emphasis: compost maturity
Experimental conditions: operational composting facilities

Abstract: The humus composition was analyzed and the humic acid characterized by UV and visible absorption spectroscopy in order to investigate the changes occurring in humus during the rotting and maturing process of city refuse compost. During the composting process, the following findings were obtained: 1) the HT (total humus) value was almost constant, but the HE (humus extract):HT ratio varied somewhat; 2) HA (humic acid) increased with decrease in FA (fulvic acid), and the PQ value increased; 3) the shoulder-like absorption at a wavelength near 270nm weakened; and 4) the RF value of humic acid increased while the Δ log K value seldom varied. The IR spectrum of humic acid gradually changed as follows: 1) the absorption band in the 1700-1600 cm^{-1} region and in the 1550-1500 cm^{-1} region increased slightly; 2) the band in the 1100-1000 cm^{-1} region decreased; and 3) the bands at 835 and 710 cm^{-1} completely disappeared. On the whole, the shape of the IR spectrum of the city refuse compost became featureless. These changes were probably due to the oxidation occurring in the composting process. It is possible that these changes can help qualitatively estimate the degree of compost maturity.

Keywords: MSW, product, quality, organic matter, maturity

Tackett, S.L., E.R. Winters, and M.J. Puz. 1986. Leaching of heavy metals from composted sewage sludge as a function of pH. *Can. J. Soil Sci.* 66:763-765.

Waste type: sewage sludge
Emphasis: metals leaching
Experimental conditions: laboratory
Location: Philadelphia, PA

Abstract: The relative short-term leaching rates of the metals Cd, Fe, Pb, and Zn from composted sewage sludge was determined over the pH range of 2.5-7.0 at unit intervals of 0.5 pH. Only Zn and Cd leached significantly faster as the pH was lowered, with both showing the greatest solubility increase over the pH range of 5.5-6.0.

Keywords: sewage sludge, concerns, leachate, product, quality, contaminants, metals

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