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16. ABSTRACT

Section 10403 of California Public Contract Code, as amended by Senate Bill 1929 in 1984, mandates that all State Agencies and Departments shall give purchase preference to compost (derived from sewage sludge) and co-compost (derived from sewage sludge and refuse) materials when they can be substituted for and cost no more than existing materials for use as soil amendments, fertilizers, and erosion control materials and in the construction of sound walls and safety barriers.

Questions regarding environmental degradation and contamination, employee and public health and safety, and the feasibility of usage of these products are addressed in this report. The information was obtained through an intensive literature survey of existing information and from a questionnaire distributed to various waste treatment and composting facilities in West Germany and Sweden.

It has been determined that good quality materials, may be used as fertilizers, soil amendments, and erosion control materials without environmental degradation. The use of these products for sound walls and safety barriers is not recommended at this time due to the uncertainty in the concentrations of the biological and chemical contaminants that may be generated from large concentrations of these materials. Allergic reactions may occur in individuals working with or living near areas where these products have been used. Long-term health effects are unknown. Regulations regarding the handling, testing, and monitoring of compost and co-compost products need to be further defined or established where none exist.

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

EVALUATION OF COMPOST AND CO-COMPOST MATERIALS FOR HIGHWAY CONSTRUCTION
PHASE I

FINAL REPORT

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NOTICE

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Neither the State of California nor the United States Government endorse products or manufacturers. Trade or manufacturers' names appear herein only because they are considered essential to the object of this document.

CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch ($ksi\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ ($MPa\sqrt{m}$)
	pounds per square inch square root inch ($psi\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ ($KPa\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)
Concentration	parts per million (ppm)	1	milligrams per kilogram (mg/kg)

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1. INTRODUCTION

Senate Bill 1929 (Appendix A) was approved by the Governor of the State of California on September 30, 1984, mandating that all state agencies, including the California Department of Transportation (Caltrans), give purchase preference to compost and co-compost products when they can be substituted for, and cost no more than, soil amendments, regular fertilizers, and erosion control materials, and for use in the construction of noise attenuation barriers (sound walls) and safety walls (crash barriers), if the products meet all applicable state standards and regulations.

Compost, as defined in Senate Bill 1929, refers to a usable end product produced by a waste management facility, from the controlled biological decomposition of sewage sludge or from a blending of sewage sludge with carbonaceous bulking materials, including, but not limited to, wood by-products, plant wastes, or refuse.

Co-compost, similarly is defined as, a usable end product produced by a waste management facility, that is derived from a blending of materials of which at least 80 percent, whenever possible, is household refuse and the remainder is sewage sludge or other comparable substitutes, including, but not limited to, nontoxic dairy wastes, livestock and horse manure, or fish wastes.

Due to the nature of the materials from which compost and co-compost products are derived, concerns regarding environmental degradation and the health and safety aspects of using these products, have been raised. Phase I (this report) investigated these problems, along with the feasibility of the intended usages, through an intensive literature survey.

A questionnaire was also developed and distributed to waste facilities in Europe to gain additional information on the subject of co-compost, since only one operating co-composting facility currently exists in the United States.

If warranted, a Phase II study will consist of the development, construction, and testing of a sound wall and/or crash barrier, along with other appropriate testing deemed necessary by the Phase I study to ensure that these materials may be utilized by Caltrans without endangering the health and well being of workers and the general public or creating an environmentally hazardous condition.

2. OBJECTIVES

1) Evaluate the effects of compost and co-compost products on the environment.

2) Evaluate the health and safety aspects relating to the use of compost and co-compost products in the construction of transportation facilities.

3) Determine the feasibility of the use of compost and co-compost materials for the construction of sound walls and safety barriers and for soil amendments, fertilizers, and erosion control material.

4) Investigate and determine the applicability of current regulations, standards, and guidelines pertaining to the safe handling and utilization of compost and co-compost products in the construction and maintenance of transportation facilities.

3. CONCLUSIONS

1) Good quality compost and co-compost products, containing safe and permissible quantities of chemical, biological, and physical contaminants may be used as soil amendments, fertilizers, and erosion control materials with no apparent short-term environmental impacts.

2) Undesirable impacts may be produced in the environment, such as, heavy metal leachate runoff and a negative aesthetic value, if compost or co-compost materials are used in the construction of sound walls or safety barriers or as embankment material.

3) Information concerning the combustibility of compost and co-compost materials was not available; however, two co-composting facilities in Sweden have reportedly been closed due to fire problems.

4) Allergic reactions may occur in individuals who use or apply compost or co-compost materials or who live in the vicinity where these products are in use. In very rare instances a common fungus found in these products may cause severe illness or death.

5) The long-term health effects caused by exposure to the heavy metals, toxic organics, and pathogenic organisms commonly found in compost and co-compost products are unknown at this time.

6) Contamination of edible food crops grown on private property adjacent to right-of-ways may occur where compost or co-compost products are used.

7) Information concerning the habitation of rats, mice, insects, and other disease-carrying animals in barriers constructed of compost or co-compost materials was not available.

8) Compost products are currently being produced at six facilities within California and are marketed as soil amendments and fertilizers.

9) Co-compost, to the best of our knowledge, is produced at only one facility in the United States (Wilmington, Delaware) and is marketed as a soil amendment.

10) Sound walls have not been constructed of compost or co-compost materials in the United States and only limited information concerning the use of these materials in European countries has been obtained.

11) Information was not found concerning the design, construction, or manufacturing of safety barriers from compost or co-compost products.

12) The maximum possible usage of compost or co-compost products by Caltrans is estimated to be 82,000 tons per year. This value assumes substitution for all sound wall construction material and for all soil amendments, fertilizers and erosion control materials currently being used by Caltrans, but excludes any safety barrier or embankment construction material.

13) Information concerning the design life of compost or co-compost sound walls and safety barriers as compared to conventional materials was not available.

14) Information regarding the construction and maintenance costs associated with compost and co-compost sound walls and safety barriers was not found.

15) Only limited criteria exist pertaining to the quality characteristics of finished compost products; criteria include pile temperatures during the composting process and maximum concentrations of lead, cadmium, and polychlorinated biphenyls (PCBs).

16) No explicit regulations, standards, or guidelines were found to exist in the United States pertaining to the use of co-compost products.

4. RECOMMENDATIONS

1) Compost and co-compost products can be used as soil amendments, fertilizers, and erosion control materials, only if "good" quality materials are used which contain permissible concentrations of heavy metals, toxic organics, pathogenic organisms, and detrimental materials, such as glass, plastic, and metal. Concerns regarding the health and safety of employees and the public should be resolved prior to initiating an implementation program.

2) Compost and co-compost materials should not be used in the construction of sound walls and crash barriers or as highway embankment construction material until further testing can be conducted. Available information does not verify that environmental degradation will not occur and that public health will not be jeopardized if these products are used in these types of applications.

3) Standards, regulations, and guidelines need to be developed by federal and state regulatory agencies, with regards to proper handling, curing, testing, and monitoring procedures for compost and co-compost products, to ensure that properly stabilized, disinfected, and noncontaminated products are produced for use by state departments and agencies.

4) A second phase study will need to be conducted in order to determine the following:

-- If the concentrations of heavy metals, toxic organics, coliform organisms, and other contaminants in both the structures and in the leachate are within acceptable public health limits.

-- Proper designs for sound walls and crash barriers.

-- Effectiveness of designs in regards to noise attenuation for sound walls.

-- Effectiveness of crash barrier designs.

-- Vector habitation within the structures.

-- Combustibility of material.

-- Most effective vegetative cover and quantities of irrigation water needed to maintain this vegetation.

-- Erosive effects of water on the structures.

-- Erosive effects of wind on dry co-compost walls.

-- Air pollution produced by wind erosion.

-- Aesthetics of walls and barriers constructed of these materials.

-- Life cycle costs of co-compost sound walls as compared to conventional construction materials.

5) If these materials are to be used by Caltrans for the construction of sound walls and crash barriers, a concerted effort should be made to inform the public of their intended usages prior to an implementation program.

5. IMPLEMENTATION

The information contained in this report could be used to establish guidelines and a course of action for a Phase II study. Copies of this report will be distributed to the Caltrans District and Headquarters Offices for information purposes and implementation. Copies will be provided to other interested parties upon request.

6. LITERATURE SURVEY

An extensive literature survey was conducted to obtain information concerning the various aspects of compost and co-compost products, including the properties, various end usage applications, and any associated environmental, occupational, and public health effects these products may cause if utilized by Caltrans.

6.1 Properties Of Compost And Co-Compost

The physical, chemical, and biological properties of compost and co-compost and the raw materials used in the production of these end products are discussed below.

6.1.1 Physical Properties

The physical composition of compost and co-compost end products may differ notably due to the nature of the raw materials utilized. As previously defined, compost is to be derived from the decomposition of sewage sludge with or without a carbonaceous bulking agent, whereas co-compost is to be a mixture of sewage sludge or other comparable material and at least 80 percent household refuse.

Generated during the treatment of waste water, raw sludge contains only 2 to 3 percent solids, but through a dewatering process, a sludge cake with approximately 20 percent solids can be achieved. Bulking agents are normally blended with the sludge to further decrease the water content and reduce the time necessary to achieve a properly stabilized end product. Common bulking agents are wood chips and saw dust, but rice hulls and peanut shells have also been used.

Depending upon the bulking agent used, it either becomes part of the finished product or screened off and recycled.

Current composting operations normally utilize one of the three following methods: 1) windrow, 2) aerated-static pile (A-SP), or 3) in-vessel. In composting via the windrow method, the materials are placed into rows with pile heights normally three to five feet. With the use of a "composter" the piles are turned two to five times per week, to ensure aerobic conditions and to maintain more uniform composting temperatures. The composting period ranges from four to eight weeks depending upon the characteristics of the materials and local climatic conditions.

A-SP composting is similar to the windrow method, except, air blown or drawn through the material eliminates the need for pile turning. The piles remain undisturbed for two to three weeks and then the material is moved to a curing area for an additional three to four week period to ensure proper stabilization prior to market preparation.

In-vessel composting has been used in European composting operations for many years but until recently has not been utilized by U. S. facilities. The waste materials are placed inside vessels where continuous agitation is used to maintain proper temperatures and oxygen supplies. A stabilized product can be achieved in less than one week utilizing this method. Although more capital-intensive, less land is required than for the open-air composting procedures and odor problems can be more easily controlled.

In the production of co-compost, the refuse is normally reduced in size with a majority of the undesirable materials removed prior to the addition of the sewage sludge. The

Swedish Association of Public Cleansing and Solid Waste Management (1) reported that the main problem that they have encountered in marketing co-compost materials was the amount of plastic and glass in the final product. Table 6.1 lists typical composition percentages of municipal refuse from Los Angeles and Davis, California indicating the difference between an urban and a more rural waste stream.

Properly decomposed compost and co-compost products result in a dark brown humus with a moisture content of 30 to 40 percent and a density of approximately 20 to 30 pounds per cubic foot. A slight musty soil odor is indicative of these end products.

TABLE 6.1
PERCENT COMPOSITION
OF MUNICIPAL REFUSE

ITEM	LOS ANGELES CITY (2)	DAVIS CALIFORNIA (3)
Cardboard	3.98	6.5
Newspaper	6.25	*
Misc. Paper	2.11	43.1
All Plastics	2.21	1.8
Trees	19.75	**
Garbage	2.85	9.5
Glass	4.28	7.5
Ferrous	6.33	9.5
Non-Ferrous	2.01	1.5
Wood	12.11	3.5
Grass & Dirt	28.01	14.3
Other	10.11	2.8

* Included with Misc. Paper
** Included with Grass and Dirt

6.1.2 Chemical Properties

The chemical constituents of compost and co-compost end products can vary considerably depending upon the source of the sewage sludge and the type of refuse or bulking agents used to produce these materials. Increased amounts of heavy metals in the storm runoff water along state highways have been reported by Racin et al. (4), and if storm runoff and sewage are conveyed by a common conduit, the increased quantity of heavy metals would be apparent in the sludge.

Another possible source of contamination is when industrial sources are connected with the residential sewer lines. In January, 1987, a Boston metal-plating company was fined $1 million for dumping toxic wastes into the local sewer system, and thus, contaminating the sludge at the treatment facility and the harbor in which the treated wastewater was discharged (5).

Chemical analyses of compost and co-compost from various facilities and the maximum allowable concentrations of these elements are shown in Table 6.2. In most instances, the maximum reported range exceeds the established toxic threshold limits, thereby classifying the sludge a hazardous waste. Continuous testing of the end products produced at each facility would be required to ensure that the products meet all federal, state, and local standards and regulations.

Additional analyses from European sources are shown in Appendix B.

TABLE 6.2
TYPICAL CONCENTRATIONS OF SELECTED TRACE ELEMENTS
IN DRY DIGESTED SEWAGE SLUDGE
(Parts per Million)

ELEMENT	Typical[1] Range MIN	Typical[1] Range MAX	L.A. County San Dist. (Compost)	East Bay MUD (Compost)	Wilmington Delaware (Co-Compost)	Toxic[2] Threshold Limits
Arsenic (As)	1.1	230	8.7	---	2.0	500
Cadmium (Cd)	1.0	3,410	41.7	30	7.2	100
Chromium (Cr)	10.0	99,000	604	180	73	2,500
Cobalt (Co)	11.3	2,490	---	---	---	8,000
Copper (Cu)	84.0	17,000	454	290	234	2,500
Fluorine (F)	80.0	33,500		---	---	18,000
Lead (Pb)	13.0	26,000	291	220	195	1,000
Mercury (Hg)	0.6	56	3.3	5	4.4	20
Molybdenum (Mo)	0.1	214		---	---	3,500
Nickel (Ni)	2.0	5,300	212	60	24	2,000
Selenium (Se)	1.7	17	4.0	---	<10	100
Zinc (Zn)	101.0	49,000	1,720	1,100	527	5,000

Note: 1) Reference # 6
2) Reference # 7

6.1.3 Biological Properties

Sewage sludge and refuse contain many types of pathogenic (disease-causing) and nonpathogenic microorganisms including bacteria, viruses, protozoa, and helminths (parasitic worms). The extent to which they are found in waste materials varies and depends largely upon diseases among community inhabitants, sanitary habits, season of the year, etc.

Testing for the presence of most pathogenic organisms is difficult, at best, due to the relatively small numbers present and the difficulty in isolating them. Coliform bacteria, although nonpathogenic, are used as indicator organisms in testing for the presence for pathogenic bacteria in waste material, since large numbers are present and testing methods are relatively easy. Table 6.3 lists some of the more common pathogens and the diseases they can cause.

Certain types of coliform organisms, including Escherichia coli (E. coli) are found to be present in soils, (9) indicating that not all coliforms characterize contamination due to human wastes. In recent years a more complete analysis has been adopted in reporting coliform counts, including not only the total coliform count, but also fecal coliforms and fecal streptococci. The quantity of total and fecal coliforms and fecal streptococci found in municipal refuse is reported by Cooper and Golueke in a 1979 report, to equal or surpass the quantity found in raw sewage sludge (10). They speculate that the majority of the indicator organisms originate from animal wastes as opposed to human wastes.

TABLE 6.3
PATHOGENIC ORGANISMS COMMONLY FOUND
IN RAW SEWAGE SLUDGE
(8)

GROUP	ORGANISM	DISEASE
Bacteria	*Salmonella typi*	Typhoid fever
	Salmonella ssp.	Salmonellosis
	Shigella ssp.	Bacillary dysentery
	Campylobacter jejuni	Gastroenteritis
	Vibrio chlolerae	Cholera
	Leptospira	Weil's disease
	Francisella tularensis	Tularemia
	Bacillus anthracis	Anthrax
Viruses	Poliovirus	Poliomyelitis
	Echovirus	Meningitus, etc.
	Coxsackie virus	Meningitus, etc.
	New enteroviruses	Meningitus, etc.
	Hepatitis Type A	Infectious Hepatitis
Protozoa	*Entamoeba histolytica*	Amebic dysentery
	Giardia lamblia	Giardiasis
Helminths	*Necator americanus*	Anemia
	Ascaris lumbricoides	Ascariasis

The most widely used approach in pathogenic destruction is the use of heat. During the decomposition process the organic portion of the waste material is converted into carbon dioxide, water, and heat. When properly regulated, ample heat is generated during the composting process for adequate pathogenic destruction. Figure 6.1 shows the reduction of the bacterial concentrations at various temperatures during a windrow composting operation (11).

In 1979 the U.S. Environmental Protection Agency (EPA) established time and temperature requirements for the utilization of composted sewage sludge (12). The criteria state that a significant reduction of pathogens will occur if a minimum temperature of 40°C is maintained for five days with four hours exceeding 55°C. In order to obtain compost with a further reduction of pathogens, temperatures need to be maintained at 55°C for three consecutive days using the aerated pile method or 15 days out of a total of 21 to 30 days using the windrow method.

Studies (6, 13, 14) have shown that even with temperatures exceeding the minimum required on the inside of the windrow, temperatures near the surface were considerably lower than the required minimum allowing the pathogenic organisms to continue to thrive.

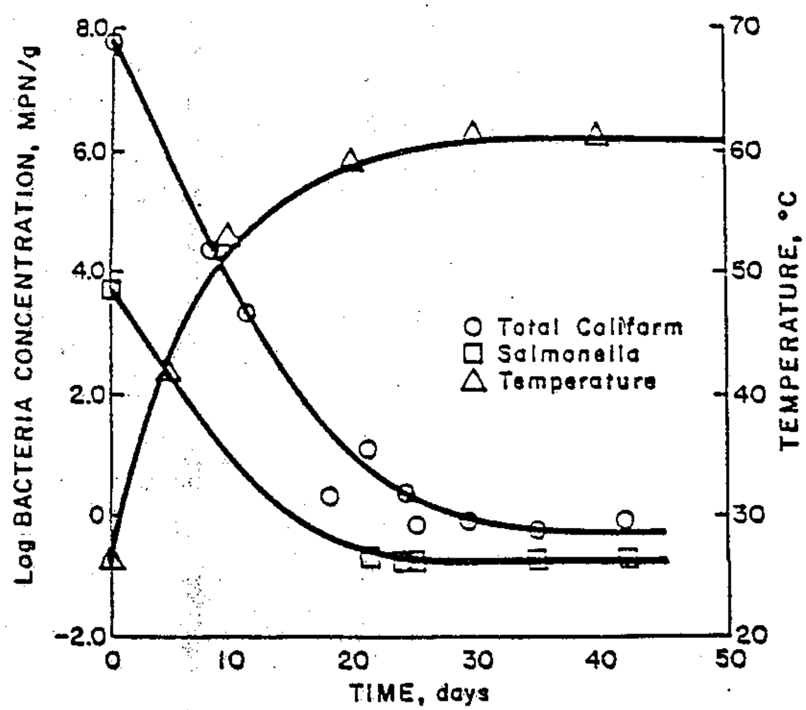

FIGURE 6.1
REDUCTION OF COLIFORM BACTERIA AND SALMONELLA sp.
DURING WINDROW COMPOSTING

Another concern relating to pile temperatures is that no maximum level has been established. The bacteria responsible for the stabilization process have a narrow temperature range in which survival and reproduction occur. If the pile temperature is allowed to exceed this limit the stabilization will be just as significantly reduced as if the minimum temperature is not achieved (15).

Classified as a secondary pathogen, fungi are found to exist in large numbers in composting sludges. The heat generated during the composting process has proven to be an ideal breeding ground for one of the most naturally occurring fungus, Aspergillus fumigatus (A. fumigatus). Though it is not classified as a primary pathogen (capable of initiating an infection in a healthy individual), studies have shown that A. fumigatus can infect individuals with existing health problems, especially leukemia or those with a kidney transplant (11, 16). Other health problems associated with A. fumigatus can be found in Section 6.3.2, Health Aspects.

6.2 End Product Uses

The end product uses of compost and co-compost products suggested by Senate Bill 1929 is as soil amendments, fertilizer, and erosion control material, and as construction material for sound walls and safety barriers.

6.2.1 Soil Amendments

The most widely used application of sludge-derived compost is as a soil amendment. Not only enriching the soil by supplying low levels of essential plant nutrients, nitrogen (N), phosphorus (K), potassium (P), and trace metals, the physical properties of the compost contribute to the loosening of heavy clay soils or increasing the water-holding capacity of sandy soils.

As previously mentioned, it is essential the only good quality materials free from unwanted glass, plastic and metal be produced, as inferior products will not be able to compete in the marketplace.

6.2.2 Fertilizers

Although compost is not classified as a true fertilizer due to the low plant nutrient content, supplemental nutrients may be blended with the compost prior to marketing to enhance the quality of the product. As reported in a United States Department of Agriculture (USDA) Bulletin (6), compost normally contains 1.0 to 1.5 percent total N, 1.2 to 2.0 percent total K, and 0.2 percent P. Essential for plant growth in small quantities, an over-application of heavy-metal-laden compost can cause severe injury or death to vegetation. The uptake of these metals by edible plants is also of serious concern. A list of heavy metal concentrations commonly found in compost and co-compost is shown in Table 6.2.

6.2.3 Erosion Control Materials

The use of compost products as erosion control materials is another approach in the ultimate disposal of these products. No explicit literature was found on the use of these products in this manner; however, in certain erosion control specifications, Caltrans does specify the use of cattle manure for which compost could be substituted. The use of these products in areas of recent construction activities would provide the slopes with erosion protection while supplying supplemental nutrients during vegetative stabilization.

6.2.4 Sound Walls

No sound walls were found to exist in the United States that have been produced from compost or co-compost products, however, several European countries have constructed noise barriers using compacted co-compost products. From an article published by a West German firm (Appendix C), sound wall construction with co-compost materials began in Germany in approximately 1979. The walls have been constructed of a wire mesh fence, lined on the inside with straw, then filled with co-compost materials via either a wet or dry method. Three different sized walls, ranging from five to ten feet in height have been constructed. Vegetation has been grown on the walls to reduce erosion and improve the aesthetics of the wall (photographs in Appendix C).

A schematic of another type of sound wall (SAB sound barrier) was submitted to Caltrans by Acosta and Associates for design consideration. This schematic is shown in Appendix D.

Another approach in the construction of sound walls is through the use of Biobricks. Manufactured from a mixture of clay, shales and sludges, the bricks have been used in the construction of several buildings in Maryland. Any pathogenic organisms present are expected to be destroyed in the brick firing process and any heavy metals in the sludges would become encapsulated reducing any associated risks (17). Since the bricks are made directly from sewage sludges and not compost end products, these products would not necessarily be related to end product uses as stated in SB 1929. However, this appears to be a method in which sludge can be used safely in the construction of sound walls.

6.2.5 Safety Barriers

During the course of this investigation, no documentation of the use of compost or co-compost products in the construction of safety barriers was found. An investigation of the design of a barrier equivalent to state of the art barriers and guard rails now employed by Caltrans would need to be undertaken prior to implementation.

6.2.6 Embankment Construction Material

Two studies have been conducted by Caltrans (18, 19) and another by James Gidley and William Sack (20) on the use of landfill material and other waste products in highway embankment construction. All three, reported favorable results, but concerns over possible environmental degradation and health effects were noted.

6.3 Associated Problems

The problems associated with the use of compost and co-compost products have been divided into three areas, environmental effects, health aspects and public opinion.

6.3.1 Environmental Effects

The environmental effects of using compost products relate to the possible degradation of soils and ground- and surface-waters in and around the area in which these products are used. The extent of the degradation is uncertain and depends largely upon the use of the compost or co-compost materials.

When used as soil amendments and fertilizers, it is important that only good quality compost or co-compost products be used. Certain heavy metals including lead, mercury, copper, cadmium, and zinc, inherently found in sewage sludges, can cause a degradation to the soils in which they have been applied. The USDA recommended limits on the concentrations of these elements in publicly distributed sludge compost are shown in Table 6.4.

The results of a leachate study conducted on refuse and sludge compost by Diaz, et al. (22) indicate that a considerable reduction in the concentration of metals occurred during a 32 week test period. If large concentrations of compost materials were placed in a relatively small area, as would occur with the construction of a sound wall, it is likely that large amounts of these metals would leach out (even after a three to four month composting period) and possibly contaminate the soil and water. Table 6.5 shows the percent reduction of the various elements that occurred during this study.

TABLE 6.4
METAL LIMITS RECOMMENDED BY USDA FOR PUBLICLY DISTRIBUTED SLUDGE COMPOST (21)

Element	ppm (dry weight basis) Without Lime	With Lime
Cadmium	12	25
Copper	500	1,000
Lead	500	1,000
Mercury	5	5
Zinc	1250	2,500

TABLE 6.5
CHEMICAL ANALYSIS OF CO-COMPOST
AT END OF 32 WEEKS OF LEACHING
(22)

Element	Initial Concentration in Sludge (mg/kg-dry)	Final Concentration[1] in Compost (mg/kg-dry)	Percent Reduction
Cadmium	51	20	60.8
Chromium	630	240	61.9
Copper	660	510	22.7
Iron	--	23,000	-
Nickel	150	100	33.3
Lead	860	1,300	N.A.
Zinc	3,520	1,800	48.9
Sodium	1,000	1,000	0.0
PO_4-P	12,000	5,050	57.9
Zinc/Cadmium	69	90	-

1) Concentration was determined after 30 weeks of leachate collection.

Information on the subject of air pollution was not found while researching this project. The amount of suspended particulate matter given off by the use of these materials would need to be field tested and further investigated prior to an implementation program.

The control of odors given off during the composting process, so as not to affect the surrounding community, is a major concern at existing composting facilities. If the material is allowed to decompose under anaerobic conditions instead of aerobic conditions, hydrogen sulfide gas, (H_2S), is produced giving off the familiar smell of rotten eggs. If the compost products are not completely stabilized prior to their use in the construction of barriers, anaerobic decomposition will occur and odor problems will exist.

Information concerning the combustibility of compost and co-compost products was not found during this investigation. The question of how readily these materials will ignite and continue to burn will need to be investigated before barriers are constructed along highway right-of-ways.

6.3.2 Health Aspects

Those involved, both directly and indirectly, with the use of compost and co-compost products could be exposed to a variety of microorganisms and chemical elements which may present potential health problems, ranging from allergic reactions to serious or fatal infections. If compost products are to be used by Caltrans and other state agencies for soil preparation or barrier construction, the health and well-being of the employees and general public need to be considered.

From the literature survey performed, few studies were found to have been conducted on the health effects of individuals exposed to compost; the results were inconclusive considering the seriousness of possible health effects. A study conducted at a composting facility in Sweden, Lundholm and Rylander (23), reported higher than normal counts of airborne bacteria existing in and around the composted materials. Symptoms of nausea, headaches, and diarrhea were reported by several of the employees.

Another study, conducted by C. S. Clark, et al. (16), over a two-year period on employees directly involved in sewage sludge composting operations, showed significantly higher levels of *A. fumigatus* in throat cultures than in cultures of fellow employees with limited or no exposure time. An excess number of abnormal skin, nose, and ear conditions was also reported for the compost workers as compared to the occasional or control groups. However, no major infections or abnormalities were reported.

In a critique written by Epstein and Epstein (24) on the findings of the study by Clark et al. (16), several oversights in the data were discussed which rebut the seriousness of the possible effects. They point out that *A. fumigatus* is the fourth most common fungus and is found growing year-around in just about every environment. In a study conducted in households, it was found to be growing in 42 percent of the bedrooms, 56 percent of the bathrooms, and 82 percent of the basements investigated.

In addition, they point out that, in fact, the larger percentage, as opposed to the larger number, of the abnormalities and allergies were reported from the intermediate exposed group, not the compost workers. Of the reported allergic reactions, all were mild and could be readily treated like other allergies. They concluded that "...possibly the intermediate exposed workers have more of these findings (allergic reactions) because they are not sensitized to the fungal antigens."

The conclusions drawn by the two studies and the critique indicate that exposure to the materials presents no major threat of infection or serious reaction to healthy individuals. Minor reactions may occur but can be easily treated. The intermediate exposed groups may be more susceptible than those exposed on a daily basis. The long-term effects of exposure are unknown at this time and require further investigation.

If these products are used for landscaping and construction purposes, the rate of exposure can be broken into three separate categories; maintenance and construction personnel, who would be directly handling these materials; motorists, who could be exposed while traveling through usage areas; and residents living adjacent to state right-of-ways where these materials have been or are being used.

The amount of exposure that state personnel would receive while working with compost products could be considered comparable to the intermediate exposed groups, as previously discussed. No major acute threat of serious infection or contamination should occur if personnel are given appropriate training in the proper handling procedures and safety precautions. Minor allergic reactions may occur in some individuals and, if warranted, reassignment of such personnel should be considered.

Motorists traveling state highways, where these products have been used, could experience a higher risk of exposure to the fungus than when traveling in areas where they have not been used. In a study conducted by Sikora, et al. (25), 21 outdoor and indoor suspected sources and 3 reference sites were monitored for amounts of *A. fumigatus* present. The results agree with other studies, indicating that fungus can reproduce during all seasons and in most types of environments, but that compost and moldy agricultural substrates offer a large reservoir of *A. fumigatus*. Table 6.6 lists several of the sources and amounts of the fungus found during four sampling periods for one year.

The final group of individuals that need consideration prior to an implementation program, are those residing adjacent to or near state right-of-ways in which these products are to be

TABLE 6.6

NATURAL AIRSPORA OF ASPERGILLUS FUMIGATUS
1979-80 SEASONAL COUNTS
(Colony forming units per cubic meter)
(25)

SITE	FALL	WINTER	SPRING	SUMMER
Lawn (At Park)	8	4	24	2
Lawn (With Mulch)	75	2	6	686
Barn	2,070	105	352	5,550
Municipal Dump	6	2	0	5
Attic	NS	1	1,160	125
Boiler Room	30	38	1	1
Green House	868	1,350	1,070	9,810
Mushroom House	88,700	740,000	580,000	67,100
Reference Sites				
School Playground	6	1	12	9
Parking Lot	7	1	12	9
Shopping Center	11	1	7	3

NS = Not Sampled

used. The low application rates used in fertilization or soil enhancement programs, and the low wind dispersion associated with these uses, should not substantially increase the numbers of A. fumigatus found in the immediate vicinity and should pose no major threat of infection to nearby residents.

Of more concern is the construction of noise and safety barriers. As per Caltrans' Design Manual (26), barriers used to reduce highway traffic noise, range in height from 6 feet to 16 feet and are located anywhere from the edge of pavement to the right-of-way line depending upon available space and local geographical conditions. If large concentrations of compost materials are placed adjacent to right-of-way boundaries, as is the preferred method, individuals will be subjected to significantly higher levels of the fungus.

As previously discussed in Section 6.3.1, (Environmental Effects), potential contamination of the soil, surface water, and ground water via leachate runoff is another possibility. Certain metals, in particular, cadmium and lead, accumulate within plant tissues and serious illness can occur if vegetation with high enough concentrations are ingested (27).

If sound walls are constructed near property lines, storm runoff water, commonly referred to as leachate, containing extremely high concentrations of these metals (22), as well as, other undesirable chemical and biological elements, may contaminate the soil and any vegetation grown on the soil. If residents have small gardens in their backyards, contamination of these edible plants may occur.

General consensus of the reports surveyed on health effects and leachate contamination agree that if good quality compost is used with limited application rates, there should be no adverse effects. No information was found in the literature on either the short or long term effects caused by sound wall construction where large quantities are placed in confined areas. Pending further investigation into this subject, sound walls should not be constructed in areas where the above mentioned risks jeopardize the environment and health of human beings.

From the literature surveyed, no information was found on the possible habitation of rats, mice, insects, or other animals in sound walls constructed of compost or co-compost products. In order to ensure that these barriers do not harbor disease carrying animals, studies on the possible habitation would need to be performed prior to an implementation program.

6.3.3 Public Opinion

Without public acceptance, the end products can be no more than what they originally were: garbage. It is not enough that a good quality compost or co-compost product be produced and utilized along state highways, but the product in question must have public approval before a successful implementation program can be conducted.

Informing the public is more art than science. Attitudes toward negative topics are slow to change, but given enough time and factual information they can and usually do. In an enlightened society, it is imperative that the impacted public be given all the facts before a project is initiated.

7. SITE EVALUATIONS

In a 1986 survey (28), 178 sewage sludge composting facilities were reported to be either operational, under construction, or in the planning stages within the United States. Of these, 89 were listed as operational, with only one being reported as producing co-compost. Within California the survey reported six operating compost facilities and another six either in the proposal or design phases.

7.1 United States

Increasing in popularity in recent years due to the rising costs associated with sludge disposal, the reported number of composting operations either functional, in the design, or construction stages has almost doubled from the 90 facilities reported in a similar 1983 survey (29). The A-SP method leads the currently operating facilities with 53. Windrow and in-vessel operations are in use at 21 and 8 facilities, respectively. Of the proposed facilities, 36 are in-vessel, 24 are A-SP and 7 are windrow. A summary of the survey is shown in Table 7.1

Four of the 178 facilities were identified as being involved with co-compost. The University of Wisconsin was listed as having a pilot project, with one facility each in the construction and design stages at Portage, Wisconsin and Burlington County, New Jersey, respectively. The in-vessel operation in Wilmington, Delaware was the only facility reported in the United States as producing a co-compost product.

TABLE 7.1
COMPOSTING FACILITIES IN THE UNITED STATES
1986 BIOCYCLE SURVEY SUMMARY
(28)

Operational	89
Pilot Projects	14
Under Construction	22
Planning, Design & Bid	28
Under Consideration	23
Not Specified	2
Total	178

Completed in 1985, the Wilmington facility became the nation's first large scale in-vessel co-composting facility. According to design estimates, the facility is capable of handling 1000 tons per day of municipal and industrial refuse and 350 tons per day of sewage sludge. Through a complex network, the refuse is shredded and air classified into separate components. The metal and glass recovered is sold as recyclable products. The organics, plastics, and paper either are used as refuse derived fuel (RDF) or, if the moisture content is too high, mixed with sewage sludge and composted into a humus material.

As the co-compost material is removed from the digesters, it is again screened to remove any noncompostable plastics and other unwanted materials. This final product is then either sold as a soil amendment or fed back into the furnaces as a source of fuel. Table 7.2 shows the predicted yearly inflow and outputs of the Delaware Reclamation Project (30).

TABLE 7.2
DELAWARE RECLAMATION PROJECT
PROJECTED INPUTS AND OUTPUTS
(Dry Weight Basis)
(30)

	TONS / YEAR
INPUTS	
Solid Wastes (refuse)	208,000
Sewage Sludge	18,000
TOTAL	226,000
OUTPUTS	
Refuse Derived Fuel	103,000
Humus	37,000
Ferrous Metals	18,000
Glass	18,000
Internal Fuel (Humus)	9,800
Sand	8,100
Nonferrous Metals	1,300
Residue	8,600
Loss in Process[1]	22,200
TOTAL	226,000

1) Conversion of Solids to Gases in Digesters

7.2 California

As previously mentioned, six compost facilities are currently operating in California with reported sludge production volumes ranging from 0.25 to 300 dry tons per day, with another six facilities in the planning stages. Table 7.3 lists the facilities, their current status, the type of system in use or proposed, and the sludge production volumes.

A waste treatment facility in Orange County, identified in a 1985 survey (31) as in the planning stages, has since decided to landfill and possibly ocean dump its sludge rather than begin composting operations due to public opposition and problems in site selection.

TABLE 7.3
COMPOSTING FACILITIES IN CALIFORNIA
(28)

Plant Name	Status	Type	Sludge Production (Tons/Day)
1) Chino	Operational	A-SP	NR
2) Hayward	Operational	Windrow	NR
3) LA County San. Dist.	Operational	Windrow	300
4) Los Alisos: El Toro	Operational	A-SP	0.25
5) East Bay MUD	Operational	A-SP	60
6) South San Francisco	Operational	Windrow	10
7) Oxnard	Design	In-Vessel	30
8) Simi Valley San. Dist.	Planning	Windrow	11
9) Santa Barbara	Planning	In-Vessel	10
10) Fallbrook	Pilot	Vermicompost	1
11) San Diego	Planning	Windrow	25
12) North San Diego County	Consideration.	Windrow	52

A-SP = Aerated Static Pile
NR = Not Reported

7.3 Trips Conducted By Others

Several trips have been conducted by non Caltrans personnel to co-composting facilities in Austria and Sweden. Mureen Kindel (President, Los Angeles Board of Public Works), Michael Miller (LANCER Project Manager, City of Los Angeles) and William Garber (City of Los Angeles, Bureau of Sanitation) on separate occasions inspected the facilities in Falkenberg, Sweden and in Salzburg, Austria. A brief description of the respective facilities and comments taken from the appropriate trip reports follow.

Falkenberg, Sweden

Constructed in 1981, the relatively small A-SP co-composting facility in Falkenberg processes 35,000 metric tons (38,500 tons) of municipal refuse and 8,000 metric tons (8,800 tons)of sewage sludge per year. Due to the reduction and separation of the refuse, approximately 12,000 metric tons (13,200 tons) of co-compost are produced on a yearly basis.

On January 22, 1985, Mr. Michael Miller visited the facility in Falkenberg. In his trip report dated May 23, 1985, (32) he describes the inputs and outputs of the facility and the functional characteristics of the operating system. He did note that there was a strong odor present, resembling cow manure, and that if a facility were to be constructed in the Los Angeles area that it would need to be enclosed.

During October, 1985 Mureen Kindel inspected the same facility and in her report dated November 20, 1985 (33), she states that she talked with Mr. Kenard Marelius, a private consultant, and Mr. Gunnar Bergvall of the Swedish Environmental Board. Their comments included,

> "...Sweden has gone the wrong way in the last 10-15 years. Composting is only a viable method of waste reduction if you need a soil development. Otherwise, mass burn."

It was also learned from Mrs. Kindel's report that two of Sweden's enclosed co-composting plants have been shut down due to odor and fire problems.

Salzburg, Austria

Completed in 1978, the co-composting facility in Salzburg was designed to handle 100,000 metric tons (110,000 tons) of domestic and industrial refuse and 25,000 cubic meters (62.5 million gallons) of waste water per year.

Once the refuse has been reduced in size, it is fed into a fermentation drum, where it is mixed with sewage sludge in a 3 to 1 ratio. The mixture is then moved to the composting area where it is placed in aerated-static piles where it remains up to 6 weeks before being marketed as a soil amendment.

In 1984, Mr. Garber visited the facility in Salzburg. The trip report was not located for the preparation of this report, however, a personnel interview with Mr. Garber was conducted (34). His main emphasis was on the marketability of the finished product and commented that the compost or co-compost end products would need to be cost-comparable with steer manure in the Los Angeles area, otherwise it would not sell. Also, plastics and glass materials have a negative impact on the aesthetics of the co-compost material.

8. EUROPEAN QUESTIONNAIRE

To obtain information on European co-composting facilities and sound wall construction, a questionnaire (Appendix E) was developed and distributed to 38 facilities throughout West Germany and Sweden. Although co-compost is produced in several of the other European countries, these two were selected due to information obtained from the literature survey, previous correspondence with selected facilities and Universities in Europe, and personal interviews conducted with individuals having inspected several facilities throughout Europe. Questions regarding the production process, quantities produced and sold, testing data, and any information on sound walls were included.

Of the 38 questionnaires distributed, responses were received from 10. Of those responding, information concerning sound walls was received from only one facility near Frankfurt, West Germany (Appendix C), however, the specific location of the wall was not given in the response.

All of the reporting facilities have relatively small operations, producing between 7,000 to 9,000 cubic meters of co-compost per year, with one reporting a production of 20,000 cubic meters (1 cubic meter = 1.3 cubic yards). Seven facilities in Sweden reported selling between 30 to 40 percent of the amount produced, and the two facilities in West Germany reported marketing 70 and 100 percent. The third facility in West Germany stopped its composting operations approximately two years ago because, as they stated, "it was not working out." Several of the facilities included test analyses of their co-compost products (Appendix B).

The end products at all locations were marketed as soil amendments or fertilizers, and in two cases, sold to landfills as erosion control material. None of the material was sold as sound wall construction material. A summary of the data returned is shown in Table 8.1.

TABLE 8.1
SUMMARY OF EUROPEAN QUESTIONNAIRE

	Sweden	West Germany	Total
Sent	22	16	38
Received	7	3	10
Producing Co-Compost	4	2	6
No Co-Compost Produced	3	0	3
Co-Composting Operations Ceased	0	1	1
Type of system			
A-SP[1]	3	1	4
Windrow	1	0	1
In-vessel	0	1	1
End product usage			
Amendments	4	2	
Fertilizers	1	0	
Erosion material	2	0	
Sound wall material	0	0	
Percent sold	30-40	70-100	

Average production 7,000 to 9,000 metric tons per year
Maximum production 20,000 metric tons per year

Note 1) A-SP = Aerated-Static Pile

9. <u>REGULATIONS</u>

The use of compost or co-compost products in any of Caltrans applications is contingent upon the compliance of these materials with all applicable regulations, standards, and guidelines developed on the federal, state, and local levels. Included in this section is a discussion on the existing regulations and guidelines and areas where more may be needed.

9.1 Existing Regulations

As per Title 22 of the California Administrative Code (7), a Waste is considered to be hazardous if any of certain organic and inorganic substances exceed their soluble threshold limit concentrations or total threshold limit concentrations. Table 9.1 lists some of these substances and their appropriate limits. The concentrations of these compounds in domestic sewage sludges are normally low enough to pose no concern of contamination, but if certain types of industrial sources are included in the sewage system, maximum allowable concentrations may be exceeded. The sludge would then become a hazardous waste requiring special handling and disposal.

Currently there are only limited criteria pertaining to the acceptable quality of finished compost products. In Title 40 the Codes of Federal Regulations (35), criteria relating pile temperatures and maximum concentrations are established. To ensure adequate bacteria and viral destruction, pile temperatures must exceed 55°C for 3 days if the vessel or aerated-static pile composting methods are used 15 days if the windrow method is used. Also, the concentrations of lead and cadmium shall not exceed 1000 and 50 ligrams per kilogram (mg/kg), respectively in the finished ...ct.

TABLE 9.1
ORGANIC AND INORGANIC PERSISTENT AND BIOACCUMULATIVE TOXIC SUBSTANCES (Partial List) (7)

	STLC (mg/l)	TTLC (Wet Weight) (mg/kg)
Inorganic Substance		
Antimony	15	500
Arsenic	5.0	500
Barium	100	10,000[1]
Cadmium	1	100
Cobalt	80	8,000
Copper	25	2,500
Lead	5	1,000
Mercury	0.2	20
Nickel	20	2,000
Silver	5	500
Zinc	250	5,000
Organic Substance		
DDT, DDE, DDD	0.1	1.
Dioxin (2,3,7,8-TCDD)	0.001	0.
Endrin	0.02	0.
Lead (Organic)	--	13
Polychlorinated biphenyls (PCBs)	5	50

1) Excluding Barium Sulfate
STLC = Soluble Threshold Limit Concentration
TTLC = Total Threshold Limit Concentration

The cumulative effect that cadmium has in plant tissue i another concern. In 1979 the EPA established regulati the annual application rate of cadmium to land produci chain crops setting the limit at 1.25 kg/ha (1.1 lb/ac reducing it to 0.5 kg/ha (0.44 lb/acre) by January 1,

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Antimony	15	500
Arsenic	5.0	500
Barium	100	10,000[1]
Cadmium	1	100
Cobalt	80	8,000
Copper	25	2,500
Lead	5	1,000
Mercury	0.2	20
Nickel	20	2,000
Silver	5	500
Zinc	250	5,000
Organic Substance		
DDT, DDE, DDD	0.1	1.0
Dioxin (2,3,7,8-TCDD)	0.001	0.01
Endrin	0.02	0.2
Lead (Organic)	--	13
Polychlorinated biphenyls (PCBs)	5	50

1) Excluding Barium Sulfate
STLC = Soluble Threshold Limit Concentration
TTLC = Total Threshold Limit Concentration

The cumulative effect that cadmium has in plant tissue is another concern. In 1979 the EPA established regulations on the annual application rate of cadmium to land producing chain crops setting the limit at 1.25 kg/ha (1.1 lb/acre), reducing it to 0.5 kg/ha (0.44 lb/acre) by January 1, 1987.

The California Department of Health Services has developed guidelines based on the federal regulations for the distribution and marketing of sludges for unrestricted use, e.g. home lawns and gardens, public parks, recreational areas, etc. From the document entitled, "Manual of Good Practice for Landspreading of Sewage Sludge," (36) the maximum concentrations recommended for lead, cadmium, and PCBs should not exceed 500, 50 and 2 mg/kg, respectively, by dry weight. Also included in the manual are the following recommendations:

1) The sludge must be thoroughly treated to assure that all pathogenic organisms are destroyed before application to the land.

2) Composted sludges may not be suitable for home garden usages due to uncertainty in the disinfection process.

3) In metropolitan areas where sludges have higher heavy metal concentrations, the use should be restricted to lawns and shrubs, with no garden usage.

4) Reasonable precautions should be taken to prevent contact of the sludge by young children.

No other regulations or guidelines regarding maximum concentrations of possible contaminate compounds or elements and finished product quality were found to exist on the state and federal levels. An investigation at the county and city levels would need to be conducted in each instance to determine if any local ordinances or regulations exist regarding these products.

9.2 Regulations Needed

With the expected increase in the usage rate of these types of products, well-defined concentration limits on not only sludges, but on the finished compost and co-compost products are needed. Besides the cadmium and lead levels, other heavy metals and organic compounds need to be further defined to permit the safe usage of these products without detrimental degradation of plant and animal life.

Temperature criteria is another area that needs further development. Currently a minimum temperature of 55°C is specified for disinfection purposes, but unless properly controlled, temperatures tend to accumulate within the piles, and the biological community that is responsible for the disinfection process may be destroyed themselves resulting in nondisinfected end products. To assure adequate pathogenic disinfection, a proper range of temperatures and exposure times at this temperature needs to be developed.

Which regulations (solid waste or sludge) co-compost would be governed by are presently uncertain and need to be defined. Existing regulations should be clarified or new ones developed to govern the use of this particular product.

Regulations are also needed in the area of product testing and monitoring. At present, no set procedurea and testing constraints are utilized and, for the most part, are left to each facility to monitor.

At present, the U.S. EPA is developing new regulations concerning sewage sludge handling and disposal techniques which should clarify some of the uncertainty that is presently attached to the use of these types of wastes. Establishment of new state regulations and guidelines can then be undertaken which would further enhance the beneficial use of these products. New regulations may reduce the quantity of solid waste material presently being sent to sanitary landfills. To implement a successful composting program, it is essential that proper regulations concerning the production, testing, and monitoring of compost and co-compost products be established.

10. FEASIBILITY OF USAGE

As defined by law, Caltrans must give purchase preference to compost and co-compost products when they can be substituted for and cost no more than equivalent materials for use in sound wall and safety barrier construction and for soil amendment and fertilizer products and erosion control material.

Based upon the different uses described below, the maximum usage of compost substitutable products currently in use within Caltrans is approximately 82,000 tons per year excluding any safety barrier or embankment construction material. The actual amount of such products that compost could substitute for, would be considerably less due to restrictions described in each of the respective applications. In comparison, over 30,000,000 tons of refuse is buried in California landfills annually according to the California Solid Waste Management Board (37).

10.1 Soil Amendments/Fertilizers

Currently, the use of soil amendment and fertilizer products has only limited applications within Caltrans. Landscape contract work, in which the majority of all landscape planting is performed, occasionally specifies that compost-related products to be used.

From 1983 through 1986 a total of 86,814 cubic yards of compost-related products were used in landscape contract work. Assuming a bulk density of 30 pounds per cubic foot, the total amount used would be approximately equal to 35,200 tons or an average of 8,800 tons per year. Table 10.1 lists the annual amounts of soil amendments, steer manure, and mulch products used in Caltrans contracts during this period.

TABLE 10.1
QUANTITIES OF COMPOST RELATED PRODUCTS
USED IN CALTRANS' CONTRACTS
(38, 39, 40, 41)

Item	Quantity Used (Cubic Yard) 1983	1984	1985	1986
Soil Amendments	10,497	4,264	4,213	3,600
Manure	40	40	0	0
Mulch-Wood Chips	15,515	23,995	14,076	10,574

Existing specifications within Caltrans (42) state that soil amendments may be derived from sewage sludge indicating that, at least, a portion of the soil amendments previously used could be of sewage sludge origin. Maintenance forces generally do not use soil amendment products, and fertilizers, when used, are of the granular type which have the needed percentages of N, P, and K than the compost-type products.

10.2 Erosion Control Materials

One type of vegetative erosion control measure that is utilized by Caltrans in highway contract work is the application of seed, fertilizer, fiber, and water via a hydroseeding operation. Applied through a hydroseeder, the mixture is blown onto areas requiring treatment.

In the past, cattle manure has been specified in certain contracts as a substitute for fiber. During the past four years the total fiber usage in this type of erosion control was 1,264 tons. Again, assuming that compost could be substituted for all of this fiber, an average total of 316 tons per year of compost could be used.

10.3 Sound Walls

Three types of programs exist within Caltrans to fund the construction of sound wall: new or reconstruction projects, Community Noise Abatement Program, and the School Noise Abatement Program. As of 1986, the School Noise Abatement Program was approximately 91 percent complete with only 12 schools remaining to be retrofitted by either classroom modification (the preferred method) or sound wall installation.

The Community Noise Abatement Program has identified a need for approximately 200 additional miles of sound wall construction. Only $16.6 million has been included in the 5-year State Highway Transportation Improvement Program for sound wall construction under this program, which at a cost of approximately $1 million per mile, will allow for only 3.3 miles of sound wall construction per year for the next five years. It is anticipated that this amount could be increased to approximately $6 to $7 million per year beginning with the 1990-91 fiscal year.

The future of new highway construction and major widening projects is unknown and the extent of barrier construction is uncertain at this time. However, it is estimated that approximately 15 to 20 miles per year may be included in these types of projects.

Assuming that a total of 20 miles of sound walls were constructed per year and that all 20 miles could be constructed of compost-related products and using a design similar to that pictured in Appendix D, a total annual usage could be approximately 73,000 tons. In reality, it is anticipated that only a small percentage of the walls could be constructed of compost materials due to limitations in right-of-ways and other geometric constraints, drainage requirements, and other environmental problems which may be related to the design of these types of walls.

As the compost materials continue to decompose, it is anticipated that additional materials will need to be periodically added to maintain the integrity and aesthetics of these types of walls. The quantities of materials and time intervals in which maintenance will be required is unknown at this time but should be considered in the total life cycle costs when comparing with other types of walls.

Other costs which should be included in the co-compost option are the amount of initial landscaping, periodic pruning and trimming, irrigation needs not required with other types of sound barriers, and the life expectancy of the wall. The information required to make a rational economic decision concerning comparable costs was not available.

Additional information will need to be gathered and research studies conducted in order to determine the answers to the following questions prior to construction of these types of walls: 1) which vegetative covers would be most suitable, 2) the type of irrigation system needed, 3) corrosiveness of the metal restraining fence (if this type is used), and 4) erodibility of the compost barrier.

Standard materials that have been used in the past for the construction of sound barriers consist of the following: masonry block, precast concrete panel, wood (post and plank or plywood), and metal. Earth berms have also been used, but large right-of-ways are required, and, unless excess local borrow is available, other materials are usually more cost-effective.

Existing Caltrans design specifications for sound walls, including noise abatement criteria levels, locations, heights, lengths, aesthetics, and maintenance considerations, may be found in the Caltrans Highway Design Manual (26).

10.4 Safety Barriers

As previously stated, no information has been found on the use of compost products in the construction of safety barriers. Currently, Caltrans utilizes several different types of barriers, including a Type 50 concrete barrier, metal beam guard rail and thrie beam guard rail, designed to reduce the severity of damage and injury in accidents. These barrier designs have undergone extensive crash testing following the guidelines established in the National Cooperative Highway Research Program Report No. 230 (43) to ensure proper structural stability and to minimize damage and injury to life and property of the motorist.

Compost related products probably could not be substituted for these types of crash barriers, but may be appropriate in other types of barriers where high speeds and major impacts would not be anticipated. No prediction on the amount of usage for this application can be made at this time.

10.5 Embankment Construction Material

The use of large quantities of compost materials for embankment construction would not be advisable at this time without conducting further research. As concluded in three previous studies, mentioned in Section 6.2.6 of this report, there are both health and environmental concerns with the quantities of heavy metals that may be present in the waste material.

Further testing in this area is needed to ensure that no soil or water contamination would occur in the construction area.

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APPENDIX A

SENATE BILL 1929

Senate Bill No. 1929

CHAPTER 1700

An act to add Article 7.5 (commencing with Section 10400) to Chapter 2 of Part 2 of Division 2 of the Public Contract Code, relating to public agency transactions.

[Approved by Governor September 30, 1984. Filed with Secretary of State September 30, 1984.]

LEGISLATIVE COUNSEL'S DIGEST

SB 1929, Campbell. State purchasing: co-compost and compost products.

Existing law requires the Department of General Services to give preference, whenever feasible, to the purchase of recycled paper products if the bids for these products do not exceed unrecycled paper products by a specified amount.

This bill would require all state departments and agencies to revise their procedures and specifications to give preference to co-compost and compost products, as defined, when they can be substituted for, and cost no more than, regular fertilizer or soil amendment products, if the co-compost and compost products meet applicable standards and regulations.

The bill would declare the findings and intention of the Legislature concerning these provisions.

The people of the State of California do enact as follows:

SECTION 1. Article 7.5 (commencing with Section 10400) is added to Chapter 2 of Part 2 of Division 2 of the Public Contract Code, to read:

Article 7.5. Co-compost Products

10400. The Legislature hereby finds and declares that it is the policy of the state to encourage the use of marketable end products which are produced as a result of superior waste management by counties, cities, and local agencies.

The Legislature further finds and declares that it is in the public interest to provide special consideration for the state purchase of co-compost and compost products because these products substantially reduce the need for solid waste disposal facilities, such as landfills, and will assist the state in providing new solutions to the alarming decrease in available solid waste disposal facilities, such as landfills.

10401. For purposes of this article, "co-compost product" means an end product which meets all of the following requirements:

93 30

(a) Is derived from a blending of materials, of which at least 80 percent, whenever possible, is household refuse and the remainder is sewage sludge or other comparable substitutes, including, but not limited to, nontoxic dairy wastes, livestock and horse manure, or fish wastes.

(b) Is usable.

(c) Is produced by the waste management facilities of counties, cities, or local agencies, or of private contractors providing waste disposal services to counties, cities, or local agencies.

10402. For purposes of this article, "compost product" means an end product which meets all of the following requirements:

(a) Is derived from the controlled biological decomposition of sewage sludge or from a blending of sewage sludge with carbonacious bulking materials including, but not limited to, wood byproducts, plant wastes, or refuse.

(b) Is usable.

(c) Is produced by the waste management facilities of counties, cities, or local agencies, or of private contractors providing waste disposal services to counties, cities, or local agenices.

10403. All state departments and agencies including, but not limited to, the Department of Transportation, the Department of Water Resources, the Department of Forestry and the Department of Parks and Recreation shall give purchase preference to co-compost and compost products when they can be substituted for, and cost no more than, regular fertilizer or soil amendment products, or both, if the co-compost and compost products meet all applicable state standards and regulations, as determined by appropriate testing. The product preference shall include, but not be limited to, the construction of noise attenuation barriers and safety walls, highway planting projects, and recultivation and erosion control programs.

10404. It is the intent of the Legislature, in enacting this article, that the revenues derived from the state purchase of co-compost products will be used by counties, cities, and local agencies to offset the costs of construction, operation, and maintenance of co-compost waste disposal facilities.

O

APPENDIX B

EUROPEAN CO-COMPOST ANALYSES

SLL
Statens lantbrukskemiska
Laboratorium
Slam- och avfallsanalyser
Tel. 018/171514

PROTOKOLL
Datum 850509
Analysnummer A- 503-84/85
Ankomstdatum 850424

Kopia av detta protokoll
har tillställts:

Uppdragsgivare

AB BORLÄNGE INDUSTRIVERK
DRIFTLAB
ATT:STENA
BOX 834
78128 BORLÄNGE
0243/28100

Kommun, reningsverk el. dyl.:
Provet märkt: FÄ KOMP PLATTA EFTERKOMP
Provtyp: KOMPOST
Provtagningsdatum: 850422
Provtagningsperiod:

Provtagare namn: A-G STENA
Provtagare tel.: 0243-20163

RESULTAT

pH.............			Al.............			% av TS
TS.............	44.5	% av prov	Fe.............			% av TS
Aska...........		% av TS	B..............			mg/Kg TS
Tot-C..........		% av TS	Hg.............	5		mg/Kg TS
Org-C..........		% av TS	Cd.............	9		mg/Kg TS
Tot-S..........		% av TS	Pb.............	987	*	mg/Kg TS
Tot-N..........		% av TS	Cr.............	57		mg/Kg TS
NH4-N..........		% av TS	Co.............	8		mg/Kg TS
NO3-N..........		% av TS	Ni.............	51		mg/Kg TS
P..............		% av TS	Mn.............			mg/Kg TS
K..............		% av TS	Cu.............	659		mg/Kg TS
Ca.............		% av TS	Zn.............	2370		mg/Kg TS
Mg.............		% av TS	PCB............			mg/Kg TS
Na.............		% av TS	DDT............			mg/Kg TS
CaO............		% av TS	Coli (35 grad).			ant./g prov
			Coli (44 grad).			ant./g prov
Sulfid	55	mg/Kg inl prov				

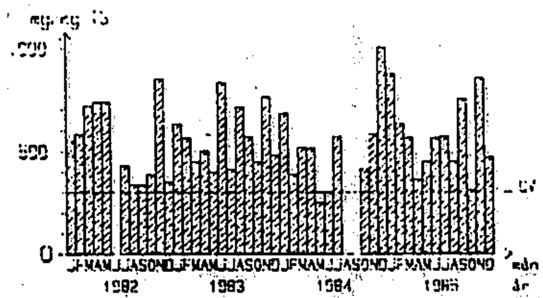
Tecknen * och ** betyder över normalhalt resp. överhalt enl. SNV Råd och Riktlinjer 1979:3

UTLATANDE

(#1-See Appendix E-3)

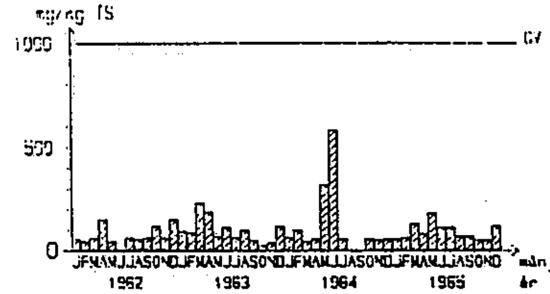
....
(Erik Jonsson)

MHAAB - KOMPOST
BLY



Medelvärde 548 563 521 560 mg/kg TS

MHAAB - KOMPOST
KROM



Medelvärde 76 96 138 90 mg/kg TS

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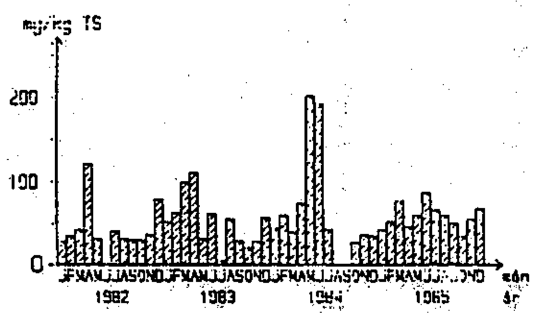
NICKEL



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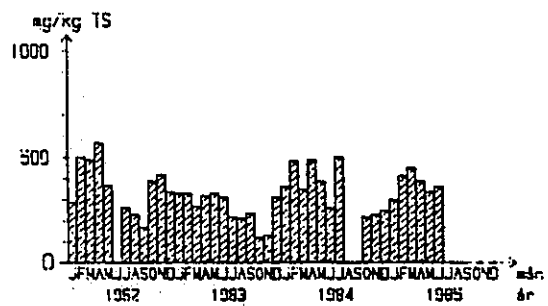
KOPPAR



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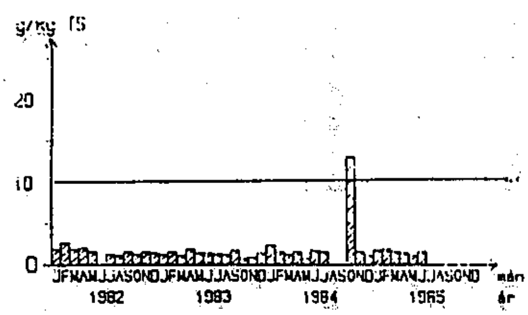
ZINK



Medelvärde 1627 1321 2617 1517

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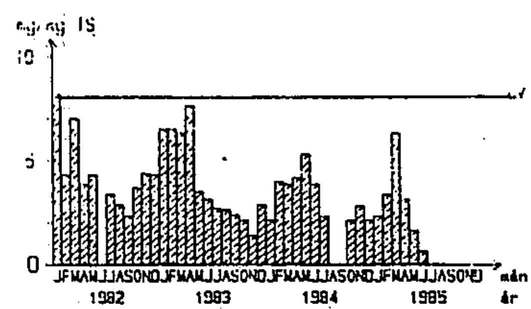
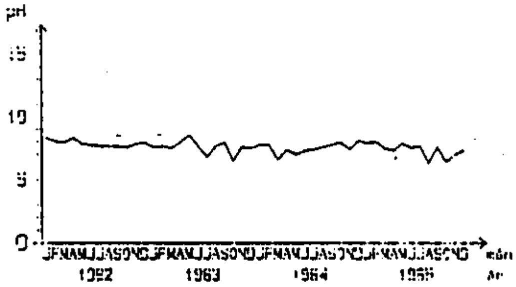
KVICKSILVER



4.4 4.0 3.3 2.0 mg/kg TS

(#21-See Appendix E-3)

MHAAB - KOMPOST
pH



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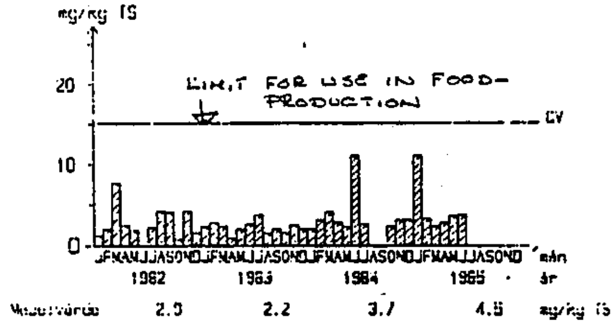
CADMIUM



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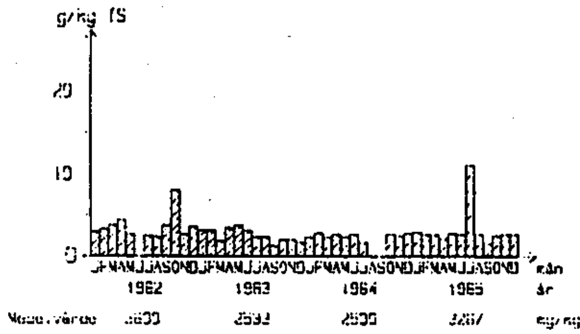
FOSFOR



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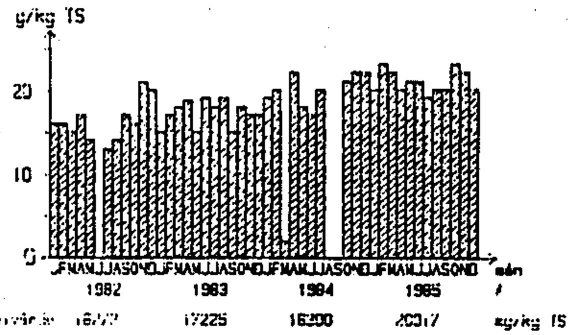
KVÄVE



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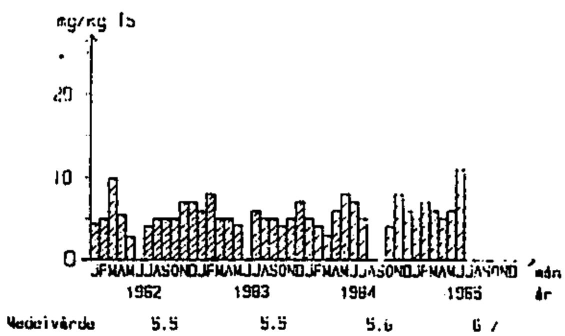
KOBOLT



(#21-See Appendix E-3)

BEZIRKSVERBAND PFALZ
LANDWIRTSCHAFTLICHE
UNTERSUCHUNGS- UND FORSCHUNGSANSTALT SPEYER
DIREKTOR: Prof. Dr. W. Kampe

Landwirtschaftliche Untersuchungs- und Forschungsanstalt · Postfach 1629 · 6720 Speyer

Riedwerke
Taunusstraße 100

6080 Groß-Gerau

6720 Speyer, den 26.09.1986
Obere Langgasse 40
Fernruf (0 62 32) 7 60 26 / 7 60 27

Az.: Dr. Ko/Sch
(Bei Antwortschreiben Aktenzeichen angeben)

Bei Rückfragen bitte die Sprechzeiten von 8.30 – 12 Uhr und von 14 – 16 Uhr beachten!

U n t e r s u c h u n g s b e r i c h t

- Analyse von Industrie- und Siedlungsabfällen -

Auftraggeber: Riedwerke Groß-Gerau

Bezeichnung der Probe: "Riedkompost" (Rotte VM 41)

Probennummer: D 802/86 Eingangsdatum: 17.07.1986 Gewicht: ca. 10 kg

Datum der Probenahme: 17.07.1986 Verpackung: Plastik.

Probenehmer: Auftraggeber

XXXXXXXXXXX/unversiegelt - XXXXXXXXXX/überbracht durch: Auftraggeber

Befund

Wasser	H_2O	%	24,4	
Trockensubstanz	TS	%	75,6	
Asche	FS	%	52,4	TS % : 69,3
Glühverlust	FS	%	23,2	TS % : 30,7
Salz	TS	%	1,4	
pH			7,5	
Volumengewicht	g/l		452	

(#24-See Appendix E-3)

Wertbestimmende Inhaltsstoffe (% in TS):

Stickstoff (ges.)	N	0,8
Ammoniak-Stickstoff	NH_3-N	0,01
Phosphat (ges.)	P_2O_5	0,7
Phosphat (CAL)	P_2O_5	0,15
Kali (CAL)	K_2O	0,3
Kalk	CaO	4,2
Magnesium	MgO	0,8
Kohlenstoff (ges.)	C_t	13,4
Kohlenstoff in der wirksamen organischen Substanz	WOS-C	8,1
Kohlenstoff der in 0,5 % NaOH und 80 % Schwefelsäure unlöslichen organischen Substanz	C	5,3
Schwefelwasserstoff	H_2S	n.b.

Sonstige Inhaltsstoffe (mg/kg in TS):

Bor	B	10,1
Cadmium	Cd	3,0
Kupfer	Cu	513
Nickel	Ni	299
Zink	Zn	940
Mangan	Mn	490
Blei	Pb	336
Chrom	Cr	154
Quecksilber	Hg	3,7
Arsen	As	5,7

Vegetationstest (xxxxxxxxxxxx) Interpretation der Ergebnisse wird nachgereicht

Mikrobiologischer Befund (siehe Anlage) (#24-See Appendix E-3)

Im Auftrag:

Müllkompostwerk Heidelberg, den 2.4.1984

Analysenergebnisse von Frischkompost...............

Jahr: 1983

Art der Untersuchung		Dimension	Anzahl d. Analysen	Mittelwerte	Minimalwert	Maximalw
Feuchtigkeit	(H_2O)	Gew.%	2	43,8	40,9	46,7
Org. Substanz (Glühverlust)		"	1	29,04	-	-
Volumengewicht (naturfeucht)		g/l	1	484	-	-
Salzgehalt	(KCl)	%	1	0,2	-	-
pH-Wert		-	1	7,3	-	-
basisch wirks. Anteile	(CaO)	%	1	3,9	-	-
Calzium (errechnet) (CaO-Wert : 1,4)	(Ca)	%	-	-	-	-
Stickstoff ges.	(N)	%	1	0,35	-	-
Stickstoff ll	(N)	mg/100g	1	59	-	-
Phosphor ll	(P_2O_5)	"	1	263	-	-
Kalium ll	(K_2O)	"	1	445	-	-
Magnesium ll	(Mg)	"	1	57	-	-
Bor ll	(B)	mg/kg	1	7,3	-	-
Zink ges.	(Zn)	"	2	662,4	601	680
Kupfer ges.	(Cu)	"	1	124	-	-
Nickel ges.	(Ni)	"	1	17,7	-	-
Cadmium ges.	(Cd)	"	2	4,6	3,2	6,0
Blei ges.	(Pb)	"	2	255,3	230	276
Chrom ges.	(Cr)	"	1	30,7	-	-
Quecksilber ges.	(Hg)	"	2	7,47	0,94	14,0
Kohlenstoff	(C)	%	1	0,35	-	-
Kohlenstoff: Stickstoff	(C:N)	"	1	59	-	-
Calzium	(Ca)	"	1	2,8	-	-
Ammoniakstickstoff	(NH_3-N)	"	-	-	-	-
Nitratstickstoff	(NO_3-N)	"	-	-	-	-
Eisen	(Fe)	mg/kg	-	-	-	-

(#29-See Appendix E-3)

APPENDIX C

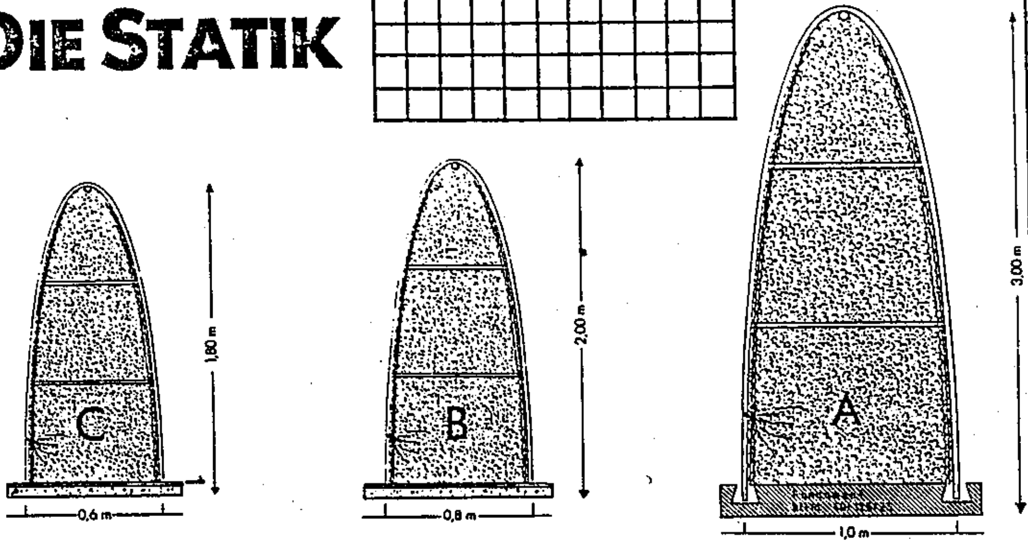
WEST GERMAN SOUND WALL INFORMATION

The following information was received from a co-composting facility located at Bischofsheim, West Germany near Frankfurt, # 24 from the list in Appendix F. Included in the literature is information on biological properties of compost, sound absorption, and construction details on three model sizes. Photographs of various installation are also provided.

DIE VEGETATIVE LÄRMSCHUTZ WAND

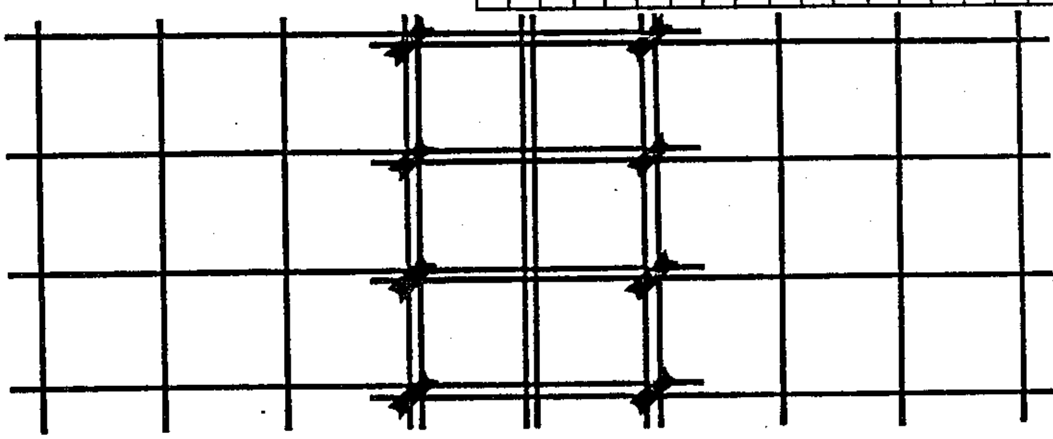
Eine lebende Hecke, deren Kern eine biologische Zelle aus Müll-Klärschlamm-Kompost ist, mit dem Absorptionswert von **8,0 dB**

Die Statik



Rohrbögen geben der Wand die Form. Das größte Modell A steht auf kleinen Einzelfundamenten aus Beton und ist statisch für Autobahnen mit einer Windlast von 1,45 KN/m² ausgelegt. Das Modell B steht auf Glasfaserkufen und findet im Kommunalen Bereich Verwendung. Das kleinste Modell C gehört in den Wirkungsbereich des Gartenarchitekten.

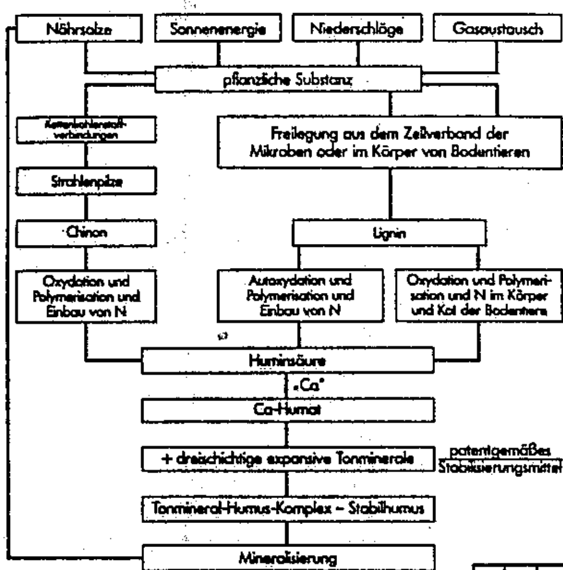
Die Technik



Alle Stahlteile sind doppelt feuerverzinkt, Schraubverbindungen aus V 2 A-Stahl. Die Glasfaserverbindungen werden gestützt, verkeilt und geklebt. Sie stehen an Festigkeit den Stahlteilen nicht nach, nur kennen sie keine Korrosion, das Material ist bodenbürtig. Die Mattenstöße überlappen doppelt an allen Verbindungsstellen und werden dort 2 mal verbunden.

DIE BIOLOGIE

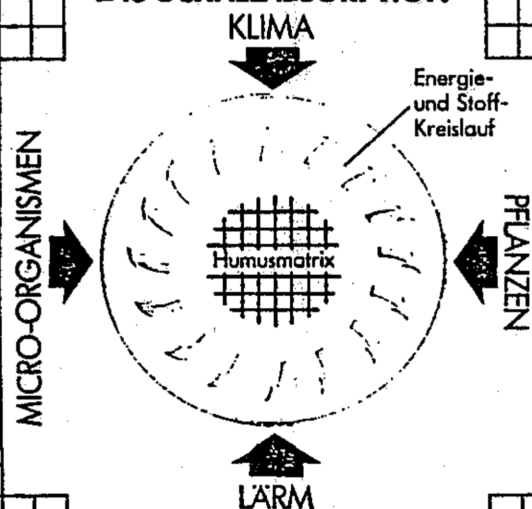
Der gärtnerische Kompost gibt seinen Humusgehalt an die Pflanzen ab. Durch eine spezielle Aufbereitung des Müll-Klärschlammkompostes mit expansiven, dreischichtigen Tonmineralien entsteht dauerhafter Stabilhumus. Er bildet die Lebensgrundlage für den abwechslungsreichen Pflanzenwuchs auf beiden Seiten der Wand. Osmose und molekulare Anziehungskraft gewähren gleichbleibende Feuchtigkeit.



ROTTEPRINZIP

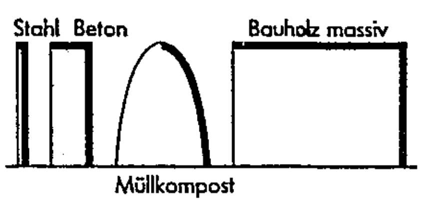
Hausmüll und Klärschlamm kommen in ein Drehrohr, in dem sehr bald der Zersetzungsprozeß mit bis zu 70° C Temperaturanstieg beginnt. Dazu ist Sauerstoff notwendig, der unter ständiger Kontrolle zugegeben wird.
Aus dem Drehrohr kommt das Substrat auf eine Rotte-Platte, wo Bakterien, Actinomyceten vor allem, weiteren Abbau der organischen Substanz vornehmen. Ist dieser ganz verschwunden und besteht die Besiedelung aus Spinnen, Milben und Würmern, dann ist – nach vorhergegangener Aufbereitung zum Stabilhumus – der Rotteprozeß abgelaufen und die Baureife erlangt.

Die SCHALLABSORPTION



Nach eigens erarbeiteten wissenschaftlichen Erkenntnissen und praktischen Erfahrungen liegen heute Qualitätsanforderungen an den Müll-Klärschlamm-Kompost vor, die die Stoff- und Energiekreisläufe in Verbindung mit der Humusmatrix zu dem hohen und zeitlich unbegrenzten Absorptionswert führen.

DIE LUFTSCHALLDÄMMUNG



Gemäß RLSW lassen sich die geforderten Schalldämmmaße durch eine dichte Wandkonstruktion erreichen, wenn die flächenbezogenen Maße von 25 kg/m², bzw. 40 kg/m² (höherer Lärmschutz) eines Materials mit geschlossener Oberfläche an keiner Stelle unterschritten wird.
Das Prüfungsergebnis ist Luftschalldämmung R_w 63 dB.

DAS SCHALLSCHUTZZEUGNIS

Um überzeugen zu können, daß aus Siedlungsabfällen, Hausmüll und Klärschlamm auf dem Wege über biochemische und biologische Abläufe neues Leben, neues Grün in der Landschaft entstehen kann und dieses Grün technische Leistungen erbringt, wurde die Wand im Hallraum eines eingetragenen Sachverständigen für Schallschutz aufgebaut und der Schallabsorptionsgrad nach DIN 52212 geprüft. Das Ergebnis ist

Schallabsorption Δ^{L}, α Str. = 8,0 dB

Patent Nr. 2808486 Schweizer Patent Nr. 631768

Erläuterungen

1 Allgemeines

Vegetative oder lebende Lärmschutzwände haben den Vorteil, daß sie neben den bautechnischen und schalltechnischen Anforderungen in hohem Maße den ästhetischen Ansprüchen von Anliegern und Straßenbenutzern genügen.

2 Bautechnische Ausbildung

2.1. Das Gehäuse
Die Wand bekommt ihre Grundform aus hintereinandergereihten Rohrbögen aus Stahl oder Glasfiber. Drei Standartmodelle finden Anwendung

Modell A = 3,0 m hoch, am Fuß 1,0 m breit
Modell B = 2,0 m hoch, am Fuß 0,8 m breit
Modell C = 1,8 m hoch, am Fuß 0,6 m breit

Bei **Modell A** – vor allem an Autobahnen gebraucht – findet der Rohrbogen in kleinen bewehrten Betonfundamenten Halt und Abstand. Die Fundamente haben eine Länge von 1,25 m, eine Höhe von 0,20 m und eine Breite von 0,25 m. Die von der RLSW (Richtlinien für Lärmschutzwände) in Ansatz gebrachte Windlast von 1,45 KN/m² wird durch sie voll aufgenommen.

Bei **Modell B** finden die Rohrbögen in Glasfiberkufen, 1,0 m lang, 10 – 12 cm breit, und 5 – 8 mm stark, Halt und Abstand in vorgestanzten Löchern, die durch aufgesetzte Muffen verstärkt werden.

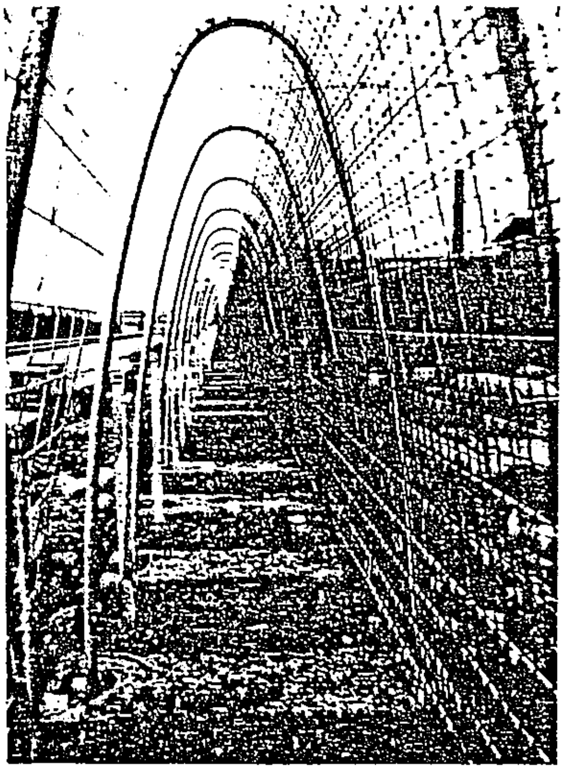
Bei **Modell C** finden die Rohrbögen gleichfalls in Glasfiberkufen – die entsprechend kürzer sind – Halt und Abstand.

Alle drei Modelle erhalten – je nach Höhe – eine oder zwei querstabilisierende Verstrebungen.
Innen sind die Rohrbögen mit festen, gitterartigen Matten verkleidet, die dem aus der Füllung entstehenden Druck standhalten. Die Matten müssen sich an ihren Enden mindestens 30 cm überlappen. Die Überlappungen sind in zwei senkrechten Reihen mit ca. 15 cm Abstand zu verrödeln. Die Kopfenden des Gehäuses sind durch Mattenteile zu verschließen und in Gitterabstand mit dem letzten Bogen zu verrödeln. Anfangs- und Endbogen erhalten eine innen angebrachte Diagonalverstrebung, die sie mit den beiden jeweils nächsten Bögen kraftschlüssig verbinden.

Kombinationen zwischen Erdwall und Lärmschutzwand o. ä. sind in vielerlei Kombinationen möglich.

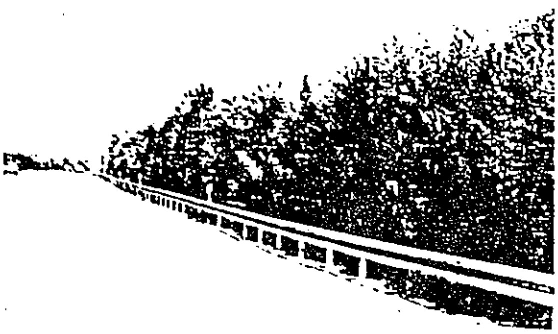
Gemäß den „Richtlinien für Lärmschutzwände an Straßen" soll der Abstand der Lärmschutzwand vom äußeren Rand der befestigten Fläche (Fahrbahn bzw. Standspur) 2,0 m sein.

Die Standsicherheit der vegetativen Lärmschutzwand ist in jedem Einzelfall durch statische Berechnung und Überprüfung durch einen zugelassenen Prüfingenieur nachzuweisen.



Autobahn Dortmund – Kassel bei Soest
Streifenfundamente und Gehäuse (XI/78)

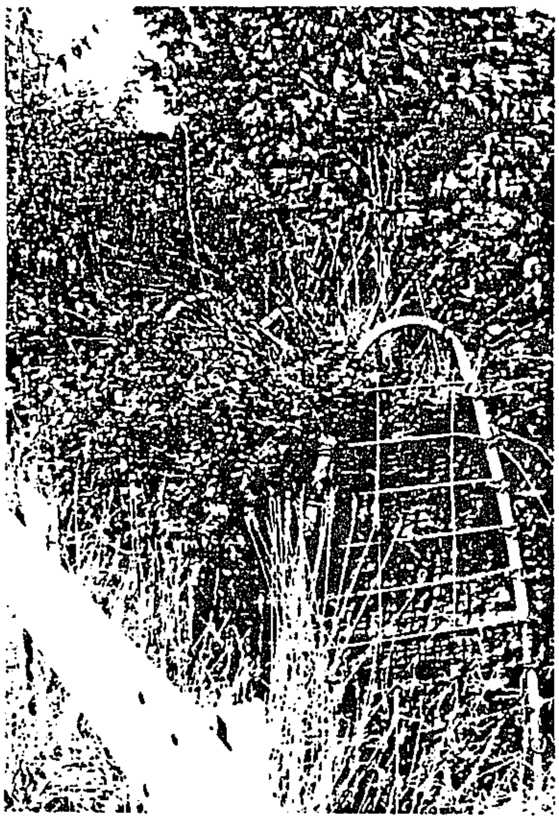
2.2. Das Füllmaterial
Das Recyclingprodukt Müll-Klärschlamm-Lagerkompost, dessen hoher Humusanteil von ca. 35 % durch den Zusatz dreischichtiger expansiver Tonmineralien stabilisiert wird, füllt den Hohlkörper. Die Stabilisierung erfolgt im Kompostwerk schon in der ersten Rottestufe, sei es durch Zugabe der Stabilisierungsmittel in der Heißphase in die Trommel oder den Turm der Anlage, oder während des ersten Umsetzens auf der Rotteplatte zum Frischkompost.
Der gesamte, weithin unbekannte Rotteprozeß zeichnet sich durch drei Phasen aus:



Nach fünf Vegetationsperioden

1. Schnell angsteigende Temperaturen zwischen 60 und 80° C, die über Tage bzw. Wochen anhalten. Dazu ist ein kurzzeitiger Sauerstoffbedarf bis zum 300 mm³/g × h erforderlich. Während dieses Zeitraumes werden sämtliche Wurmeier, Salmonellen, Unkrautsamen und so weiter abgetötet.

2. Dem Abklingen der Temperaturen folgt eine dichte Besiedlung mit Pilzen, Milben und Kolembolen, die durch ihre Fraßtätigkeit an den aufgeschlossenen organischen Bestandteilen für einen weiteren Abbau sorgen. Am Ende dieses Abschnittes sind keine organischen Strukturen mehr zu erkennen. Das Volumen vermindert sich deutlich sichtbar.



Autobahn Köln – Olpe bei Gummersbach,
Kopfstück der Wand, Scheitel durch Fahrtwind abgetragen.

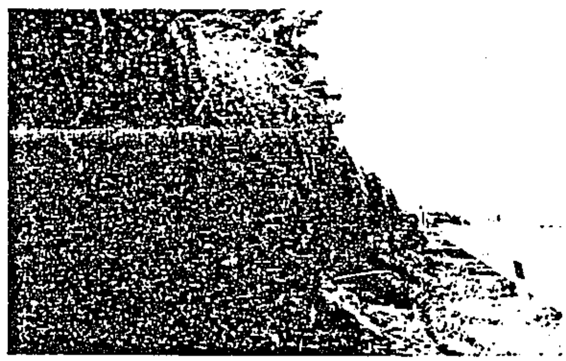
Nach vier Vegetationsperioden

3. Die Entwickung des Humusanteils im Kompost als Rotteprodukt unterliegt der Tätigkeit der Actinomyceten, von denen mehrere Stämme an der Aufbereitung beteiligt sind. Zum Abschluß entwickelt sich ein Stamm (act. aurantiacus, Act. flavos u. a.) der Antibiotika produziert, um damit sämtliche Viren zu eliminieren. Während des ganzen Zeitraumes ist mehrfaches Umsetzen notwendig, um Reduktionszonen zu vermeiden.

Ehe die geschilderte Entwicklung nicht beendet ist, kann an eine Bepflanzung des Substrates nicht gedacht werden, weil entweder Hitze oder Antibiotika die Pflanzen zum Absterben bringen.

Dauert die Fertigung normalen Lagerkompostes 3 – 6 Monate, so dauert die Rotte bis zur Baureife 6 – 12 Monate. Der zeitliche Ablauf der Rotte ist abhängig von der Herkunft und Zusammensetzung des Ausgangsmaterials.

Die sich aus der Tätigkeit der Organismen entwickelnden Stoff- und Energiekreisläufe lassen aus dem Ganzen – dem Gerüst und seinem Füllmaterial – eine Struktur biologischer Zellen entstehen, deren Vielfalt einen hohen Grad ökologischer Sicherheit gibt.



Schnellstraße Düsseldorf – Essen bei Velbert
Bepflanzung mit Rankern

Nach vier Vegetationsperioden

Der Einbau des Füllmaterials

Die Baureife des Stabilhumuskompostes zeigt sich durch normale Bodentemperatur, durch das völlige Fehlen organischer Strukturen, durch Kresse-Test und

Laboruntersuchung auf das Verhältnis zwischen Braun- und Grauhumaten.

Zum Naßeinbau des vorbereiteten Stabilhumus wird dieser soweit mit Wasser zersetzt, (max. 50 %), daß er mit einer Betonpumpe eingefüllt werden kann. Damit der Kompostbrei nun nicht durch die verhältnismäßig großen Maschen der gitterartigen Matten herausfließt, wird das gesamte Gerüst innen mit einer Strohmatte ausgekleidet. Nach dem Einfüllen des Stabilhumus ist die Strohmatte so feucht, daß sie mit Gräsern und Kräutern angesät werden kann und schnell grün wird.

Da das zum Einfüllen zugesetzte Wasser sehr schnell wieder abfließt, ist mit einem Volumenverlust von bis zu 25 % in den ersten 8 Tagen zu rechnen. Das Auffüllen erfolgt nun mit trockenem Stabilkompost. Damit dieser nicht durch Wind abgetragen wird, ist zu empfehlen, den Scheitel der Wand mit Rollrasen (etwa 30 cm breit) abzudecken.

Für den Trockeneinbau des Verfüllmaterials wird ein pneumatisches Förderaggregat (s. Mähdrescher) eingesetzt. Der Einbau erfolgt in Schichten von 30 – 50 cm, die anschließend durch Benetzung mit Wasser verdichtet werden. Die Durchfeuchtung sollte nur bis zur Stichfestigkeit des Materials – wobei gleichzeitig die notwendige Verdichtung erfolgt – ausgeführt werden.

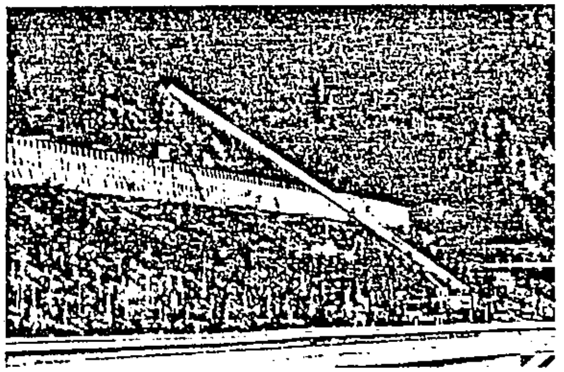
Für die Fertigstellungspflege ist eine Bewässerungsanlage auf der ganzen Scheitellänge unerläßlich. Ihr Wirkungszeitraum ist aber auf echte Trockenperioden zu beschränken, d. h. in einem Gebiet mit 700 mm Niederschlägen im Jahr etwa 6 Wochen.

3 Schalltechnische Eigenschaften

Gemäß RLSW lassen sich die geforderten Schalldämm-Maße durch eine dichte Wandkonstruktion erreichen, wenn die flächenbezogenen Maße von 25 kg/m² eines Materials mit geschlossener Oberfläche an keiner Stelle unterschritten wird.

Da gemäß Zeugnis vom 02. 10. 1978 des Erdbaulaboratoriums Wuppertal der stabilisierende eingebaute MK-Kompost ein Gewicht von 1.000 kg/m² hat, ist Luftschalldämmung bei der vorliegenden Wandstärke in vollem Maße gegeben, d. h. daß die in den „Vorläufigen Richtlinien für Lärmschutz" unter 4.1a geforderte Pegelminderung für die Pegelspitzen von 25 dB (A) überschritten werden. Das gilt für alle drei Modelle.

Die Schallabsorption – im Hallraum eines Prüfungsingenieurs gem. DIN 52 212 mit Δ^L A, α, Str. = 8,0 dB festgestellt – bleibt nur dann konstant, wenn der Humusanteil in der im Optimum des Rotteprozesses erreichten Höhe (30 – 40 %) erhalten, also stabilisiert werden kann. Die patentgeschützte Stabilisierung des Humusanteiles erfolgt, wie beschrieben, durch Zugabe von expansiven, mehrschichtigen Tonmineralien. Die Tatsache der Humusstabilisierung mit zeitlich zunehmender Tendenz stellte Prof. Dr. R. Kickuth, Lehrstuhl für Ökochemie an der Gesamthochschule Kassel-Witzenhausen nach eingehenden Untersuchungen am 07. 07. 1979 gutachtlich fest.



Autobahn Kiefersfelden – Innsbruck, Verfüllen des Gehauses

Nach drei Vegetationsperioden

4 Biologische Funktion

Für die Aufrechterhaltung des Stoffkreislaufes wird von der Pflanze, als biologischem Bindeglied, in der vegetativen Lärmschutzwand gefordert:

1. Schneller Abschluß der Pflanzendecke zur Schaffung eines Mikroklimas auf dem steil aufragenden Profil.

2. Nachschaffung von Humusvorräten durch reges Wurzelwachstum auf dem Substrat MK-Kompost, das **Baureife** erlangt haben muß.

So entsteht eine biologische Zelle, die durch Osmose innerhalb der Strukturen und durch Hygroskopie der winzigen Einzelteile, durch eigene Energie- und Stoffkreisläufe ein solches Eigenleben führt, daß negative Einflüsse von außen – z. B. Trockenheit, Hitze oder Frost – keinen Einfluß nehmen können.

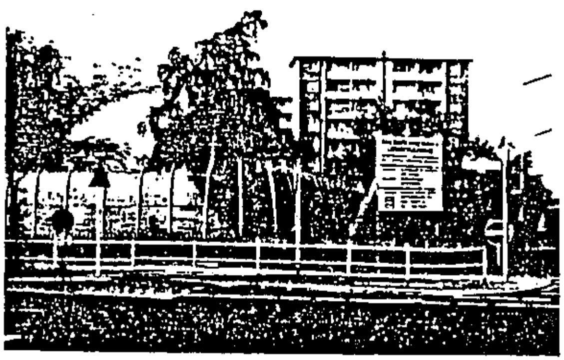
Die Zusammenstellung der Pflanzen muß von Fall zu Fall neu vorgenommen und dem jeweiligen Standort angepaßt werden. Insbesonders kommt der Frage nach dem Wintergrün Bedeutung zu, wenn die vegetative Lärmschutzwand in Siedlungsnähe Aufstellung findet. – Allgemein kann man eine Dreiphasenordnung voraussetzen:

1. Straßenseitige Bepflanzung des Fußbereiches durch Salzresistente
2. Wandbepflanzung durch Bodendecker, Ranker und Klimmer.
3. Scheitelbepflanzung durch Kleinsträucher zur Auflockerung der starren Horizontalen.

Gleichsam neben den schalltechnischen Aufgaben vermittelt die Bepflanzung der vegetativen Lärmschutzwand das Aussehen einer lebenden Hecke, die sich in die Landschaft einbinden läßt und im Wohnungsumfeld merklich die Situation verbessern kann.

Die Vegetative Lärmschutzwand ist ein bauliches Verknüpfen von notwendiger Lärmschutztechnik und möglicher Ästhetik auf der Basis Müll-Recycling und bietet eine naturverbundene Maßnahme zum Lärmschutz.

Manfred Karsch
PLANEN & BAUEN, Windscheidstraße 18
1000 Berlin 12



Stadtautobahn Berlin, Südring
Gehäuse vor dem Verfüllen

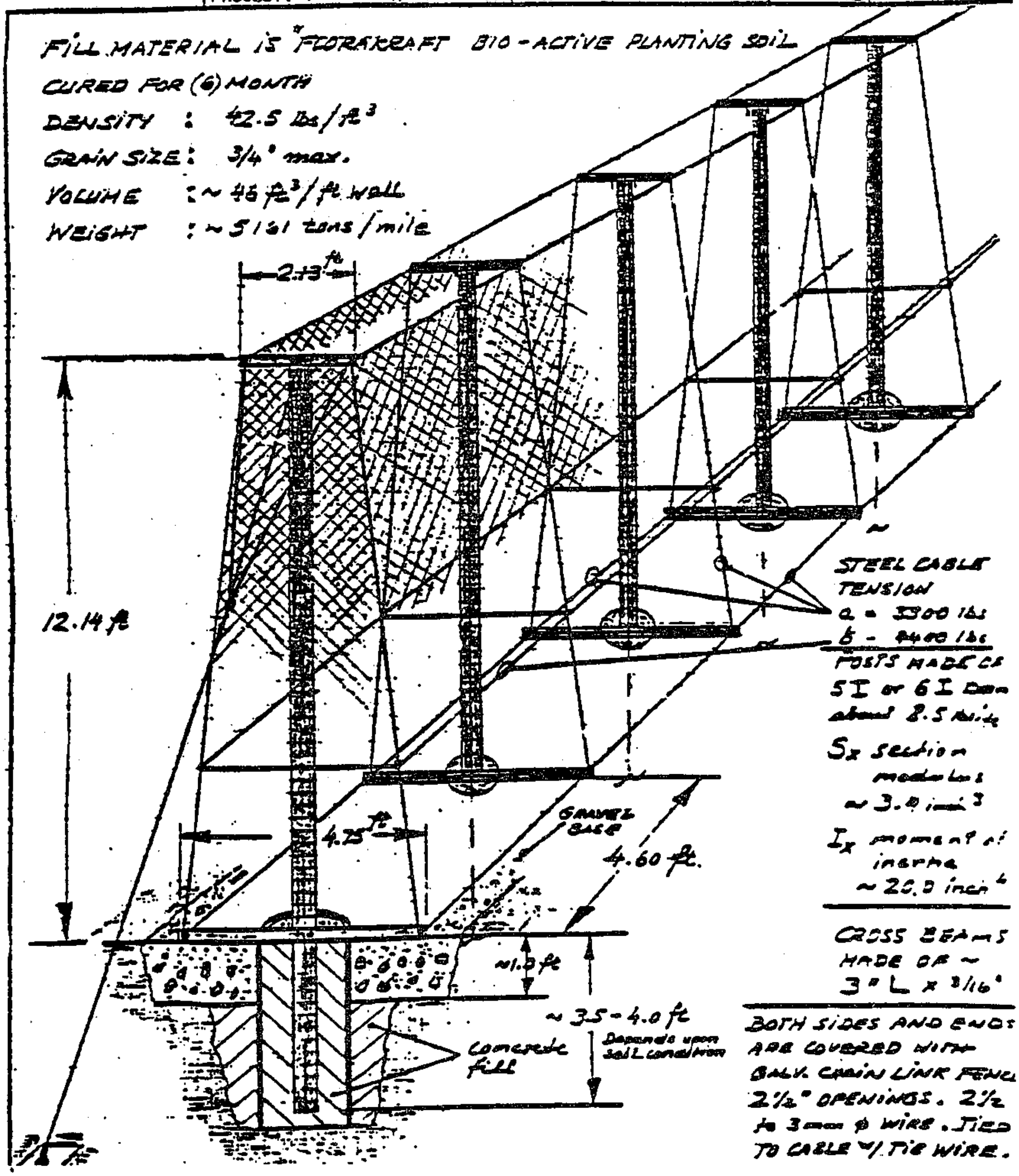
Versuchs- und Referenzwand auf Betonplatte
Ramsbeck/Sauerland, nach zwei Vegetationsperioden

APPENDIX D

SAB SOUND BARRIER INFORMATION

The following schematic of an SAB sound barrier was submitted to Caltrans by Acosta and Associates for design consideration.

ITEM: SAB – SOUND BARRIER	DATE: 11-Jan-84	SHT.
PATENT PROTECTED		
PROJECT: ACOSTA / CALIF. NO.	BY:	CK



APPENDIX E

EUROPEAN QUESTIONNAIRE

QUESTIONNAIRE

NAME AND ADDRESS OF FACILITY ...

____
____
____

ARE YOU ...

___ A PRIVATE COMPANY
___ GOVERNMENT CONTROLLED (GOVERNMENT AGENCY)
___ OTHER ______________________

TYPE OF TREATMENT FACILITY AND QUANTITY OF WASTE RECEIVED ...

___ HOUSEHOLD REFUSE ______________
___ INDUSTRIAL REFUSE ______________
___ WASTE WATER (SLUDGE) ______________

IS COMPOST PRODUCED AT YOUR FACILITY?

___ YES
___ NO

COMPOST IS A MADE FROM ...

___ SEWAGE SLUDGE
___ HOUSEHOLD REFUSE
___ INDUSTRIAL REFUSE
___ COMBINATION (CHECK APPROPRIATE BOXES)
___ OTHER ______________________

WHAT TYPE OF SEPARATION SYSTEM IS USED TO REMOVE THE FOLLOWING MATERIALS FROM THE REFUSE USED?

___ FERROUS METALS ______________
___ NON-FERROUS METALS ______________
___ PLASTICS ______________
___ GLASS ______________
___ OTHERS ______________

TYPE OF TREATMENT SYSTEM USED TO PRODUCE COMPOST ...

___ WINDROW
___ AERATED STATIC PILE
___ IN-VESSEL
___ OTHER ______________________

RATE QUALITY OF COMPOST PRODUCED ...

___ GOOD
___ FAIR
___ POOR

HOW MUCH DOES IT COST TO PRODUCE COMPOST? ______________

HOW MUCH COMPOST IS ...

___ PRODUCED? ______________
___ SOLD? ______________

WHAT IS COMPOST SOLD AS AND HOW MUCH MONEY IS IT SOLD FOR?

___ SOIL AMENDMENTS ____________________
___ FERTILIZER ____________________
___ EROSION CONTROL MATERIAL ____________________
___ SOUND WALL MATERIAL ____________________
___ LANDFILL MATERIAL ____________________
___ OTHER ____________________

DO YOU KNOW THE LOCATION OF ANY SOUND WALLS BUILT OF COMPOST MATERIAL?

___ NO
___ YES ____________________
(WHERE?)

CAN YOU RECOMMEND WHERE WE CAN GET MORE INFORMATION ON SOUND WALLS CONSTRUCTED OF COMPOST MATERIALS?

____
____
____

DO YOU PERFORM PHYSICAL, BIOLOGICAL OR CHEMICAL TESTS OF THE COMPOST?

___ YES
___ NO

IF SO COULD YOU PLEASE ENCLOSE A COPY OF RECENT TEST RESULTS WHEN YOU RETURN THIS QUESTIONNAIRE.

DO YOU FEEL COMPOSTING IS A GOOD AND VIABLE ALTERNATIVE TO SOLID WASTE DISPOSAL?

___ YES
___ NO ____________________
(WHY NOT?)

THANK YOU FOR ALL YOUR TIME AND EFFORT.

The European questionnaire was sent to the following entities in Sweden and West Germany:

#	CONTACT	LOCATION	REPLY CODES
1	Per Helje	BORLANGE, SWEDEN	1-A,4
2	Bertil Johansson	FALKENBERG, SWEDEN	NR
3	Jan Kaijser	JONKOPING, SWEDEN	3
4	Dahlsson	LANDSKRONA, SWEDEN	NR
5	Lars Backstrom	HUDDINGE, SWEDEN	NR
6	Erik Nord	MALMO, SWEDEN	3
7	Stig Nilsson	VAXJO, SWEDEN	NR
8	Torbjorn Rehnstrom	LUDVIKA, SWEDEN	NR
9	Nils Gustavsson	LUND, SWEDEN	NR
10	Nils Wiklund	SUNDSVALL, SWEDEN	NR
11	Anders Schelin	STOCKHOLM, SWEDEN	3
12	Christer Floren	MORRUM, SWEDEN	1-A
13	Varbergs kommun	VARBERG, SWEDEN	NR
14	Kjell Johnsson	JONKPING, SWEDEN	NR
15	Tore Lundin	UPPSALA, SWEDEN	NR
16	Ingemar Lundstrom	HUDDINGE, SWEDEN	NR
17	S. Renhallningsverk	VALLENTUNA, SWEDEN	NR
18	Henning Svensson	STENUNGSUND, SWEDEN	NR
19	Jean Larsson	STENUNGSUND, SWEDEN	1-W
20	Torbjorn Lilja	SUNDSVALL, SWEDEN	NR
21	Bo Hjortdahl	FALKENBERG, SWEDEN	1-A,4
22	Bengt Skagersjo	AKERSERGA, SWEDEN	NR
23	Klaus Beckenbach	ALZEY, WG	NR
24	Egon Peglow/Jacobi	BISCHOFSHEIM, WG	1-A,4,5
25	A.A. Ernst	DUISBURG-HUCKINGEN, WG	NR
26	Herr Nordmeier	ENNEPETAL, WG	NR
27	Ewald Rettig	FLENSBURG, WG	NR
28	Otto Kirschner	GEISELBULLACH, WG	NR
29	H. Wagner	HEIDELBERG 1, WG	1-V,4
30	Ernst Becker	MERGELSTETTEN, WG	NR
31	Werkmeister Schmidt	BAD KREUZNACH, WG	NR
32	Werner Derwand	LANDAU-QUECHHEIM, WG	NR
33	Hans Grote	LEMGO 1, WG	NR
34	Dieter Langenbrunner	HAMBURG 65, WG	NR
35	Emil Hein	SCHWEINFURT, WG	NR
36	Herr Spannbauer	STUTTGART, WG	2
37	Werner Classen	WESTERLAND/SYTL, WG	NR
38	Heinz Schreiber	ORTSTEIL MALSCHENBERG, WG	NR

REPLY CODES

1 = Produces Co-Compost

-W = Windrow
-A = A-SP
-V = In-Vessel

2 = Co-Compost Operations Ceased
3 = No Co-Compost Production
4 = Co-Compost Analyses Returned
5 = Sound Wall Information

NR = No Response

APPENDIX F

DEFINITIONS

DEFINITIONS

Aerated-Static Pile (A-SP) - A composting process similar to windrow composting, except air is drawn or blown through the pile, decreasing the time required to obtain a stabilized material. This method is sometimes called "area composting."

Co-Compost - The usable end product produced by a waste management facility that is derived from a blending of materials of which at least 80 percent, whenever possible, is household refuse and the remainder is sewage sludge or other comparable substitutes including, but not limited to, non-toxic dairy wastes, livestock and horse manure or fish wastes.

Compost - The usable end product produced by a waste management facility that is derived from the controlled decomposition of sewage sludge or from a blending of sewage sludge with a carbonaceous bulking material including but not limited to wood by-products, plant waste or refuse.

Household Refuse - A combination of food wastes (animal, fruit and vegetable residues) and rubbish (paper, plastics, glass, ferrous and nonferrous metals, and garden trimmings) generated from domestic sources.

In-vessel - A composting process in which the materials are placed in an enclosed vessel and mechanically agitated. Temperature and oxygen requirements and odor problems are more easily controlled than in the other processes.

Leachate - Liquid which has percolated through solid wastes and has extracted dissolved and suspended materials, including biological and chemical constituents.

Pathogenic Organisms - Any disease causing organism harmful to man, usually bacterium or virus.

Vector - An animal or insect that transmits a disease-producing organism, including rats, mice, mosquitos, etc.

Windrow - A composting process in which the sorted or shredded material is placed into rows, normally 3 to 5 feet in height, and allowed to decompose. Piles are turned 2 to 5 times per week to allow for adequate oxygen supply and regulation of the heat generated.