行政院所屬各機關因公出國人員出國報告書

（出國類別：訪問考察）

考察歐美堆肥處理與生物可分解塑膠政策與技術出國報告

服務機關：行政院環境保護署
出國人職稱：科長
姓名：賴瑩瑩

出國地點：比利時、美國
出國期間：八十九年十二月三日至十二月十七日
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行政院研考會/省（市）研考會
編號欄

考察歐美堆肥處理與生物可分解塑膠政策與技術

出國報告

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出國報告

壹、 前言

廢棄物管理及溫室效應問題為目前國際上主要關切的環保議題，生物可分解塑膠及堆肥處理，將可提供作為廢棄物處理及減少二氧化碳排放方面可行的解決方式之一。美國穀物協會在這一方面向來已推動多年，此次邀集產、官、學、研等方面之單位，請其推派代表組成考察團，赴歐、美等先進國家，就廢棄物處理相關政策，推動堆肥處理方式相關之法令、制度、實務，及生物可分解塑膠研發技術、檢測方法、標誌、產品應用情形、市場等進行實地了解及交換意見。另並至美國夏威夷參加生物可分解研討會，經由各國研究生物可分解塑膠之專家發表論文中，可了解各國於此領域之研發技術。在美國穀物協會的安排下，本團在短短 15 天的行程中所獲得的助益相當大。對未來政府相關政策的擬定、技術研究發展方向，日後我國環保生物可分解材料協會的業務推動，與台灣業界日後的發展均提供了一套完整的依據，期能吸取相關推動經驗以加速於國內推動之。

貳、考察期間

中華民國八十九年十二月三日至十二月十七日，為期十五天。

參、出國考察人員

姓 名	職 稱	服務單位
賴瑩瑩	科 長	行政院環境保護署

陳文德	科　長	行政院農業委員會
于　寧	總經理	環境與發展基金會
黃建銘	主　任	塑膠工業技術發展中心
林逸郎	總經理	偉盟工業股份有限公司
張學義	副代表	美國穀物協會

肆、考察訪問與參加研討會行程

日　期	行　程
12月3日（星期日）	
19：35	搭乘荷蘭航空公司 KL#878 班機自中正機場啟程。
12月4日（星期一）	
05：35	抵達阿姆斯特丹。
07：00	轉荷蘭航空公司 KL#1723 班機飛往比利時。上午 7：50 抵達布魯塞爾。 （夜宿 Holiday Inn，City Center）
12月5日（星期二）	
09：30－11：30	參觀比利時北區民間 VLAR 有氧發酵堆肥工廠。由技術部經理 Bart Tambuyser 解說比利時有機廢棄物處理法令、有機廢棄物處理收費標準、現場觀察該廠處理有機廢棄物製造堆肥情形。
15：00－18：00	拜訪位在德國科隆 Interserroh 公司。由 Joran Reske 及 Ulrich Kinner 解說。 （夜宿 Holiday Inn，City Center）

12月6日（星期三）

09：00－12：00　　拜會比利時 Organic Waste System 公司，由實驗室經理 Bruno De Wild 說明歐盟廢棄物處理政策、歐盟各國有機廢棄物處理現況與未來展望，以及該公司經營項目作詳盡介紹。

14：30－16：30　　參觀比利時 Organic Waste System 公司在 Brecht 所建 DRANCO 厭氧發酵技術處理有機廢棄物工廠。由實驗室經理 Bruno De Wild 詳細說明工廠設備、運作與發電、堆肥處理情形。

（夜宿 Holiday Inn，City Center）

12月7日（星期四）

09：00－11：00　　就歐洲拜會、參觀情形作討論及資料整理。

14：25－15：35　　搭乘西北航空公司#8328 班機由比利時布魯塞爾飛往荷蘭阿姆斯特丹。

16：35－18：25　　搭乘西北航空公司#55 班機由荷蘭阿姆斯特丹飛往美國明尼蘇達州 Minneapolis。

（夜宿 Marriott Hotel，City Center）

12月8日（星期五）

09：00－11：00　　由 Cargill Dow Polymers 公司派員至 Marriott Hotel 八樓會議室，向中、韓兩訪問團說明該公司以玉米澱粉經化學醱酵產生聚乳酸（PLA）製造生物可分解塑膠情形，以及未來產品研發情形。

14：00－17：00　拜會 Minneapolis 環保局。

（夜宿 Marriott Hotel，City Center）

12 月 9 日（星期六）　資料整理與討論。

（夜宿 Marriott Hotel，City Center）

12 月 10 日（星期日）

09：35－23：30　搭乘西北#935 班機，由 Minneapolis 飛往 Honolulu Hawaii，中途停靠洛杉磯時，飛機故障，改搭夏威夷航空公司 HA#9 班機，抵達比原訂時間延後 7 小時。

（夜宿 Sheraton Moana Hotel）

12 月 11 日（星期一）　由於抵達時間延遲，本日拜會活動取消。就歐洲行程與明尼蘇達州參訪情形，就每人心得提出報告與資料整理。

12 月 12 日（星期二）

上午　自 Sheraton Moana Hotel 換到 Hyatt Regency Waikiki

15：00－20：00　The 6th International Scientific Workshop on Biodegradable Polymers and Plastic and 9th Annual Meeting of the Bio/Environmentally degradable Polymers Society. 研討會報到。

17：00－18：00　美國穀物協會邀集中、日、韓三國代表團研商未來可分解塑膠的檢驗方法、標準、驗證、標章及堆肥品質齊一化等問題作意見溝通與交流。

17：00－18：00　研討會晚宴。

12 月 13 日（星期三）

至　　　　　　研討會

12 月 16 日（星期六）

12 月 16 日（星期六）

09：35－13：30　　搭乘西北航空 NW#9 班機，由夏威夷飛往日本成田機場。

12 月 17 日（星期日）

18：15－21：35　　搭乘西北航空 NW#7 班機，由日本成田機場返國。

伍、考察訪問重要成果紀要

一、參觀比利時 VLAR 有氧醱酵堆肥廠

VLAR 為比利時一民間堆肥處理公司，由比利時政府投資部分資金成立。該公司專門處理比國北部地區公園、私人庭院花木殘枝、家庭蔬果、廚餘等廢棄物發酵為堆肥作資源回收工作，VLAR 公司每年處理有機廢棄物量能為五萬二千公噸，進行堆肥後其產品生產量每年約二萬三千公噸。

在比利時，法令規定有機廢棄物不可直接以掩埋方式處理，此法令已施行約一年。故促成有機廢棄物以堆肥方式處理，政府亦協助業者興建堆肥廠，目前該國已設有六座堆肥廠。VLAR 公司所處理的有機廢棄物由政府垃圾車或由民間業者運送。比利時政府按廢棄物重量及運送型態不同，給予不同的處理費用。以不加包裝方式進廠，政府按每公噸支付 2,750 比利時法郎（純粹之樹枝每公噸給付減少 1,000 法郎）；以可分解（Biodegradable）塑

膠袋包裝送達者，每公噸處理費用為2,800比利時法郎。

在堆肥化處理方面，當有機廢棄物送進工廠後，先經初步篩選及吸除金屬物質後再傳送至廠房進行醱酵。全部發酵時間為十一週，每週翻堆一次，每次翻堆後往前堆放，最後一堆即為第十一週已完全腐熟之堆肥。整個堆肥過程十一週之間，前四週之溫度達60℃，以後逐漸降溫，第四週以後溫度逐漸降為35℃，另並以生物濾床控制臭味問題。完全腐熟之成品包裝後送另一倉庫堆放待售，每公斤售價為0．一五比利時法郎(每公斤約新台幣0．一二元)。

為維護堆肥品質，在比利時已建立一套發證及驗證制度。堆肥成品之品質按農業部之規定管理，其符合品質標準者由OVAM(屬政府單位)進行發證，並由VLACO公司(屬非營利民間組織)作檢測，並有可能至市面上抽檢堆肥成品之品質。

VLAR公司在處理包裝廢棄物，遭遇比較大的困難為每週收取家庭有機廢棄物一次，由於包裝袋係用生物可分解塑膠袋（Biodegradable plastic bag），此種塑膠袋係為資源回收可以堆肥化處理，但比較早包裝者已開始分解破裂，如有家庭再用PE袋包裝，難以於進行堆肥前分類撿選，造成處理困擾。

二、拜訪德國Interseroh公司

該公司自一九九一年成立，主要業務內容為進行包裝廢棄物資源回收收集、再生之整合及管理，一九九九年營業額為五五四·七百萬馬克，稅後盈餘為九·八百萬馬克，目前有七百六十位員工。其與德國境內八萬個事業廢棄物產生源（如麥當勞）簽約、建立資源物收集系統，在末端部分，並與六百個廢棄物分類回收工廠

及三百家再生廠簽約，將各事業產生之資源物送往再生。本項回收系統有別於DSD系統，DSD系統係回收一般家戶產生之資源物，而該公司回收者為事業單位產生者，由於產生源較為集中，收集成本較低，故收費費率較DSD系統約便宜二至三成。

該公司並介紹德國生物可分解塑膠之發展及可堆肥包裝廢棄物之管理情形如下：

(一)德國實施資源回收制度已有十年，已依法公告製造、輸入、販賣業者有回收的責任，據該公司估計，對於應用於包裝之生物可分解高分子化合物，其市場需求在未來應呈成長趨勢。

(二)對於傳統塑膠及生物可分解塑膠在製造成本部分，目前雖然後者較前者貴約三至四倍，在未來預估製造成本應可縮短於二倍以內，而若考慮分類回收再生之成本後，因後者可以堆肥方式再生資源，較之傳統塑膠須經前分類之回收成本（塑膠須分為七類），成本較為低廉，故預估未來兩者之整體成本(製造及回收成本)將會相當接近。故生物可分解塑膠市場競爭力可望提高。

(三)對於使用後之生物可分解塑膠其收集管道來源主要來自三方面：

1. 家庭廚餘桶；

2. 事業單位（例如速食店）；

3. 大型節慶或活動（如音樂會或運動比賽）。

(四)在德國，對於可進行堆肥之包裝或容器，須要經驗證單位如DIN CERTCO認證（certificate）後，即由德國生物可分解材料會（IBAW）授予可堆肥標章(IBAW-Logo)於包裝或容器上，以利消費者辨別。生產生物可分解塑膠粒子之製造工廠

其產品應經可堆肥化之測試，其時間為六個月，費用為一萬五千美元；以生物可分解塑膠為原料之製造廠部分，其產品須經四週可堆肥化之測試，所需費用為一千元美金。

(五)Kassel 計畫

Kassel 市為生物可分解塑膠工業活動之中心，此計畫將生物可分解塑膠(以下簡稱 BDP)進行堆肥處理之應用於有機廢棄物之管理，為世界上有關此方面之最大的示範計畫。計畫期間從公元 2000 年 2 月進行到 2001 年 7 月，參加者包括工業界（如 Bayer、BASF，及其他廢棄物管理公司、生物可分解塑膠製造業、托盤、飲料杯及吸管、紙杯之 coating 業等)、民間團體及學術單位，德國聯邦政府農業部並成立基金，並由顧問公司作為計畫管理者。

此計畫施行重點為，為利民眾配合，以 BDP 製之包裝容器產品可在超市買得到，民眾將以 BDP 製成之包裝廢棄物丟至有機廢棄物分類桶，此類廢棄物並以堆肥方式處理，而堆肥後之產品將應用於農業上。

BDP 製之包裝容器應用產品範圍為：裝乳製品、水果及蔬菜、肉類等之包裝或容器、超級市場購物袋、裝有機性廢棄物的袋子及速食店用後即丟之餐具等。

最基本的問題為民眾是否會將 BDP 製成之包裝廢棄物丟入有機廢棄物分類桶或者投入其他材質之包裝，為此計畫成功的要件。相關資料詳如附件一。

三、拜訪比利時 Organic Waste System 公司

本次拜訪歐洲地區廢棄物處理相關機構均由 Organic Waste

System（簡稱 O.W.S）公司實驗室經理 Bruno De Wild 細心及妥善安排，並提供歐盟對廢棄物處理政策現況與未來展望，以及該公司經營項目作詳盡介紹，其用心令人佩服，在此特別向其表示謝意與敬意。由於該公司提供資料甚有供國內參考價值，乃分類整理加以簡介。

(一)歐盟廢棄物處理政策

1.訂定廢棄物處理優先順序：

為維護生態環境，強化資源利用，歐盟對廢棄物處理，訂定優先順序，供各國作為訂定相關法律及執行之指導原則。

(1)首先由廢棄物減量（Reduce）著手。

(2)其次為廢棄物再使用（Reuse)。

(3)廢棄物再利用為物料或進行堆肥（Material Recycling-Composting)。

(4)廢棄物焚化回收熱能之再生化（Recovery)。

(5)最後才考量以掩埋（Land filling）方式處理。

在不同國家對於第(3)及第(4)之優先順序有不同看法，部分國家第(3)優於第(4)；部分國家第(3)同於第(4)。

2.訂定廢棄物處理之最高指導原則（Directives)：

(1)包裝材料指導原則：

歐盟訂定以 1994 年為基期年，在五年內對於包裝材料的再利用(Recycling)之比例需達到 25 至 45%，而且如廢紙，廢玻璃容器或廢塑膠類等個別包裝材料之再利用比例不得低於 15%。至於再生化（Recovery）之比例需達到 50 至 65%。

(2)掩埋（Land filling）處理指導原則：

有機廢棄物禁止以掩埋方式處理。本項規範之目的為防止排放 CO_2、CH_4 等導致溫室效應氣體及防範經由淋洗作用造成地下污染。

據統計，歐盟在 1998 年之廢棄物以掩埋方式處理者仍達 60％以上。尤其英國利用礦坑作廢棄物掩埋場最為代表。歐盟站在資源回收立場，希望逐漸降低掩埋方式之比例，以公元 1995 年掩埋量為基礎，至 2006 年降為 75％，至 2009 年降為 50％，至 2016 年再降至 35％之水準。

(3)堆肥處理指導原則：

堆肥之優點為降低溫室效應之 CO_2、CH_4 等氣體排放，增加土壤中有機質含量，改善土壤理化性質，推動綠色農業(Green Agriculture)，可作為"碳"的收集槽，以達資源永續利用之目的。

另外，歐盟為控制堆肥品質，防範遭受重金屬污染，規定製造堆肥之原料，其重金屬含量，須低於下列標準：Zn(150ppm)，Cu(50ppm)，Ni(25ppm)，Cd(0.5ppm)，Pb(50ppm)，Hg(0.5ppm)，Mo(1ppm)，Se(0.75ppm)，As(5ppm)，F(100ppm)，Cr(50ppm)。(註：堆肥產品重金屬含量為上述原料標準之兩倍)。

(二)歐盟對於廢棄物以堆肥化處理之現況與展望

歐盟各國對於有機廢棄物經由堆肥化處理情形隨著各國環保意識，地理條件、經濟因素等，有不同考量，也產生不同結果，一般而言，德國、荷蘭、比利時、丹麥等國最重視堆肥化處理，瑞士、奧地利等次之，至於法國、西班牙等正

積極規劃中。

依據荷蘭、德國、比利時三國在1996年統計廢棄物經由堆肥化、焚化及掩埋三種方式處理，除比利時外，以堆肥化處理廢棄物之每公噸成本最低，其次為掩埋，費用最高者為焚化，以德國為例，廢棄物以焚化處理每公噸需486美元，掩埋為402美元，至於以堆肥處理者為151美元。

歐盟各國廢棄物必須自行處理，以堆肥化方式處理更彰顯其重要性。因此，教育訓練宣導配合政策制定及軟硬體建設配套措施紛紛提出。各國辦理情形概述如次：

1. 德國：1998年生物廢棄物堆肥處理工廠有600家，其中90%為好氧性處理，另外10%以厭氧性處理。
2. 荷蘭：1990年至1995年加強教育宣導。至1998年全國人口有93%實施堆肥化處理，當年以堆肥化處理數量佔全部廢棄物之30至40%。
3. 奧地利：推動家庭農場實施堆肥化。
4. 瑞士：自公元2000年元月起，禁止可燃性廢棄物以掩埋方式處理，預計堆肥化處理佔所有廢棄物之30%。
5. 瑞典：預估50%農家實施堆肥處理。

(三)O.W.S.公司與有機廢棄物處理技術

Organic Waste System（簡稱O.W.S.）公司創設於1988年，資本額為五千萬比利時法郎，公司職員四十人，每年營業額為600萬美元。該公司營業額不大，但屬於著名的專業公司。該公司營業項目分為三大類：

1. 實驗室內檢測（Laboratory test）：

(1)生物可分解（Biodegradation）及可堆肥化

(compostability)物質檢定。

(2)生物毒性檢測（Ecotoxicity test）。

(3)堆肥品質分析（Compost Quality analyses）。

2. 諮詢服務（Consulting Services）：

(1)廢棄物堆肥化（Waste Composting）。

(2)崩解性廢棄物管理（Integrated Waste Management）。

(3)有機廢棄物之管理（Management of Organic Wastes）。

(4)堆肥化及厭氧性消化之研發（Developments to Composting and Anaerobic Digestion）。

3. 負責 DRANCO 無氧醱酵技術研發：

有機廢棄物經由厭氧性醱酵過程處理，產生甲烷生物性氣體(Biogas)提供電力並產生腐植性之產品(Humus-like Product)。

4. 檢驗程序與方法：

該公司對於生物可分解物質是否為可堆肥化物之檢測方式具有公信力，前後向 ISO、CEN（歐盟認證機構）、DIN（德國認證機構）及 ASTM（美國認證機構）之申請認證。

對於廢棄物是否屬於生物可分解物質，依據 ISO14851、14855、14852 等標準進行檢測，材料測定時間達 6 個月，且可分解為二氧化碳及生質(Biomass)之比例達 90％以上，如有添加劑致難以分解者，全部添加劑之比例不得高於 5％。

在是否符合崩解性部分，在廠商送該公司後之 12 週內完成檢測，在 12 週後，崩解物質通過 2mm 正方形篩網達 90％以上者，才認為符合崩解性之標準。另並在堆肥成品種

植兩種植物測定發芽及生長情形檢驗堆肥毒性。

符合測定標準者，發放檢驗報告。如經營堆肥廠商取得符合標準報告，可向BPI(北美)、DIN(德國)或O.K. Compost等機構申請使用其標示，使堆肥品質獲得保證。

四、參觀比利時DRANCO厭氧醱酵工廠

比利時 O.W.S.公司對於以厭氧醱酵方式堆肥及可分解性檢測技術具專業化水準，因此該公司在開發有機廢棄物以堆肥方式處理的技術一直持續發展。針對廢棄物的種類不同，發展出兩套堆肥技術專利。其中之一為DRANCO系統，專門處理較乾燥的有機廢棄物（庭園樹枝）；另一為 DRANCO-SEP 系統，處理市場、食品廢棄物等水分含量較高的有機廢棄物。

兩項處理系統基本原理相同，有機廢棄物進廠後，經過篩選塑膠、大型木塊、紙類等廢棄物，以螺旋輸送前進時，將廢棄物破碎為4公分以下碎裂物，再注入蒸汽及厭氣槽內液體加以混合後，將混合物送入厭氣槽內進行無氧醱酵，醱酵時間2至3週，槽內溫度為 50 至 58℃。厭氧醱酵槽內產生氣體以甲烷為主（甲烷佔55至60%），甲烷供發電，電力並可供鄰近社區使用。

廢棄物在槽內2至3週後，固形物經脫水（水分含量約50%）再送入倉庫進行有氧醱酵，經 2 至 3 週即成腐植性之產物。但兩項系統比較不同的是，DRANCO 系統在槽內固形物比例約 15 至 40%之間；至於DRANCO-SEP系統在厭氧性槽內之固形物比例較低，約5至20%。

O.W.S.公司在1984年首先於比利時Gent地區興建DRANCO系統示範工廠，其後在印尼、美國、澳地利及日本亦興建示範工廠。

1992 年以後正式建立營運工廠，截至 2000 年元月，在比利時、澳地利、德國、瑞典等已建立 7 座 DRANCO 營運工作，其中以 2000 年元月在比利時 Brecht 所建第二廠規模最大(第一廠在 1992 年建立)，每年可處理廢棄物容量為 5 萬公噸。

至於實際運作方面，以 1993 年在奥地利 Salzburg 所建 DRANCO 系統作介紹，該工廠可以處理 30 萬人口產生之有機廢棄物，工廠每年最大處理量為 2 萬公噸，產生堆肥 4,700 公噸。工廠操作人員為 5 名。在厭氧氣槽內保持溫度 50 至 55℃之間，槽內固形物比例佔 15 至 30%之間，槽內醱酵時間 20 至 30 天，每公噸廢棄物產生氣體 120 至 170 立方公尺，其中甲烷佔 50 至 65%。

在歐洲有機廢棄物處理不論經由有氧醱酵或厭氧醱酵方式處理，每年均在成長中，至於各國選擇之處理方式，以有氧醱酵或厭氧處理並不一致。一般而言，有氧醱酵營運成本較低，但厭氧性醱酵處理有下列優點：

(一)以 O.W.S. 發展厭氧性槽係圓筒直立型，所需土地為一般好氧性醱酵倉庫面積之 1/3。

(二)對廚餘等水分含量較高之廢棄物處理較為方便（以好氧醱酵處理需要添加木屑等，以利空氣流通)。

(三)可回收電力。

(四)在密閉槽醱酵較不易傳播臭味。

(五)可在都市鄰近地區興建。

相關資料詳如附件二。

五、美國 Cargill Dow 公司製造研發生物可分解塑膠情形

該公司主要業務原為生產穀類，為提高穀類之附加價值，及

考量廢棄物處理、資源回收、溫室效應等環保問題，遂投入以穀物為原料製造高分子化合物(polymers)之領域。該公司所研發之高分子化合物稱為"PLA"，已投資幾十億美金進行研發及量產，在美國並已申請獲核准一百多種專利權，目前工廠正興建中，預定在 2001 年底其 PLA 產能每年可達 140,000 公噸，預料將可對生物可分解塑膠的市場造成相當的突破。

PLA 的基本製造流程為將穀物醱酵為乳酸，再成為聚乳酸，再作成 PLA 粒子後，可製造成纖維、包裝材料及化學介質等三大領域之產品。如：不織布、地毯、牛仔褲、新娘禮服、衣服、免洗杯、瓶子、包糖果的塑膠膜等。

目前在技術上努力之目標有三方面：一為希望減少製造流程中能源之消耗量，及降低氮氧化物、硫氧化物及二氧化碳之排放；二為開發穀類原料來源，可降低成本及減少二氧化碳之排放；三為提高 PLA 之附加價值，即儘量減少材料之使用量及發展可使用 PLA 製造產品之技術。

在環境的觀點部分，主要以產品生命週期分析的方法來比較生物可分解塑膠及一般傳統塑膠間之差異。其內容為從原料及其上、下游，即從製造、使用及廢棄過程，整體分析其能源之消耗量、二氧化碳之排放量等因子，惟其中原油及農作物原料的分析資料取得很困難。生物可分解塑膠及一般傳統塑膠間最大之差異為，前者之原料為農產品，其在生產過程係由大氣中吸收二氧化碳，而後者之原料係由開採原油而得。由該公司所提供資料中，不論作成杯子(PS/PLA)或瓶子(PET/PLA)，生物可分解塑膠皆優於一般傳統塑膠。

PLA 主要製成熱塑性高分子化合物類產品，預估每年市場潛

力為500,000公噸，預估可減少百分之二十至五十的石化原料使用量，對於包裝、膜及纖維之製造可提供另一種選擇。若如該公司預測，可達量產之目標，其售價若可降至每磅美金五十分至一美元，可視為工程塑膠之革命性發展。相關資料如附件三。

六、拜會美國明尼蘇達州環保局

美國明尼蘇達州環保局就該州政府環保單位組織、一般廢棄物管理政策、資源回收執行情形，特別是堆肥制度之推動，作一介紹。

(一)廢棄物管理現況

1.該州人口數有四百五十萬人，在一九七０至一九八０年代垃圾處理以掩埋為主，近十年來積極推動廢棄物資源回收工作，目前回收率為四十％，在回收物中廢紙張、紙板、鋁罐尚有市場經濟誘因，而廢塑膠部分則無。

2.在訂定廢棄物管理政策主要考量廢棄物處理優先順序、資源回收之目標、家庭有害廢棄物及其他相關管制規定等。並會考量減少能源之使用、避免臭氧層的破壞及經濟可行性。該州廢棄物處理優先順序依序為：

(1)減量、再利用（reduce、reuse）；

(2)回收（recycling）；

(3)庭園及食物類廢棄物進行堆肥（composting）；

(4)都市混合廢棄物進行堆肥式焚化，以再生資源（resource recovery）；

(5)可回收甲烷作為燃料之掩埋處理；

(6)無法回收甲烷熱能之掩埋處理。

而在各項處理方式之成本分析為，堆肥、焚化及掩埋分別約為 70、60、40 美元/ton。

3.下列廢棄物禁止以掩埋方式處理：

電器、庭園廢棄物、機油、輪胎、鉛蓄電池、可充式電池、含水銀的物品、含水銀、鎳鎘乾電池等。

4. 有關推動資源回收工作在經濟面影響，據三年前的調查研究顯示，計增加了八千人的工作機會，相關行業的產值每年計十億美元，並造就三十億美元的經濟活動。

5.在家庭有害廢棄物的處理部分，未來仍應加強在每個市鎮（county）進行教育的工作，並需要訂定管理計畫，以能從垃圾中分出有害物質，避免造成環境污染。

(二)堆肥制度推動情形

本部分係就該州推動堆肥制度的規劃、設備、經濟分析、操作管理、實施心得、相關法令及執行現況進行介紹。

1. 有關堆肥廠的設計內容包括：進廠原料、前分類設備、粉碎設備等，並考量廢水、廢氣等二次污染問題；並具備資源回收、燃料利用等功能，及讓產品穩定、成熟、具市場接受度。

2. 有關興建堆肥廠之投資成本如下：

（1）可將廢棄物進行能源回收者為 175,000 美元/ton/天；

（2）混合廢棄物進行堆肥者為 150,000 美元/ton/天；

（3）在產源即進行分類後之堆肥者為 100,000 美元/ton/天。

3. 有關堆肥廠之操作，其財務分析如下：

（1）債務部分 50 美元/ton；

（2）膳餘物處理成本 25 美元/ton；

（3）人力成本 25 美元/ton；

（4）操作維護費 10 美元/ton，州政府並對市鎮進行補助，目前為 2 美元/ton。

4. 有關堆肥處理方式經濟方面之分析如下：

（1）可保留較多之土地（以掩埋處理需使用土地）；

（2）可從廢棄物中回收資源及能源，可幫助降低成本；

（3）可協助降低運輸成本（如果掩埋場距離遙遠）；

（4）降低掩埋場清理成本；

（5）降低地表水及地下水污染之危機；

（6）降低危害人體健康危機。

5. 該州在推動堆肥制度後獲得主要經驗如下：

（1）進廠原料之確保方面：應確保數量之穩定性及進廠原料成份之變化情形，是否隨不同季節、時令而有所差異。

（2）進廠原料成份中是否含污染物方面：以環境保護之觀點，應考量有機化合物、重金屬及惰性物質等；以市場接受度之觀點，應考量惰性物質、塑膠、金屬、可溶解鹽等。

（3）堆肥產品市場接受度方面：其產品使用者或出售對象為何，係作為苗圃栽培、給政府使用或作為建築之用等；其市場需求之產品規格為何，其項目包括粒子大小、營養成份（N.P.K.，PH 值，可溶解鹽）、重金屬含量、惰性物質標準等。

6. 有關堆肥制度之實施，亦已訂定相關法令規章，訂定目的為保護人體健康及環境，其主要內容為：

（1）設備設計操作最低要求：包括防止臭味、降低病原菌、防止病媒感染、控制放流水以避免污染地下水等項目。

（2）都市廢棄物堆肥場場址設計：包括場地整地、控制人員進出、將河流引開，物品之貯存、路線規劃、控制臭味等項目。

（3）操作方面：包括訂定操作維護手冊、人員訓練、物品管理、預防病原菌之程序等項目。

（4）成品部分：包括採樣及測試計畫、成熟度測試（PH、水份、粒徑大小、N. P. K. 比、可溶解鹽內容）等項目。並將堆肥產品分為二類訂定各類重金屬、PCB 含量之標準。

（5）最終使用：產品可作為肥料、特殊肥料、土壤改良劑或植物改良劑等。並將產品分為第一類及第二類，第一類之使用在用途部分並無限制，第二類之使用則有所限制。

7.在實施情形部分，堆肥場之設置及廢棄物之收集部分為公營，部分為民營。廢棄物每週約收集二～三次，民眾須至商店購買可分解塑膠袋裝可進行堆肥之廢棄物。另民眾應將廢棄物分為可堆肥物及不可堆肥物：

（1）可堆肥物：

①Green waste：庭園枝葉等；

②廚餘（Food waste）：肉、骨頭、蔬菜、咖啡、泡茶

包、蛋殼、麵包類、乳品類等。

③濕及已污染之紙（wet and soiled paper）;

④紙尿褲及衛生用品。

（2）不可堆肥物：

①可回收物質：紙、金屬類、塑膠瓶、玻璃瓶等可回收再利用之物品等；

②其他一般垃圾及有害物品等。

相關資料詳如附件四。

陸、赴夏威夷出席生物可分解塑膠國際研討會

本次國際性研討會內容包括各國生物可分解塑膠的推動情形、製造技術研究發展、產品應用及未來展望等，主講者包括歐洲、美、加、中國大陸、日本等，其議程詳如附件五，茲將相關內容彙整如下：

一、全球高分子化合物可生物分解及堆肥化現況

本篇由美國穀物協會 Dennis Kitch 提出報告，鑑於傳統以石油為原料製造之塑膠袋不易分解，造成垃圾處理危機，地球溫室效應，垃圾以焚化方式處理產生戴奧辛（Dioxin）與垃圾處理費用高昂等因素，促使各國考量資源回收利用。因此，有機物質再利用（Recycling）及以生物高分子製造塑膠產品使用後再以堆肥處理，達到永續經營的觀念邏輯受到重視。

各國近年來紛紛致力於生物高分子化合物製造塑膠纖維產品的研發，並對使用後以堆肥化處理的研究均投入相當人力與經費進行。由於渠收集各國現況資料豐富，可供我國參考，乃就其報告作整理。

(一)美國：已有幾家著名工廠投入資金準備量產生物分解性塑膠之原料。包括 Cargill Dow 於公元 2000 年元月在亞利桑納州 Blair 建廠，將以玉米澱粉為材料製造聚乳酸（PLA）；Du Pont 公司亦於 2000 年 8 月設廠，將生產生物可分解之聚脂（polyester）原料。

(二)德國：成立 Kassel 計畫，在公元 2000 年2月起至 2001 年7月，選取 14 萬人作環保垃圾分類，將庭園花草、樹枝、廚餘、果皮等有機廢棄物放入可分解塑膠袋再放入收集桶（Biobin），以進行堆肥處理試驗，試驗正進行中。

(三)荷蘭：居民對於有機廢棄物以回收再利用（Recycling）之比例為世界上最高的國家。目前有機廢棄物處理傾向以厭氧性醱酵處理，但未來在成本及防範土壤污染考量下，可能又走回焚化的路線。

(四)義大利：該國對於推動將有機廢棄物丟入有機塑膠袋的措施非常成功，預估至 2001 年推動成效會超過荷蘭。

(五)日本：日本在 2000 年5月訂定創造永續社會的基本法（The Basic Law to Create a Sustainable Society）規定，對於每年產生 50 公噸有機廢棄物的業者，必須將其轉化為飼料或回收利用，在鄉村及郊區推動有氧醱酵之堆肥化系統，在都會地區則將採厭氧性醱酵處理系統，以節省土地面積，減少臭味散佈。

另外，日本政府要求企業對於包裝材料應負最終處理的責任，企業公司必須付包裝材料的最終處理費用。

在民間部分，由企業界出資支持的日本有機利用協會（Japan Organic Recycling Association，簡稱 JORA）在

2000 年 8 月 1 日成立，將與國際民間組織及相關協會合作，推動有機廢棄物回收再利用及建立國際一致性的有機廢棄物處理產生堆肥之品質標準等。另外，日本在 1990 年所組成的生物可分解塑膠協會（Japan Biodegradable Plastic Society），已在2000年建立生物可分解塑膠的認證標章Green Pla。

(六)印尼：TOYOTA 公司在 2000 年 10 月 20 日宣佈，將在印尼建造年產5萬公噸，由玉米澱粉發酵產生之聚乳酸（PLA）生物性塑膠的工廠。

(七)台灣：台灣由日本媒體瞭解焚化方式產生戴奧辛（Dioxin）問題，因此，目前在政策上，政府強烈支持有機廢棄物回收（Recycling），在台北市及若干城市舉行將垃圾製造堆肥的示範計畫；台北市更積極垃圾分類，回收資源垃圾。農政單位對生物可分解塑膠在農業用途的研究也列為優先研發項目。

在民間相關協會部分，目前已有環保生物可分解材料協會（Environmentally Biodegradable Polymer Association），協助相關產業進行可分解塑膠的應用研究與有機堆肥的推廣。Dennis Kiech 在會中對台灣所採取措施表示佔讚揚。

(八)中國大陸：在華中及華北地區土壤缺乏有機質，以及沙漠化逼近北京，促使大陸政府重視環保問題，目前正與日本商洽談有機材料援助外，在香港及上海進行廚餘堆肥化計畫，以及推動以生物可分解塑膠袋收集有機廢棄物計畫。

(九)泰國：在泰國北部清邁地區進行皇家堆肥化計畫，在曼谷正建造堆肥化工廠。泰國未來可能是生物可分解塑膠的主要生

產者。

(十)韓國：至公元 2005 年對於食物殘餘及有機廢棄物禁止以掩埋方式處理。在漢城及其他都市正進行食物殘餘進行堆肥處理，目前可分解塑膠已開始利用，初期以 30%為目標，最終為達到 100%全部用可堆肥化之生物可分解塑膠袋。

(十一)馬來西亞：電子產業以及外銷供國外消費包裝材料，將來可能是優先採用可堆肥化之材質。

(十二)印度：在都會地區實施有機廢棄物的再利用，新德里及龐貝城禁用傳統塑膠袋。

(十三)紐西蘭：至公元 2010 年將禁止有機廢棄物以掩埋方式處理，且不採取焚化措施，而積極推動堆肥化及再利用政策。

(十四)巴基斯坦：透過學校教育宣導垃圾分類與再利用措施。

(十五)澳洲：澳洲政府舉辦奧林匹克運動會，採取生物可分解粉紅色塑膠袋，數量超過一百萬只，搏得各界讚揚；坎培拉已採取零掩埋政策"Zero Landfill Policy"。

二、國外生物可分解塑膠技術發展情況及未來趨勢

生物可分解塑膠可應用的產品非常多，主要應用於短效性一次使用即丟的產品，因這些產品佔廢塑膠的比例最大。

(一)依用途可分為：

1.無須耐久性之產品：如購物袋、食品容器、飲料品連接環、吸管等，這些均是用完即丟的產品，使用量相當大。

2.無法回收之產品：其產品的特點為回收管道限制，處理困難等，如醫療廢棄物。

3.協助垃圾減量之產品：如垃圾袋、堆肥袋、紙尿布等，其用

量也非常可觀。

4.醫療及衛生用品：如繃帶、人造骨骼及移植、棉花棒、復健、生理用品等。

5.需要控制分解時間之產品：如農業用膜、藥物釋放系統等。

(二)若依製程又可分為：

1.押出發泡成型：如發泡緩衝材、形狀發泡成型、墊材、保溫材等均是押出發泡所形成的生物可分解產品。

2.射出成型：如高爾夫球座、寵物用咀嚼物、刀、叉、湯匙等用完即丟的免洗餐具等均是用射出成型的技術所得到的可生物分解產品。

3.吹膜成型：如緩衝泡包裝膜、積層貼合用膜、衛生材料用膜、農業用覆蓋膜及各式製袋用膜等等，均可選適當的生分解塑膠材質(如 PCL 與 Starch 聚合物等)利用吹膜成型的技術製得各式各樣的薄膜。

目前只有國外幾家大廠有能力生產生物可分解塑膠的原料，且產量並不多，故原料價格比較高(如表一)。

表一 國外生物可分解塑膠發展現況

來源	商品名	製造商	組成	用途	價格
微生物生產	Biopol	英 ICI	PHBV	薄膜、吹瓶等	8.00~10.00 (美元/磅)
化學合成	CPPA	比 Solvay	PCL	推肥袋、尿片等	3.00(美元/磅)
	TONE	美 UCC	PCL	推肥袋、尿片、薄板等	2.70(美元/磅)
	EcoPLA	美 Cargill	PLA	薄膜、吹瓶、紗線、射出等	1.00~3.00 (美元/磅)
	LACEA	日三井東壓	PLA	薄膜、吹瓶、紗線、射出等	800(日圓/kg)
	LACTY	日島津	PLA	薄膜、吹瓶、紗線、射出等	800(日圓/kg)
	Bionolle	Showa	Aliphatic Polyester	薄膜、吹瓶、紗線、射出等	600(日圓/kg)

據悉，目前全球生產不可分解之塑膠原料一億噸，而製造於一次性使用丟棄的包裝材料將近 3,000 萬噸，包裝材料所生產之污染問題已使各國政府傷透腦筋，這部分正是最需要用生物可分解塑膠取代的產品；相信生物可分解塑膠之潛在包裝市場、非包裝用膠膜市場及取代聚苯乙烯發泡之市場潛力是無限的。

表二、三及四為美國、日本及歐洲的生物可分解塑膠之市場現況，各種生物可分解塑膠已達一定程度的使用量，其未來的市場潛力估計是不斷的成長。

表二 美國市場之商業化生物可分解塑膠

商品名	塑膠名	生產公司	產能(噸/年)
EcoPLA	PLA	美，Cargill	113,500 (mid-1996)
Biopol	PHBV	英，ICI	5,000~10,000
Tone	PCL	美，Union Carbide	＜4500
	PVOH	美，Air Product	70,000~90,000
Bionolle	Polyester	日，Showa	3,200
Mater-Bi	澱粉合膠	義，Novamont	23,000
Planet		美，Planet	4,500
合計：			約 230,000 噸/年

表三 日本市場之商業化生物可分解塑膠

商品名	塑膠名	生產公司	產能(噸/年)
Biopol	PHBV	英，ICI	--
Bionolle	Polyester	日，Showa	3,000
Mater-bi	Starch 合膠	義，Novamont	--
LACTY	PLA	日，Shimadzu	100
LACEA	PLA	日，Mitsui Toatsu	100
合計：			3,200 噸/年

表四 歐洲市場之商業化生物可分解塑膠

Polymer Developer	Trademark Name(s)	Key Components
Avebe	—	Starch-based blends
BASF	—	Polyesters,Polyaspartic acid*
Bayer	BAK 1095-PEA	Polyesteramides
Biopac*	Biopack	Extrusionable Starch Materials
Biotec	—	Starch- based blends
Boehringer, BPI, Ethicon	PLA/PLGA	Polyesters
Deutsche Gelatin AG	Gelatin	Polypeptide(Proteins)*
EMS Chemie/Battelle	Amylose*	Extrusionable Starch Materials
EPI	DCP™	Polyethylene/Additives
Fermentation Institute	PHB	Polyesters

	copolymers	
Fluntera AG	Fluntera Plast	Extrusionable Starch Materials
Idroplast	__	Poly(vinyl alcohol)*
Mazzucchelli	Hydrolene	Cellulose acetate
Fortum Oil	Poelait™	Poly(lactic acid)
Novamont	Mater-Bi™	Starch-based blends
Novon Polymers AG	Novan	Extrusionable Starch Materials
Solvay	__	Poly(caprolactone)
Storopack	__	Foamable Starch Materials
Sunstarke	Potato starch*	Foamable Starch Materials
Technicoat	Tech-No-Bag™	Polyethylene/Additives
TubizemPlastics(Rhone Poulenc)	Cellulose acetate	Modified Cellulose
United Paper Mills	__	Cellulose derivatives

*Materials soluble in water media

雖然生物可分解塑膠價格仍偏高，難與便宜的傳統塑膠競爭，但因環保意識的抬頭，未來幾年估計生物可分解塑膠的需求量將快速增加，當全面量產時，其價格應可與傳統塑膠比擬，而能取代傳統塑膠之產品。

三、「可堆肥化」標誌

由國際生物可分解產品組織（International Biodegradable Products Institute, BPI）及美國堆肥協會（U.S. Composting Council, USCC）所共同推出的「可堆肥化」(Compostable)標誌，

是頒發給能夠快速、完全及安全堆肥化的塑膠類產品的標誌。可以使用這種標誌的產品，是經過科學證明，能夠在都會區或商業化的堆肥作業下，進行生物分解與堆肥化的。它們的堆肥化過程與牛皮紙袋、落葉枯枝及食物殘渣無異。

(一)可堆肥化塑膠之背景

多年來，有一些廠商聲稱他們的塑膠能生物分解或堆肥化。但是一旦實際堆肥化，這些產品卻僅崩解為碎片而形成大量的塑膠殘渣。如果要將它們移除並加以掩埋，必須耗費大筆經費。因此這些產品的不良表現，讓許多使用者心生懷疑與困惑。雖然最近已經有真正可以完全生物分解的材料出現，但是如何以科學性測試方法判定哪些是真正可以生物分解及堆肥化產品的問題，卻直到目前才獲得解決。

BPI 與 USCC 聯手解決這個令人困惑的問題。利用標準化之科學測試方法，能夠在都會與商業堆肥場中堆肥化的產品將被「驗證」為「可堆肥化」。這種驗證方式將使得堆肥製造者、消費者、政策制定者、地方政府官員及其他人都能鑑別可以完全堆肥化而不會留下有害或持久性殘渣之塑膠。

(二)證明可堆肥化的科學根據

美國測試與材料學會（ASTM）於 1999 年宣布了一系列鑑別可堆肥化塑膠的測試方法與準則，ASTM D6400-99，「可堆肥化塑膠之規格」(Specifications for Compostable Plastics)。這些方法是經過 8 年研究之結果，這項研究係於美國進行但有全球多位頂尖科學家及企業界人士參與。這些測試方法係模擬在一個典型的、操作良好的都會或商業化堆肥系統下所發生之狀況。

若欲通過 ASTM 測試，塑膠產品必須為：

1. 生物可分解：與紙或其他可堆肥化物質有一致之分解速率，能分解為二氧化碳、水及生質（biomass）。
2. 崩解：肉眼不可見，亦不需在堆肥化後予以移除。
3. 對環境安全：分解過程中不得產出任何有害之副產品，同時堆肥必須能促使植物成長。

獨立之科學家將審查每件產品之資訊，如果能證明某產品符合 ASTM D6400-99 之準則時，該產品始能獲頒「可堆肥化」標誌。

(三)獲得「可堆肥化」標誌之產品

消費者鍾愛塑膠產品的原因，在於其產品有強韌、質輕、省能等優點，但是除了塑膠瓶與某些產品在美國已有回收系統外，並不是每種塑膠物品都能成功地分類並回收，尤其是有食物殘渣之容器。

因此使用生物可分解塑膠於下列之用途特具意義：

（1）用完即丟式盤、杯及刀叉等。

（2）食品殘渣桶之內襯，

（3）庭園落葉枯枝等之收集袋。

(四)核發「可堆肥化」標誌之準則

1. 申請「可堆肥化」標誌之產品，必須符合下列準則：

產品符合或超過 ASTM D6400-99 之規格，檢驗報告需由合格實驗室出具，測試方法需依據 ASTM D6400-99 所述。

2. 產品符合下節所述之申請要項並持續符合本驗證計畫之規範。

（1）申請者已繳交所有應付費用予 BPI。

（2）申請者已與BPI簽定「正確使用標誌之同意書」，

（3）申請者之負責人簽署書面文件，同意遵守本計畫之規範。

（五）申請要項與審查

申請者需將下列文件寄送BPI，地址為331 West 57th St., Suite 415, New York, NY 10019, USA，收件者為 Chair, Scientific Review Committee.

1. 要求驗證產品為「可堆肥化」之信函（cover letter）。

2. 下列與產品有關之資訊或文件：

(1)產品之描述。

(2)產品之配方，包括所有塑膠、高分子、中間體、惰性填料、添加劑及其他物質之名稱與百分比，其總量應為100%。本項資訊尚應包括產品之IR與X-ray光譜。

(3)產品之代表性樣本一件。

(4)金屬化（mineralization）與崩解（disintegration）數據，此等數據應係採用 ASTM D5338-98 測試方法與 ASTM D6400-99之6.2節所述之崩解測試方法所得者。

(5)生態毒性（ecotoxicity）數據，此數據應係採用 ASTM D6400-99,6.4 節所述之生態毒性測試方法所得者，重金屬測試應依據ASTM D6400-99之6.4.1節。

(6)任何可以證明本產品符合ASTM D6400-99之其他資訊。

(7)由申請者之負責人所簽署，證明本產品或本產品之生產者，符合聯邦、州及地方法規之文件。

3. 由合格實驗室提出之證明應含：

(1)所有實驗均係在該合格實驗室確實進行，

(2)所有測試方法均符合 ASTM D6400-99 標準之規定，

(3)由申請者提出之報告皆為正確、真實者，

(4)合格實驗室或其雇員/職員/經理均與申請者無利害衝突。

4. 申請費

(1)審查費

a. 若未獲得其他類似之標誌時，每件產品約美金 5,000 元。

b. 若已獲得其他類似之標誌時，如 DIN Certco 或“OK Compost”時，每件產品約美金 1,200 元。

(2)證書費（Licensing Fee）

產品淨售價（gross sales）之 0.5%。

(六)本驗證計畫之效益

1. 容易辨識之標誌

本計畫所使用之「可堆肥化」標誌，可使消費者、堆肥製造者、採購商或政府人員，快速辨識出真正可以完全分解並堆肥化之產品。

2. 獨立驗證

塑膠產品製造商將申請資料送交 BPI，由 BPI 邀請獨立之科學家進行驗證。

3. 有完整之科學根據

ASTM D6400-99 是經過 8 年研究之結果，通過本標準之要求，可證明塑膠產品與牛皮紙、落葉枯枝、食物殘渣一樣，可以完全、安全及快速分解。

4. 為堆肥製造者節省費用

在美國，為分離並處置一般塑膠垃圾，堆肥製造者每年需付出數百萬美元之費用，若改用可堆肥化塑膠，可以減少本項費用。

(七)ASTM D6400-99 標準

本標準包括三項測試方法，第一項是測試產品（或材料）是否可以被細菌，在可接受之速率下，轉換為二氧化碳；第二項是測試材料之崩解能力，其碎片不可以堵塞住篩選設備；第三項測試是決定其產出之堆肥是否可以促進植物生長。

(八)驗證現況

目前 BPI 已驗證通過一家一件產品，另有兩件產品申請中。

四、「可堆肥化」及「生物可分解」塑膠產品測試標準

為使生物可分解塑膠產品能夠被消費市場、社會大眾及政府法規所接受，這些材料在適當的廢棄物管理設施（例如堆肥場中）的生物可分解性需要被展現。因此政府機構、使用者及市場都希望有一系列標準出現，以便量化這些產品的生物可分解性與可堆肥化性（Compostability）。

對於生物可分解性，ISO 14850 系列標準中，已有三項標準與之有關。分別為 14852、14853、14855。但是如果要確定某種生物可分解塑膠可以 100%被土壤吸收利用，則需要有「可堆肥化」之標準。以 ASTM D6400-99 標準而言，要求被測試物質符合下列三項準則：

(一)於 180 天內，展現與天然之生物可分解高分子具有相同之生物分解速率及程度，如生物分解速率較低，可以延長到 365

天，但須使用碳 14 標示之測試基質。

(二)應在活性堆肥中崩解至無肉眼可見，可辨識之碎片（利用 2.0mm 篩網過濾時，少於總重量 10%（乾重)之碎片留於篩網之上)。

(三)不具生物毒性—對堆肥中細菌生長及促進植物生長之能力不造成影響。

其他類似之標準尚有德國之 DIN V54900 及歐盟之標準 EN 13432。EN13432:2000 標準之全名為「包裝—對於可以經由堆肥與生物分解而回收之包裝的要求事項。包裝之最終接受度之測試系統與評估準則」(Packaging—Requirements for packaging recoverable through composting and biodegradation. Test scheme and evaluation criteria for the final acceptance of packaging.)

此外 ISO TC61/SC5/WG22 亦正討論喜氣堆肥相關標準草案，即 ISO CD 15986.3。

五、其他關於生物可分解塑膠之研發及技術

(一)Gregory Bohlmann，美國 SRI 研究院

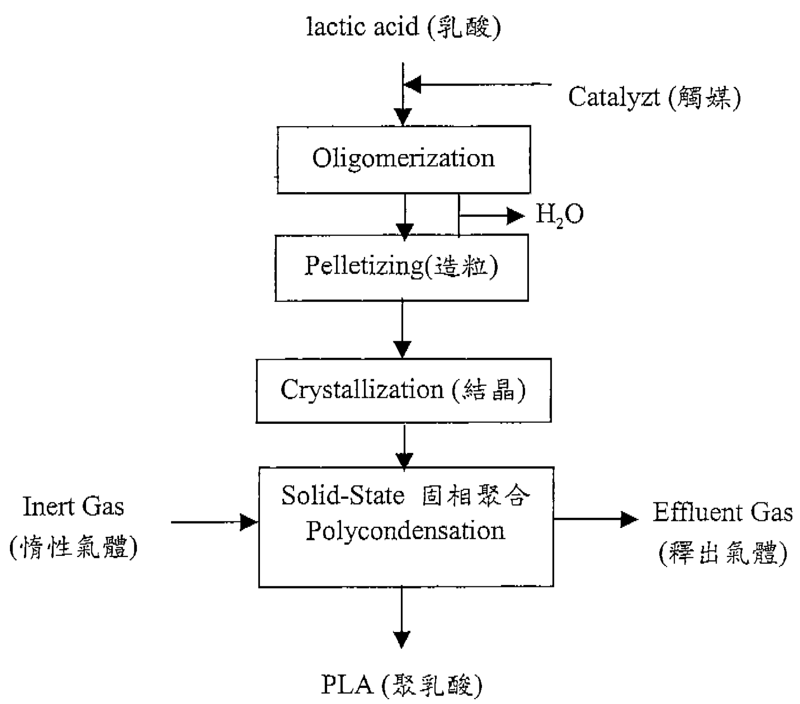
由六碳糖經過醱酵方式生產之化學品，在目前已有三種產品，即乳酸（lactic acid)，1,3-propanediol 及 succinic acid。其生產費用如下：

lactic acid 醱酵法	以年產 440 萬磅之規模計算，出廠價為每磅 0.5 美元
1,3-propanediol	以年產 600 萬磅之規模計算，出廠價為每磅 0.45

醱酵法 正在開發中	美元 以年產 1200 萬磅之規模計算，出廠價為每磅 0.38 美元
succinic acid 醱酵法開發中	尚無法估計

(二)Shinji Ogawa，日本 Mitsui Chemicals 公司

Mitsui 公司所開發生產聚乳酸（PLA）之 MCI 製程，具有不需使用溶劑、簡便及成本降低之特點，其製程如下：

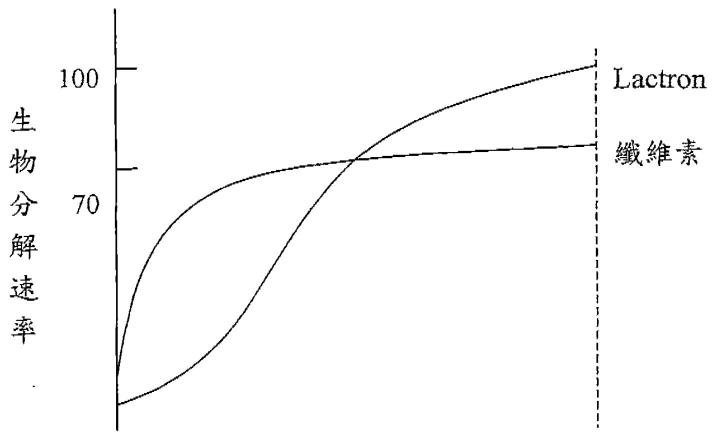


此外，其成品中，D-lactic 聚合體之含量較傳統方法為低，並且不含 lactide.。

(三)Keio Yamanaka，日本 Kanebo Gohsen 公司

Kanebo 公司由 10 年前開始研發 PLA 產品，PLA 具有高

結晶度、高熔解度及高透明度之特性，但卻較脆較硬。但 Kanebo 公司經由 melting spinning 所生產之 Lactron 纖維卻具有與已商業化之尼龍與聚脂纖維相等之韌性，因此可具有許多種用途。Kanebo 公司已成功地將其應用於各式成衣、農業覆膜、垃圾袋、毛巾等。

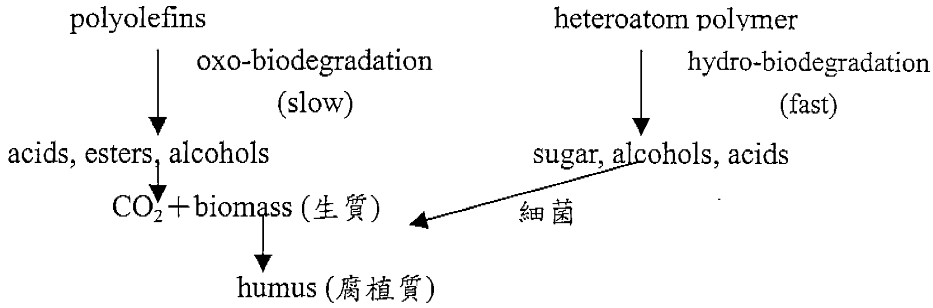


分解速率在初期雖然較纖維素低，但 20 天後便可超過纖維素而達到完全分解。

Lactron 製成之紡織品可以燙，可以洗，但最好勿用高溫（<120℃）洗燙。此外，其染色性亦甚佳。

(四)Gerald Scott，英國 Aston University

高分子之生物分解可以分為兩種機制，純碳鏈高分子（如 Polyolefins）為氧—生物分解（oxo-biodegradation），而不純碳鏈（heterocarbon）之高分子（如改質澱粉與 alkyl polyester）則為水—生物分解（hydro-biodegradation）。前者在堆肥環境下分解快速，後者則較慢。



經過 15 年之研究，作者發現 PE 覆膜的生物吸收（bioassimilation）作用係分兩階段進行：(1)無生命、有氧狀態下之分解，使得 PE 膜表面轉變為親水性，(2)有生命（細菌）狀態下，細菌利用小分子量之 PE，使之分解。細菌中的酵素，尤其是 cytochrome P450，因為可以將氧轉化為氧的自由基（$O^{\circ}{}_2$），而此自由基與金屬元素作用，形成具有高活性之氫氧自由基(°OH)，進而將高分子材料氧化分解，最終成為二氧化碳與生質。

作者認為目前 ASTM 或歐盟之「可分解高分子」測試標準，係針對不純碳鏈高分子材料而制定的，完全排除碳鏈高分子，故係一不合理的標準，因此已提出異議。

六、亞洲有機再生網路組織 (Asian Organic Recycling Network)

由參加本次研討會之日本、韓國、台灣、美國及紐西蘭等各國推動生物可分解塑膠及堆肥之民間團體，在美國穀物協會發起之下，成立亞洲網路組織工作小組，以共同推動各國生物可分解塑膠及堆肥工作。並擬訂其任務、推動策略及工作項目如下：

(一)亞洲有機有機再生網路組織之任務

1.推動將有機物質由掩埋/焚化處置改為再生資源。

2.利用本網路組織，促進會員機構間，關於有機物質回收之資訊、與科技之開發與交換。

3.對政策制定者、消費者及企業界之宣導教育以提升公眾認知度。

4.促使國際與國家標準組織及早針對有機物質回收（Organic Recycling）及可以用有機方法回收（Organically Recyclable）之物質與產品（包括生物可分解塑膠）制定一致化之標準與驗證程序，並採用 ISO 9000 與 ISO 14000 系列標準做為良好作業規範。

(二)策略性目標

1. 標準

發展草案以便提交國際/國家標準組織，制定堆肥/堆肥化之標準。

(1)建議 ISO TC207 針對有機物回收設立工作小組。

(2)美國堆肥協會（U. S. Composting Council，簡稱為 USCC）已完成之「評估堆肥與堆肥化之測試方法」(Test Methods for Evaluating Composting & Compost，簡稱為 TMECC）可以做為草案。該份報告係經過 10 年，耗資超過 100 萬美元之研究成果，目前已送交美國農業部（USDA）出版中。

(3)USCC 的「可堆肥化」驗證計畫已建立若干執行程序，包括採樣、測試、樣品準備、送樣、實驗設備安裝等程序（均已涵蓋於 TMECC 中)。

(4)其他相關議題：著作權/授權/翻譯/出版/分銷。

2.堆肥操作員之訓練

(1)為確保公眾信心並達到 ISO 9000 品質系統之要求，有必要進行訓練。

(2)基本教材為 USCC 之堆肥操作員訓練手冊。可能需因應各個國家之特殊文化或其他特性而略做修正。而 USCC 將在明年進行整本手冊之更新。

(3)USCC 已設置「堆肥專業人員授證委員會」(Compost Professional Credentials Committee)，以發展專業操作員驗證計畫（2000 年 11 月）。

(4)其他相關議題：ISO 標準有無涵蓋訓練、ISO 標準是否要求訓練之文件、國際間認知/登錄/認證程序著作權/授權/翻譯/出版。

3.可堆肥化標誌

依據國際/國家之標準設置並鼓勵國家性可堆肥化標誌之相互承認，如 IBPI/USCC/DIN Certco/OK Compost 等標誌。

(三)成立亞洲有機再生網路組織需執行之工作

1.鑑別參與亞洲有機再生網路組織之各國代表/組織/聯絡人，包括亞洲各國與澳洲/紐西蘭。

2.日本有機資源協會(Japan Organic Recycling Association，簡稱為 JORA)預定於 2001 年秋季於東京舉辦亞洲有機再生網路組織堆肥研討會。JORA 期待各國推薦代表/組織。

3.有關研討會之協調，於東京會議之後，是否爾後每三年舉行一次國際研討會，並由各國輪流主辦。

4.有關網站之設計與建置，各國應有自己之網站，藉由連結至主網站。

5.爭取經費支持，以保持本組織為自願性參與組織。

6.評估是否與歐洲網路組織聯盟，進行資訊交換或數據連結。

7.評估是否針對特定研究予以經費補助，並研究補助方式，相關議題如：熱帶氣候條件下之堆肥與國家地理位置有關。

8.評估是否設獎學金及進行交換學生。

(四)亞洲有機再生網路組織之立即性工作

1.針對各國生物可分解塑膠之政策與政府補助計畫進行調查。

2.針對各國堆肥之政策與政府補助計畫進行調查。

3.堆肥效益之文件化

(1)傳閱對象：農業、營建、政策制定者及一般民眾。

(2)成本效益評估：堆肥並不僅是土壤改良劑，其他價值性之界定。

4.由有機廢棄物回收與交易，可取得碳排放信用額度（Carbon Emission Credit,簡稱為 CEC)。另有機物回收協會具有量測、驗證及稽核供交易用之 CEC 能力，此能力提供了未來有持續性收入之機會。

5. 其他相關議題：發展量化堆肥 CEC 之科學、發展驗證/稽核計畫、前述工作之一致化（harmonization)、國際組織之承認、堆肥設備及製程驗證(能驗證設備製造商宣告之第三者驗證組織)。

6. 亞洲有機再生網路組織做為仲介者，以作為技術及合作投資案之連絡站。

7. 美國穀物協會(USGC/Bio Materials Team Asia)在被要求之下，將對各國之秘書處提供協助，以促進亞洲有機再生網路組織之溝通。另亞洲有機再生網路組織未來將以兩年為期，

輪流由志願者擔任秘書處，時間另訂。

柒、考察心得

一、影響生物可分解塑膠市場之因子，在美國為市場導向，其主要以發展生物可分解塑膠作為取代石化原料之替代品，故著力於工業部分之研究努力，可將其作為衣服纖維（作成牛仔褲、衣服、新娘禮服等）。而在歐洲主要為政策導向，主要之政策為歐盟所訂包裝、掩埋及堆肥指導原則，促成生物可分解塑膠在歐洲市場之發展。

二、歐洲廢棄物處理之優先順序依序為（1）reduce；（2）Reuse；（3）material recycling-composting（4）附帶能源回收之焚化；（5）掩埋處理。在第（3）、（4）部分不同國家可能有不同的看法，如德國、比利時即認為（3）優於（4），而在法國將（3）、（4）等同看待。

三、對於以焚化之處理方式，因為要控制戴奧辛之問題，故其所需成本相對提高；另在歐盟掩埋指導原則中規定有機廢棄物不能以掩埋處理，部分國家並已明文規定有機廢棄物禁止以掩埋方式處理。基於前述因素，故在部分國家力倡以堆肥之處理方式進行資源回收，此種方式值得我國借鏡。而以生物可分解塑膠作成之塑膠袋裝有機廢棄物進行堆肥亦已為相當普遍的作法。

四、對於短效性一次即丟、難回收之物品，因回收再生利用價值低，過去在國內對於如何進行資源回收曾引起熱烈的討論。由此次考察觀之，未來以生物可分解塑膠為原料製成，使用廢棄後再以堆肥方式進行資源回收，為目前各國考量推動的

可行方式，而目前仍受限於價格問題，故尚未普遍。其應用物品包括：塑膠袋、緩衝材、紙杯 coating、塑膠杯、用後即丟之刀叉、餐盤、速食店之漢堡盤、雞塊盤、優格杯、農業用綑綁帶、紙尿褲等。

五、所參訪之明尼蘇達州，堆肥已成為主要大力推動的垃圾處理方式，相關之法令、制度及硬體設施均已建立。而在全面推動前，曾依不同型態之地區及產生源進行垃圾分類之宣導、示範及調查計畫，以作為實施之依據，對於堆肥廠之運作如進廠原料之成份、產品之品質及市場接受度等，亦有詳盡之規劃。另州政府亦編列預算補助地方政府以此方式進行資源回收。

六、所參訪之堆肥處理設施，其產品多作為土壤改良劑，其觀點為與其浪費大量費用處理垃圾，何不將其中之有機廢棄物進行堆肥，可讓有機物回歸於土壤中，提高土壤之有機性，可作為碳的收集槽（carbon sink）。

七、在日本、韓國部分，對於有機廢棄物之資源回收工作亦極力推動，韓國訂定有機廢棄物之回收率於 2002 年達到 50%。在日本部分，於 2000 年通過 2001 年施行之食品回收法，對於有機廢棄物之資源回收亦已提出一強力宣示，民間已成立日本有機資源協會(JORA)推動有機廢棄物之資源回收工作。故生物可分解塑膠之發展亦相形重要，該二國亦已建立相當之基礎。

八、從 Cargill-Dow 公司之簡報得知，新世代低成本之聚乳酸塑膠原料於 2002 年將正式上市，由此項產品拋磚引玉，許多大廠如 Du Pont、Bayer….等大廠均跟進生產低價位產品，塑膠產

品將有一大變革。

捌、建議事項

一、我國堆肥處理，目前以畜牧業之排泄物為主，將來為垃圾減量以及有機廢棄物之循環利用，對於廚餘、庭院樹枝，應以堆肥化處理較為妥適。可減少 CO_2 排放，並將有機質回歸農田，以改進土壤性質，增進農作物品質。

二、生物可分解塑膠產業與堆肥化處理是一體兩面且相輔相乘，缺一不可。以生物可分解塑膠袋包裝有機物廢棄物一齊作堆肥處理在國外先進國家已普遍利用，我國尚未起步，建議在都會地區，可先試辦實施。

三、在永續利用之循環型社會(recycling-based society)的國際潮流下，比較生物可分解塑膠及一般塑膠二者之應用方向，由經濟層面之角度觀之，除製造成本以外，經廢棄後末端之回收成本及再利用價值之因素亦應整體納入考量。

四、對於可以堆肥方式進行資源再利用之生物可分解塑膠，在國內尚缺乏標識制度，應儘早建立完整及健全的標識及檢測系統，以利政府、民眾及業者等共同遵循。

五、國人對於生物可分解塑膠之利用與環保關係尚屬陌生，未來亦應進行宣導教育，讓民眾建立正確之觀念，以利推動。

六、參觀了 VLAR 與 DRANCO 兩家好氧與厭氧之堆肥處理場，發現國內尚須努力的空間極大。包括民眾的環保及道德教育、確實的垃圾分類、綠色消費等，在在影響了資源回收的執行成果。

七、目前世界大廠均有相關產品發表，但成本過高，是最大障礙，

故發展低成本的生物可分解塑膠材料是相當迫切的。而原料的成本通常與市場是相對的，市場打開後，大量生產的成本相當低廉，但目前除 Cargill-Dow 為正式量產外，其餘均以試產(pilot)價格供應，故不易普遍。參考歐美國家之經驗，政府部門之法律規範十分重要，當某些應用經政府機關強制指定後(如裝廚餘之塑膠袋)，均能對市場產生某種程度的刺激，市場即可慢慢打開。

八、目前國內環保生物可分解材料協會已經成立，日後可與日本、韓國等建立起亞洲有機再生網路，並進而與美國及歐洲國家等連結成環球網路，將來可對政府相關政策之擬定作建言，另對於如何降低 CO2 及甲烷等之排放量，有機農業之倡導，有機廢棄物之堆肥化技術發展，促進生物可分解塑膠之研究等，均為該協會將來推動之主要工作目標。

附件一

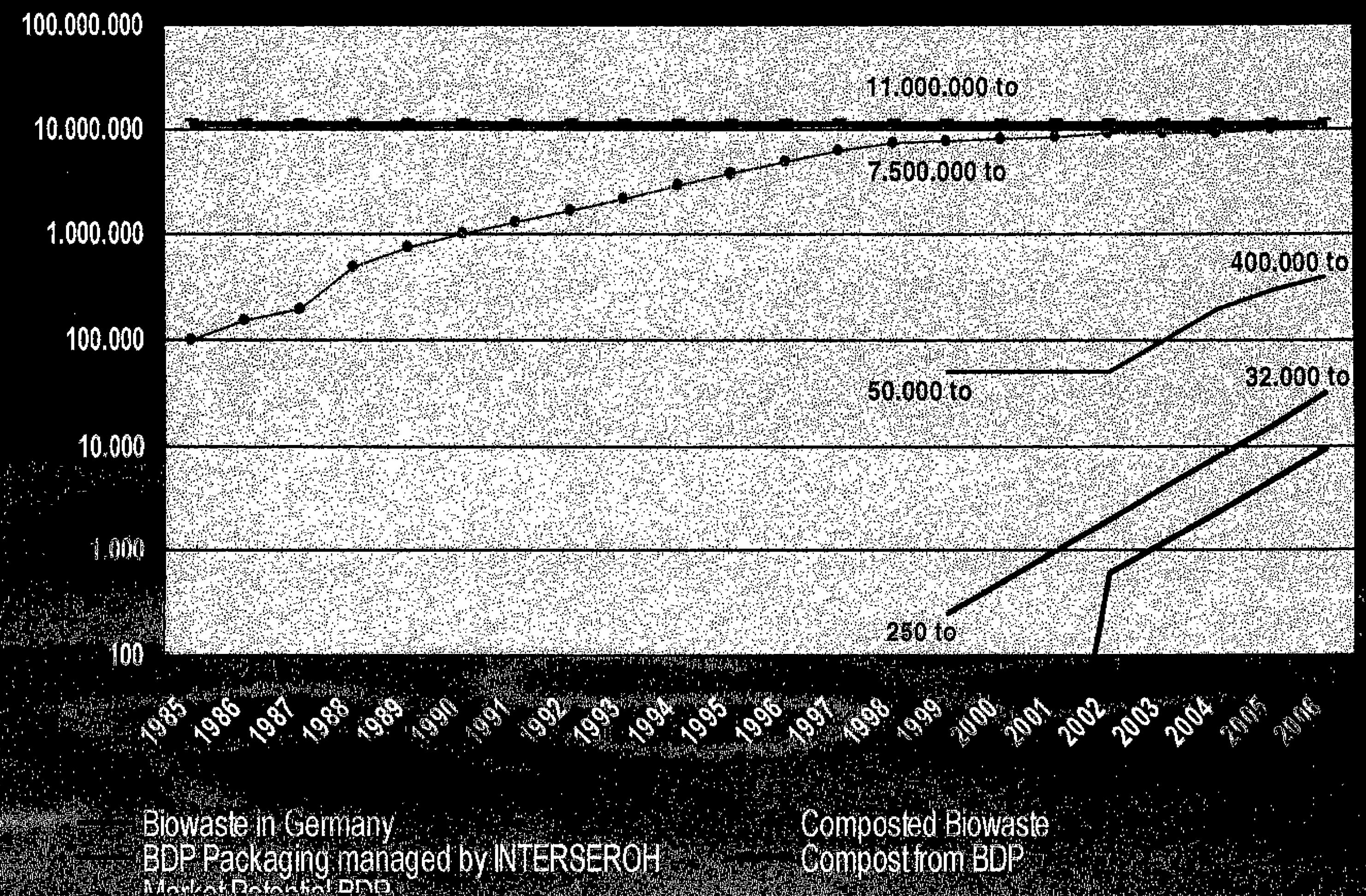
附件一

INTERSEROH Entsorgungsdienstleistungen

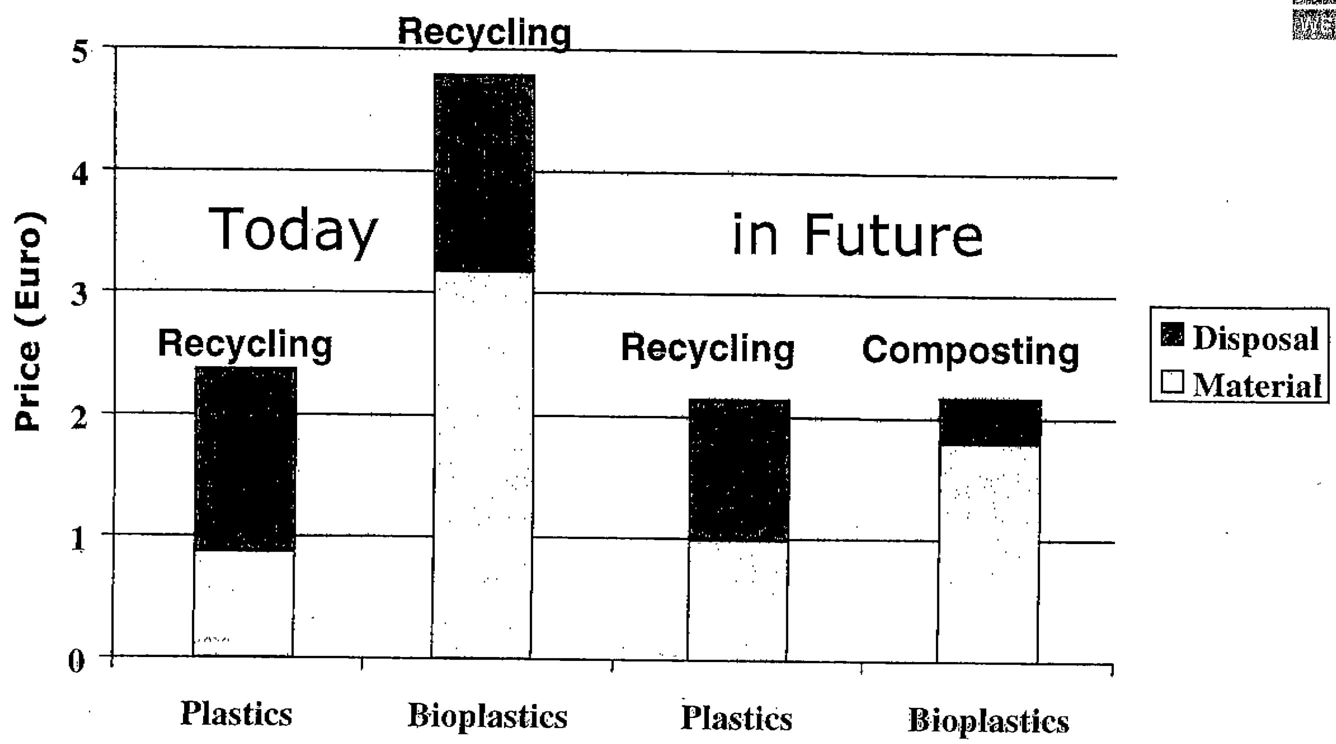
INTERSEROH Waste Management for Compostable Packaging

INTERSEROH Service for distributors of compostable packagings according to the German Packaging Ordinance (§6 (3) and §16 (2)

Market data:
Biowaste and Potential for BDP - Packaging



Costs for Material & Recovery



Concept

- **Main areas of activity:**

- Collection via Biobin

- Business Customers, e.g. Fast Food chains

- Events (Concerts, Sports etc.)

Price reduction:

In Phase 1 (ISD acts as ‚third party') only 80 % of the listed prices will be charged.

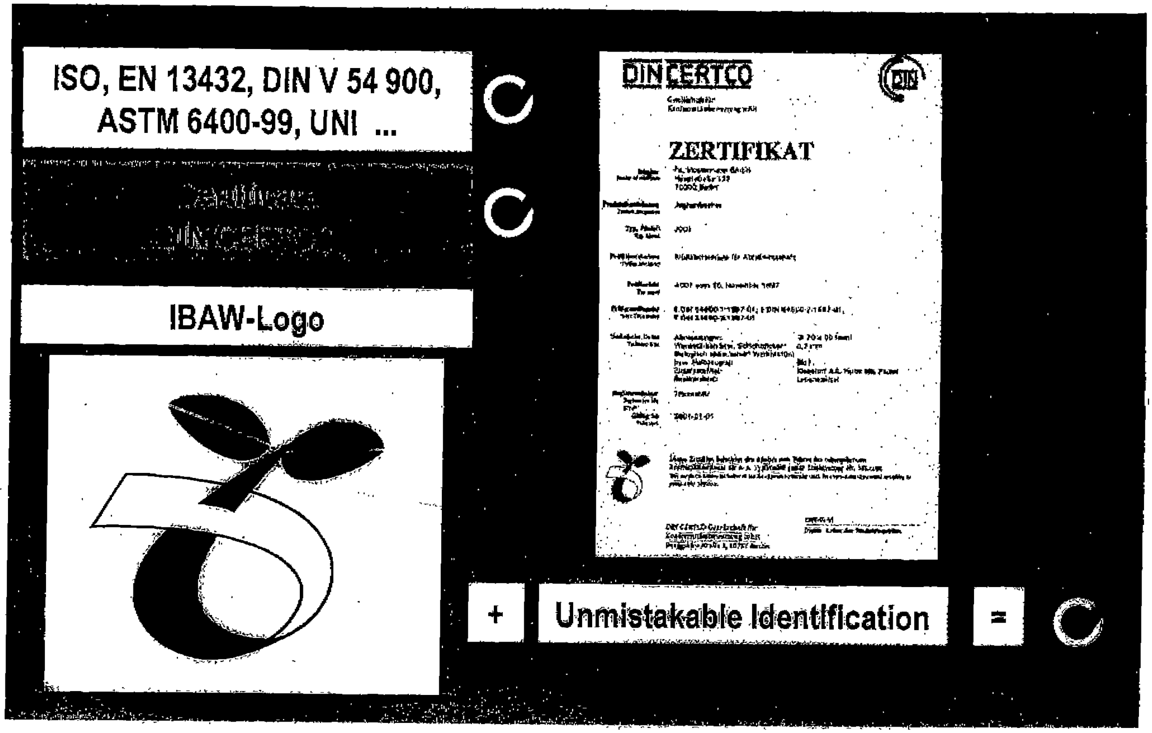
Costs

- ‚Lower rates, when higher amounts of licensed packaging':

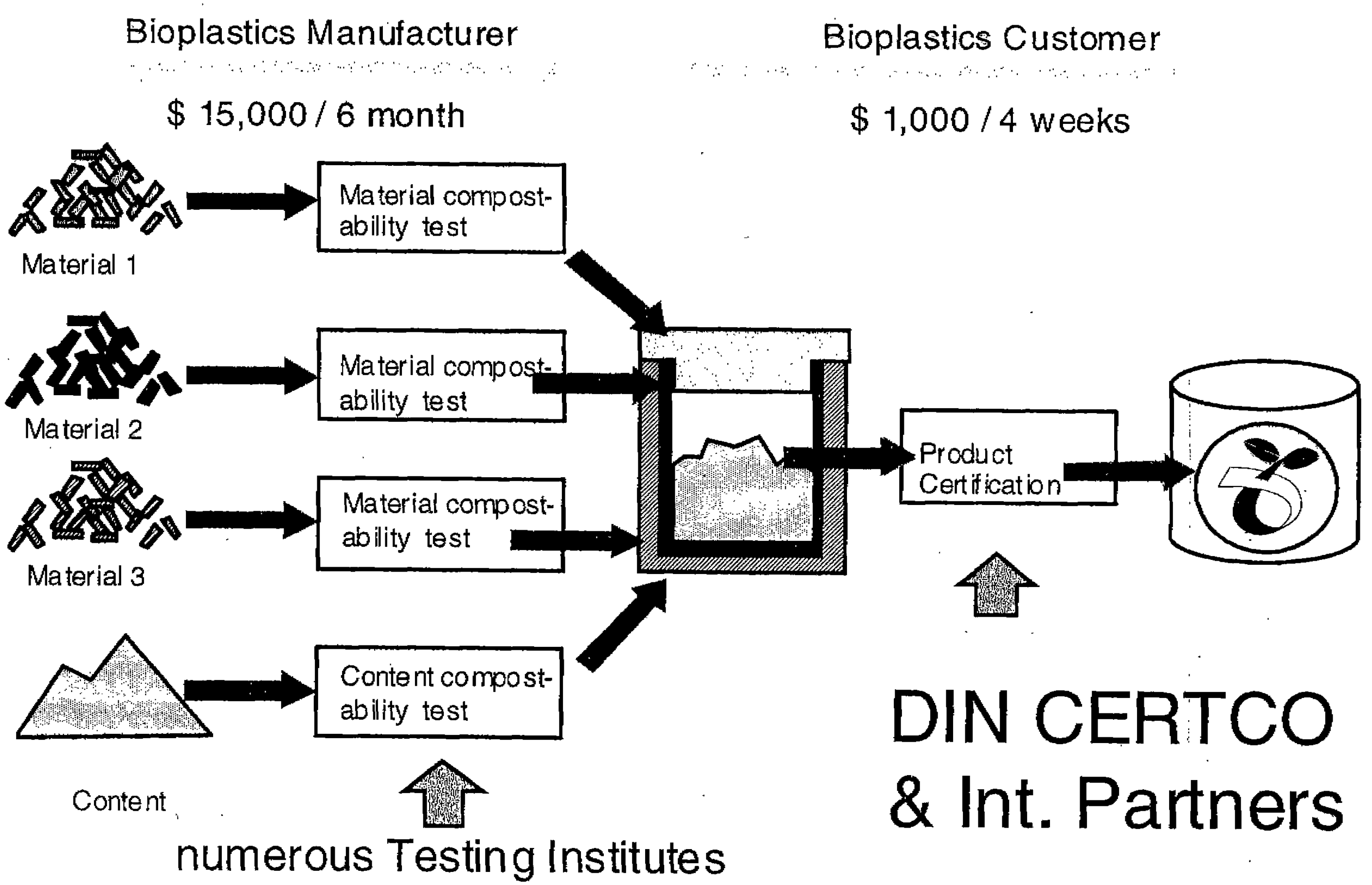
Licensed packaging p.a. (sum)	price per ton
up to 999 t	950,00 DM
1.000 to 2.499 t	750,00 DM
2.500 t to 4.999 t	690,00 DM
5.000 t to 9.999 t	650,00 DM

Preconditions for licensing with INTERSEROH

- Packaging has to be certified by DIN CERTCO or equivalent & has to be marked with the IBAW Logo



Certification Scheme



Memorandum of Understanding

between

International Biodegradable Products Institute
Institut International Des Produits Biodegradables

(referred below as BPI)

and

DIN CERTCO Gesellschaft für Konformitätsbewertung mbH,
Burggrafenstraße 6, 10787 Berlin, Germany

(referred to below as DIN CERTCO)

This letter expresses the willingness of BPI and DIN CERTCO to recognize and honor the validity of each other's certification system and logo with the following provisions:

- Certified materials and products must meet appropriate national or local regulations (for example heavy metal levels).
- Documents and data used for certification are found to be complete by each organization.

Additionally, the BPI and DIN CERTCO plan to recognize the technical expertise of the testing labs and scientific reviewers used by each organization.

The BPI and DIN CERTCO agree to develop comparable application procedures and forms in order to facilitate product approvals.

Both organizations agree to attempt to harmonize biodegradable and compostable standards for polymeric materials and products and packaging, containing polymeric materials in ISO.

Each certification organization will collect revenues for the display of their respective logo within their region as per the fee structure established by their own organization.

November 15, 2000

Frederic Scheer
President of the BPI

Jürgen Nebun
Managing Director of DIN CERTCO

Ramani Narayan, Ph.D.
BPI Scientific Committee

Jörn Reske
DIN CERTCO Certification Committee

INTERSEROH Waste Management for Compostable Packaging

Identification concept in Germany

kompostierbar

INTERSEROH® RECYCLING BIOLOGISCH ABBAUBARE WERKSTOFFE

Ecology

- ‚Triple Bottom Line': Sustainable technology, feasible also in small scales

  → developing countries: Use of regional products from agriculture, production and recovery after use in the same region

- Leading experts on environment become aware

- First LCA / LCI studies

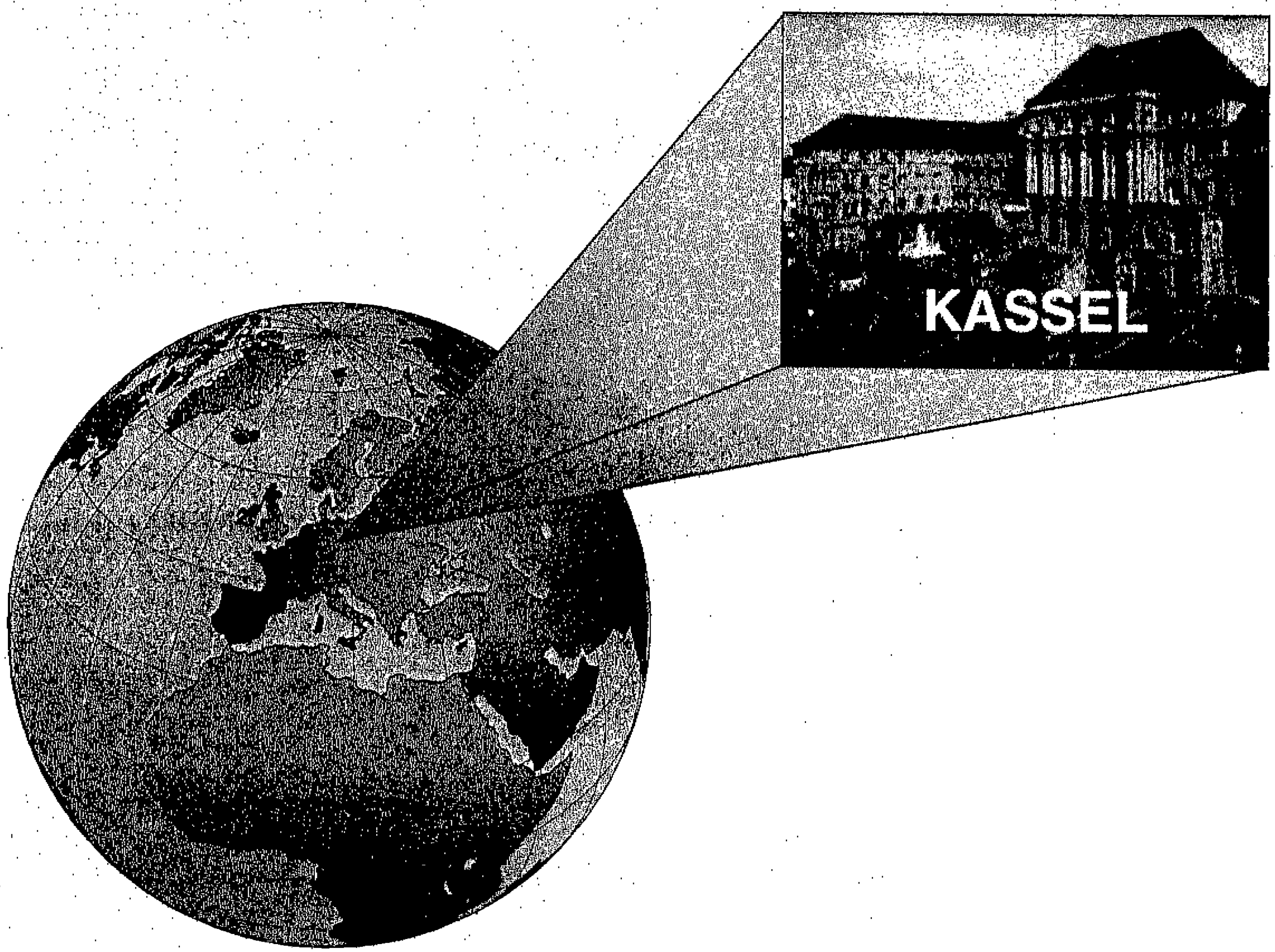
Demonstration Project Biodegradable Polymers (BDP):

Use of Compostable Packaging in Biowaste Management

The Largest Application Trial Worldwide

- BDP-packaged products in supermarkets
- Consumers dispose BDP packagings into the biobin
- Packagings will be composted resp. fed to biogasification
- Application of the resulting compost in agriculture

Kassel: From February 2000 until July 2001 the center of the biopolymer industry's activities



Basic Question:

Will consumers put BDP-packagings into the biobin

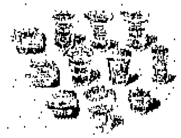
(and no other packaging)?

➔ Misthrows ?

Which BDP-packaging?

Broad range of products from fall 2000 until summer 2001:

Packaging for:



Dairy Products
(regional and national brands)

Fruit and Vegetables
(regional and national suppliers)

Meat and Deli's

Shopping bags / Biowaste bags

Food service items

Who runs the trial?

- Industry
  - Apack
  - BASF
  - Bayer
  - Biocorp
  - Biotec
  - Cargill Dow Polymers
  - DIN CERTCO
  - Interseroh
  - Frischmann/Kivo
  - Natura
  - Novamont
  - UPM
  - Wiedemann
  - Meggle
- Project Partners: IBAW e.V.; Bauhaus University Weimar
- Funded by the Federal Ministry of Agriculture (through Fachagentur Nachwachsende Rohstoffe e.V.)
- Projektmanagement: Lichtl Consulting

Information about the demonstration project:

Projektmanagement

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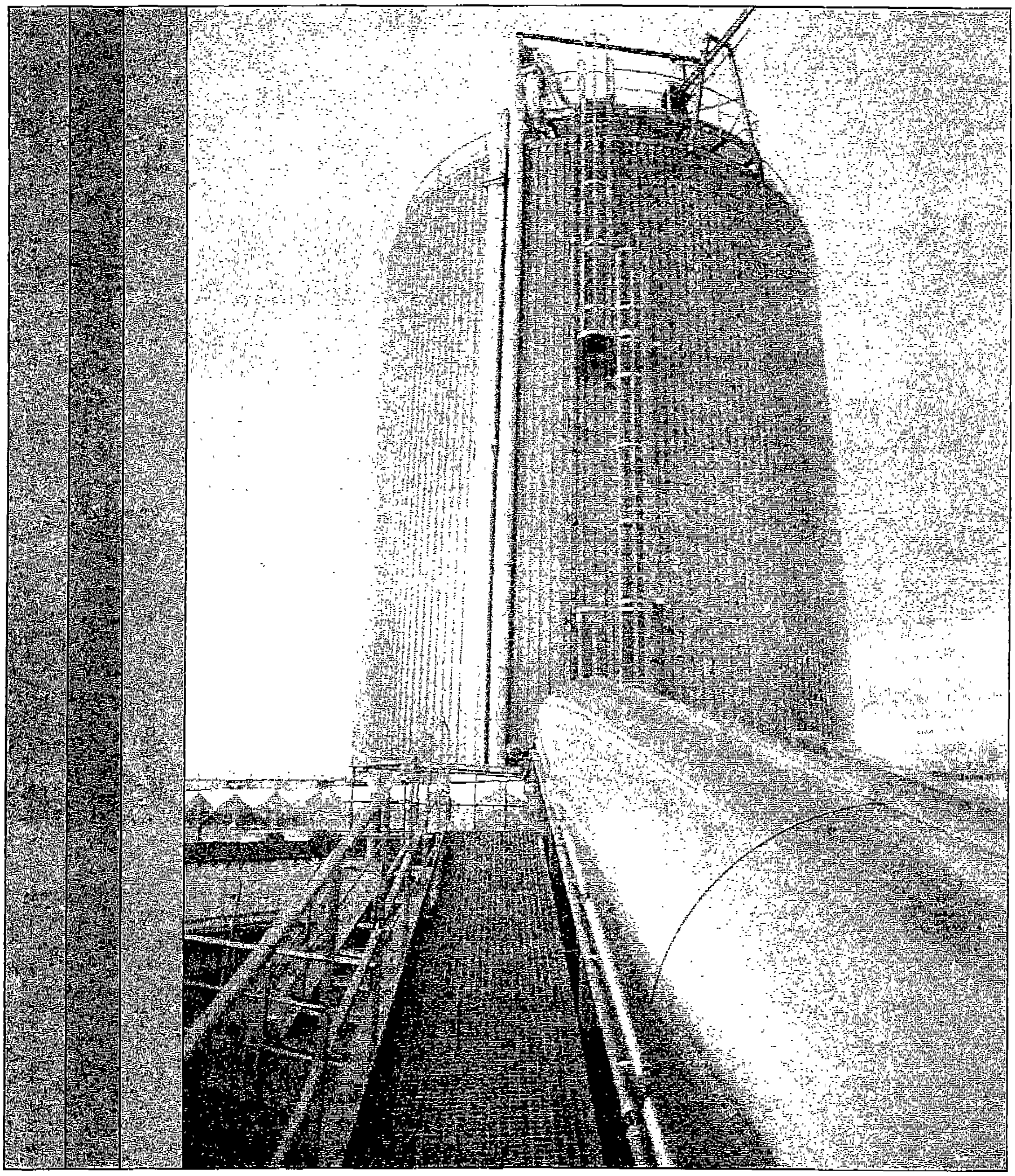
附件二

附件二

Organic Waste Systems



DRANCO PLANT SALZBURG

ANAEROBIC COMPOSTING OF BIOWASTE

The biowaste treatment plant in Salzburg

Since december 1993 the DRANCO-plant in Salzburg has been treating all the separately collected biowaste from the broader Salzburger area. The SAB -Salzburger Abfallbeseitigung- is owner and operator of the plant. The operation of the plant started together with the collection of biowaste in the area. The DRANCO process converts the organic waste into biogas and compost. The plant has a capacity of 15.000 to 20.000 tons per year and was built in only 15 months. The total investment price is 150.000.000 Austrian Shillings.

General characteristics of the plant		
Number of inhabitants in collection area		300.000
Capacity of the plant	average	15.000 tons/y
	maximum	20.000 tons/y
Compost production	average	3.500 tons/y
	maximum	4.700 tons/y
Daily processing capacity	average	60 tons/d
	maximum	90 tons/d
Working hours		250 d/y
		5 d/w
		8 h/d
Operating staff		5 people

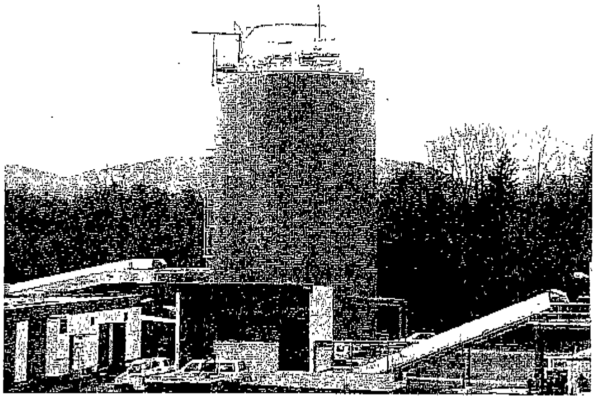
PRETREATMENT OF THE BIOWASTE

The biowaste is transported in closed vehicles and dumped into a feeding unit in the delivery hall. From here it is transported by belt conveyors towards a manual sorting station where impurities are removed. Subsequently the biowaste is shredded in a hammermill and screened in a 40 mm trommel screen to remove impurities. The oversize is sent to a container while the undersize of the sieve passes a ferrous metal separator and is stored in an intermediate buffer, before going to the digestion unit.

Characteristics of the incoming biowaste	
Kitchen waste	60-90 %
Garden waste	10-40 %
Total solids (TS)	32 %
Volatile solids (VS) on total solids	70 %
Kjeldahl nitrogen (kJ-N) in g/kg on fresh weight	6
C/N-ratio	20

ANAEROBIC DIGESTION OF THE PRETREATED BIOWASTE

The fresh biowaste coming from the intermediate buffer is transported towards the mixing unit of the feeding pump, where it is mixed with digested residue coming from the reactor. Steam is added to raise the temperature of the substrate to 55°C. The material is pumped into the digester. The fermentation of the organic material takes place in a vertical reactor under thermophilic conditions, without any addition of water. There is no internal mixing or agitation in the reactor during the digestion process. The material passes through the reactor from top to bottom where it is removed by an extraction system. The extracted residue is partially sent to the mixing unit of the feeding pump where it is mixed with fresh biowaste and partially transported to the posttreatment.

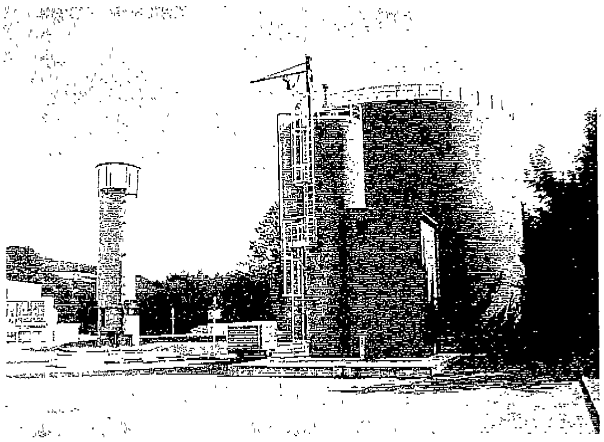


DRANCO reactor for the treatment of biowaste in Salzburg

Process parameters DRANCO-plant Salzburg	
Digestion process	one-phase
Process temperature	50 - 55 °C
TS-content in the digester	15 - 30 %
Retention time	20 - 30 days
Loading	5 - 8 kg VS/m³.d
Biodegradability	65 - 90 %
Biogas production per ton input	120 - 170 Nm³
Biogas production rate	3 - 5 Nm³/m³.d
Methane content	50 - 65% CH_4

AIR TREATMENT

The exhaust air of the plant coming from the delivery hall, the electro-mechanical equipment and the post-composting unit is removed and cleaned in a biofilter. The biofilter has a surface of 300 m² and treats 45.000 m³ exhaust air per hour.



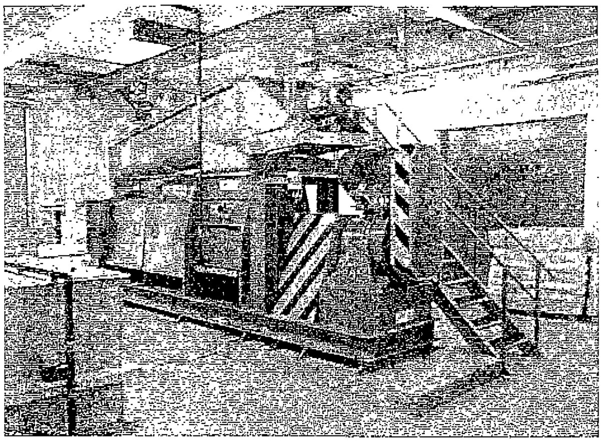
Gas storage for biogas and landfill gas. In front at the right the desulphurization unit for the landfill gas

BIOGAS TREATMENT

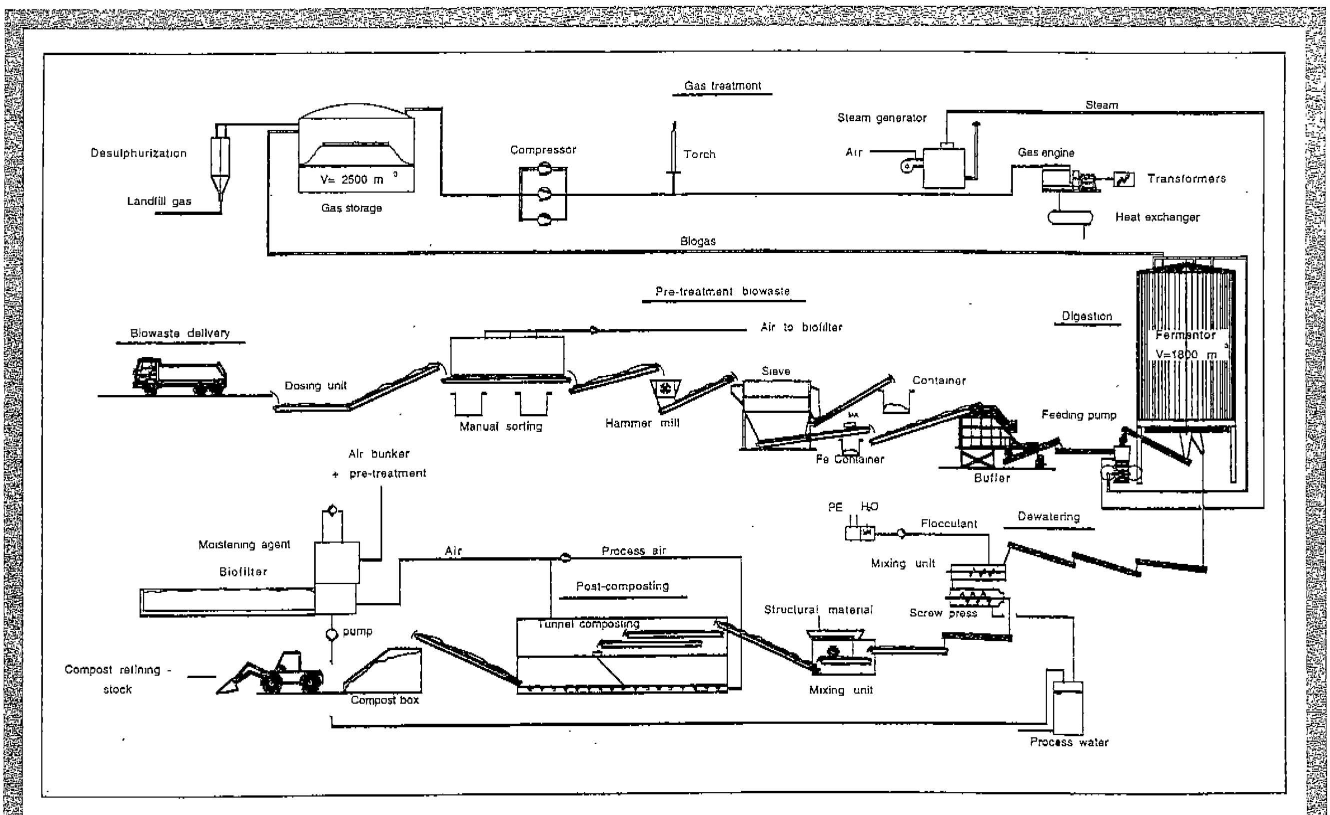
The produced biogas is collected in a gas tank and mixed with desulphurized landfill gas. The gas is partially used in a steam generator for the production of process heat. Most of the gas is transformed into electricity by means of biogas engines with a total installed electrical power of 1.6 MW. The produced electricity is consumed in the plant itself and for the larger part utilized by other installations at SAB.

POSTTREATMENT OF THE DIGESTED RESIDUE

The digested material is mixed with flocculants before being dewatered in a screw press. The press cake has a total solids content of 50%. A computer controlled tunnel composting system subsequently stabilizes the residue during two to three weeks. The press water is sent to the adjacent waste water treatment plant.



Screw press for dewatering of the residue



Schematic overview of the DRANCO-plant in Salzburg

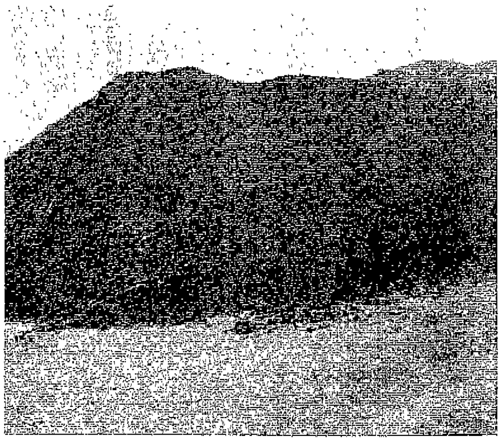
REFINING OF THE COMPOST

After two to three weeks the compost is extracted automatically and sent to a refining screen. The compost meets all Austrian standards. The compost is being sold as a soil amendment product.

Characteristics of the produced compost

Parameter (*)	Unit	Average	ONORM S2200 Klasse I
Dry matter (DM)	% on fresh weight	51	50 - 75
Volatile solids (VS)	% of DM	41	> 20
Kj-N	% of DM	1.9	-
P_2O_5 total	% of DM	0.66	-
P_2O_5 avail.	% of DM	0.38	-
K_2O total	% of DM	0.63	-
K_2O avail.	% of DM	0.35	-
pH	-	7.7	-
Conductivity	mS/cm	0.7	< 2
C/N	-	13	-
Chrome	mg/kg DM	37	70
Nickel	mg/kg DM	24	42
Copper	mg/kg DM	53	70
Zinc	mg/kg DM	200	210
Cadmium	mg/kg DM	< 1	0.7
Merury	mg/kg DM	0.3	0.7
Lead	mg/kg DM	44	70

(*) Heavy metals related to 30% VS



Compost of the DRANCO-plant Salzburg after refining

The Company

Organic Waste systems, in short O.W.S., is a private company under Belgian law, constituted in 1988. O.W.S. has developed the patented DRANCO process and offers turn-key installations for the anaerobic treatment of biowaste. The DRANCO process is flexible and can treat source separated biowaste with a low total solids content as well as the organic fraction of municipal solid waste with a high content of total solids.

Before building the plant in Salzburg O.W.S. had constructed several demonstration units. Since July 1992, O.W.S. also operates a full scale DRANCO plant with a capacity of 10.000 tons per year at Brecht, Belgium, 30 km North of Antwerp.

O.W.S. has its own research lab to further develop the concept of anaerobic treatment and to test the biodegradability and compostability of consumer products as packaging materials, detergents, bioplastics, etc. O.W.S. also provides consulting services in the area of solid waste management, compostability and other related areas.

For more information, please contact:

OWS

Organic Waste Systems n.v.

Dok noord 4 - B-9000 Gent - Belgium

Tel.: (+32)-9-233.02.04 - Fax : (+32)-9-233.28.25

DRANCO

anaerobic digestion of organic waste

Organic Waste Systems

The company

Organic Waste Systems (O.W.S.) is a stock company under Belgian law, constituted in 1988. The company has a capital of 50.000.000 Belgian Francs and is specialized in anaerobic composting and biodegradability testing.

O.W.S. developed and fully owns the patented DRANCO technology, consisting of the DRANCO process and the DRANCO-SEP process. This advanced anaerobic waste treatment technology converts organic wastes into biogas and Humotex, a stable humus-like product.

The staff of **O.W.S.** has been responsible for the development of the DRANCO technology from the very beginning in 1980. Next to the activities around the DRANCO technology, **O.W.S.** offers laboratory testing and consulting services on all aspects of biological solid waste treatment.

In the USA, **O.W.S.** is represented through **O.W.S. Inc.**, its fully owned daughter company in Dayton, Ohio.

O.W.S. offers:

DRANCO/DRANCO-SEP processes

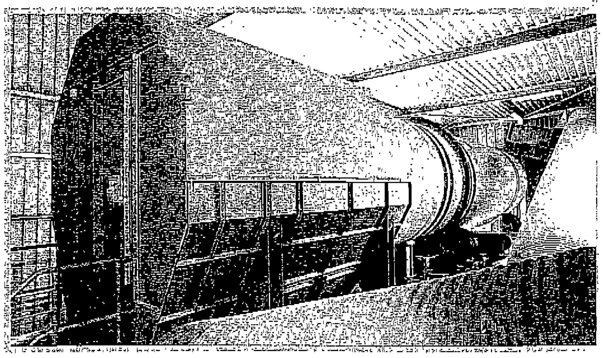
- basic and detailed engineering
- equipment supply
- turn-key installations
- start-up and operating services
- laboratory and pilot test-runs

Laboratory testing

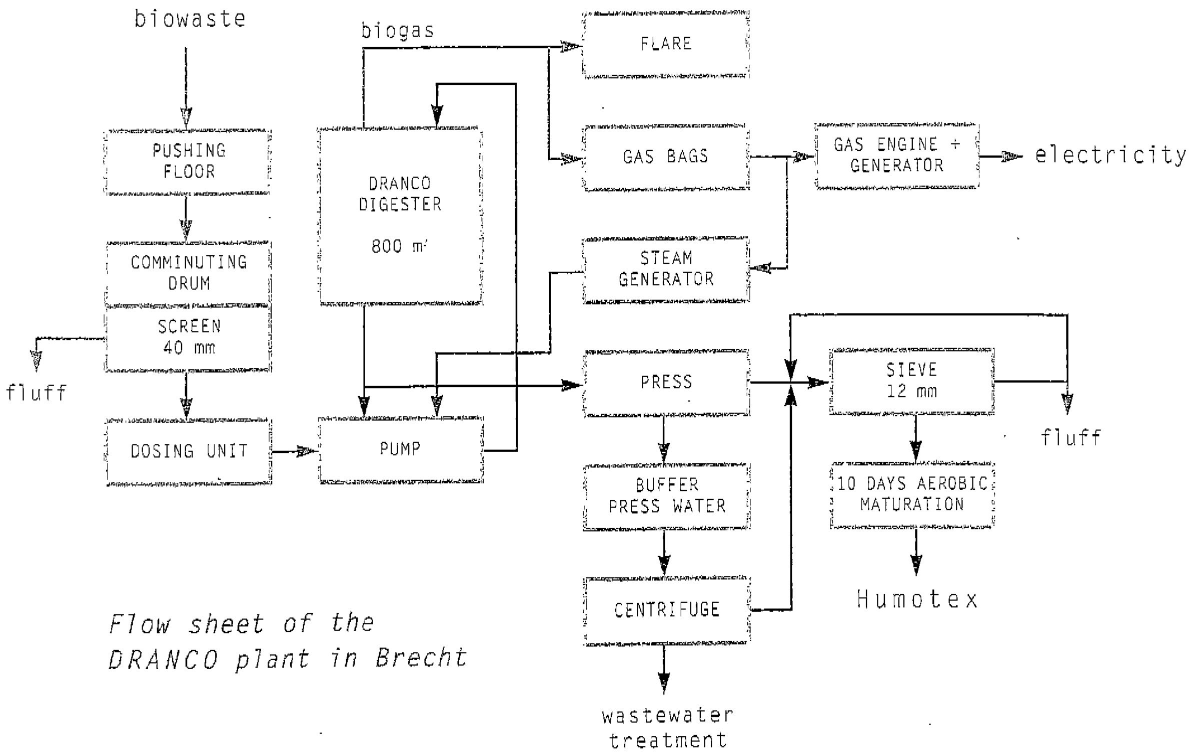
- biodegradation and compostability tests
- ecotoxicity tests
- compost quality analyses

Consulting services

- waste composition
- integrated waste management
- management of organic wastes
- developments in composting and anaerobic digestion

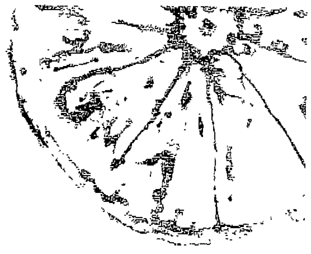


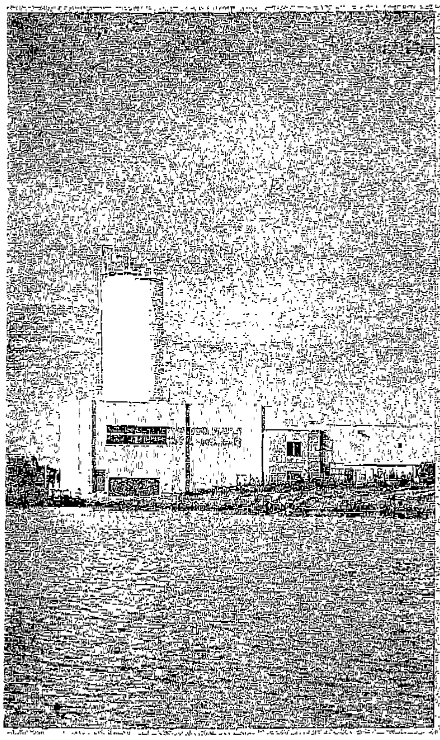
Comminuting drum of the Brecht plant



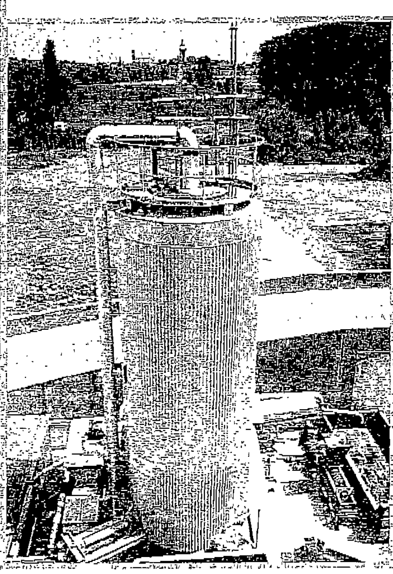
Flow sheet of the DRANCO plant in Brecht

The DRANCO technology

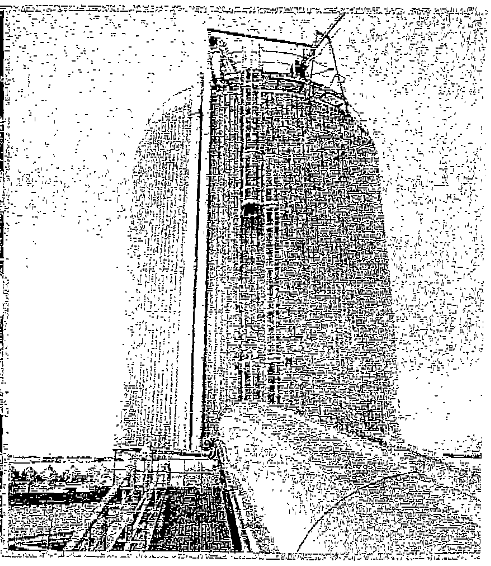




RANCO installation at Brecht (Belgium) treating 2000 tons of biowaste per year The plant was ·arted up in July 1992



The first DRANCO demonstration installation was erected in Ghent (Belgium) in 1984 and was used for developing the thermophilic digestion of household garbage and biowaste (DRANCO process) and pure market and food waste (DRANCO-SEP process)



DRANCO plant in Salzburg (Austria) with a capacity of 20000 tons of biowaste per year. The plant is in operation since December 1993

Advanced biotechnology for environmentally friendly and cost-effective organic waste treatment

O.W.S. offers two processes in function of the waste to be treated: the DRANCO process and the DRANCO-SEP process. The DRANCO process consists of a thermophilic, one-phase anaerobic fermentation step, which is followed by a short aerobic maturation phase. During the anaerobic digestion phase, the organic material is converted into biogas. This process takes place in an enclosed digester. The total solids (TS) content in the digester depends on the input material and may vary between 15 to 40 %. For market waste, food waste and other wet substrates, the DRANCO-SEP process was developed which operates according to the same fermentation principles as the DRANCO process, but is designed for operation between 5 to 20 % total solids. This flexibility of the DRANCO technology allows the treatment of a wide range of different input materials. The digested residue is extracted from the digester, dewatered to a TS-content of about 50 % and then stabilized aerobically during a period of approximately two weeks. The aerobic maturation ensures complete stabilization of the material which cannot degrade any further under anaerobic conditions. The final product is called Humotex and is a very hygienically safe and stabilized soil amendment.

The DRANCO advantages:

- Energy production with high biogas yield
- High quality compost production (Humotex)
- Minimum of odor
- No dust formation during process
- Little surface area required
- Automated process control
- Simple and reliable digester design
- High wastestream flexibility (DRANCO/DRANCO-SEP process)
- Proven and stable thermophilic digestion process
- Controlled external inoculation

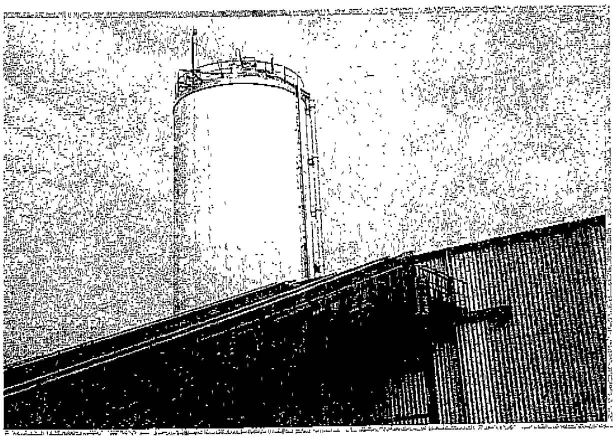
The DRANCO feedstocks:

The DRANCO technology can be used for various types of organic wastestreams:

- biowaste and other source-separated organic wastestreams
- the organic fraction of mixed waste obtained through mechanical separation
- dewatered sewage sludge
- other organic wastestreams, including non-recyclable paper, market waste, industrial organics etc...

The DRANCO parameters:

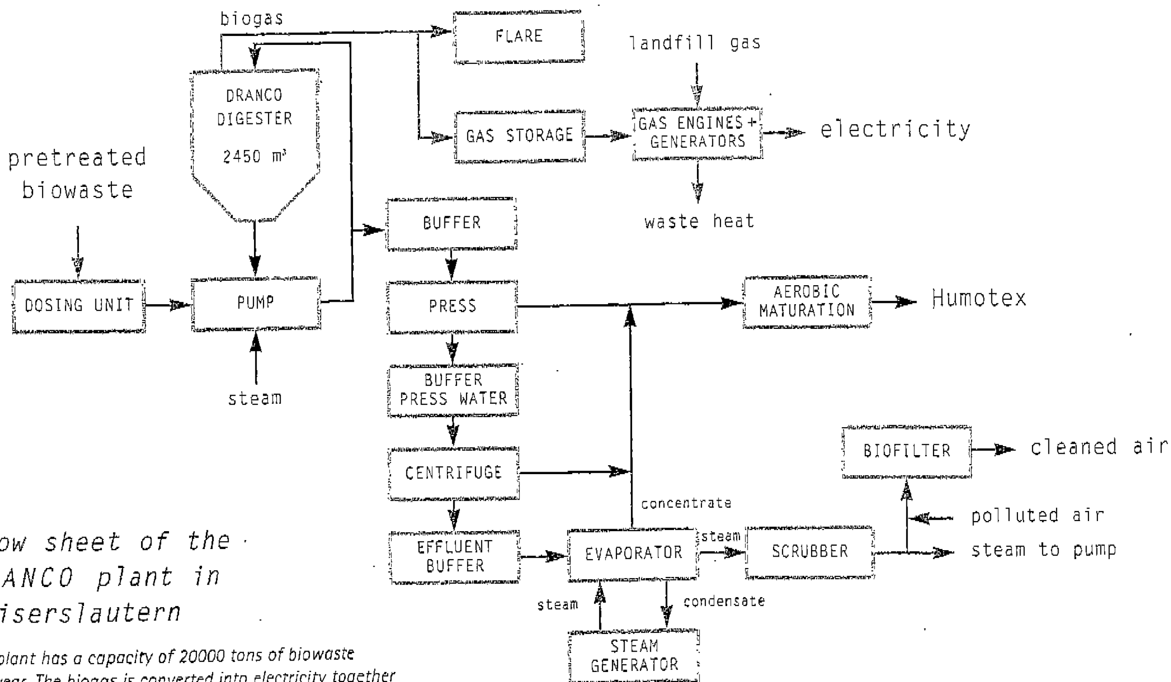
digester loading : 10 to 20 kg $COD/m^3_{reactor} \cdot day$
temperature range : 50 to 58 °C
retention time : 15 to 30 days in the digester
energy production : 100 to 200 m^3 of biogas per ton of waste (55 to 60 % methane)
electricity production : 170 to 350 kWh per ton of waste



DRANCO installation at Bassum (Germany) for the treatment of 11000 tons of rest waste per year and the option to add an additional amount of 2500 tons of sludge. The plant was started up in the spring of 1997.

Optimal recovery of the energy produced in the DRANCO process applied in Switzerland

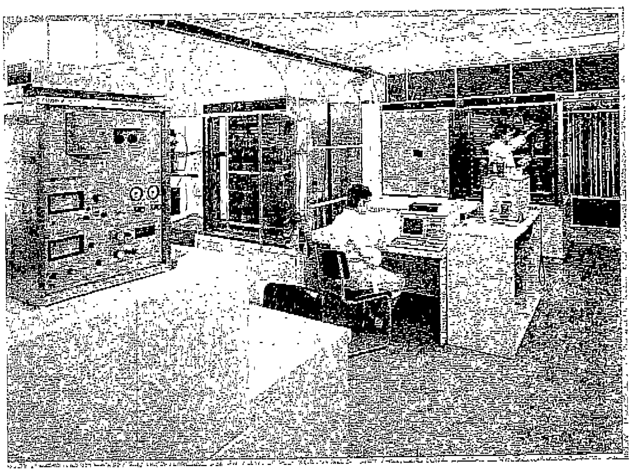
The company Alpha Umwelttechnik AG, the licensee of **O.W.S.** in Switzerland, has built a DRANCO plant for the treatment of 11000 tons of biowaste per year in Aarberg, Switzerland. The biogas of the plant is transformed into electricity by using a gas engine and a generator. The thermal energy produced is utilized in the DRANCO plant itself as well as in a concrete factory in the neighborhood. The total efficiency of the energy recovery averages about 67 % during the year, with peaks of 85 % during the winter time.



Flow sheet of the DRANCO plant in Kaiserslautern

The plant has a capacity of 20000 tons of biowaste per year. The biogas is converted into electricity together with landfill gas. The waste heat produced by the gas engines is utilized to evaporate the press water. As a result this plant does not produce any wastewater.

Laboratory testing and consulting



O.W.S. has established a fully-equipped laboratory for biodegradation tests and compostability studies, particularly aimed at bioplastics and novel packaging materials. Contract research is offered on a world-wide basis, through a fully-owned subsidiary in Dayton, Ohio and a partnership with DJK International Inc. in Tokyo, Japan.

O.W.S. has more than 15 years of experience in R&D on biological treatment of solid waste. The O.W.S. laboratory department is certified for quality control according to the OECD system of GLP (Good Laboratory Practices).

For several years already, O.W.S. has been in the vanguard of the development of new tests and procedures for determining biodegradability and compostability.
The company is the official Belgian delegate to ISO and CEN working groups in this area and is also actively engaged in ASTM, DIN and various professional associations.

In cooperation with AIB-Vinçotte Inter, an international organisation for quality control, the 'OK COMPOST' certification and labelling program was launched.
In this program, true compostability of products can be demonstrated and guaranteed.

Biodegradation tests are not limited to composting conditions but also include simulation of sewage water, seawater, soil, septic tank, etc. Alternatively, biodegradation tests are performed on the basis of radiolabelled carbon. Other laboratory analytical capabilities comprise ecotoxicity tests, waste composition, biodeterioration and compost quality tests. In addition to the laboratory tests, consulting services are provided in the field of integrated waste management, composting legislation and developments, etc.

DRANCO Installation Reference List

Type of Plant	City, year	Country	Capacity (ton/year)	Type of waste
Demonstration plants	Ghent, 1984	Belgium		various
	Bogor, 1986	Indonesia		market waste
	Graz, 1990	Austria		mixed waste
Full-scale plants	Brecht, 1992	Belgium	12000	biowaste and non-recyclable paper
	Salzburg, 1993	Austria	20000	biowaste
	Bassum, 1997	Germany	13500	rest waste and sludge
	Aarberg, 1997	Switzerland	11000	biowaste
	Kaiserslautern, 1998	Germany	20000	biowaste

References Laboratory Testing

500+ samples tested for biodegradability and/or compostability, including bioplastics, packaging materials, paper products, mineral oils, detergents, specialty chemicals, etc.

50+ clients from more than 15 different countries, including Biotec (Germany), Cargill (USA), Kimberly-Clark (USA), Mölnlycke (Sweden), Novamont (Italy), Showa Denko (Japan), Monsanto (USA) and many others.

100+ types of solid waste characterized in view of biological treatment, including various types of mixed municipal solid wastes, various sources and kinds of biowaste and different industrial wastestreams

References Consulting Services

Field study on source-separated waste collection and biowaste definition for a consumer product company.

Project on the composition of restaurant waste and the feasibility of separate waste collection and biological treatment for a fast-food restaurant chain.

Survey of industrial solid wastes and feasibility of anaerobic biogasification for a regional authority.

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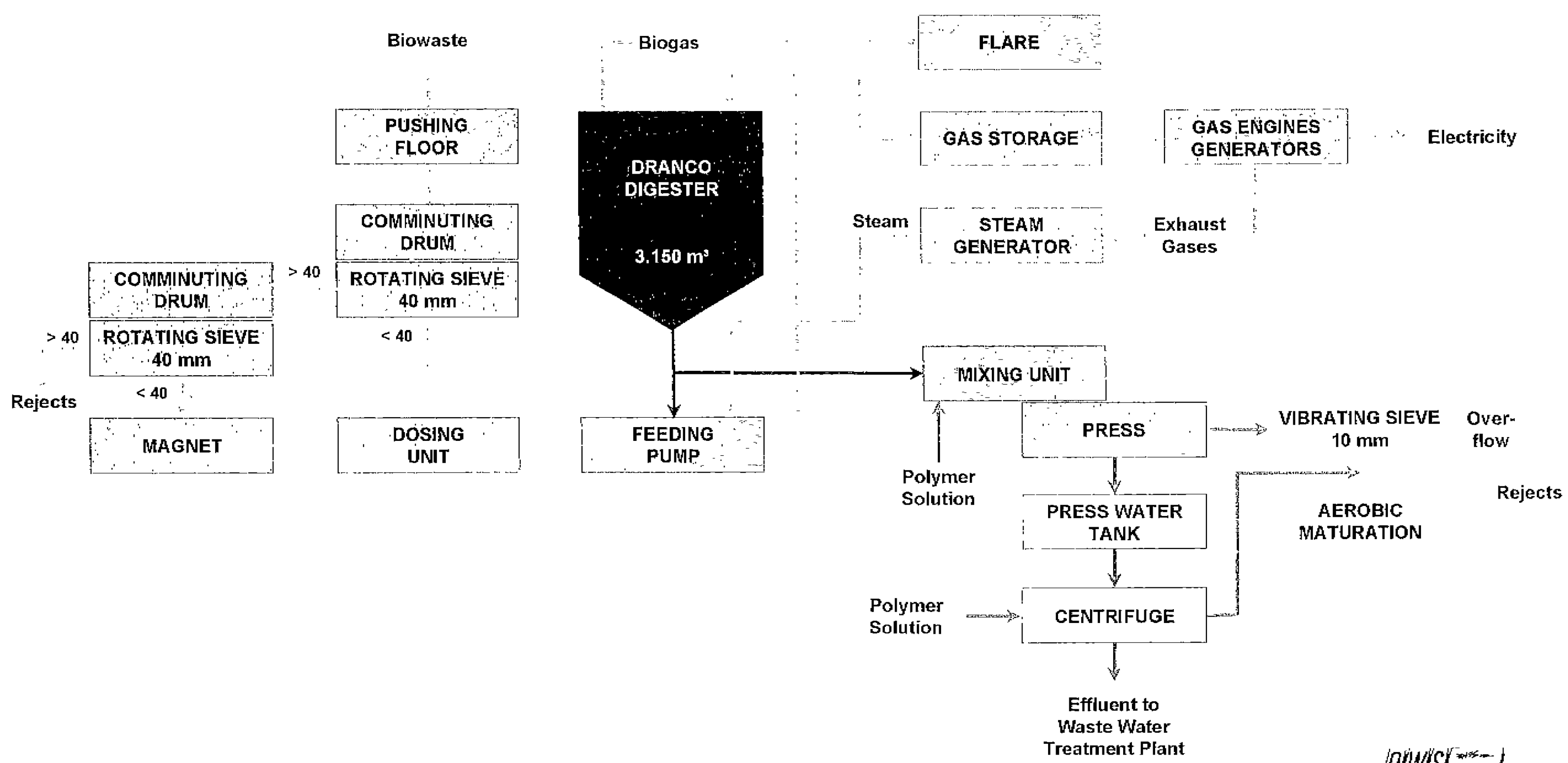
DRANCO PLANT BRECHT II (BELGIUM)



- Capacity : 35.000 tons/y -

OWS Organic Waste Systems

Anaerobic digestion of solid waste: state-of-the-art

L. De Baere

Organic Waste Systems N.V., Dok Noord 4, B-9000 Gent, Belgium

Abstract In order to make a correct assessment of the state-of-the-art of the technology, a study was made on the development of digestion capacity for solid waste in Europe. The study was limited to plants in operation or under construction that were treating at least 10% organic solid waste coming from market waste or municipal solid waste. A total treatment capacity for solid waste organics, excluding the tonnage used for sewage sludge and manures, evolved from 122,000 ton per year in 1990 to 1,037,000 ton available or under construction by the year 2000 in 53 plants across Europe, an increase by 750%.

Both mesophilic and thermophilic technologies have been proven, with about 62% of capacity being operated at mesophilic temperatures. Wet and dry digestion are almost evenly split, while a clear choice was made for one-phase systems instead of two-phase systems, which represent only 10.6% of capacity. The capacity provided by co-digestion systems is limited, while there is a rising interest in digestion of mixed household waste.

The reliable performance has been demonstrated for all types of anaerobic digestion systems. On the basis of the Dranco technology, a single-phase thermophilic dry digestion process, performances were reached similar to high-rate wastewater digestion. An annual average loading rate of 18.5 kg COD/m^3.day, resulting in a biogas production of 9.2 m^3/m^{3}reactor.day was obtained at a full-scale plant. The plant operated at a retention time of 15.3 days. Feedstocks range from clean organic wastes (31% dry matter) to heavily polluted grey waste organics (57% dry matter). Average dry matter concentrations of the digested residue of 41% were obtained.

Keywords Anaerobic digestion; capacity; performance; thermophilic; state-of-the-art

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Introduction

Anaerobic digestion has become an established and proven technology for the treatment of solid waste, coming from municipal solid waste, market or other industrial organics. In order to determine the state-of-the-art, an overview of the plants in operation or under construction was made over a period of 10 years. To accomplish that, a set of criteria were set forth in order to give a reliable assessment:

- Only digestion plants treating at least 10% of organic solid waste, coming from municipal or market solid waste, were taken into consideration, with a minimum capacity of 3,000 ton per year.
- The capacity is the designed capacity for the plant, unless specified differently by the supplier/operator. For biowaste, the total capacity was used while for mixed and grey waste plants, only the actual capacity going into the digesters was used. If operation of the plant ceased, then the digestion capacity was decreased accordingly during that year.
- The plants taken into consideration had to be at least under construction. No plants were taken that were awarded or contracted and where actual site works had not commenced or where the projects were not expected to be in operation by the middle of 2000. For the year 2001, a prognosis was made based on current tenders for very realistic projects.

It was hoped that these guidelines would establish a reliable view on the development of the technology.

Technology trends in capacity

Evolution of capacity

A total of 53 plants were identified that met the criteria for selection, totalling a capacity of 1,037,000 ton per year of organic solid waste up to the year 2000. Capacity increased at a rate of around 30 kton per year during the period between 1990 to 1995, while the rate of increase averaged 150 kton per year for the period 1996 to 2000. An increase of 200 kton per year is expected in 2001. (See Figure 1).

The increase in number of plants for those same periods rose from 2.4 plants per year installed to 7.2 plants per year, with the addition of 10 plants in 1998 alone. Most of the plants (30) were constructed in Germany and represented a capacity of 449,605 ton, with an average of 14,987 ton annual capacity. Nine plants were constructed in Switzerland but only had a total combined capacity of 78,500 ton/year, or 8,722 ton annual capacity on average. These capacities are rather small compared to the larger projects constructed in Belgium, The Netherlands and France, where average capacities were more of the order of 30 to 50 kton per year.

An overall trend towards larger projects can be observed. The average capacity, initially at 24,420 ton gradually decreased as small plants were being constructed in Switzerland and Germany on biowaste. However, since 1998, the size of the projects has been rising towards averages of 50,000 ton per year for the projects in the following years as large grey or mixed waste digestion projects are being planned. This increases the total average capacity from a low of 15,632 in 1997 to 21,704 ton per year in 2001.

All digestion plants were initially operated at mesophilic temperatures. The first thermophilic plants were dry fermentation plants and came on line in 1992 and 1993. The capacity of mesophilic operation increased by 350,000 ton during 1994 through 1999, while thermophilic capacity increased by 280,000 ton, or 70,000 ton and 56,000 ton per year respectively (see Figure 2). Some years, more mesophilic plants are added while during other years more thermophilic capacity is constructed as can be seen from Figure 3. No clear trend can be observed. It can be expected that the increase will be level for both temperature ranges, even though more suppliers are starting to provide thermophilic digestion.

Thermophilic operation was developed later but has been established as a reliable and accepted mode of fermentation. It provides the added benefit of treating the waste at higher temperatures and thereby increasing pathogen kill-off during the anaerobic phase. The added amount of heat does not seem to stop companies operating thermophilically, as higher gas production yields and rates are being claimed by various suppliers.

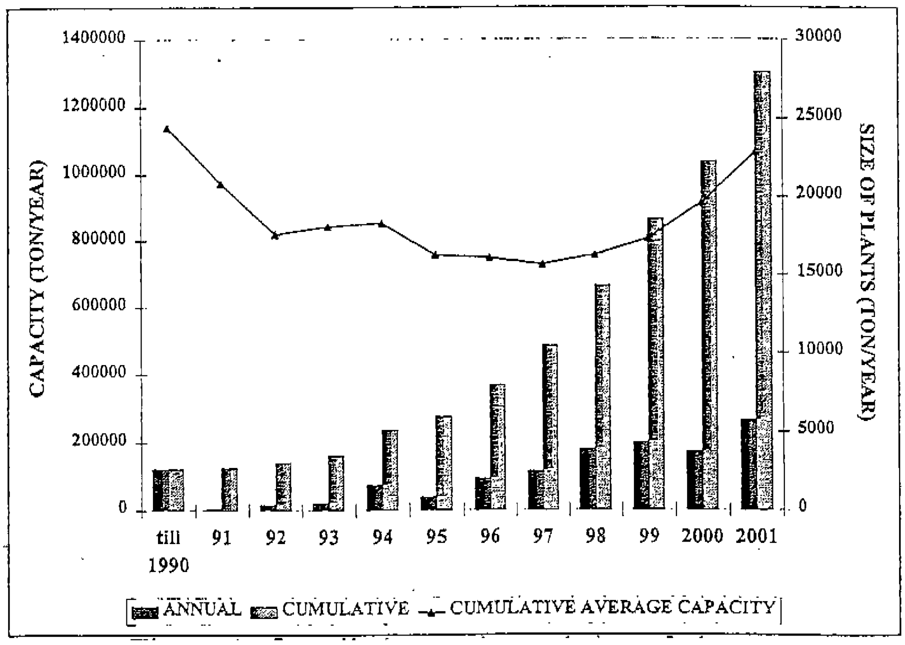


Figure 1 Installed capacity and size of plants

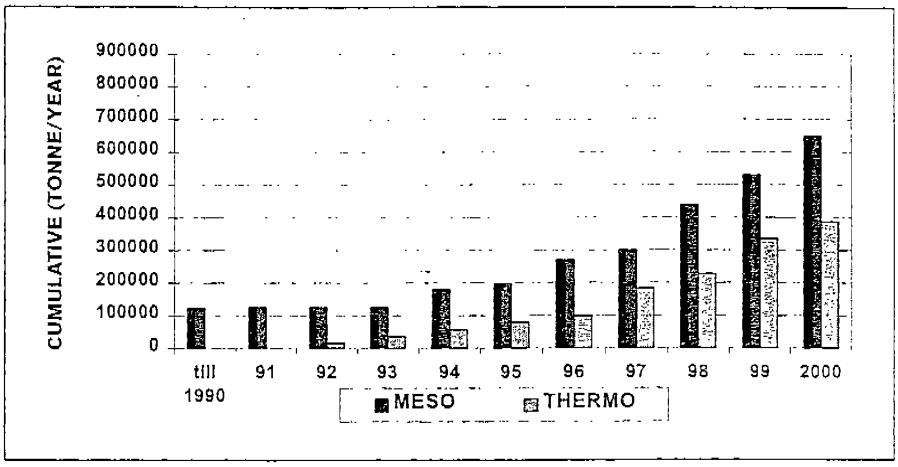


Figure 2 Mesophilic versus thermophilic : cumulative capacity

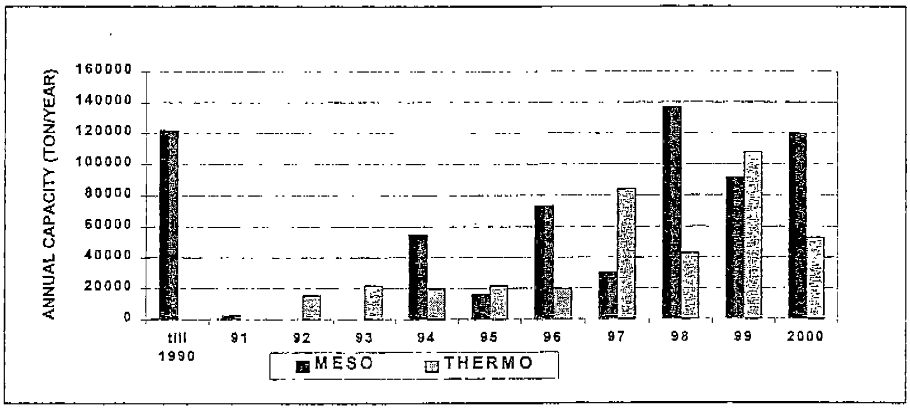


Figure 3 Mesophilic versus thermophilic : annual capacity

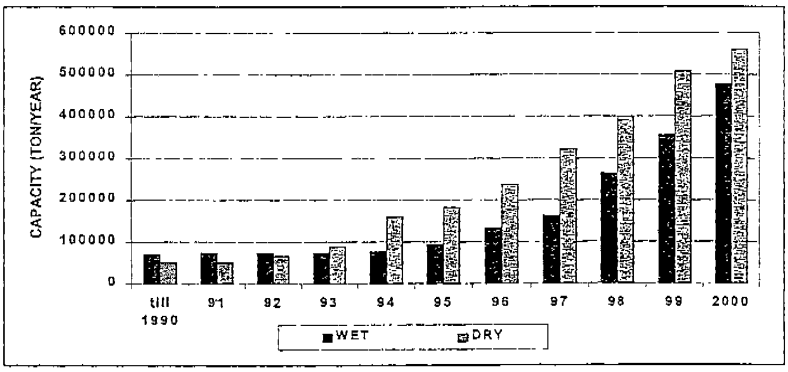


Figure 4 Wet versus dry

Wet versus dry fermentation

Most of the treatment capacity for solid waste was provided by wet digestion systems (more than 15% solids) at the beginning of the 1990's. From 1993 onwards, more dry digestion plants were constructed and in 1998, more than 60% of digestion capacity was provided by dry fermentation systems (see Figure 4). Some larger wet digestion plants are currently under construction. Dry digestion capacity is expected to be 561,000 ton per year by 2000,

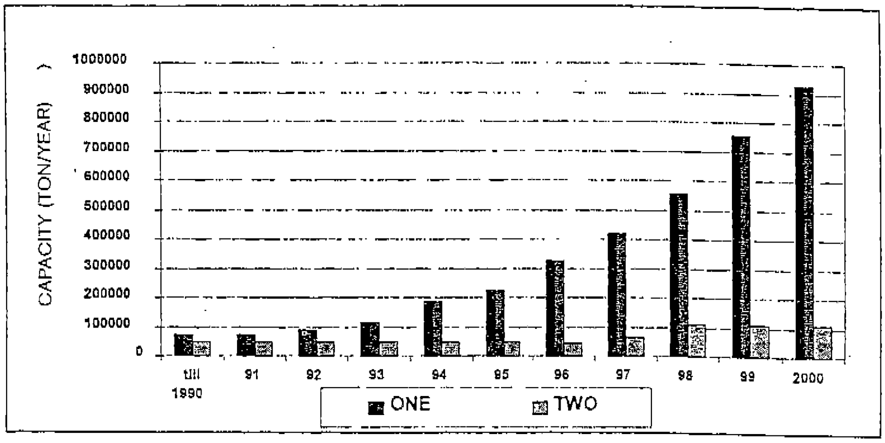


Figure 5 One phase versus two phase

representing 54% of the total capacity. No clear technology trend can be observed at this moment. Much will depend on the success of wet systems to deal with mixed and grey municipal solid waste.

Two-phase versus one-phase digestion

A lot of research has been carried out regarding two-phase and one-phase digestion. Even three-phase systems have been proposed. In practice however, two-phase digestion has not been able to substantiate its claimed advantages in the market place.

First of all, the added benefits in increasing the rate of hydrolysis and methanization have not been proven. On the other hand, high digestion rates have been obtained in one-phase systems. The added investment cost and operating complexity for two-phase systems have caused two-phase systems to be limited to a small market share. The increase in two-phase digestion was limited to only 60,000 ton over a 10-year period, from an existing capacity of 50,000 ton to a capacity of 110,000 ton in 2000 (see Figure 5).

Only 10.6% of the available capacity is provided by two-phase digestion systems. In 1996, there was even a decrease of capacity as one two-phase plant was taken out of operation. Most of the added capacity is derived from 2-phase plants operating on manure with organic solid waste as a co-substrate.

Codigestion

Codigestion is less applied than was expected (see Figure 6). It is quite common that an organic solid co-substrate is added to manure digesters in small amounts, but often these co-substrates are high-energy yielding industrial sludges and only quite exceptionally, solid waste from households or market waste is added. Among the projects identified, only 70,605 ton or 6.7% of the organic solid waste treated was done so by means of codigestion, mostly with liquid manure.

Solid waste often requires specific handling and pretreatment, so that a plant designed for liquid treatment can only treat clean types of waste that need little or no removal of inerts or size reduction. Also, solid waste tends to pollute the manure with different types of heavy metals and inerts, foreign to manure or sludge.

The addition of manure or sludges to solid waste treatment plants is also very limited. The additional investment for receiving tanks and pumps is not often made and liquid waste is not desirable since there is an excess of water that needs to be dealt with.

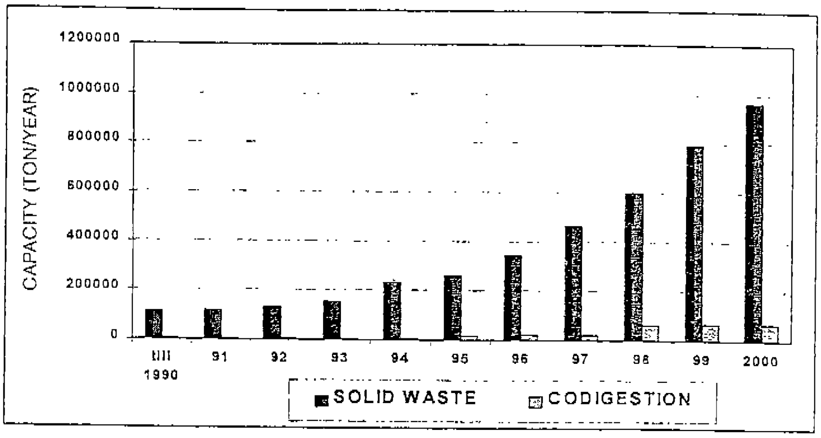


Figure 6 Codigestion versus solid waste digestion

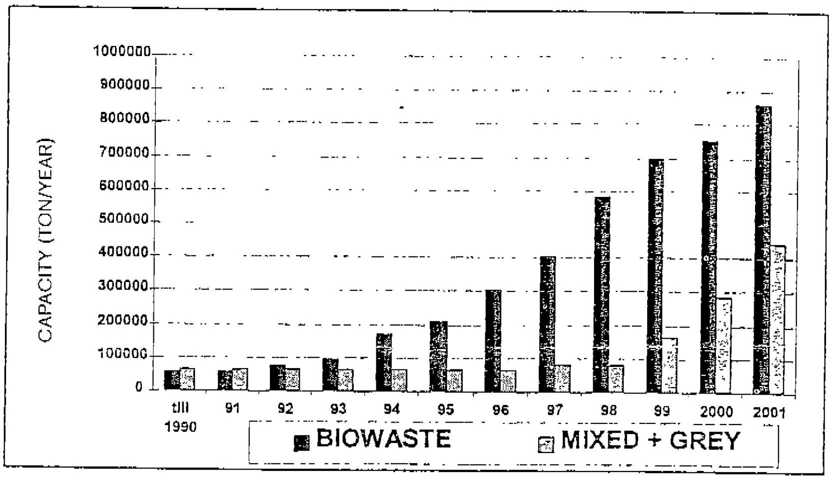


Figure 7 Mixed versus biowaste

Mixed waste versus biowaste

A whole development has taken place in the introduction of source separated collection, in which the collection of organic solid waste is done in separate bins at the household level. This has caused a boom in the construction of composting plants for biowaste.

Digestion of mixed household waste remained stable, but in the last couple of years, an increased interest can be observed in the treatment of mixed waste (see Figure 7). It is expected that mixed waste treatment will increase from 79,500 ton in 1998 to 374,500 ton in 2001, an increase of almost 100,000 ton of capacity per year.

Anaerobic versus aerobic

Anaerobic systems, however, could not benefit from the surge in composting capacity in the mid nineties to the same extent as aerobic systems (see Figure 8). Aerobic composting capacity increased with around 7,512,000 ton during the period of 1990 to 1999. Anaerobic digestion provided an increase of 443,000 ton in capacity, or only 6% of the total capacity increase (Grüneklee, 1997; Kern 1998,1999).

Anaerobic digestion was not considered as a fully proven technology until around 1995, a time at which many of the technology choices had already been made in favour of aerobic systems. The technology also was more expensive and many municipalities chose less risk and less investment. However, continued development has proven anaerobic digestion to

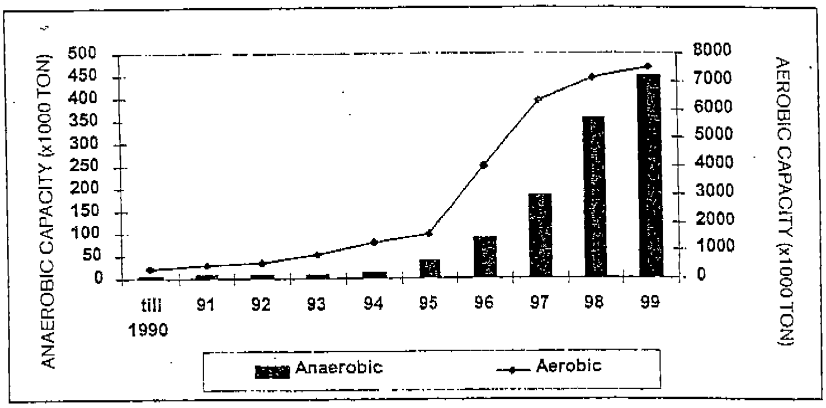


Figure 8 Development of aerobic and anaerobic composting capacity in Germany

be cost-competitive and a reliable performance has been demonstrated over a longer period of operation in various digestion plants.

Anaerobic capacity currently represents less than 5% of the total composting capacity in Europe. In some countries, however, the market share has reached more than 10% such as in The Netherlands and Belgium, where 15.6% and 11.9% of the composting capacity is provided by anaerobic technologies. This coverage even exceeds 25% of the capacity in larger composting plants in Switzerland. (Table 1).

Performance

Anaerobic digestion has obtained a place among the treatment technologies for organic solid wastes. The advantages have been proven to be significant and are justified even in light of initial higher investment costs in comparison to aerobic composting plants. Some of these performances and advantages will be highlighted further on, on the basis of the Dranco technology.

Operating parameters

High and consistent gas production rates can be achieved by using dry thermophilic operation. Optimisation of a plant in Brecht, Belgium has led to the consistent improvement and increase in gas production rates over a period of 7 years. A gas production rate of 9.2 m^3 biogas per m^3 of active digester volume was reached as an average annual rate. Peak weekly production rates of almost 13 m^3 of biogas were obtained. (Figure 9). These high rates as annual operating averages correspond to loading rates of approximately 18.5 kg of COD/m^3reactor.day of which 65% is converted to biogas. The average retention time during the year 1998 was 15.3 days, but when excluding the winter months the retention time was 13.7 days for March–November.

The dry matter averaged to 31.3% for the digested residue coming out after digestion. Values ranged from 25 to 37% dry matter depending on the season and an average pH of 8.3, indicating stable digestion. (Table 2).

Flexibility and energy

An important advantage of anaerobic digestion has been demonstrated to be the high flexibility in treating different types of wastestreams, ranging from wet to dry and from clean organics to grey waste.

Table 3 shows three plants treating significantly different organic wastestreams. The Salzburg plant treats a wet biowaste fraction with an initial dry content of 31% and a low ash content. Biowaste in Brecht is also collected from a more rural area, while non-recyclable

Table 1 Capacity in some European countries

	Ton/Year capacity	% of composting capacity
Germany	449,605	6%
Belgium	67,000	15.6%
The Netherlands	197,000	11.9%
Switzerland	78,500	26.6%

paper, such as diapers, paper napkins, etc., are also included. Dry matter is therefore higher, around 40% with a volatile solids of 55%. On the other hand, grey waste is being treated in Bassum. This is the waste remaining after source separated collection of biowaste, but still contains a significant amount of organics, mainly food and non-recyclable paper. The grey waste is screened over a sieve of 40 mm and the undersize is fed to the digester. This fraction represents 30% of the incoming grey waste and contains most of the fines and small organics. It also contains stones, glass and inerts smaller than 40 mm. Glass is around 10 to 15% by weight. The dry matter is high, namely 57% with 51% of volatile solids.

Anaerobic digestion has been used successfully over at least 2 years for each of these substrates, with a digester operating at 22, 31 and 41% dry matter in the digested residue respectively. Ranges as wide as from 17 to 47% were observed for the same digester configuration.

Energy production has remained an important parameter, even though energy prices have been dropping. The greenhouse effect, sustainable development and the ozone layer depletion have all contributed to the value of anaerobic digestion as a renewable energy source.

The contribution in renewable energy is not negligible. Anaerobic digestion requires on average an additional 15 kWh per ton of energy in comparison to aerobic composting plants. When this is taken into account, then the biogas generated at the three plants under consideration, yields a surplus energy of 165 kWh, 220 kWh and 245 kWh per ton for the plants of Brecht, Salzburg and Bassum respectively. This represents a value of 14 to 21 Euro per ton.

Conclusions

Anaerobic digestion of solid organic waste has been established as a reliable technology in Europe. There are currently more than 50 full-scale plants with a treatment capacity of more than 1 million ton per year. In several countries, anaerobic digestion capacity is

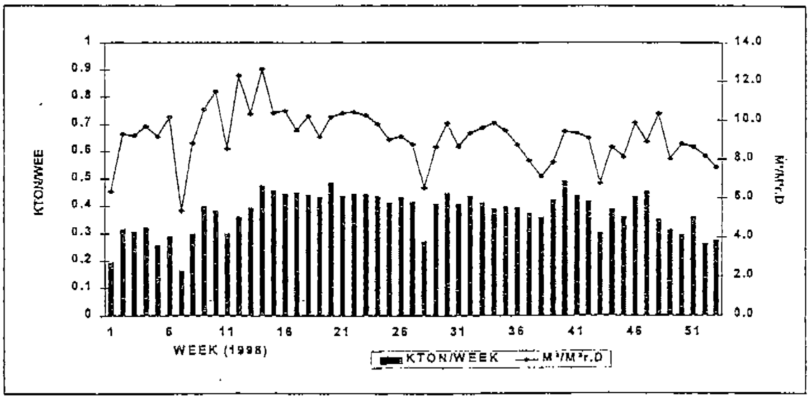


Figure 9 Biogas productivity and tonnage fed (Brecht)

Table 2 Performance of Dranco plant Brecht, Belgium, in 1998

Tonnage Fed:	20,049 ton
Gas yield:	102.5 Nm^3/ton (55% CH_4)
Gas production rate (m^3/m^3 reactor.day):	9.2
Retention time:	15.3 days (13.7 excluding winter)
Loading rate per day:	14.9 kg VS/m^3 or 18.5 kg COD/m^3 (65% conversion)
Dry matter:	31.3% (25–37%)
pH:	8.3
Height in digester:	19.6 metres

Table 3 Comparison of waste composition and process parameters of the Dranco plants in Brecht, Bassum and Salzburg

Dranco Plant	Salzberg, Austria	Brecht, Belgium	Bassum, Germany
Capacity	20 000 t/y	20 000 t/y	13 500 t/y
Kitchen Waste	80%	15%	grey
Garden Waste	20%	75%	waste
Paper Waste	—	10%	
Dry Matter Substrate	31%	40%	57%
Volatile Solids Substrate (on Dry Matter)	70%	55%	51%
Dry Matter Content in the Digested Residue	22%	31%	41%
	(17–27%)	(25–37%)	(35–47%)
Nm^3 biogas/ton of Waste	135 Nm^3/t	103 Nm^3/t	147 Nm^3/t

already treating more than 10% of the organic waste, and capacity is steadily increasing all across Europe.

Both mesophilic and thermophilic and wet and dry systems have been marketed successfully. Two-phase and codigestion systems have so far been limited to around 10% of the capacity. A trend towards the treatment of mixed and grey waste can be observed, and is resulting in large-scale plants in the range of 100,000 ton instead of the average 20,000 ton per year capacity installed thus far.

Digestion has increased dramatically due to the introduction of source separate collection. However, most of the composting infrastructure was constructed when anaerobic digestion as a technology was not fully established on a full-scale. It can be expected in the next years, that digestion capacity will be added when existing composting plants need to be remodelled or when the capacity of the plant needs to be enlarged.

As far as performance is concerned, high biological decomposition rates have been demonstrated over long periods of time, even exceeding many of the high-rate wastewater treatment plants, such as USAB or fixed bed digestion systems for industrial wastewaters. A net energy surplus of 165 to 245 kWh per ton of waste treated can be generated in the form of electricity. Besides the energy production, important advantages such as high flexibility and reduced odors will make anaerobic digestion very attractive in the next millennium.

References

Grüneklee, C. (1997). Development of composting in Germany. Proceedings of the International Conference on "*Organic Recovery and Biological Treatment into the Next Millennium*", ORBIT 1997, Harrogate, United Kingdom, 313–316.

Kern, M., Fulda, K. and Mayer, M (1998). Stand der Biologischen Abfallbehandlung in Deutschland, Teil I: Kompostierung. *Müll und Abfall*, **11**, 694–699.

Kern, M., Fulda, K. and Mayer, M. (1999). Stand der biologischen Abfallbehandlung in Deutschland, Teil 2: Vergärung. *Müll und Abfall*, **2**, 78–81.

DRANCO REFERENCE LIST

I. Demonstration plants

1. *Demo plant Gent, Belgium*
   - Substrate : mixed garbage and biowaste
   - Volume : 60 m^3
   - Year : 1984

2. *Demo plant Bogor, Indonesia*
   - Substrate : market waste
   - Volume : 30 m^3
   - Year : 1986

3. *Demo plant Florida, USA*
   - Substrate : mixed garbage
   - Volume : 1 m^3
   - Year : 1989

4. *Demo plant Graz, Austria*
   - Substrate : mixed garbage
   - Volume : 5 m^3
   - Year : 1990

5. *Demo plant Kagoshima, Japan*
   - Substrate : garbage and manure
   - Volume : 30 m^3
   - Year : 1998

II. Full-scale plants

1. Brecht I

Location :	Brecht, Belgium (near Antwerp)
Project :	DRANCO-plant for the anaerobic digestion of source-separated organic waste
Capacity :	20,000 ton/year
Start-up :	July 1992
Client :	IGEAN
Operating company :	DRANCO nv (a subsidiary of O.W.S.)

2. Salzburg

Location :	Bergheim-Siggerwiesen, Austria (near Salzburg)
Project :	DRANCO-plant for the anaerobic digestion of source-separated organic waste
Capacity :	20,000 ton/year
Start-up :	December 1993
Client :	Salzburger Abfallbeseitigung Gesellschaft (SAB)

3. Bassum

Location :	Bassum, Germany
Project :	DRANCO-plant for the anaerobic digestion of the organic fraction of grey waste and sludge
Capacity :	13,500 ton/year
Start-up :	June 1997
Client :	Abfallwirtschaftgesellschaft mbH (AWG)

4. Aarberg

Location:	Aarberg, Switzerland
Project :	DRANCO-plant for the anaerobic digestion of source-separated organic waste
Capacity :	11,000 ton/year
Start-up :	January 1998
Client :	Vergärungsanlage Seeland AG (VEGAS)

5. Kaiserslautern

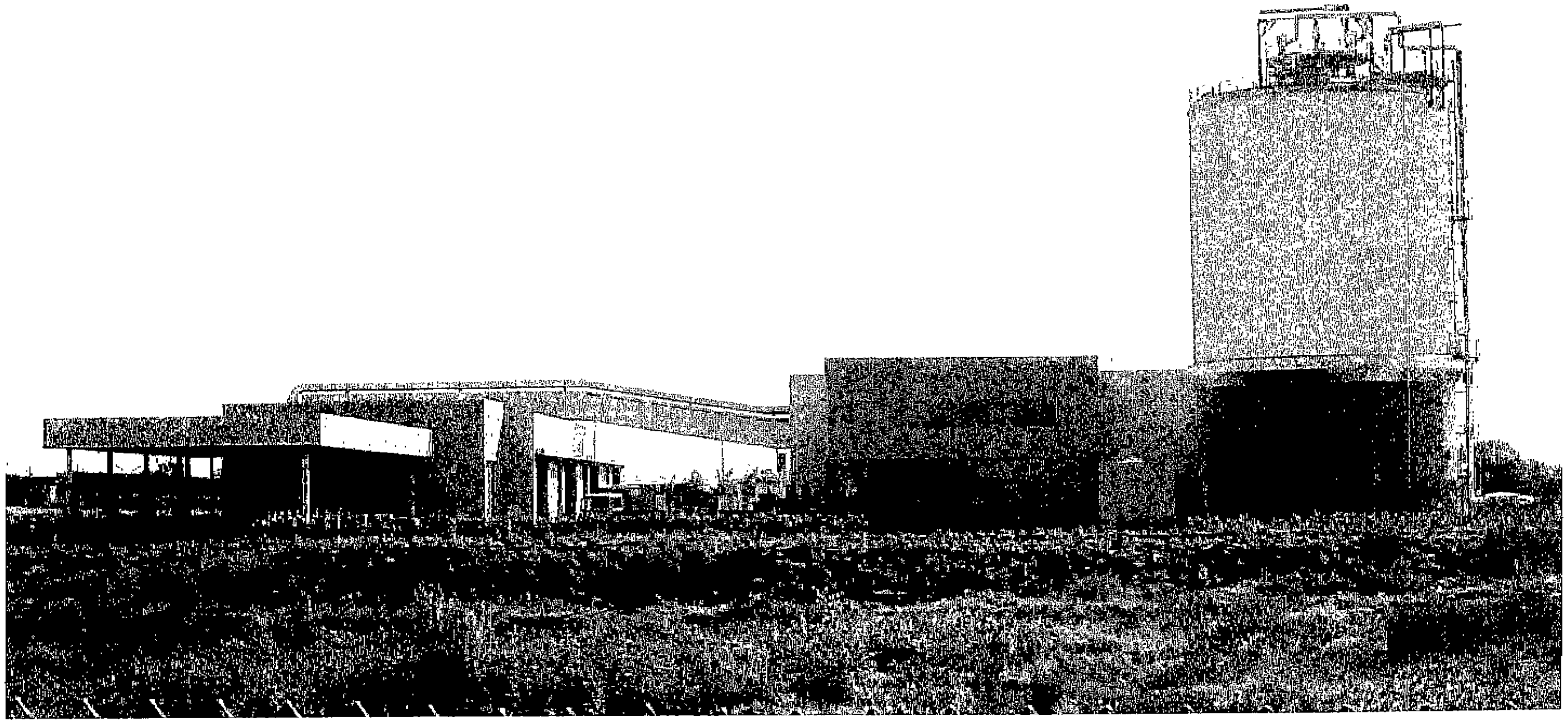
Location :	Kaiserslautern, Germany
Project :	DRANCO-plant for the anaerobic digestion of source-separated organic waste
Capacity :	20,000 ton/year
Start-up :	January 1999
Client :	Zweckverband Abfallwirtschaft Kaiserslautern ZAK

6. Villeneuve

Location :	Villeneuve, Switzerland
Project :	DRANCO-plant for the anaerobic digestion of source-separated organic waste
Capacity :	10,000 ton/year
Start-up :	February 1999
Client :	SA Compost Chablais-Riviera

7. Brecht II

Location :	Brecht, Belgium (near Antwerp)
Project :	DRANCO-plant for the anaerobic digestion of source-separated organic waste
Capacity :	50,000 ton/year
Start-up :	January 2000
Client :	IGEAN



DRANCO plant Brecht II (Belgium)

*** Capacity : 50.000 tons/y * Digester volume : 3.150 m³ * In operation since January 2000 ***

OWS
Organic Waste Systems

PRICES WASTE MANAGEMENT OPTIONS
(1996, in US$ per ton)

	Holland	Germany	Belgium
1) Composting	60	151	80
2) Incineration	135	486	110
3) Landfilling	105	402	75

OWS Organic Waste Systems

BREAKTHROUGH OF COMPOSTING ?

- GERMANY : 30 million people
- HOLLAND : 15 million people
- BELGIUM : 4 million people
- AUSTRIA - SWITZERLAND : 11 million people
- FRANCE - ITALY : first projects
- SPAIN - UK - SWEDEN - ... : not relevant

TOTAL : 60 million people

Organic Waste Systems

PACKAGING DIRECTIVE 94/62/EC ?

	RECYCLING	RECOVERY
After 5 years	25-45% (At least 15% per material)	50-65%
After 10 years	TO BE REDEFINED (with view on substantial increase	

- Upward derogations granted to Denmark, Germany and Holland
- Downward derogations granted to Greece, Ireland and Portugal
- Recycling = material, organic and energetic

(Priority to be defined only after LCA's)

prEN 13432 :
1) MATERIAL CHARACTERISTICS

- ORGANIC MATERIAL : VS > 50% of TS
- HAZARDOUS SUBSTANCES, e.g. HEAVY METALS :

MAXIMUM 50% OF NORM FOR COMPOST

Zn	150	Cr	50
Cu	50	Mo	1
Ni	25	Se	0.75
Cd	0,5	As	5
Pb	50	F	100
Hg	0.5		

Organic Waste Systems

EN 13432 : TECHNICAL ASPECTS

- MATERIAL CHARACTERISTICS
  - VOLATILE SOLIDS - HEAVY METALS
- BIODEGRADATION
  - 90% PASS LEVEL (ABSOLUTE or RELATIVE) - 6 MTHS
  - NATURAL MATERIALS EXEMPTED
- DISINTEGRATION
  - PILOT-SCALE
- COMPOST QUALITY
  - CHEMICAL ANALYSES
  - ECOTOXICITY TESTS : 2 PLANT TESTS + IN FUTURE ANIMAL TOXICITY TESTS ?

附件三

附件三

Cargill Dow

Where performance comes naturally™

NatureWorks™ PLA Work-in-Progress

Pat Gruber, Ph.D.
Vice President
Chief Technology Officer

NatureWorks™
Cargill Dow Polymers LLC

Where we came from

- 12 years ago
- Annually renewable resources
- Reduce fossil resources & $C0_2$
- Develop value added properties & economically viable

Agenda

- Business Opportunity
  - Application
  - Benefits
- Environmental Performance
  - Energy Use
  - Carbon Dioxide
  - Disposal Options

Cargill Dow LLC

- Building a platform of products made from renewable resources
  - Polymers & Chemical Intermediates
- Initial Commercialization Phase
- 140,000 MT PLA Capacity by end of 2001
- Global Stand-alone organization
- Several Hundred Million Dollar Investment
- >110 US Patents Issued, 400 Pending Worldwide

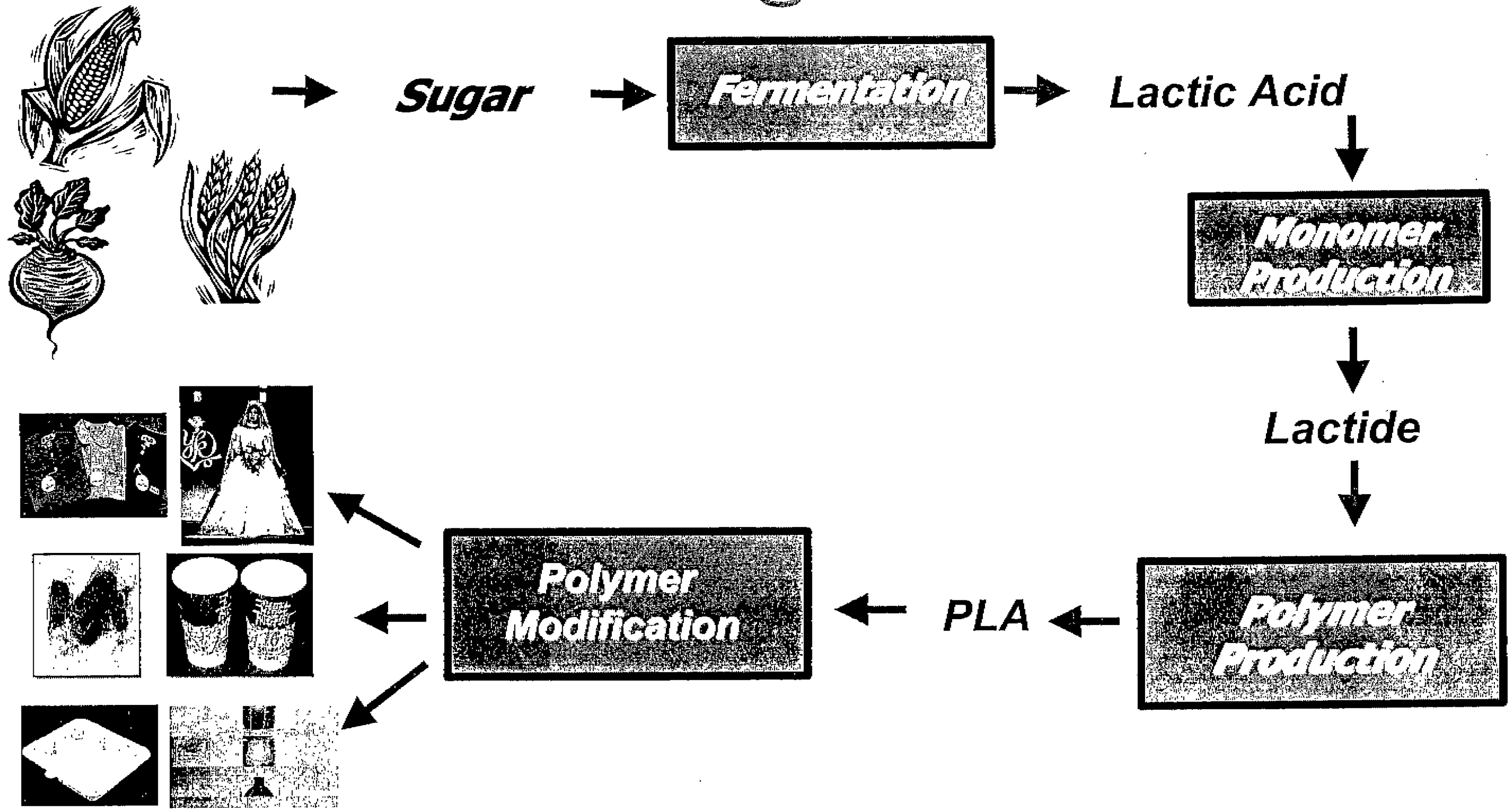
What Cargill Dow is About:

- Develop and Deliver Value Added Properties
  - Create new solutions
- Reducing “environmental footprint”
  - Drive down use of fossil resources
  - Reduce emissions of green house gases
  - Use our products to help customers and consumers to reduce their environmental footprint
- Design products with end-use disposal in mind from outset
  - Waste Options
  - Assist customers in design of their products

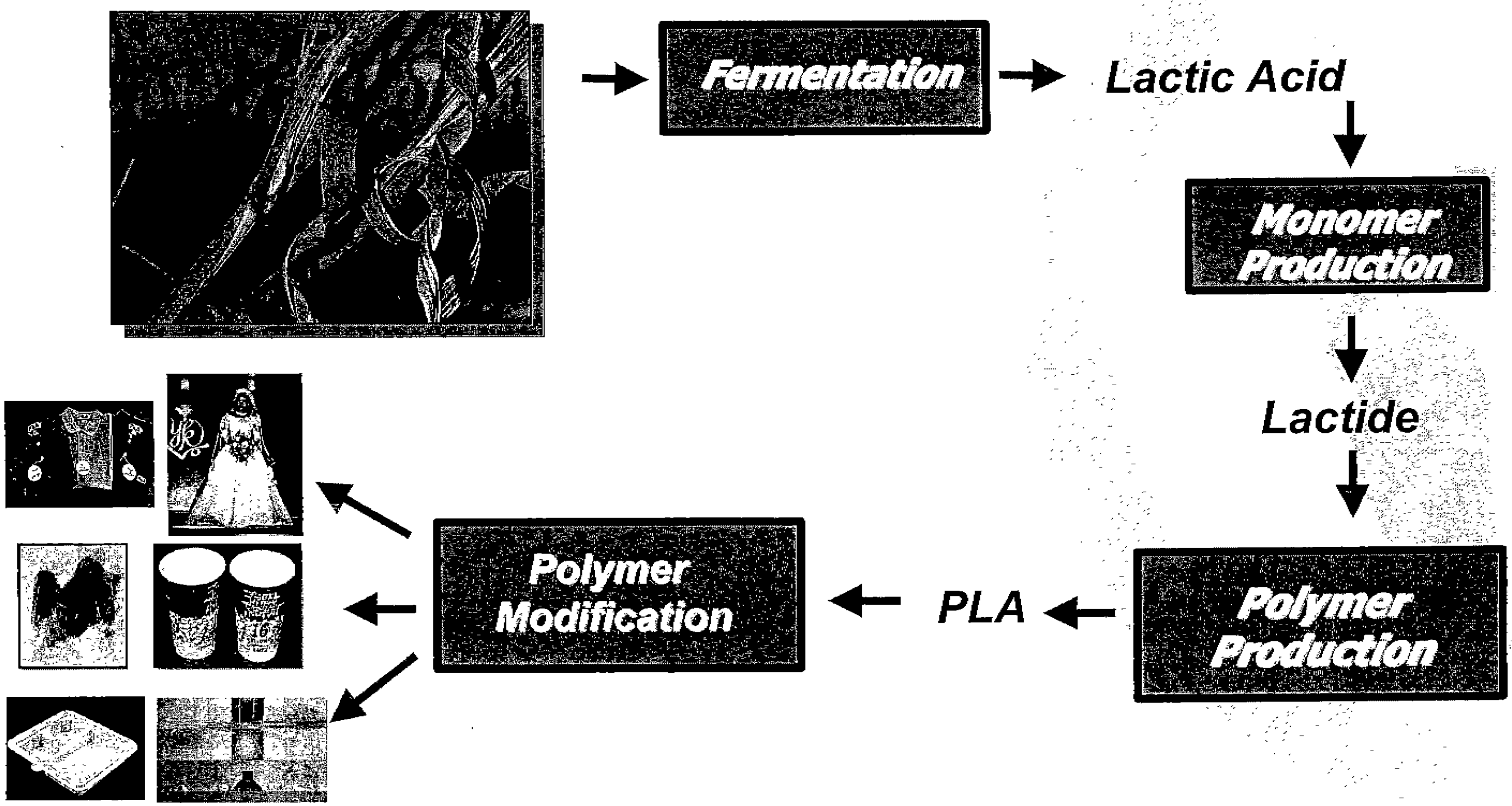
Fermentation Based Company

- Core strength & competency
- Long-term potential use of multiple crops & biomass
- Wide range of products
- Reducing environmental impact

PLA Manufacturing Overview



PLA Manufacturing Overview



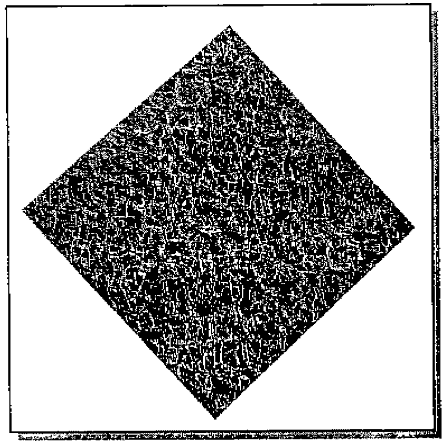
Initial Target Markets

- Fibers
- Packaging
- Chemical Intermediates

Market Opportunity is Created Because PLA has Attributes that Add Value

Fiber Applications

Carpet Tiles



Apparel

Industrial Fibers and Non-wovens

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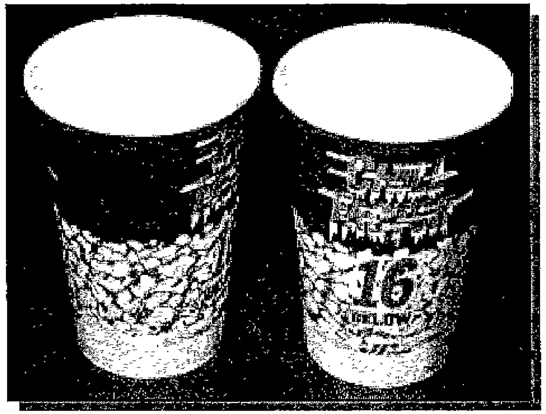
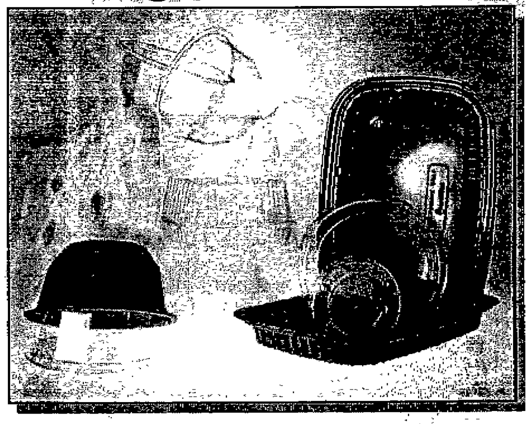
PLA Packaging Applications

Films

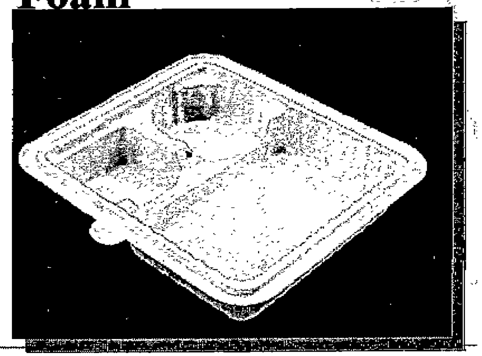
Coated papers



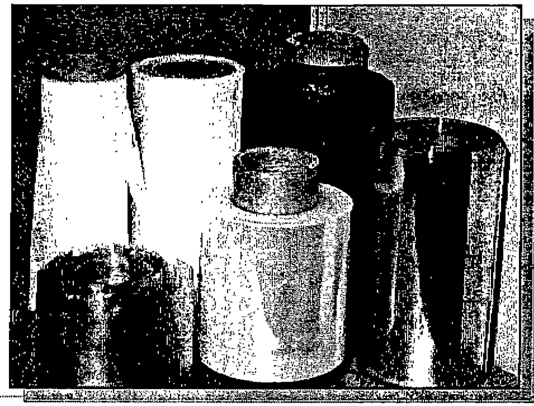
Rigid containers



Foam



PLA Packaging



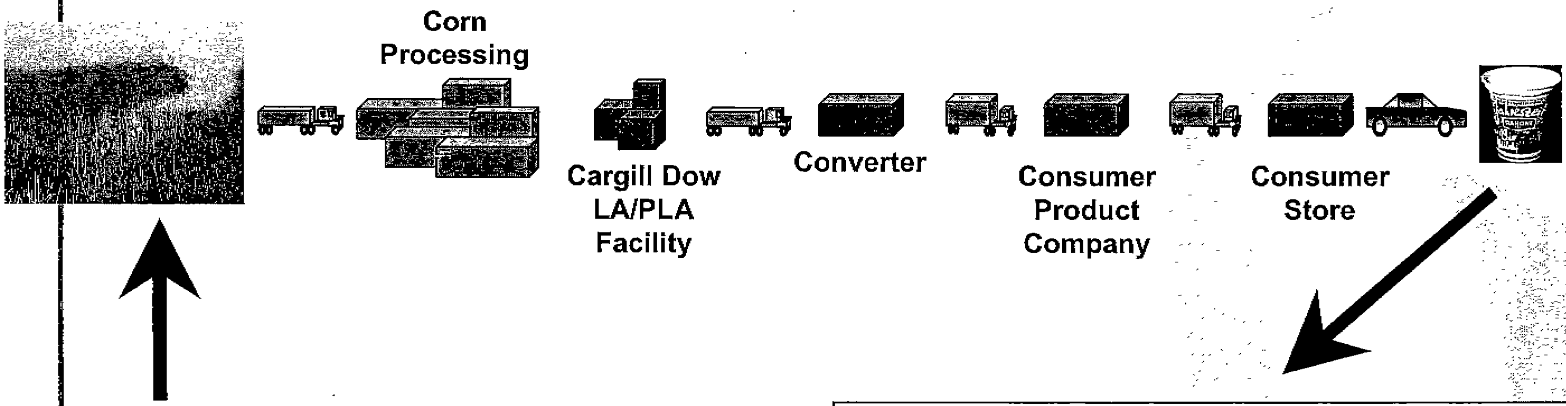
Technology Goals

- Reduce Energy of our Process
  - Reduces NOx and SOx as well
  - Reduce CO_2
- Develop Biomass Feedstock Source
  - Lowers Cost
  - Reduces CO_2
- Develop Enhanced Products made from PLA
  - Reduced material use
  - Develop products using the special attributes of PLA

Environmental Footprint

- Measure all inputs and outputs
  - Raw materials, upstream and downstream
  - All products through manufacturing and product use and disposal
- Energy, CO_2, other impacts on environment
- Use the information to take action to improve!

Taking a full look at total environmental footprint

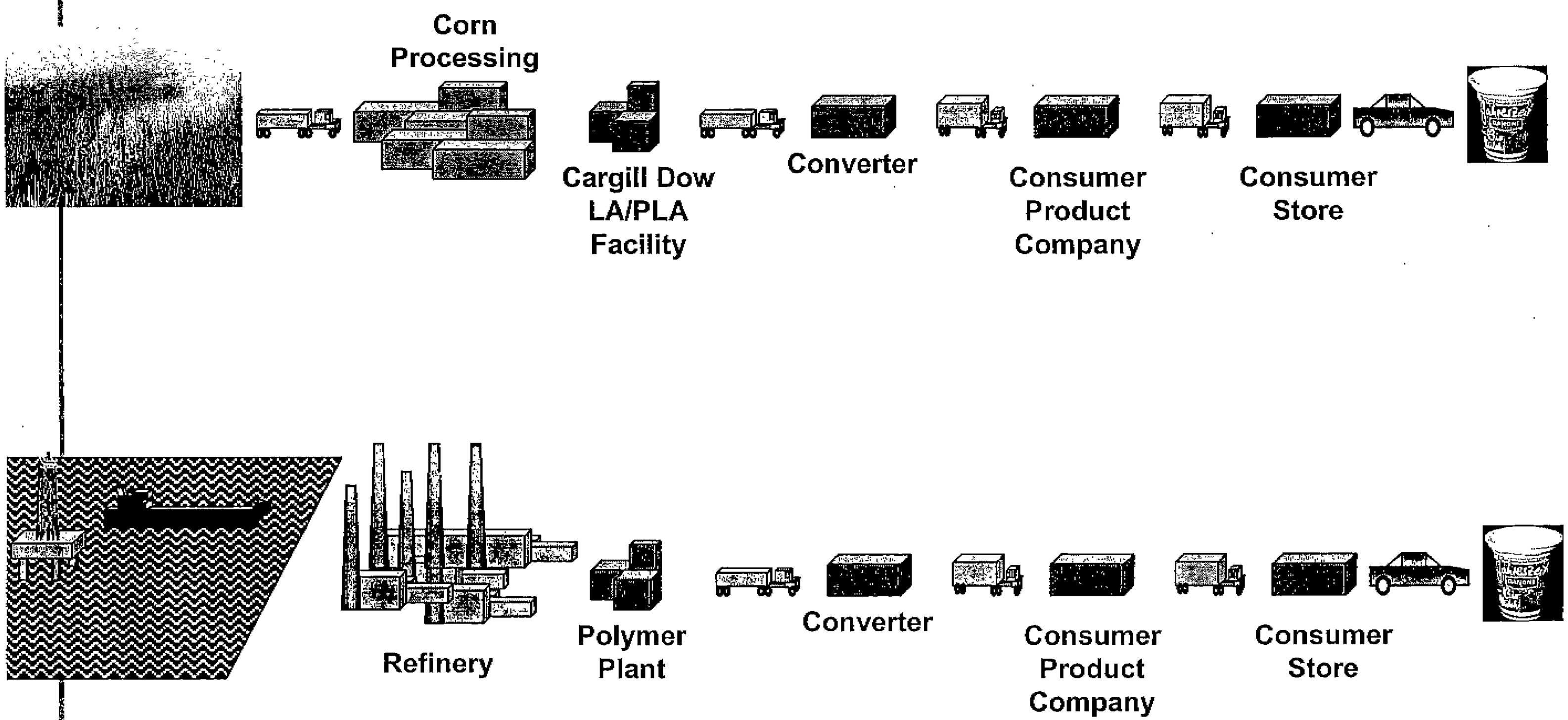


Water
Fertilizer Production
Pesticide, Herbicide Production

Waste Management System

Incineration
Recycle
Composting
Anaerobic Digestion
Landfill

Comparisons

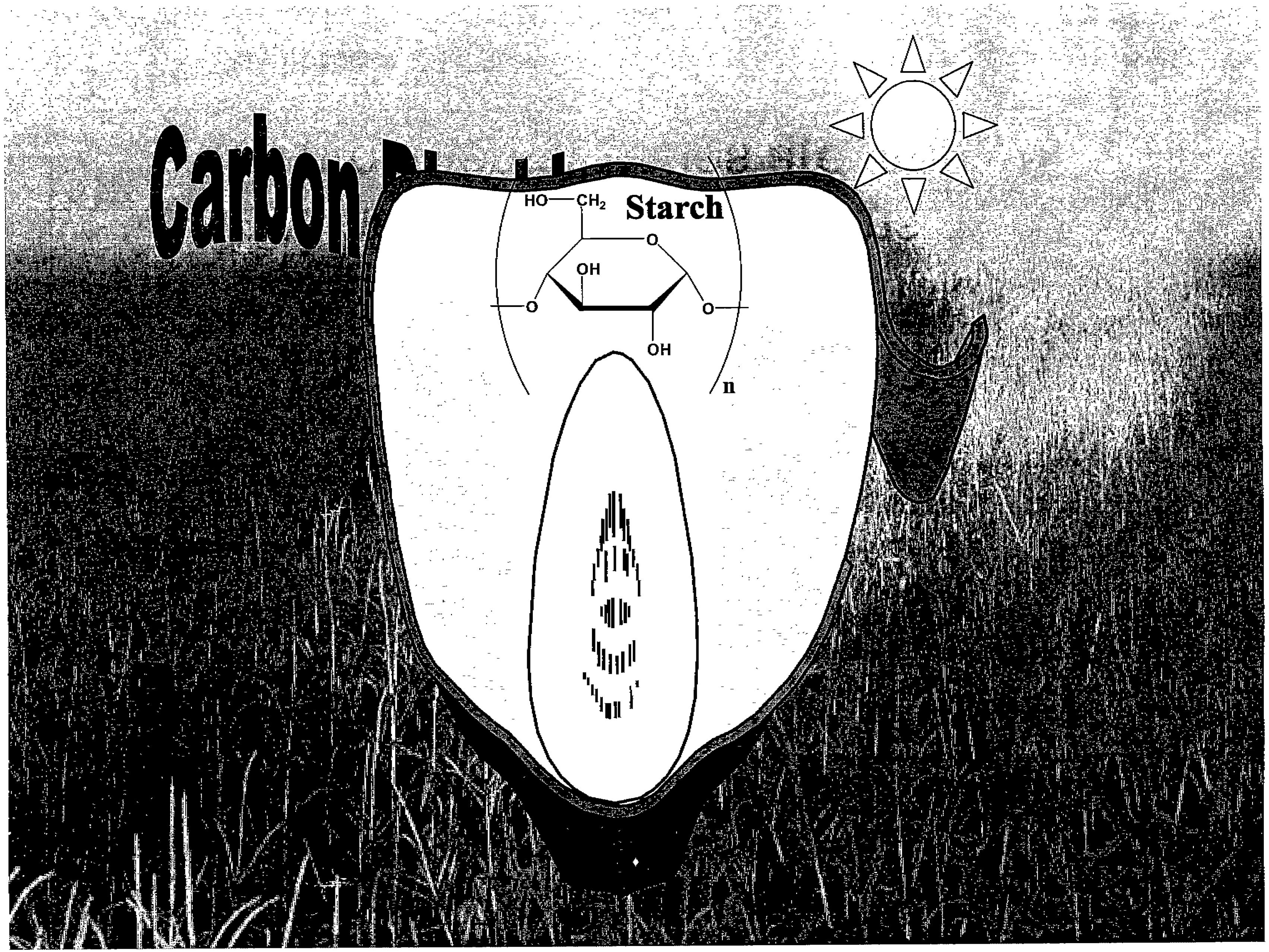


A Good Start on Life Cycle

- "Real" Raw Material Data is Difficult to Obtain
  - Oil
  - Agriculture
- Still sorting out farming practices in Nebraska and Iowa
  - Soil Conservation
  - Low Impact Farming
- We haven't finished building our first plant yet

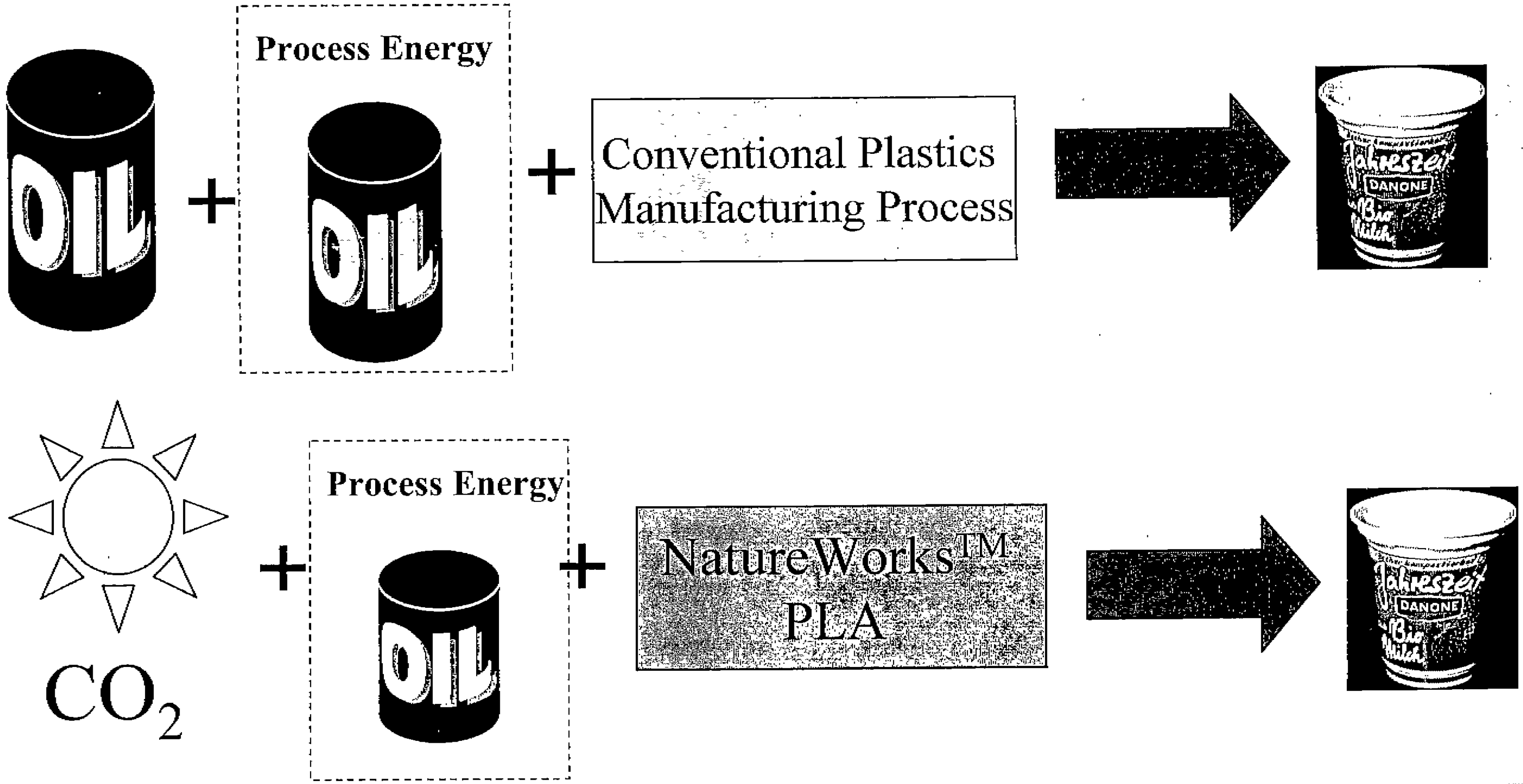
Understanding ***"Environmental Footprint"*** is crucial to making raw material, process, product choices.

Solving a problem like solid waste does no good if, for example, other unacceptable forms of environmental issues are created

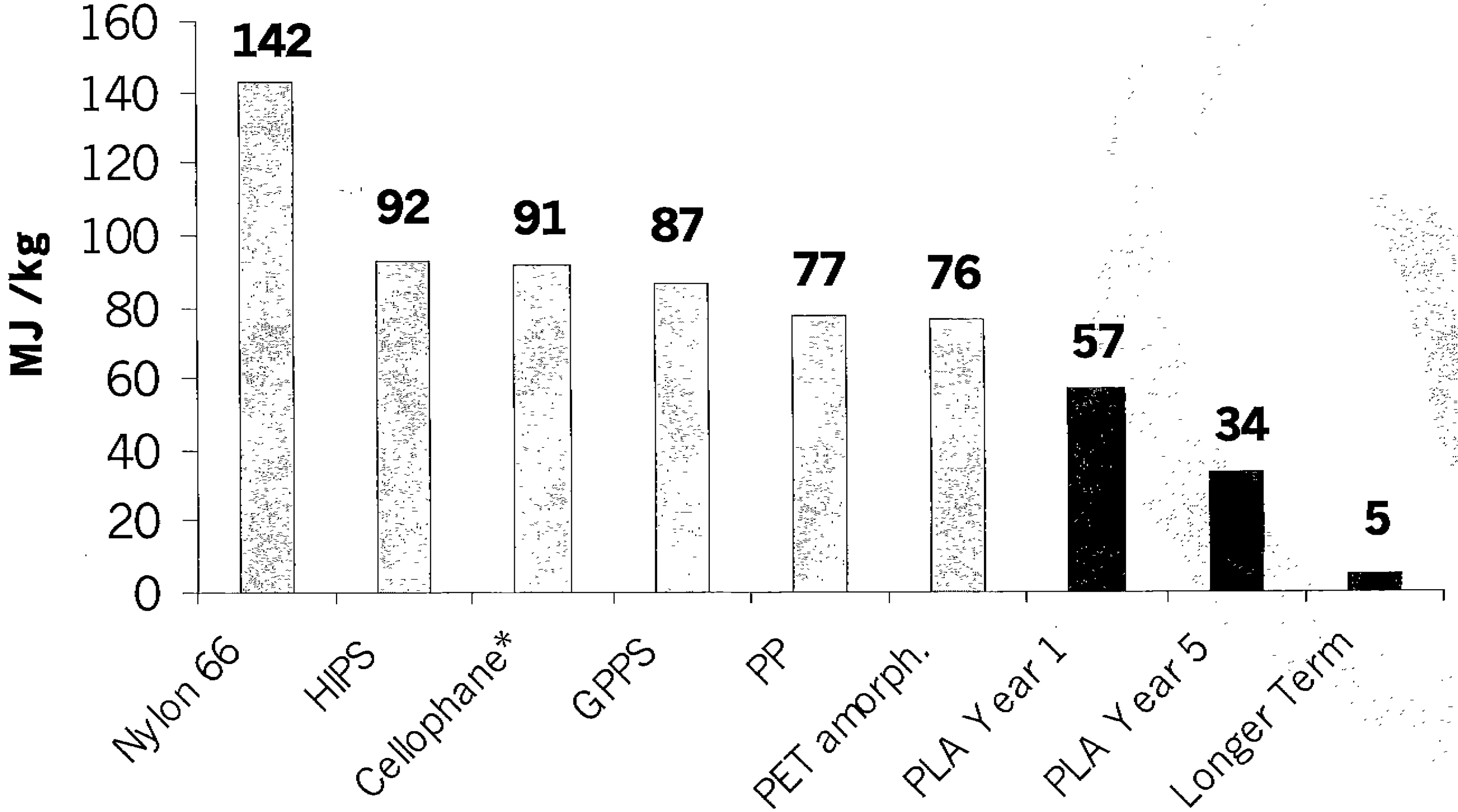


Carbon
Starch
HO—CH2
OH
OH
n

Renewable Resource Benefit



Fossil Resource use in Common Plastics Measured in Energy



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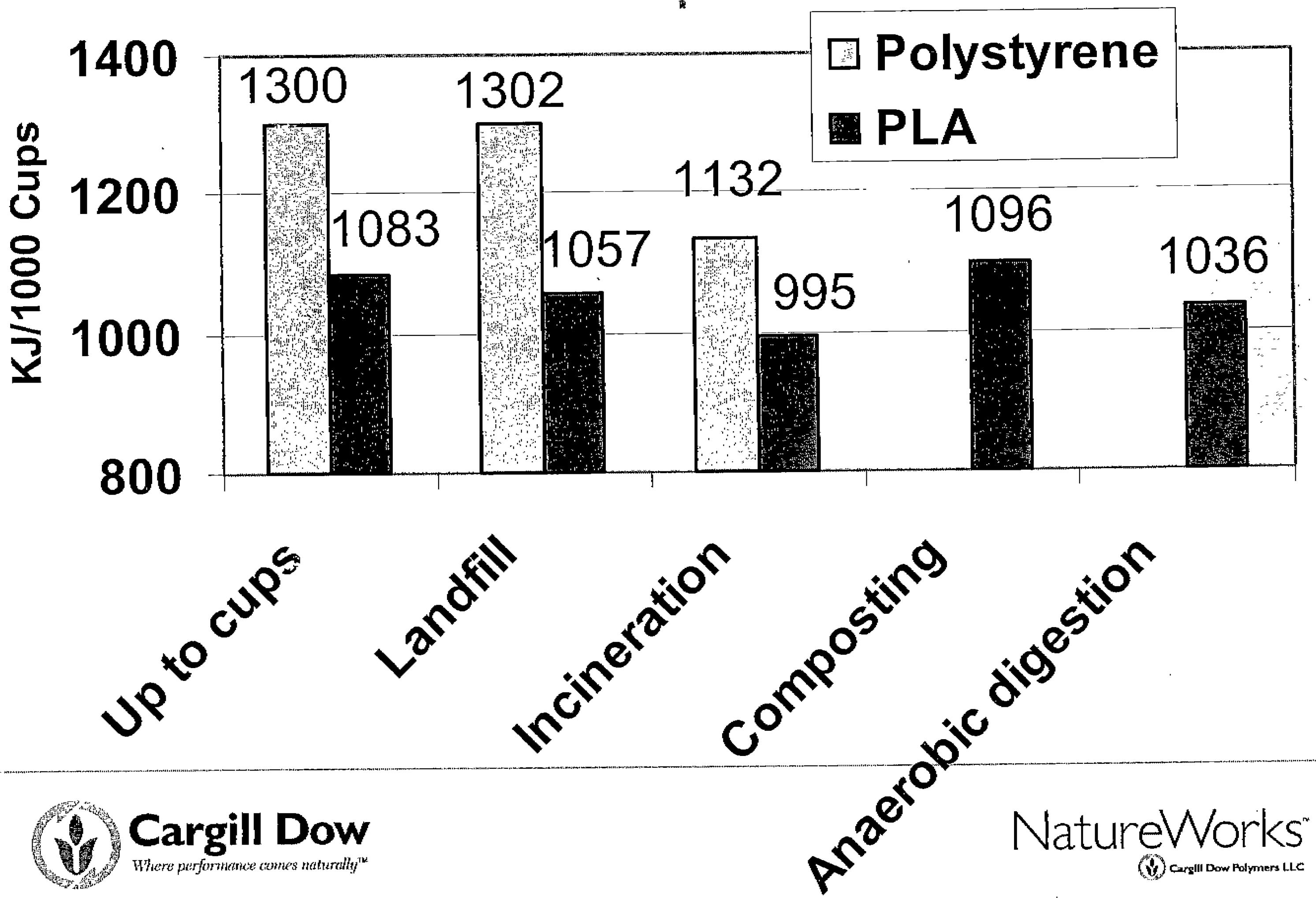
Fossil Resource Use Cradle to Grave PLA versus PS cups



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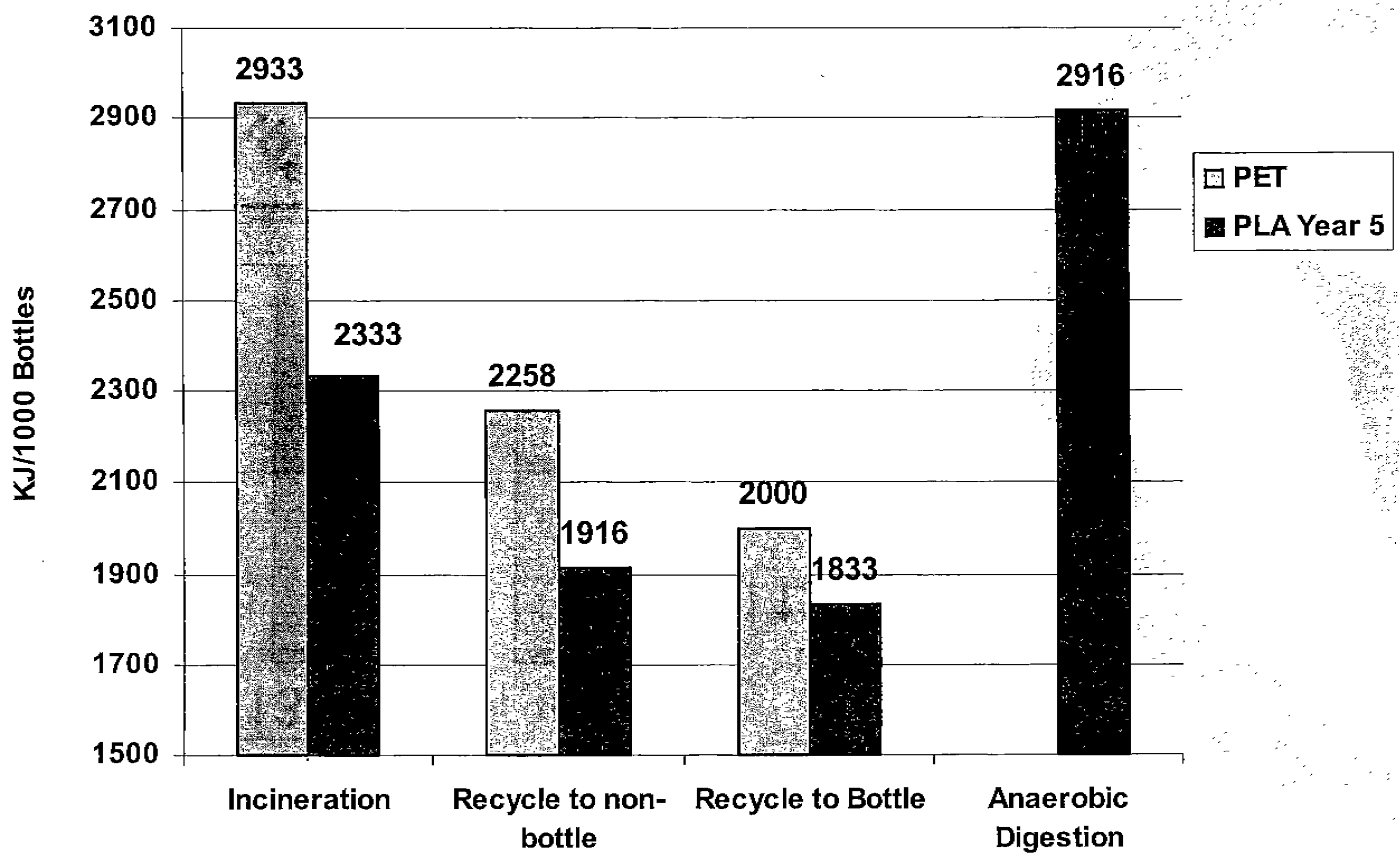
Cradle to Grave: Bottles Fossil Resource Use



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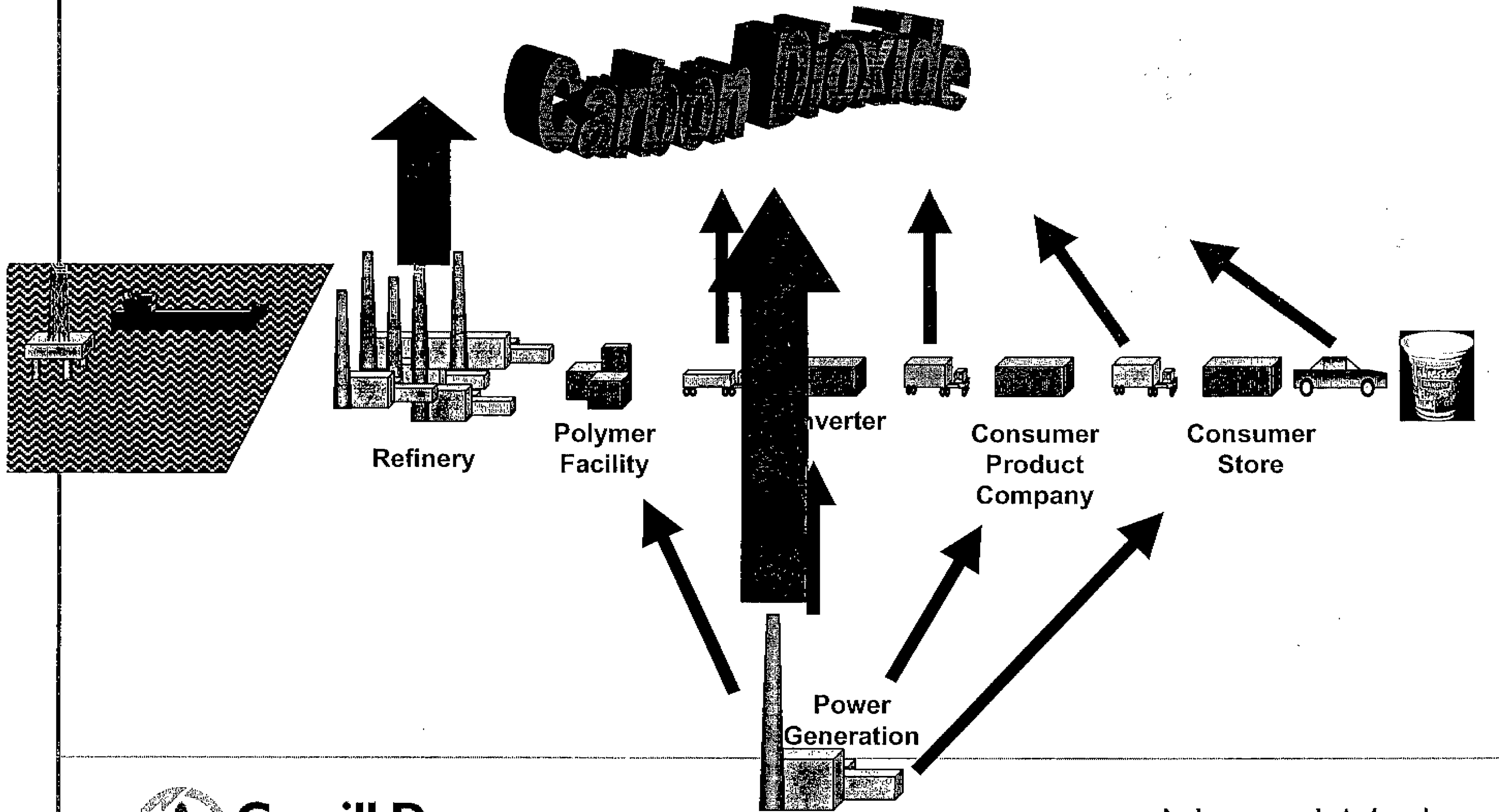
CO_2 Emissions with Typical Plastics



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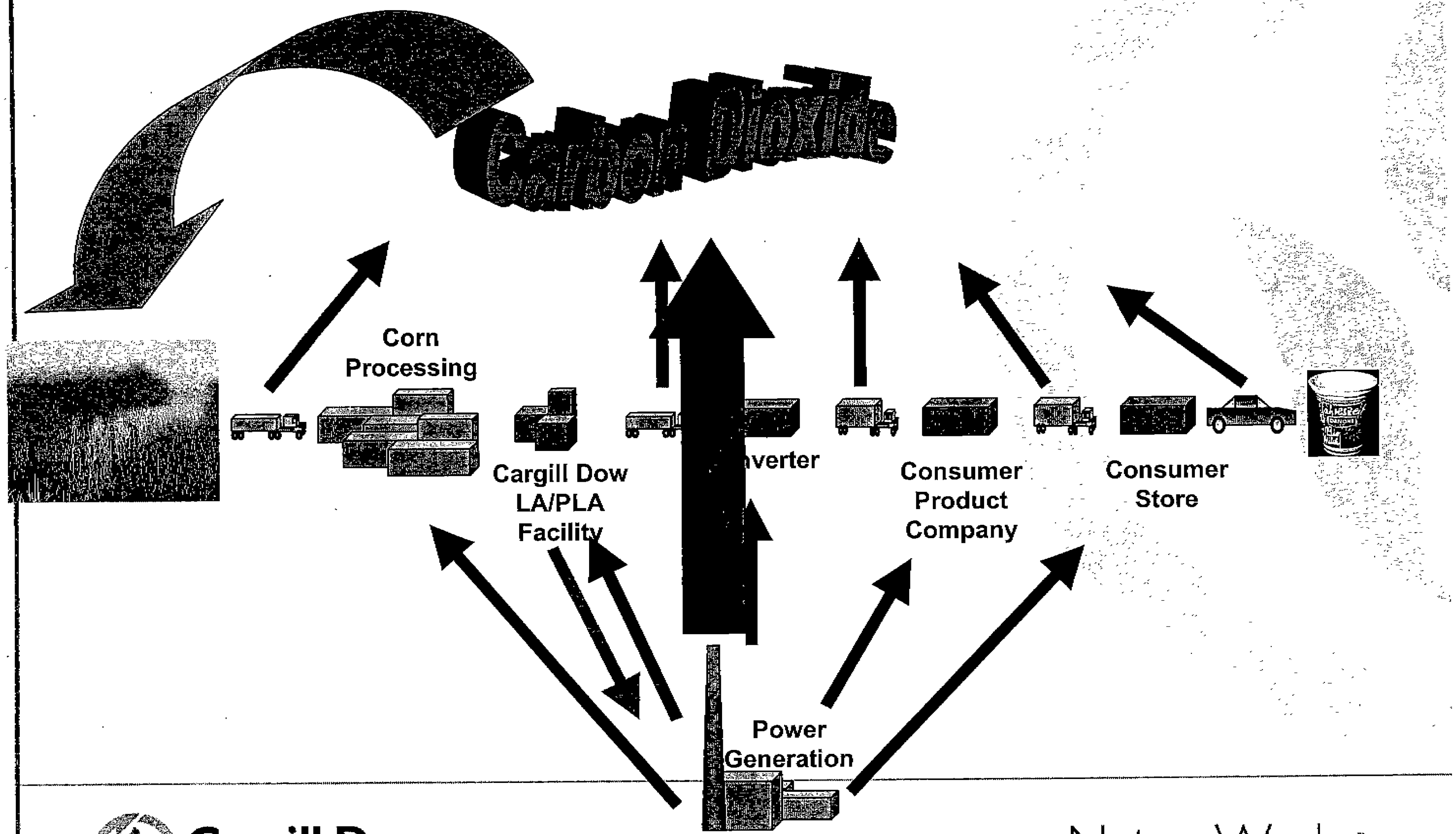
CO_2 Emissions with PLA



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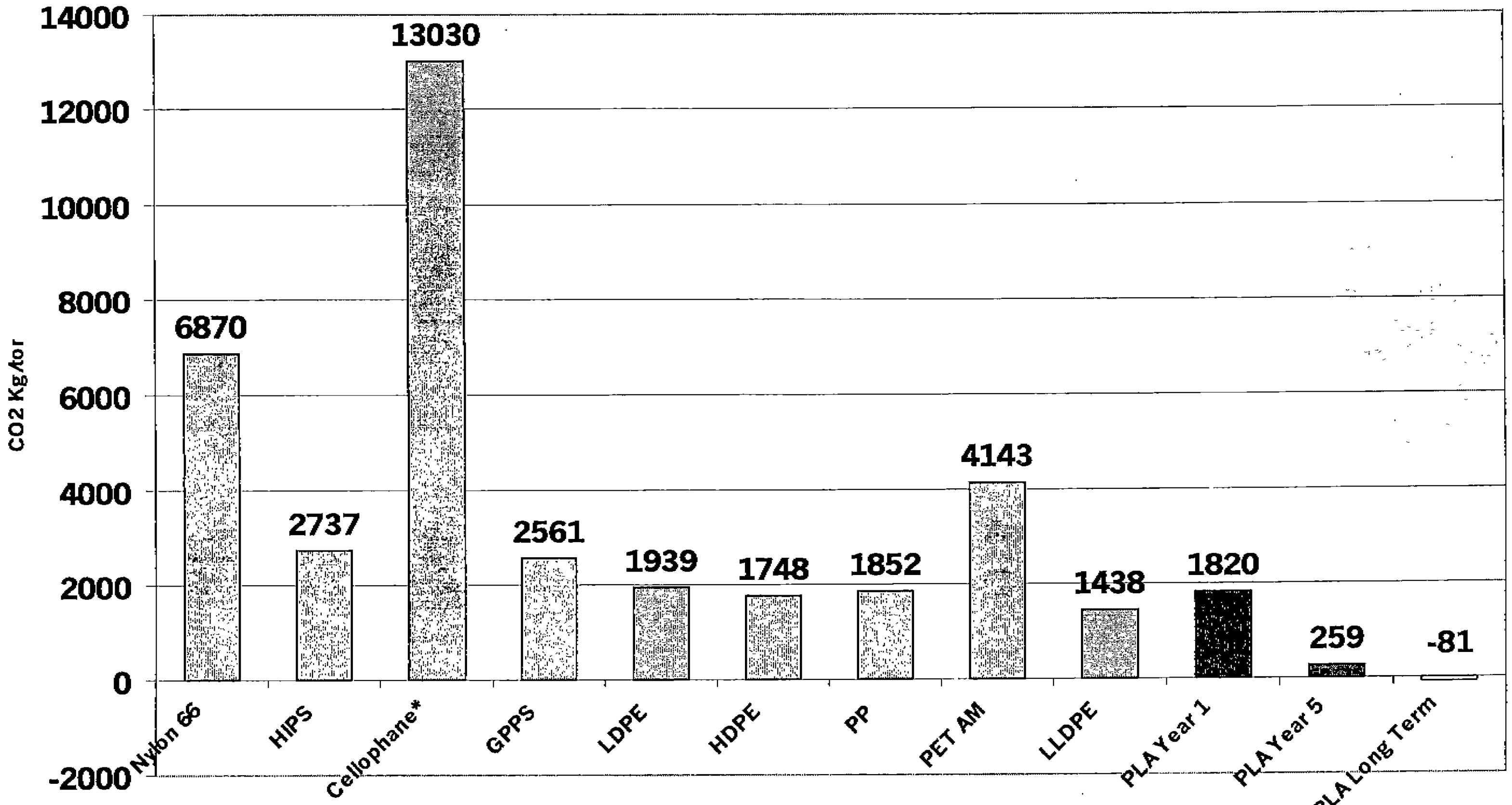
Net CO_2 Emissions: Cradle to Pellets



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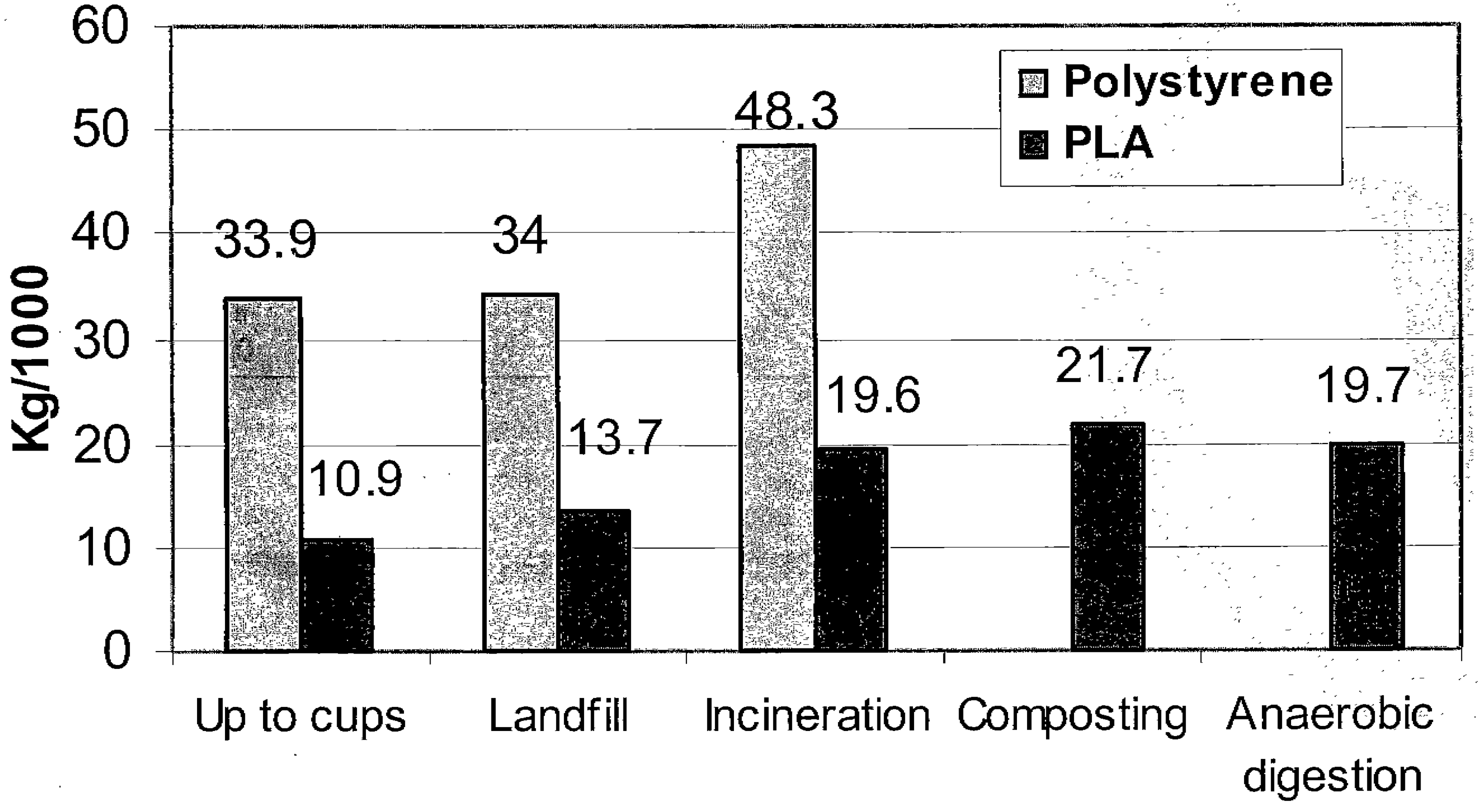
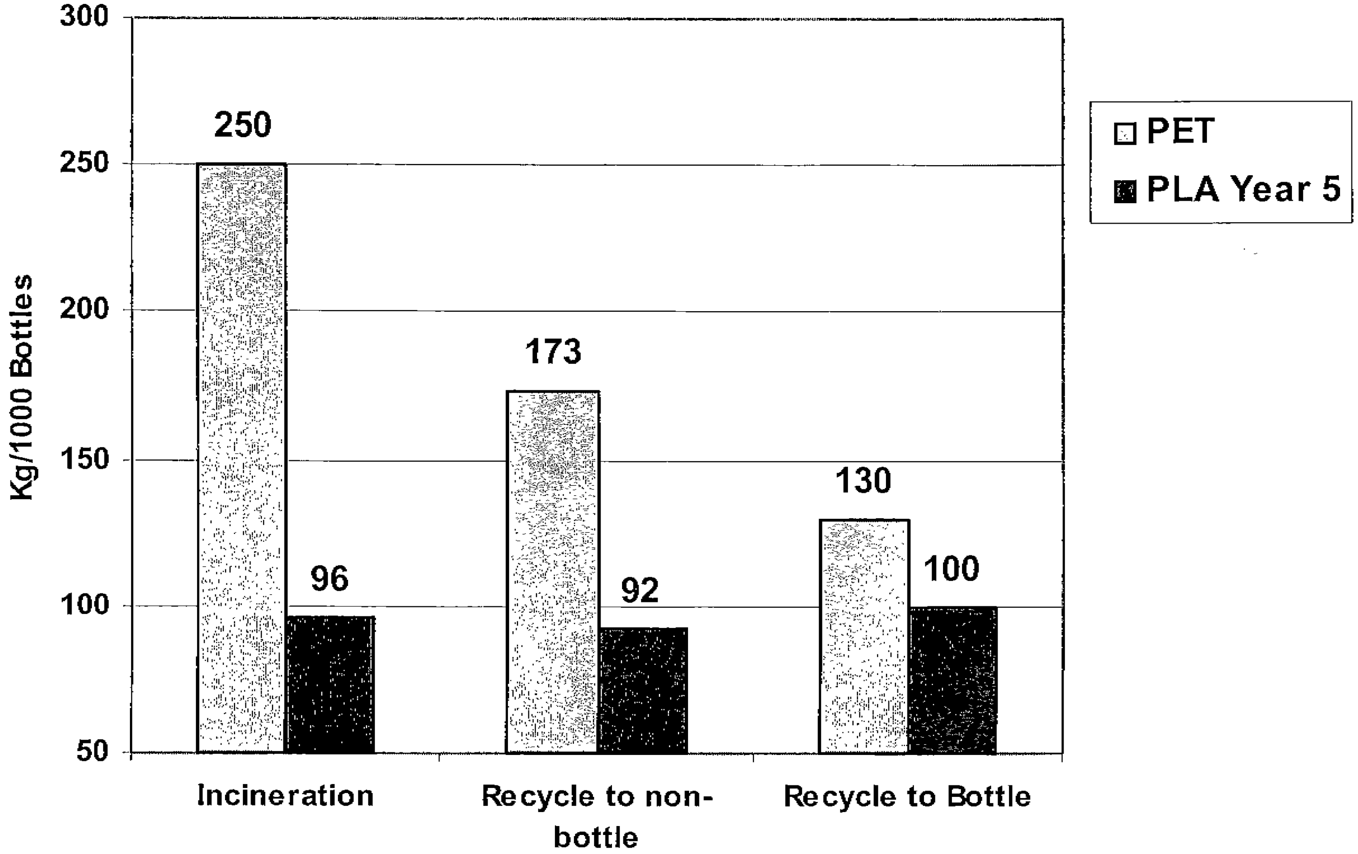
Gross Carbon Dioxide Emission Cradle to Grave PLA versus PS cups



Cargill Dow
Where performance comes naturally™

NatureWorks™
Cargill Dow Polymers LLC

Cradle to Grave: Bottles CO_2 Emissions



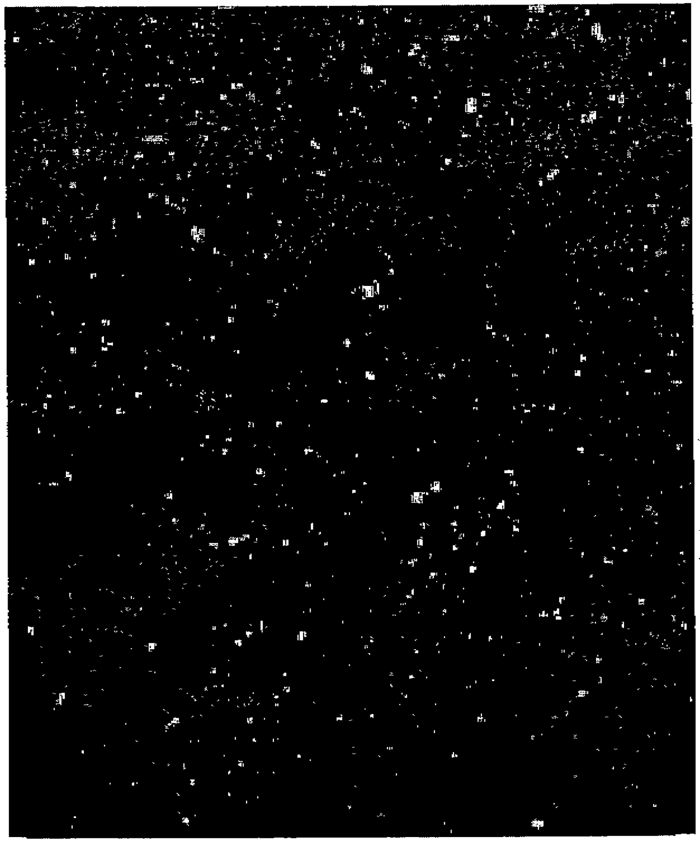
Designed to Fit Any Waste Management System

- Recycle
- Incineration
- Landfill
- Composting
- Anaerobic Digestion

Composting

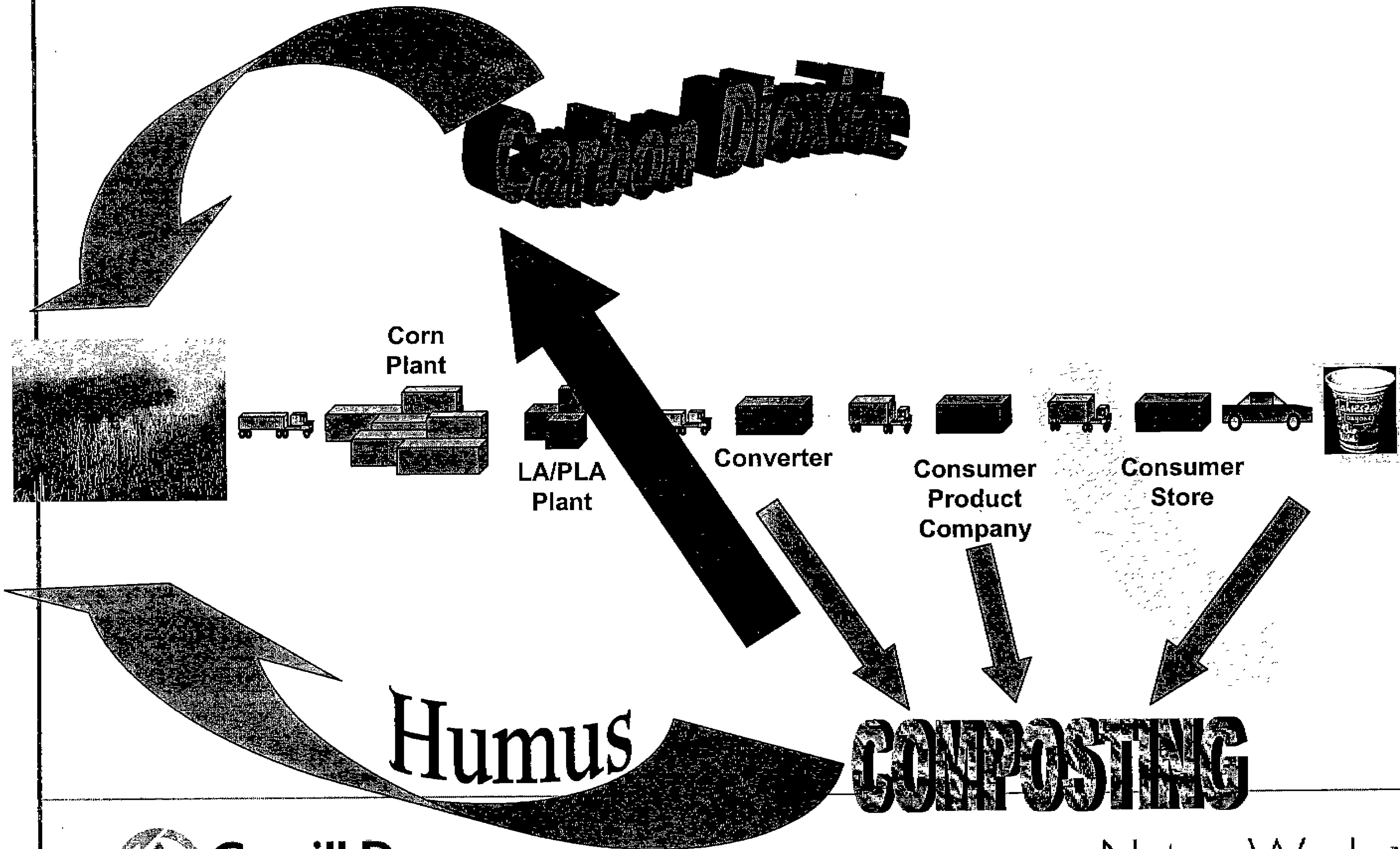
- Requires the specific conditions of high temperature and moisture found in municipal compost systems

- Specific Conditions requirement allows for products to be designed for normal use



Day 47

Composting of PLA



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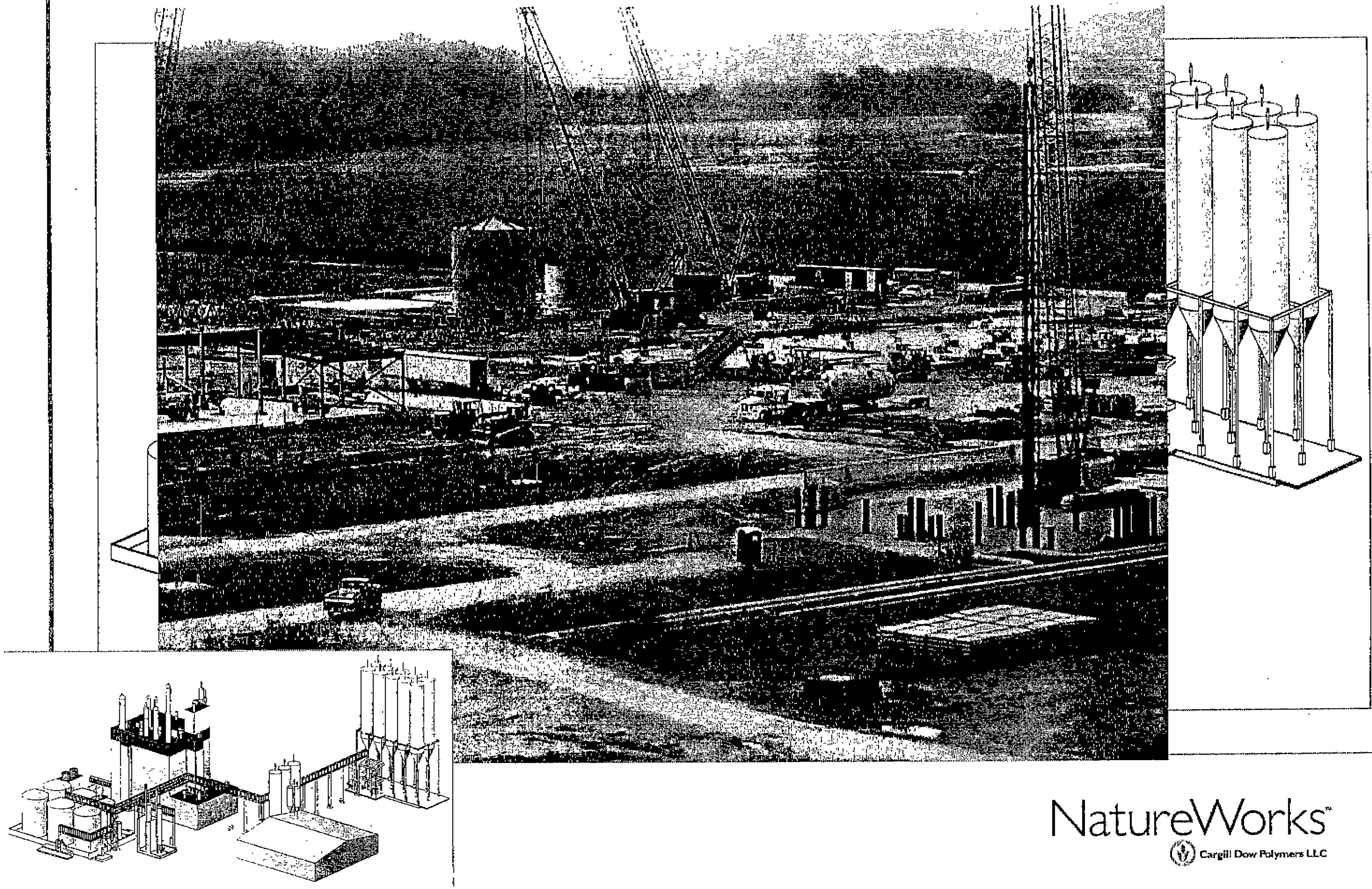
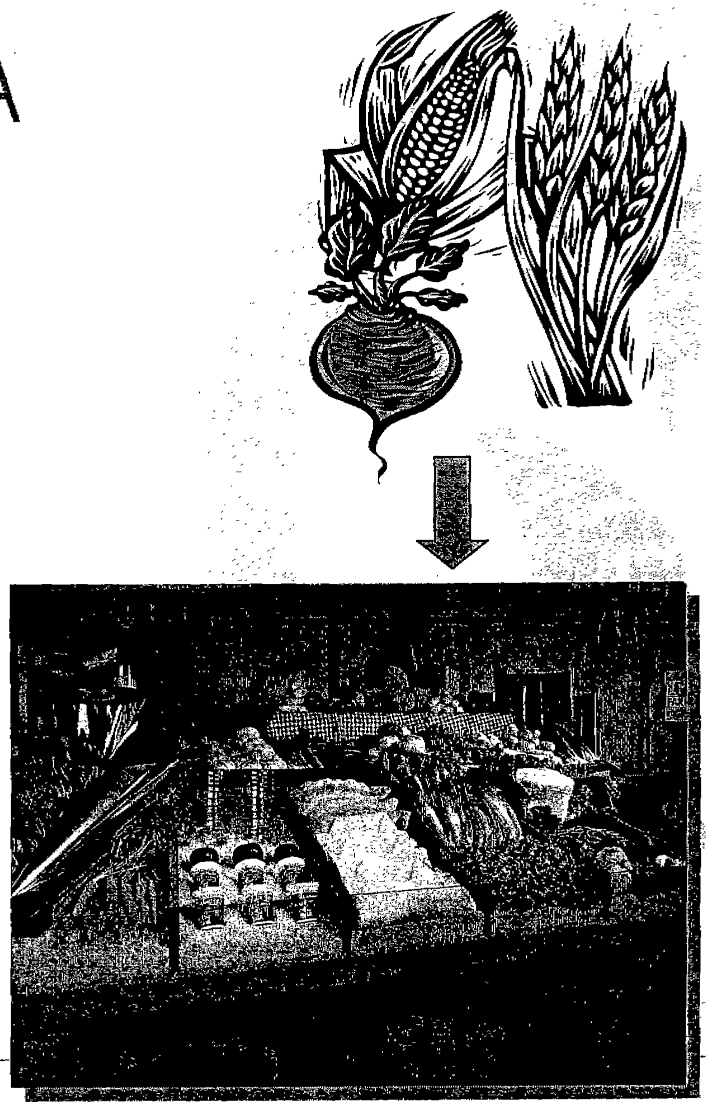
PLA Plant-Blair NE August 2000



NatureWorks™
Cargill Dow Polymers LLC

NatureWorks™ PLA

- A new thermoplastic polymer family.
- Derived from annually renewable resources like corn.
- 20 to 50% fossil resource reduction
- Provides packaging, film and fiber solutions
- Potential market approaching 500,000 metric tons per year
- *We are just beginning!*



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附件四

Composting in Minnesota

December 2000

1 Composting in Minnesota

December 2000

2 Content of Presentation

- Review:
  - government structure
  - Minnesota policies
  - compost programs/facilities
  - economics of composting
  - operations
  - what we have learned
  - regulations

3

4 Minnesota Solid Waste Policy

- Solid Waste Hierarchy
- Recycling Goal
- Bans
- Household Hazardous Waste

5 MN's Solid Waste Hierarchy

(1) waste reduction and reuse;

(2) waste recycling;

(3) composting of yard waste and food waste;

(4) resource recovery through mixed municipal solid waste composting or incineration;

6 MN's Solid Waste Hierarchy (continued)

(5) land disposal which produces no measurable methane gas or which involves the retrieval of methane gas as a fuel for the production of energy to be used on-site or for sale; and

(6) land disposal which produces measurable methane and which does not involve the retrieval of methane gas as a fuel for the production of energy to be used on-site or for sale.

7 Recycling Goals

- By December 31, 1996:
  - Metropolitan Counties must recycle 50 percent by weight of the total waste generated
  - Greater Minnesota Counties must recycle 35 percent by weight of the total waste generated.

8 Household Hazardous Waste

- Each county is required to have:
  - education program, and

– management plan

The removal of the materials from the waste stream reduces the toxicity of the finished compost, ash or MSW.

9 ## Materials Ban from Land Disposal

- appliances
- yard waste
- used motor oil
- tires
- lead-acid batteries
- rechargeable batteries and products
- products containing Mercury
- dry-cell batteries containing mercuric or silver oxide electrodes or nickel-cadmium batteries

10 ## Mixed Municipal Waste Generation 1998

11 ## MSW Composition

12 ## Compost Programs/Facilities

13 ## Compost Programs/Facilities

- Compost facilities not in operation at this time:
  - East Central
  - Wright County

14 ## Facility Design

- Specifications for feedstock material
- up-front sorting equipment/process
- shredding, mixing equipment
- invessel system
- windrow system
  - static pile
  - aerated static pile
  - turned pile
- Screening system

15 ## Financial Aspects

- Capital Costs for waste-processing facilities in $/ton/daily installed capacity:
  - waste-to-energy - 175,000
  - mixed waste composting - 150,000
  - source separated composting - $100,000

16 ## Economic Viability

- Most sensitive financial variables:
  - debt service (principal and interest) - up to $50/ton
  - residual disposal costs (including costs to recycle, incinerate, or landfill non-compostables - up to $25/ton

- labor costs - up to $25/ton
- repair/maintenance - up to $10/ton

17 ## Economic Viability

- Waste recovery systems:
  - conserve land - landfills consume land
  - recover resources and energy from waste - helps to defray system costs
  - can reduce transportation cost if landfills are remote
  - reduces landfill clean-up costs
  - reduces risk of surface and ground water
  - reduces risk to human health

18 ## Learning's

- Feedstock
  - quantities
  - types
  - composition
- Contaminants
- Market specifications

19 ## Feedstock

- Assure a supply of organic material
  - quantity on a daily/annual basis
  - voluntary contracts
  - municipal, franchised or organized collection of organic material
- Identify the composition
  - types of organic material
  - percent of each type of organic material
  - chemical make up

20 ## Contaminants

1 • Environmental
  - organic compounds
  - metals
  - inerts

2 • Market
  - inerts
  - plastics
  - metals
  - soluble salts

21 ## Market Specifications

- Identify markets
  - nursery industry
  - government
  - construction industry
- Material specifications

- particle size
- nutrient value (NPK, pH, soluble salts..)
- metal content
- inert standards

22 ## Regulations

- Purpose:
  - Protect Human Health and the Environment

23 ## Regulations

- Yard Waste
- minimal regulations
  - prevent odors
  - reduce pathogens
  - prevent vector problems and aesthetic degradation
  - control surface water to prevent leachate leaving the facility

24 ## Regulations

- MSW Composting Regulations
  - Site design
    - site preparation specifications
    - controlled access to site
    - divert surface water away from site operations
    - lined compost pad needed for composting, curing and storage of immature compost
    - control odors

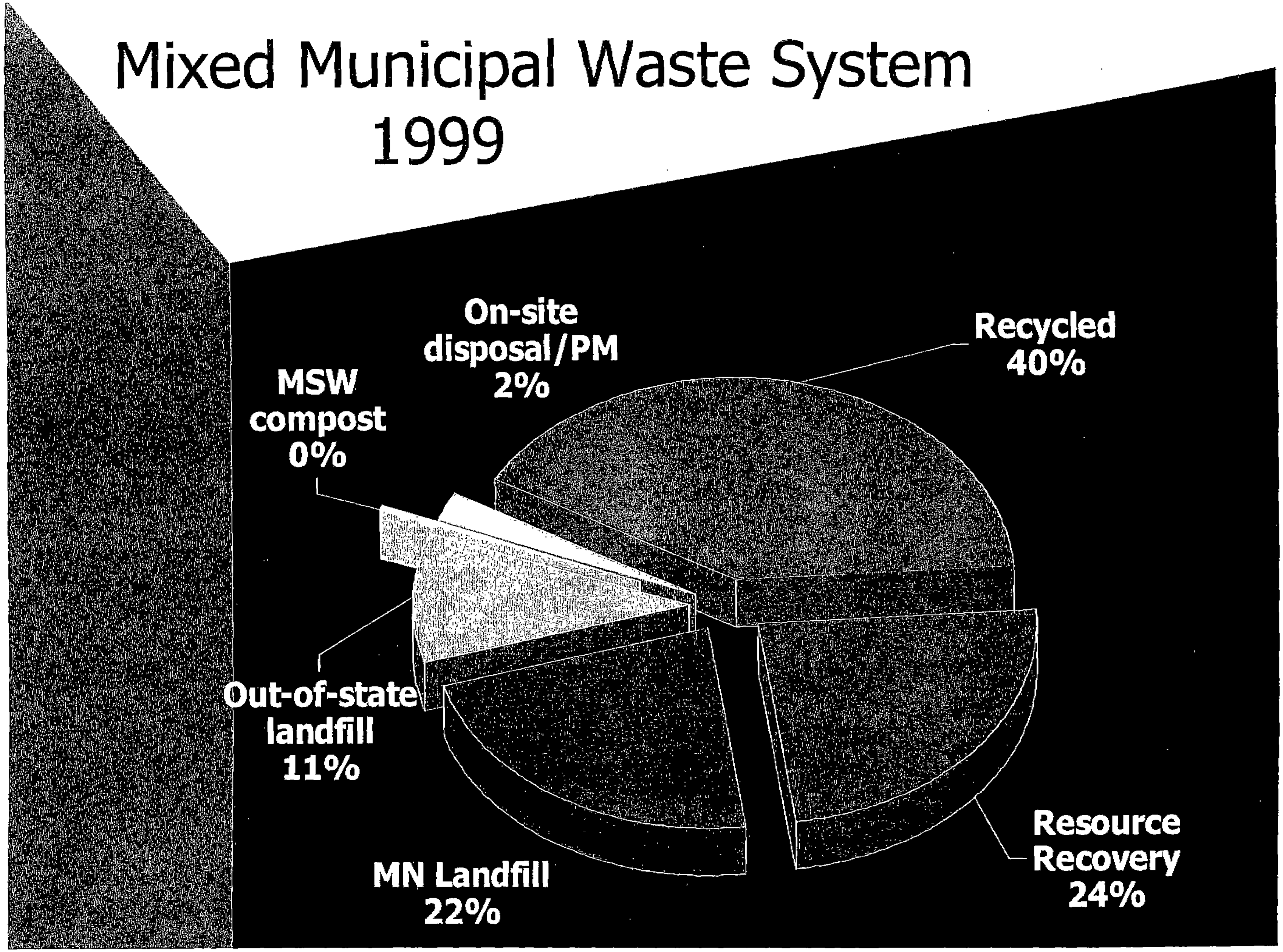
25 ## Regulations

- MSW Composting Regulations
  - Operations Requirements
    - operation and maintenance manual
    - personnel training program
    - materials management requirements
      - waste delivered to designated delivery area
      - salvageable and recyclable materials must be containerized or store
      - compost residuals stored to reduce odors, vectors and in an aesthetically pleasing manner
    - Process to further reduce pathogens (PFRP)

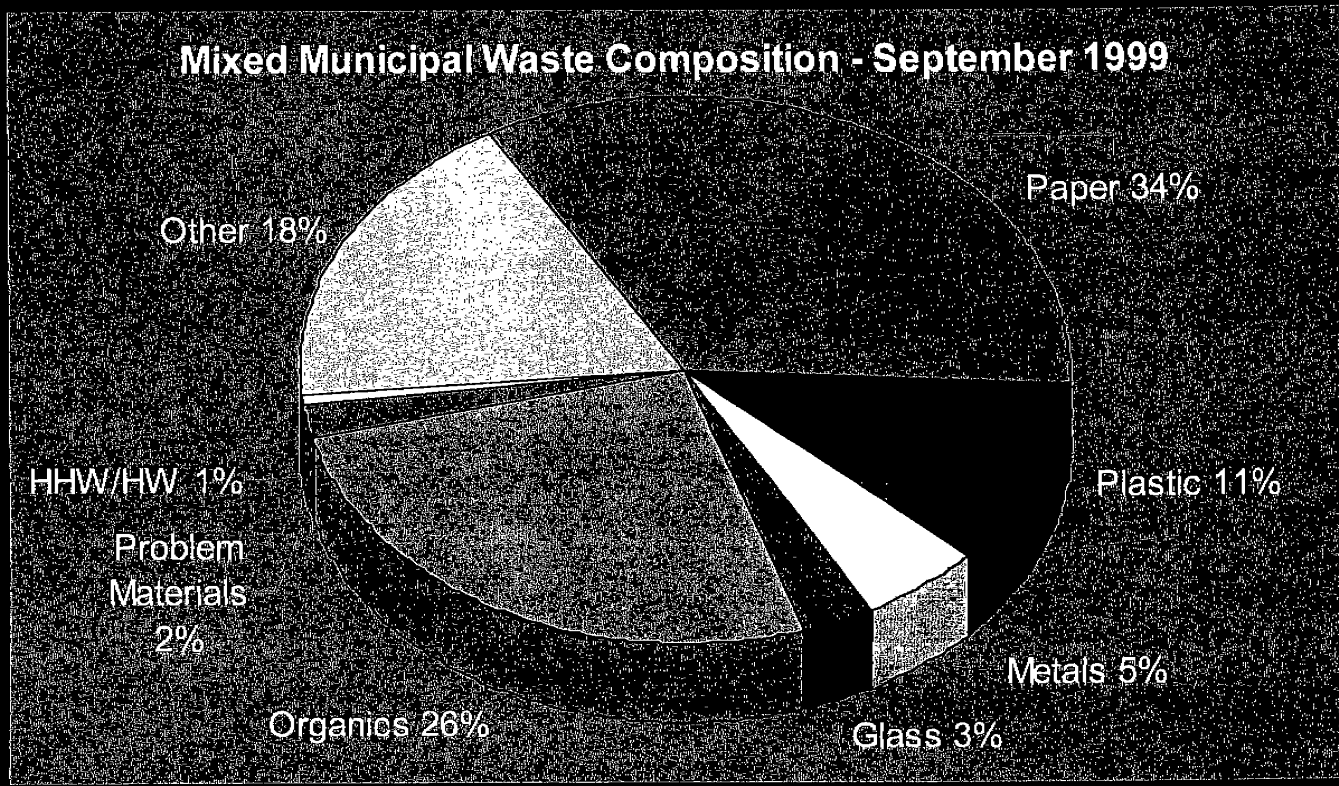
26 ## Regulations

- MSW Composting Regulations
  - Test Methods
    - sampling and testing plan for finished compost
    - compost maturity test protocol
    - Test parameters: pH, moisture content, particle size, NPK ratio, soluble salt content
    - Metals: Arsenic, Cadmium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, PCB, and Zinc.

Mixed Municipal Waste System 1999



MSW Composition 1999



Compost Programs/Facilities

SKB	Yard waste source separated	> 50 tons/day
Swiss	mixed municipal waste	> 25 tons/day
Swift	source separated organics	> 25 tons/day
Fillmore	source separated organics	> 25 tons/day
Lake of the Woods	mixed municipal waste	> 25 tons/day
WLSSD	mixed municipal waste	> 25 tons/day
Hutchinson	source separated organics	> 25 tons/day
Prairieland	mixed municipal waste	100 tons/day

Minnesota Rules, Table of Chapters

Table of contents for Chapter 7035

7035.2836 COMPOST FACILITIES.

Subpart 1. **Scope.** The requirements of subparts 4 to 7 apply to the owner and operator of a facility used to compost solid waste, including source separated compostables except as provided in part 7035.2525, subpart 2. The owner or operator of a yard waste compost facility must comply with subparts 2 and 3 only.

Subp. 2. **Notification.** The owner or operator of a yard waste compost facility shall submit a notification form to the commissioner on a form prescribed by the commissioner before beginning facility operations. The notification must include: the facility location; the name, telephone number, and address of the contact person; the facility design capacity; the type of yard waste to be received; and the intended distribution of the finished product.

Subp. 3. **Operation requirements for yard waste compost facility.**

A. Odors emitted from the facility shall comply with the applicable provisions of any agency odor rules.

B. Composted yard waste offered for use must be produced by a process that includes turning of the yard waste on a periodic basis to aerate the yard waste, maintain temperatures, and reduce pathogens.

C. Compost will not contain greater than three percent inert materials (dry weight) that are greater than or equal to four millimeters as determined by the testing procedure under subpart 5, item J, subitem (3).

D. By-products, including residuals and recyclables, must be stored in a manner that prevents vector problems and aesthetic degradation. Materials that are not composted must be stored and removed at least weekly.

E. Surface water drainage runoff must be controlled to prevent leachate leaving the facility. Surface water drainage run-on must be diverted from the compost and storage areas.

F. The facility shall be constructed and operated to prevent discharge of yard waste, leachate, residuals, and the final product into waters of the state.

G. The facility operator shall submit an annual report to the commissioner by March 1 of each year for the preceding calendar year that includes the type and quantity, by weight or volume, of yard waste received at the compost facility; the quantity, by weight or volume, of compost produced; an average of the inert test results; the quantity, by weight or volume, of compost removed from the facility; and a market description.

Subp. 4. **Design requirements for solid waste compost**

facility. The owner or operator of a compost facility shall submit an engineering design report to the commissioner for approval with the facility permit application. The engineering report must comply with the design requirements in items A to G.

A. Site preparations must include clearing and grubbing for the compost operating and storage areas, building locations, topsoil stripping, excavations, berm construction, drainage control structures, leachate collection system, access roads, screening, fencing, and other special design features.

B. Access to the facility must be controlled by a perimeter fence and gate or enclosed structures.

C. Surface water drainage must be diverted around and away from the site operating area. A drainage control system, including changes in the site topography, ditches, berms, sedimentation ponds, culverts, energy breaks, and erosion control measures, must comply with part 7035.2855, subpart 3, items C to E.

D. The composting, curing, and storage areas for immature compost must be located on a liner capable of minimizing migration of waste or leachate into the subsurface soil, groundwater, and surface water. The liner must have a permeability no greater than 1×10^{-7} centimeters per second and, if constructed of natural soils, be at least two feet thick. The liner must comply with part 7035.2855, subparts 3, item A; 4; and 5.

E. Liquid in contact with waste, immature compost, and residuals must be diverted to a leachate collection and treatment system. The leachate collection and treatment system must comply with part 7035.2855, subpart 3, item B, and the applicable portions of part 7035.2815, subpart 9, items B to K.

F. The facility must be designed for collection of residuals and must provide for the final transportation and proper disposal of residuals.

G. The facility must be designed and operated to control odors in compliance with the applicable provisions of any agency odor rules.

Subp. 5. **Operation requirements for solid waste compost facility.** The owner or operator of a compost facility shall submit an operation and maintenance manual to the commissioner for approval with the facility permit application. The manual must include a personnel training program plan, a leachate management plan, and a compost sampling plan and must comply with the operation requirements in items A to L.

A. All access points must be secured when the facility is not open for business or when no authorized personnel are on site.

B. The personnel training program plan must address the requirements of part 7035.2545, subparts 3 and 4, and the specific training needed to operate a compost facility in compliance with this subpart and subparts 6 and 7.

C. All wastes delivered to the facility must be confined to a designated delivery area and processed or removed at least once a week to prevent nuisances such as odors, vector intrusion, and aesthetic degradation.

D. All salvageable and recyclable materials must be containerized or stored and removed from the facility in a manner that prevents nuisances such as odors, vector intrusion, and aesthetic degradation.

E. All compost residuals must be stored to prevent nuisances such as odors, vector intrusion, and aesthetic degradation. The residuals must be removed and properly disposed of at least once a week.

F. The leachate management plan must describe how the facility will store, reuse, or dispose of collected leachate. If leachate is to be recirculated into the compost, it must be added prior to initiating the PFRP process described in item I.

G. Odors emitted by the facility must comply with any applicable agency odor rules.

H. The owner or operator must cover or otherwise manage the waste to control wind dispersion of any particulate matter.

I. Compost must be produced by a process to further reduce pathogens (PFRP). The temperature and retention time for the material being composted must be monitored and recorded each working day. Three acceptable methods of a PFRP are described in subitems (1) to (3):

(1) The windrow method for reducing pathogens consists of an unconfined composting process involving periodic aeration and mixing. Aerobic conditions must be maintained during the compost process. A temperature of 55 degrees Celsius must be maintained in the windrow for at least three weeks. The windrow must be turned at least once every three to five days.

(2) The static aerated pile method for reducing pathogens consists of an unconfined composting process involving mechanical aeration of insulated compost piles. Aerobic conditions must be maintained during the compost process. The temperature of the compost pile must be maintained at 55 degrees Celsius for at least seven days.

(3) The enclosed vessel method for reducing pathogens consists of a confined compost process involving mechanical mixing of compost under controlled environmental conditions. The retention time in the vessel must be at least 24 hours with the temperature maintained at 55 degrees Celsius. A stabilization period of at least seven days must follow the enclosed vessel retention period. Temperature in the compost pile must be maintained at least at 55 degrees Celsius for three days during the stabilization period.

J. The owner or operator must comply with the compost sampling and testing plan approved by the commissioner. Proposed changes to sampling equipment or procedures must be submitted to the commissioner for review and approval. Testing must be conducted when each batch of compost matures. The plan must include the sampling and testing requirements in subitems (1) to (6).

(1) The compost maturity must be determined using testing protocol described in the sampling plan. "Mature" means more than 60 percent decomposition has been achieved as determined by an ignition-loss analysis and one test method

D. All salvageable and recyclable materials must be containerized or stored and removed from the facility in a manner that prevents nuisances such as odors, vector intrusion, and aesthetic degradation.

E. All compost residuals must be stored to prevent nuisances such as odors, vector intrusion, and aesthetic degradation. The residuals must be removed and properly disposed of at least once a week.

F. The leachate management plan must describe how the facility will store, reuse, or dispose of collected leachate. If leachate is to be recirculated into the compost, it must be added prior to initiating the PFRP process described in item I.

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(1) The compost maturity must be determined using testing protocol described in the sampling plan. "Mature" means more than 60 percent decomposition has been achieved as determined by an ignition-loss analysis and one test method

(a) the training and experience qualifications of persons who collect samples;

(b) equipment used to collect, process, and store samples;

(c) sampling equipment cleaning procedures and other actions taken to prevent sample contamination;

(d) the location or locations where samples are collected;

(e) procedures used to collect grab samples;

(f) procedures used to process grab samples to form composite samples;

(g) chain-of-custody and sample storage procedures; and

(h) compost sampling quality assurance and quality control measures.

(6) The sampling plan must describe how the test results from the samples required in subitems (1) to (4) will be utilized to define the compost at distribution, and must include:

(a) a description of the batch process, statistical average, or other method used to classify the compost, and assign it physical and chemical properties; and

(b) a description of the method used to calculate the cumulative and annual pollutant loading rates for Class II compost.

K. An annual report complying with part 7035.2585 must be submitted to the commissioner by March 1 of each year for the preceding calendar year. A record of the following information must be maintained at the facility and included in the annual report:

(1) the quantity of source-separated compostables or solid waste delivered to the facility;

(2) the quantity and general material breakdown of recyclables and rejects removed from the waste;

(3) the sources and quantities of other materials used in the compost process, such as nutrient or bulking agents;

(4) a summary of temperature and retention time for all compost produced verifying that the process, set out in item I, to further reduce pathogens is being met;

(5) the quantity and classification of all compost produced;

(6) a summary of all lab analyses conducted according to the sampling plan approved under item J;

(7) a record of each Class II compost distribution, including the following:

(a) a copy of the information sheet or label accompanying all Class II compost distributions according to subpart 7;

(b) the name of the compost user and a legal description of the application site location, including the quantity of compost and acreage over which it was distributed;

(c) copies of the letters of notification to the local governments; and

(d) a copy of the United States Geological Survey map of the application site and the surrounding areas showing contours and surface waters.

L. If, for any reason, the facility becomes inoperable, the owner or operator of the facility must notify the commissioner within 48 hours and implement the contingency action plan developed under part 7035.2615.

Subp. 6. **Compost classification.** Compost produced at a solid waste compost facility must be classified as Class I or Class II compost based on the criteria outlined in items A and B. Compost test results shall be used to classify the compost according to the approved sampling plan under subpart 5, item J, the maturity standard in subpart 5, item J, subitem (1), and the PFRP requirement in subpart 5, item I.

A. Class I compost must meet the following criteria:

(1) Class I compost cannot exceed the contaminant concentrations in milligram per kilogram on a dry weight basis as listed in the following table or Code of Federal Regulations, title 40, section 503.13(b)(3), as amended, with the exception of mercury, which cannot exceed contaminant concentrations of five milligrams per kilogram.

Contaminant	Concentration (mg/kg)
Arsenic (As)	41
Cadmium (Cd)	39
Copper (Cu)	1,500
Lead (Pb)	300
Mercury (Hg)	5
Molybdenum (Mo)	18
Nickel (Ni)	420
Selenium (Se)	100
PCB	6
Zinc (Zn)	2,800

(2) Class I compost must not contain greater than three percent inert materials (dry weight) greater than or equal to four millimeters as determined by tests according to the approved sampling plan under subpart 5, item J, subitems (1) to (5).

B. Class II compost consists of any compost that fails to meet the Class I standards and meets the criteria in subitems (1) and (2):

(1) Class II compost must meet the following pollutant loading rates and have a PCB concentration that does not exceed six milligrams per kilogram.

Pollutant	Cumulative Pollutant Loading Rate (lbs/acre)	(kg/hectare)
Arsenic	37	41

Cadmium	34	39
Copper	1,338	1,500
Lead	267	300
Mercury	5	5
Molybdenum	16	18
Nickel	374	420
Selenium	89	100
Zinc	2,497	2,800

Pollutant	Annual Pollutant Loading Rate (for a containerized compost)	
	(lbs/acre)	(kg/hectare)
Arsenic	1.8	2
Cadmium	1.7	1.9
Copper	66.8	75
Lead	13.3	15
Mercury	0.25	0.25
Molybdenum	0.5	0.5
Nickel	18.7	21
Selenium	4.5	5
Zinc	124.6	140

(2) Class II compost must not contain greater than four percent inert materials (dry weight) greater than or equal to four millimeters as determined by tests according to the approved sampling plan under subpart 5, item J, subitems (3) and (5).

Subp. 7. **Compost distribution and end use.** The owner or operator of a solid waste compost facility shall submit a compost distribution plan to the commissioner for approval with the facility permit application. The plan must comply with the requirements in items A to C.

A. Compost distributed or marketed as a fertilizer, specialty fertilizer, soil amendment, or plant amendment, as defined in Minnesota Statutes, section 18C.005, must be registered with the Minnesota Department of Agriculture.

B. The allowable end uses for the compost must be listed and described in the plan.

C. Class I compost may be distributed for unrestricted use. Class II compost may be distributed on a restricted basis. The commissioner or a compost operator trained as required in subpart 5, item B, shall determine the appropriate distribution for a Class II compost used in land application. Compost proposed to be distributed for end uses other than land application may be distributed with the commissioner's approval or as part of the approved facility compost distribution plan under this subpart. All Class II compost distributed must be accompanied by an information sheet or label describing the compost product and its physical and chemical quality, including at least the following information:

(1) the name and address of the generator;

(2) a statement from the generator certifying that the compost meets the Class II classification standards under subpart 6, item B, and providing the standards;

(3) a list of best management practices to use when applying the compost;

(4) the annual or cumulative application rate calculated according to the testing and reporting methods approved under subpart 5, item J, subitem (6);

(5) the compost maturity tested and reported according to subpart 5, item J, subitem (1);

(6) the compost inert content tested and reported according to subpart 5, item J, subitem (3); and

(7) a statement of the compost parameter values tested and reported according to subpart 5.

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6th ISBP / 9th Annual BEPS
Honolulu, HI
2000 Final Program

Tuesday, December 12, 2000

3:00 – 8:00 PM Arrival/Registration

7:00 – 9:00 PM Welcome Reception

Wednesday, December 13, 2000

8:15 AM Greetings/Opening remarks: Goodwin, Doi, Willett

Session 1: Plenary Session: Sustainability, Renewable Resources, and Biobased Products (Chair: J.L. Willett)

8:30 AM Bruce Dale, Michigan State University
"Greening" the Chemical Industry: Research Priorities for Biobased Products

9:00 AM Pat Gruber, Cargill Dow LLC
Sustainable Design of Polymers and Materials

9:30 AM Gunnar Schornick, BASF
Polymers and Plastics for Sustainable Development

10:00 AM Gregory Bohlmann, SRI Consulting
Chemicals from Renewable Resources

10:30 - 10:50 BREAK

Session 2: Polyesters - Modification and Properties (Chair: Y. Doi)

10:50 AM Naoki Asakawa, Tokyo Institute of Technology
Hydrogen Bond Formation and Solid Properties of Poly(M-caprolactone)/thiodiphenol blends

11:20 AM Seung Soon Im and Eui Sang Yoo, Hanyang University
Morphology and Degradation Characteristics of Aliphatic Polyesters Introduced by Various Functional Groups

11:50 AM Babu Gaddam and Denise Rutherford, 3M Company
Chemical Modification of Poly(hydroxyalkanoate)s

12:20 - 2:00 PM LUNCH

Session 3A: Degradation (Chair: A.C. Albertsson)

2:00 PM R. Tillinger, B. De Wilde, and S. Verstichel, Organic Waste Systems
Biodegradation in Soil and Anaerobic Digestion: New Developments in Standardization

2:30 PM Ramani Narayan, Michigan State University
The Scientific Rationale Behind Biodegradable/Compostable Standards

Wednesday, December 13, 2000 (Cont'd)

3:00 PM Graham Swift, GS Polymer Consultants
Progress in the Development of Biodegradable Polymers

Session 3B - Polyesters: Synthesis and Degradation (Chair: S. Y. Lee)

2:00 PM M. Vert, University of Montpelier
3H and 14C Radio-labeling of Polyalkanoates to Monitor their Degradation and Bioassimilation in Complex Media

2:30 PM C. Wu, The Chinese University of Hong Kong
Degradation of Polymeric Nanoparticles and Their Potential Application

3:00 PM S.Y. Lee, KAIST, Korea
Polyester Production by Bacterial Fermentation

3:30 - 3:45 BREAK

Session 4A - New Developments in Polyolefin Degradation (Chair: G. Swift)

3:45 PM Gerald Scott and David M. Wiles, Aston University and EPI Environmental Products
Programmed-Life Plastics from Polyolefins: Applications and Testing Protocols

4:15 PM Anne-Christine Albertsson, Royal Institute of Technology, Stockholm
The Dynamic Interaction between the Polymer and the Environment during Degradation

4:45 PM F. Kawai, M. Watanabe, M. Shibata, S. Yokoyama, Y. Sudate, Okayama University
Model Analysis of Biodegradability of Polyethylene Was by Microorganisms

Session 4B - PHAs: Enzyme Structure and Function (Chair: G.Q. Chen)

3:45 PM T. Yamane, H. Nakano, S. Ueda, A. Maehara, Nagoya Univ., Utsunomiya Univ., and RIKEN
Expression Mechanism of the Gene Encoding Granule-Associated Protein Involved in Bacterial PHA Synthesis

4:15 PM Ken-ichi Kasuya, Gunma University
Structure and Properties of PHA Depolymerases

4:45 PM K. Yamashita, Y. Aoyagi, H. Abe, and Y. Doi, RIKEN
Analysis of Function of PHB Depolymerase from Alcaligenes faecalis T1 by Using Quartz Crystal Microbalance

Session 5 – Poster Session & Reception

6:00 - 9:00 Poster Session

Thursday, December 14, 2000

Session 6A - Modification and Properties of Polysaccharides (Chair: R. Muller)

8:00 AM B. Koroskenyi, G. Li, and S. McCarthy, University Massachusetts Lowell
Synthesis of Biodegradable Polymers Activated by Microwave Radiation

8:30 AM J.J. de Vlieger, S. Fischer, L. Batenburg, and H. Fischer, TNO Inst. Applied Physics
Biodegradable Nanocomposite Food Packaging

9:00 AM W. Orts, G. Nobes, G. Glenn, G. Gray, L. Hansen, and M. Harper, USDA-ARS-WRRC
Blends of Starch with Poly(vinyl alcohol)/ethylene Copolymers for Use in Foam Containers

Session 6B - Poly(hydroxyalkanoate) Synthesis (Chair: Y. Inoue)

8:00 AM R. Thiruvenkatam and C. Scholz, University Alabama-Huntsville
Progress in Biopolymer Synthesis in Simulated Microgravity

8:30 AM H. Satoh, H. Takabatake, A.S.M. Chua, T. Mino, and T. Matsuo, University of Tokyo and Toyo University
Production of Poly(3-hydroxybutyrate) by Activated Sludge Treating Domestic Sewage

9:00 AM H. Takabatake and T. Mino, University of Tokyo
Stability of PHA Production by Activated Sludge

9:30 AM G.Q. Chen, Tsinghua University
Polyester Production by Bacterial Fermentation

10:00 - 10:30 BREAK

Session 7A - New Developments in Renewable Materials - Natural Rubber (Chair: W. Orts)

10:30 AM Katrina Cornish, USDA-ARS-WRRC
Biochemical Regulation of Rubber Biosynthetic rate and Molecular Weight

11:00 AM Katrina Cornish, USDA-ARS-WRRC
R & D Leading to the Commercialization of Nonallergenic Latex from Guayule

11:30 AM Jeffrey Martin, Yulex Corp.
The Commercialization of Nonallergenic Rubber Latex from the Desert Shrub Guayule

Session 7B - Poly(lactic acid): Processing, Structure, and Properties (Chair: M. Vert)

10:30 AM J. Dorgan, J. Palade, H. Lehermeier, D. Knauss, J. Wegner, and S. Dec, Colorado School of Mines
Effects of Stereochemical Content and Chain Architecture on the Properties of Poly(lactic acid)

11:00 AM P. Smith, M. Leugers, B. Landes, C. Langhoff, S.-H. Kang, X.-Z. Yang, and S.-L. Hsu, Dow Chemical Company and University Massachusetts Amherst
Characterization of the Evolution of Morphology of Poly(lactic acid) as a Function of Deformation

Thursday, December 14, 2000 (Cont'd)

11:30 AM S.-H. Hyon, F. Jin, and S. Tsutsumi, Kyoto University
Hydrostatic Extrusion of Poly(L-lactide)

12:00 - 2:00 PM LUNCH

Session 8A - Water Soluble Polymers (Chair: G. Schornick)

2:00 PM M. Mukouyama, Nippon Shokubai
L-Aspartic Acid and its Application for Water Soluble Biodegradable Polymer

2:30 PM S. Sikes, G. Swift, and A.P. Wheeler, Folia, Inc. and Clemson University
A Breakthrough Platform for Water Soluble and Superabsorbent Biodegradable PolyAmino Acids Based on Aspartic Acid

3:00 PM M. Takehara, M. Saimura, A. Ikezaki, Y. Inoue, and H. Hirohara, The University of Shiga Prefecture
Characterization of Poly(M-Lysine)s with Low Polymerization Degree Biosynthesized by Streptomycetes

Session 8B - Degradation of Polyesters (Chair: S. Goodwin)

2:00 PM T. Iwata and Y. Doi, RIKEN Institute
Structure and Biodegradation of Aliphatic Polyester Crystals

2:30 PM S. Matsumura, Keio University
A New Strategy for Sustainable Polymer Recycling: Enzymatic Polymerization and Degradation

3:00 PM R.-J. Müller, D.-M. Abou-Zeid, and W.-D. Deckwer, Gesellschaft Biotechnologische Forschung
Biodegradation of Natural and Synthetic Polyesters under Anaerobic Conditions

3:30 - 3:45 PM BREAK

Session 9A - Structure and Properties of Polysaccharide Materials (Chair: T. Iwata)

3:45 PM M. Stading and M. Anker, Chalmers University
Rheological and Barrier Properties of Edible Films in Relation to Microstructure

4:15 PM G. Glenn, W.J. Orts, G. Nobes, and G. Gray, USDA-ARS-WRRC
In-situ Laminating Process for Baked Starch-Based Foams

4:45 PM L. Averous, O. Martin, and L. Moro, CERME
Plasticized Wheat Starch Based Biodegradable Blends and Composites

5:15 PM G. Zhou, J.L. Willett, C. Carriere, and V. Wu, USDA-ARS-NCAUR
Rheological Characterization of Starch-Filled Polyester Composites

Session 9B - Poly(lactic acid) (Chair - J. Dorgan)

3:45 PM Y. Kimura, Kyoto Institute of Technology
Synthesis, Properties, and Applications of Poly(L-lactic acid)

Thursday, December 14, 2000 (Cont'd)

4:15 PM S. Ogawa, S. Obuchi, M. Ajioka, and N. Kawashima, Mitsui Chemicals, Inc.
New Production Process of Poly(lactic acid), "LACEA", for Sustainable Development

4:45 PM K. Yamanaka, Kanebo Gohsen LTD.
Properties and Application of LACTRON PLA Product

Friday, December 15, 2000

Session 10A - Production and Preparation of Agricultural Fibers (Chair: G. Nobes)

8:30 AM S. Amaducci and P. Struik, University of Wageningen
Agronomy of Production of High-Quality Hemp Fibre in Europe

9:00 AM D.E. Akin, D. Himmelsbach, and W.H. Morrison III, USDA-ARS-RRC
Biobased Fiber Production: Enzyme Retting for Flax/Linen Fibers

9:30 AM B. Kurek, INRA
Customizing Fibers with Enzymes and Biomimetic Catalysts

Session 10B - Synthesis of Polyesters (Chair: S. Matsumura)

8:30 AM Z. Zhong, P. Dijkstra, and J. Feijen, University of Twente
A Novel Calcium-based Initiating System for the Living Ring-opening Polymerization of Cyclic Esters: A Potential Way Towards Nontoxic Polyesters

9:00 AM M. Arcana, O. Giani-Beaune, R. Schue, F. Schue, W. Amass, and A. Amass, Universite Montpellier and Ashton University
Ring-opening Copolymerization of Racemic Butyrolactone with Caprolactone by Distannoxane Derivatives Catalysts

9:30 AM H. Seliger, Y.-J. Lee, and G. Saad, Univ. Ulm and Cairo University
Biodegradable Polyester-urethanes based on Bacterial Poly((R)-3-hydroxybutyrate)

10:00 - 10:30 AM BREAK

Session 11A - Utilization of Agricultural Fibers (Chair: W. Winter)

10:30 AM R. Rowell, S. Lange, and M. Davis, USDA Forest Products Laboratory
Bonding Fiberboards using Components Coming From the Fiber - A New Look at an Old Idea

11:00 AM G. Nobes, W. Orts, and G. Glenn, USDA-ARS-WRRC
Use and Effects of Agricultural Fibers and Fillers in Baked Starch-Based Foam Composites

11:30 AM J. Lawton and R. Shogren, USDA-ARS-NCAUR
Effect of Aspen Fiber and Polyvinyl Alcohol on the Properties of Baked Starch Foam Trays

Session 11B - Degradation of Polylactide Materials (Chair: Y. Kimura)

10:30 AM T. Williams, J. Rancourt, and J. Todd, Polymer Solutions, Inc.
The Influence of Degradation on the Structural Characteristics of Resorbable Polymers

Friday, December 15, 2000 (Cont'd)

11:00 AM — Y. Tokiwa, H. Pranamuda, A. Jarerat, and H. Nishida, National Institute of Bioscience and Human Technology
Microbial and Enzymatic Degradation of Polylactide and Silk Fibroin

11:30 AM — J. Todd, T. Williams, and J. Rancourt, Polymer Solutions, Inc.
GC Analysis of Chiral Monomer Units in Polylactide and Poly(lactide-co-glycolide)

12:00 - 1:30 PM LUNCH

Session 12A - New Developments in Renewable Materials (Chair: J.L. Willett)

1:30 PM — B. Vijayendran, Battelle
Soybean: A Versatile Plant for Developing Chemical Feed Stock from Renewable Resources

2:00 PM — Z. Petrovic, W. Zhang, I. Javni, and A. Guo, Pittsburg State University
Composites from Soy-Based Resins Reinforced with Natural Fibers

2:30 PM — H. Chen and J. Li, University of Vermont
Biodegradation of Whey Protein-based Edible Films

3:00 PM — M. Yoshioka and N. Shiraishsi, Kyoto University
Graft-Copolymerization of Cyclic Esters to Cellulose Acetate and Biodegradability of the Products

Session 12B - Biodegradable Plastics R & D - Global Perspectives (Chair: D. Kitch)

1:30 PM — E. Chiellini, University of Pisa
Environmentally Degradable Plastics in Europe

2:00 PM — K. Ohshima, Biodegradable Plastics Society, Japan
Biodegradable Plastics Industry in Japan

2:30 PM — Y.H. Kim, KIST, Korea
Status and Prospects of Biodegrable Plastics in Korea

3:00 PM — S. Miertus, ICS, Italy
ICS-UNIDO Programmes and Activities on Environmentally Degradable Plastics

4:00 - 6:00 PM BEPS Business Meeting

6:30 PM BEPS Awards Banquet

Saturday, December 16, 2000

Session 13 - Advances in Cellulose Technology (Chair: G. Nobes)

8:30 AM — W.T. Winter, A. Stipanovic, D. Bhattacharya, M. Grunert, and S. Zhang, SUNY
Cellulose Nanocrystals: Surface Modification for Use in Stimuli Responsive Materials and Composites

9:00 AM — J. Collier, B. Collier, S. Petrovan, and X. Wei, Univ. Tennessee
Rheology and Orientation Development during Elongational Flow of Lyocell Solutions

Saturday, December 16, 2000 (Cont'd)

9:30 AM B. Collier, M. Dever, S. Petrovan, J. Collier, Z. Li, and X. Wei, Univ. Tennessee
Rheology of Lyocell Solutions from Different Cellulose Sources

10:00 - 10:15 AM BREAK

Session 14 - PANEL DISCUSSION

10:15 – 12:00PM *Impediments, Opportunities, and Perspectives in the Acceptance and Development of Biodegradable Consumer Materials*

Panel members: R. Narayan
E. Cheillini
J.L. Willett
R. Tillinger
A. Graf
G. Swift
D. Kitch
K. Ohshima
Y.H. Kim

12:00 Noon MEETING ADJOURNED

Composting & Biodegradable Polymers: A Global Situation Report

12/11/00 Honolulu, Hawaii December 2000 1

"A continuing challenge to the international commercialization of biopolymers and establishing the supporting organic recycling infrastructure is the lack of harmonized standards in biorecycling."

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US Grains Council BioMaterials Project

- Dennis Kitch, Director for Biomaterials WOW (Japan)
- Byon Ryoi Min, Associate Director (Korea)
- Clover Chan, Assistant Director (Taiwan)
- Emily French, Manager of Business Development (WasDC)
- Eichi Takeshita, BioMaterials Biorecycling Consultant (Japan)

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US Grains Council

- Non-profit farmer and industry based organization
- Offices in 10 countries, activities in 80 countries
- "Develop international markets for US Corn (Maize), Barley, Sorghum and **co-products**."
- Biopolymers and Biomaterials have been significant areas of activity for >10 years
- Organic recycling infrastructure development is part of the Biomaterials Agenda

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The New Impetus (Outside the US)

- The World has a "Garbage crisis" with plastic residue everywhere
- Global Warming
- Dioxin contamination from waste incineration is a critical "public issue"
- Conventional plastics have been identified a major source of dioxin (in the public perception)
- Organic Recycling and Biopolymers are seen as a part of the solution

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Tipping Fees

- USA: $12-80 / ton
- EU: $125-300 / ton
- SEA: $80- 350 / ton
- Japan: $250 – 600 / ton

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The New Impetus (inside the US)

- 1996 Farm Bill supporting Industrial uses
- Biomass
- Executive order
- Organic fraction diversion
- International Trade
- Sustainability

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Sustainability

- Major corporate commitments and investments: Ford, DuPont, Dow, Toyota,etc.

BUT

- Industry does not have the tools to manage carbohydrate feedstocks
- Buzz word, working on definition
- Not necessarily biodegradable

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Manufacturer's Extended Responsibility

- EU & Japan
- Japan: PET bottle = material $1.00 / lb, recycling costs = $3.50 / lb
- Germany: DSD system is adding $2-3 / lb for recycling costs (sliding scale)
  - EC is considering adopting DSD type system

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International Trade in Organic fertilizers and Compost: Organic farming

- Training
- Standards
- Certification
- Auditing

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Carbon Credits Trading from biorecycling

- Serious investments in biorecycling infrastructure
- Funding appears to be available
- Studies indicate substantial GHG reductions are possible

BUT

- Science is lacking
- Trading requires quantification & certification
- LCA methodology is not sufficient

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Organic Recycling Networks

- European Network (established)
- Asia Network (now)
- Global Network (next)

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USA

- Cargill Dow — January, 2000
- Dupont — June, 2000
- ADM — August, 2000

Canada

- Nova Scotia to ban disposal of unprocessed organics;
- Creation of infrastructure for managing residential and ICI food residuals

Germany

- Kassel Project
  - 1 year project October 1, 2000
  - 140,000 population
  - Well funded, continuing public education
  - Demonstrate the collection of biomaterials in the "BioBin"
  - Collect data on "miss throws"
  - "Make or Break" project

The Netherlands

- Currently the highest rate of organic recycling of residential organic waste: > 98%
- Strong move towards Anaerobic digestion.
- Strong political move away from organic recycling, return to incineration
  - Costs and fears of soil contamination

Italy

- Very successful implementation in N. Italy of residential organics collection in biopolymer bags
- May surpass the Netherlands collection % in 2001

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Japan: The Basic Law to Create a Sustainable Society (May, 2000)

- Generators of organic waste (>50 mt / yr) **must divert** to feed use or organic recycling
- Feed from food waste is not practical due to transportation costs
- Aerobic composting in rural or semi-urban areas
- Anaerobic digestion in urban areas

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Japan cont.: Plastic & Packaging Recycling Law

- Manufacturers will have "extended responsibility" for product packaging.
- Companies must pay for the ultimate disposal of packaging.
- Annual volumes and recycling rates will be reported. And audited
- Fees will be based on actual volumes and rates - and will go up!

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Plastic & Packaging Recycling Law

- Fees will reflect actual disposal costs, weighted to penalize less environmentally benign disposal
- Thermal recovery is rated as a less desirable method of disposal, not recycling
- Fees will be higher for public collection and disposal systems
- Highest for landfill burial

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Biopolymer Market in Japan

- Film
- Fiber
- Packaging
- Containers

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Japan Organic Recycling Association (JORA)

- Established August 1, 2000
- Coordinate national organic recycling efforts
  - Public, private, industry & academic coalition to coordinate, standardize and implement organic recycling
  - Support of international sister organizations
  - Creation of a Network for technical exchange
  - Harmonization of standards for international trade in organics

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JORA cont.

- Formal cooperative agreement signed with the US Composting Council
- August 27, 2000
- Agreements with other organizations to be formalized

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Japan Biodegradable Plastic Society

- Established 1990
- Industry based
- Logo program June 2000
- "Green Pla" logo mark
- Founding Member of JORA

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Indonesia

- October 20, 2000 announcement by Toyota to build 50Kmt PLA plant

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Taiwan

- Taiwan Biodegradable Plastic Society
- ROC Organic Recycling association

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Taiwan

- Incineration is seen as an "interim solution"
- Dioxin awareness from Japanese media
- Strong policy support for organic recycling
- Large scale composting demonstration projects underway in Taipei and several other cities
- Source separated residential and commercial organic waste collection in Taipei is possible
- Agricultural use of Biodegradable polymers is a high priority project

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China

- ASTM / ISO standards are being considered
- Food residual composting demonstration projects are in planning / development stage for Hong Kong and Shanghai
- Biodegradable bags will be used for collection in the demonstration projects
- Degradable PE bags are under reconsideration due to recalcitrant residuals

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China cont.

- Organic material soil deficit in NE and Central China
- Desertification nearing Beijing is a serious environmental threat
- Organic material as Overseas Development Aid from Japan is under discussion

Korea

- Food residuals and other organic materials will be banned from Landfills by 2005
- Food residual composting underway in Seoul and several other cities
- Biodegradable bags are being used for collection
  - Initially "30% biodegradable content" bags
  - 100% biodegradable is the policy goal

Thailand

- Royal composting projects underway in Chang Mai, Northern Thailand
- Composting facilities under construction near Bangkok
- Thailand is a potential major producer of bioploymers

Malaysia

- Electronics industry will be the early adopter of compostable intermediate and consumer packaging for export markets.

India

- Supreme Court has appointed a special master to implement an integrated waste management system nation-wide
- Organic recycling in urban areas is to be implemented
- Conventional Plastic bags banned in New Delhi & Bombay
- Plastics bags washing up in drifts 1 meter deep along some seashores
- Packaging "extended responsibility" for consumer goods to be implemented

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Pakistan

- Nation-wide waste separation and recycling education has been started by NGO's in K – 6 year primary schools

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New Zealand

- Landfills will be closed to organics by 2010
- No untreated waste will be accepted
- No incineration
- National composting and recycling policy
- Significant research effort to create a <u>**Branded**</u> sustainable forest products industry using biodegradable adhesives and finishes

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Australia

- 2000 Olympics: Over 1 million biodegradable bags (BioCorp) used, colored PINK!. Problems with contamination by conventional straws, lids and condiment packages.
- Landfill diversion requirements are coming into law
- Canberra (national capitol) has Zero Landfill policy

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NEXT

- Fuel Cells
- Biorefineries
- Paints, adhesives & solvents
- Detergents

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Dec 16, 2000
Hawaii.

■ EDPs DEVELOPMENT / MILESTONES

- **1970** - Companies started to be interested in EDPs during the oil crisis in need of forming an oil-free technology.

- **1990** - Companies resumed interest in EDPs in need of fighting the negative public image they had developed as society became more environmentally conscious.
  - Plastic waste management take-off.
  - Production and commercialization of polyolefin-starch based "biodegradable" plastics.

- **1995** - Companies involved in production of EDPs from oil feedstock and renewable resources.
  - Hybrid plastics from petropolymers and natural polymeric materials.
  - Second/third industrial revolution.

BILL
on
Law Provision in Environmental Matter*

Art. 23 - Actions for avoiding the environmental dispersion of non biodegradable products of common use

"Within one year from the data of the enforcement of the present law, items like hearing stubs, plastic cutlery, kitchen-ware, plastic bags for organic waste collection, and packaging foam have to be made with biodegradable materials exclusively according to the UNI 10785 standard"

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* Approved by the Italian Republic Senate

EDPs Production in Europe

Polymer Developer	*Trademark Name(s)*	*Key Components*
Avebe	—	Starch-based blends
BASF	—	Polyesters, Polyaspartic acid*
Bayer	BAK 1095 - PEA	Polyesteramides
Biopac*	Biopack	Extrusionable Starch Materials
Biotec	—	Starch-based blends
Boehringer, BPI, Ethicon	PLA/PLGA	Polyesters
Deutsche Gelatin AG	Gelatin	Polypeptide (Proteins)*
EMS Chemie / Battelle	Amylose*	Extrusionable Starch Materials
EPI	DCP™	Polyethylene / Additives
Fermentation Institute	PHB copolymers	Polyesters
Fluntera AG	Fluntera Plast	Extrusionable Starch Materials
Idroplast	—	Poly(vinyl alcohol)*
Mazzucchelli	Hydrolene	Cellulose acetate
Fortum Oil	Poelait™	Poly(lactic acid)
Novamont	Mater-Bi™	Starch-based blends
Novon Polymers AG	Novan	Extrusionable Starch Materials
Solvay	—	Poly(caprolactone)
Storopack	—	Foamable Starch Materials
Sunstarke	Potato starch*	Foamable Starch Materials
Technicoat	Tech-No-Bag™	Polyethylene / Additives
Tubize Plastics *(Rhône Poulenc)*	Cellulose acetate	Modified Cellulose
United Paper Mills	—	Cellulose derivatives

* Materials soluble in water media

LANDFILL DISADVANTAGES

- Uncontrolled Disposal of Waste in the Landfill
- Production of Methane Gas
  Green House Effect
- Leachate Infiltration into the Soil, Pollution of Surface Water, Ground Water, Soil and Air
- Risk to Human Health and to Global Environment

■ COUNCIL DIRECTIVE 1999/31/EC ON LANDFILL OF WASTE *

Reference Directives
75/442/EEC on Waste, 91/689/EEC on Hazardous Waste
96/61/EC Integrated Pollution Prevention & Control

- **Art.5**
  Total Biodegradable Municipal Waste to Landfill Referred to Biodegradable Municipal Waste (Weight) Produced in 1995
  - Reduction to 75% by 2006
  - Reduction to 50% by 2009
  - Reduction to 35% by 2016

- **Alternatives**
  - Recycling and Composting
  - Biogas Production
  - Materials/Energy Recovery

(*) Issued April 26th, 1999. To be brought into force in each state not later than two years from the issue.

POTENTIAL UTILIZATION AREAS FOR DEGRADABLE POLYMERS

PACKAGING	CONSUMPTION	TECHNICAL UTILIZATIONS	PLANT PROTECTION	AGRICULTURE & GARDENS	MEDICINE
Washing bags	One-way cutlery	Denitrification of water	Herbicide bands	Fertilizer bags	Medicine capsules
Waste bags	Napkins	Degradable carrier for chemicals	Pesticide bands with controlled lay off	Films	Serving material
Carrier bags	Sanitary towels		Dispenser	Cover films	Degradable carrier for medicines
Eggcups	"Litter products" (e.g. golftees)			Harvest bounding yarn	Fixing of fractures
Fast-food				Rentilization as animal food after sterilization	Orthopaedical surgery
Drinking packages				Bounding material	
Paddings				Sockets	
Cosmetics					
Hygienesector					
Pharmaceutics					
Washing & Cleaning					

■ EUROPEAN STANDARDS ON PACKAGING & PACKAGING WASTE - TC261/SC4

CR 13695-1

Packaging - Requirements for Measuring and Verifying the Four Heavy Metals (Cr, Rd, Hg, Pb) and Their Release into the Environment, and Other Dangerous Substances Present in Packaging"

■ EUROPEAN STANDARDS ON PACKAGING & PACKAGING WASTE - TC261/SC4

EN 13430:2000

"Packaging - Requirements for Packaging Recoverable by Material Recycling"

EN 13431:2000

"Packaging - Requirements for Packaging Recoverable in the Form of Energy Recovery Including Specification of Minimum Inferior Calorific Value"

EN 13432:2000

"Packaging - Requirements for Packaging Recoverable Through Composting and Biodegradation. Test Scheme and Evaluation Criteria for the Final Acceptance of Packaging"

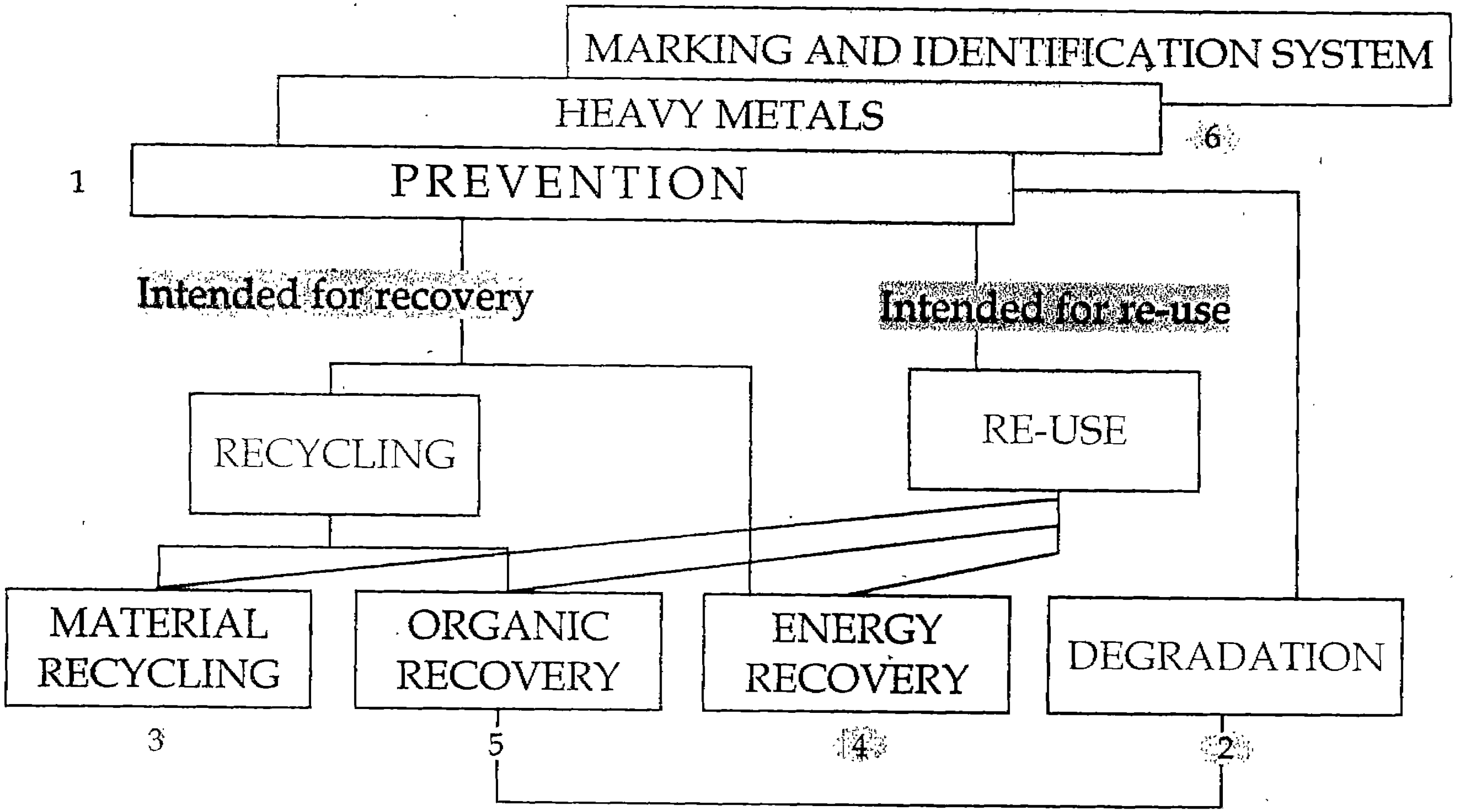
■ EUROPEAN STANDARDS ON PACKAGING & PACKAGING WASTE - TC261/SC4

EN 13427:2000
Packaging - Requirements for the Use of European Standards in the Field of Packaging Waste (Umbralla Norm)"

EN 13428:2000
"Packaging - Requirements Specific to Manufacturing and Composition - Prevention by Source Reduction"

EN 13429:2000
"Packaging - Reuse

Packaging & Packaging Waste
CEN TC261 - SC4



ICS-UNIDO Workshop
Sharjah (UAE)
March 19-23, 2000

■ TECHNICAL COMMITTEES FOR STANDARDIZATION ON PLASTICS & PLASTIC WASTE MANAGEMENT

CEN TC 261/SC4

Packaging & Packaging Waste

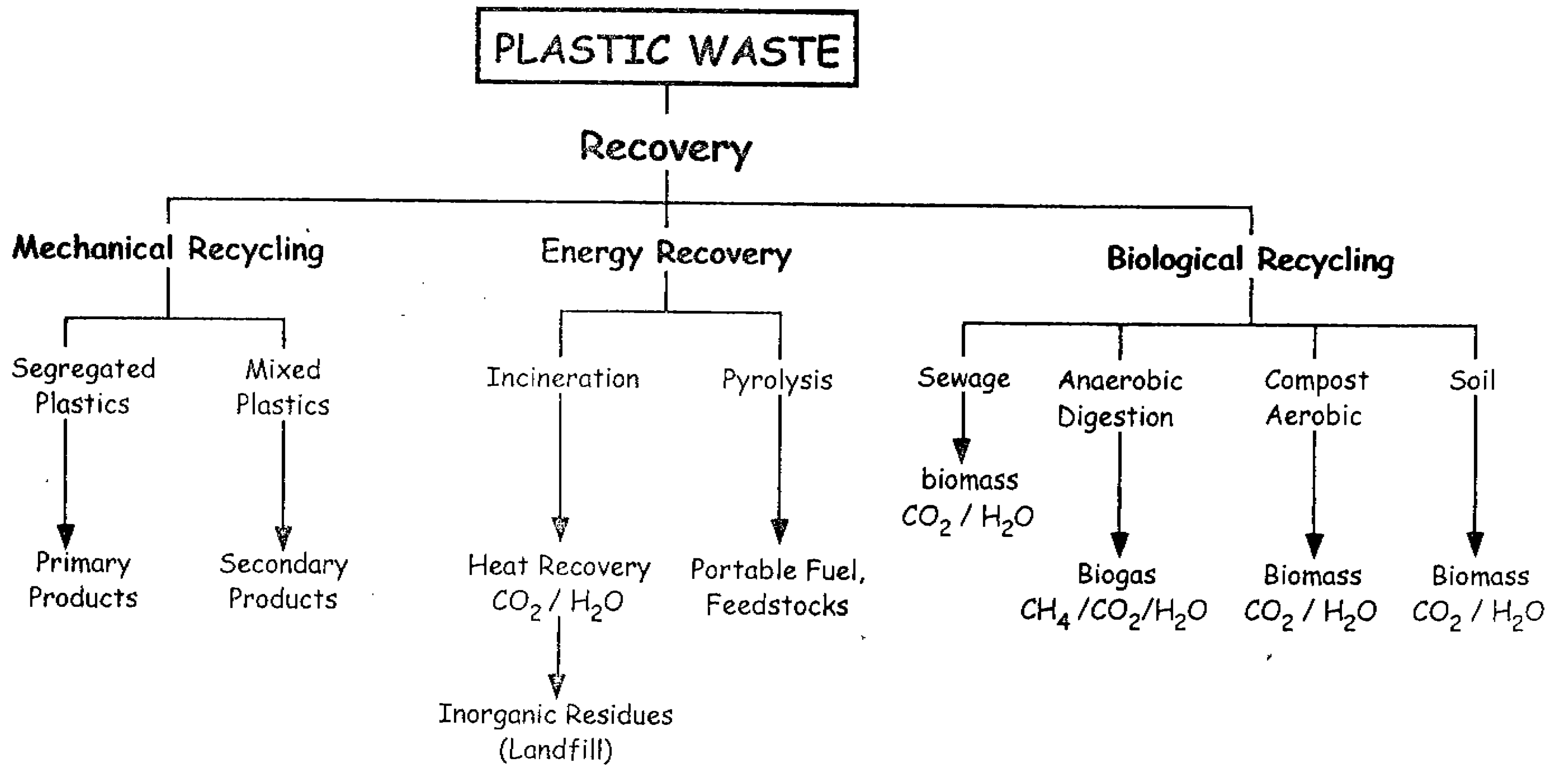
CEN TC 249/WG9

Plastics - Characterization of Degradability

Targets for EC Packaging Waste Management Legislation

1. By mid-year 2001, between 50% and 65% by weight of packaging waste has to be recovered.
2. Within target 1 and within the same time frame, between 25% and 45% by weight of packaging materials in packaging waste has to be recycled.
3. Within the targets 1 & 2 frame, a minimum of 15% of each material category, e.g. plastic packaging, must be recycled.

PLASTIC WASTE MANAGEMENT OPTIONS



Asia Network

Japan- Korea-Taiwan-US Working Group
December16, 2000
Honolulu, Hawaii

Participants (contact list attached):

Environmentally Biodegradable Plastics Association, EBPA (Taiwan)
Japan Organic Recycling Association, JORA (Japan)
Korea Organic Waste Recycling Council, KOWREC (Korea)
U.S. Composting Council, USCC (USA)
International Biodegradable Products Institute, IBPI
BioEnvironmental Plastics Society, BEPS (USA)
Japan Biodegradable Plastics Society, BPS (Japan)
Forest Research (New Zealand)
US Grains Council, USGC, Japan, Korea, Taiwan, WADC

MISSION OF THE ASIA NETWORK:

1) "To promote the maximum diversion of organic materials from landfills & incineration to utilization as organic resources."
2) "To form an Asian Network of allied organizations to foster the development and exchange of organic recycling information, science and technology."
3) "Promote education and public awareness of organic recycling and biodegradable products to policy makers, consumers and business."
4) "Development and harmonization of standards and certification procedures regarding organic recycling through the national and international standardization bodies to achieve ISO 9000 levels using 14000 series standards/guiding principles."
5) Development and harmonization of standards and certification procedures regarding organically recyclable products / materials including biodegradable plastics through the national and international standardization bodies.

STRATEGIC GOALS:

-Standards:

Develop protocols to submit to international / national standards bodies for creation of Compost / Composting standards.

1) Proposal to ISO to establish a new working group for organic recycling within subsection TC 207 – Environmental Management Standards Section.
2) Evaluate the US Composting Council (USCC) "Test Methods for Evaluating Composting & Compost" (TMECC) documents as a basis for submitting national composting protocols to national / international bodies.
    a. The USCC TMECC was over 10 years at $1million+. Submitted to USDA for publication by the US Government Printing Office. Publication targeted for late spring 2001. USDA or USCC will publish it.
    b. USCC "Seal of Testing Assurance" Logo Program (STA). Step Two towards development of better product quality standards. Utilizes uniform procedures and

protocols for sampling, testing, preparing samples, submission of samples, lab set up, etc. (procedures are included in the TMECC).

Issues:
Copyright / Licensing / Translation / Printing / Distribution costs

-Training of Compost operators

Required to assure public confidence and achieve ISO 9000.

Suggested base document: USCC Training manual for compost operators, perhaps adapted to specific country/cultural issues. Important update of entire manual will be done in upcoming year by USCC.

USCC established a Compost Professional Credentials Committee to develop certification programs for operators and managers. (Nov. 2000).

Issues:
Where does training fall under ISO?
Is documentation of training required by ISO standards?
International recognition / registration / accreditation process.
Development funding & Costs to administer?
Copyright / Licensing / Translation / Printing

-Compostability Logo

Establish and encourage mutual recognition of national Compostability Logos based on established international / national specification standard.

IBPI / USCC Logo program, DIN/Certco, OKCompost, etc.

Tasks to Establish the Asia Network

1) National representatives or association / contacts will be identified and contacted throughout Asia & Aus/ NZ to participate in the Asia network.

2) JORA is proposing to host an Asia Network Composting Conference in Tokyo Autumn, 2001. JORA requests others to suggest or nominate representative organizations or representatives from countries throughout Asia & Aus / NZ.

3) Conference coordination – create the schedule of a rotating international conference to follow Tokyo; the organization of the conference is done by the local host. Create a 3 year schedule?

4) Website design and hosting; each country organization creates own website, but linked to International website. International website can be quite simple (w/ world

map linked to each organization?) Each organization linked to the international website.

5) Identify Resources, Funding & Budget

Maintain as a volunteer Organization?

-Work Tasks for the Asia Network:

1) Alliances w European Network ?
2) Information exchange / Data base links
3) Funding of specific studies….how to fund specific studies? Tropical condition composting – tie into country locale.
4) Scholarships / student exchanges

Immediate Projects for Asia Network

-**Survey of policies** and government support programs for **biodegradable plastics**.

-**Survey of policies** and government support programs for **composting**.

-**Document benefits of compost** (Obtain and circulate the ORCA LCA study on benefits on compost utilization – contact Ramani Narayan)

1) Target audience: Agriculture, construction, policy makers & the lay person
2) Cost benefit analysis: Compost is more than a soil conditioner, what is it worth?

- Carbon Emission Credits from Organic Waste Recycling Trading

Organic Recycling associations are uniquely equipped to measure, certify and audit CEC for trading purposes. This provides opportunities for ongoing revenue to the organizations.

Issues:
Develop the science of quantification (carbon emission credit composting)
Develop a Certification / Auditing program (discussion of carbon credits currently being held)
Harmonization of above
Recognition by International bodies.

Asian Network as Matchmaker: Technology / Joint Venture contacts

Next steps:

USGC/ Japan / BioMaterials Team Asia will offer assistance to the national secretariat to facilitate communication of the Asia Network if requested.

The Asia Network will undertake a rotating bi-annual volunteer secretariat at a date to be determined.

The attendees agree to report on the approval or recommendations of their national organizations by February 28th, 2001.