International Conference on Green and Sustainable Innovation 2009
December 2 – 4, 2009, Chiang Rai

# ENVIRONMENTAL PRODUCT DECLRATION OF WASTE DISPOSAL IN A SANITARY LANDFILL: CASE STUDIES OF BANGKOK MUNICIPALITY ADMINISTRATION IN KAMPANGSAN LANDFILL SITES

Anurat Sasomsub[1] and Kitikorn Charmondusit[2*]

[1]*International Program of Industrial Ecology and Environment, Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Nakornpathom 73170, Thailand*
[2]*Eco-Industry Research and Training Center, Faculty of Environment and Resource Studies, Mahidol University, Salaya Campus, Nakornpathom 73170, Thailand.*

**Abstract**

Municipal solid waste (MSW) management becomes a major issue facing developing cities. Bangkok is one of those cities who generate a large amount of MSW per day. After the collection service for all households is completed, the majority of MSW is typically sent to landfills at fully utilized sanitary landfills after collection. This aim of the present study is to evaluate the potential environmental impact associated to urban waste dumpling in a sanitary landfill by using the environmental product declaration (EPD) tool. The study was based on the material from the covered area of Bangkok Municipality. The resource of the investigation is originated from Tarang transfer station; locate at the northern part of Bangkok and Nongkam transfer station; locate at south-western part of Bangkok. Nevertheless, the resource or the MSW would be hauling over to the site area, which is located in Kampangsan district, Nakornpathom. Through the application of EPD, this work was signified the importance of the four major phases, which includes transportation phase, landfill phase, leachate phase and biogas phase. The results show that the amount of diesel oil used was the key factor to identify the emission produced from the transferring phase. The compositions of waste influenced to the environmental burdens of landfill and leachate phases. The biogas management shows the best practicable option that benefits the environment.

**Keywords:** Environmental Product Declaration; Municipal Solid Waste; Kampangsan Landfill Site; Nakornpathom; Sanitary Landfill

## 1. Introduction

Even though many parts of Thailand still openly dump their MSW, in the mean time Bangkok has already minimized its open dumping to almost none. While Bangkok gathers all the waste and delivers its MSW to three different transfer stations. Due to challenging factors such as, funding, political matters or domestic technology, etc, Bangkok Metropolitan Administration (BMA) sees that the suitable method for Bangkok waste management scheme at this stage would be "landfilling".

In year 2000 municipal solid waste in Bangkok city generated roughly 9,130 tons per day or 3.33 million tons per year. Bangkok Metropolitan Administration was able to manage 9,040 tons per day or 3.30 millions tons per year, which was 99% of the total waste generated. BMA processes the waste by appointed private sectors to manage the disposal of the waste [3]. The waste from Nongkam and Tarang transfer stations, which is about 5,563 tons per day, is transferred to Amphur Kampangsan, Nakhonpathom Province. The waste from On Nut transfer station is transferred to Amphur Bangplee Samuthprakarn Province at about 3,578 tons daily, but nowadays, the waste has been shifted to the dump site of the landfill site at Chachuengsao.

From the record of BMA, the amount of waste generated has been increasing consistently. Moreover, BMA has a hard time finding the disposal areas or sites. Therefore, BMA set the strategy of reducing, reusing and recycling the waste for the fifth development plan of Bangkok (1997-2001). The target was to recycle at least 20% of the total waste generated within year 2001. The Department of Public Cleansing (DOPC) of BMA set a project for encouraging people to reduce, reuse and recycle. Fifty Bangkok local authorities followed such a project by starting to exercise school, villages, town houses, shopping malls, temples, government offices, etc, to reduce, reuse and recycle their waste. The record was kept since November 1998 where 11,630 tons of waste was able to be reused. Within two years, the number increased to 22,227 tons per year [10]. Even though the strategy of reduce, reuse and recycle is affective in a certain extent, an enormous amount of waste generated still requires a proper management disposal.

Though MSW is not as contagious as hazardous waste, without a proper way of treating the waste, there would be tremendous effects upon the environment. Landfilling has its own impacts onto the environment; depending on the characteristic of the waste and the process of the disposal. Thus, it is important for BMA to acknowledge the impact on the environment and set and meet the standard for landfilling. Bangkok is a big city with numerous amounts of people, therefore, its environment deserves a proper treatment and caring attitude in the way we use resources and deal with unavoidable wastes.

In order to acknowledge the impact on the environment and meet the standard for landfilling, the framework of the Environmental Product Declaration (EPD) needs to be applied. Environmental Product Declaration (EPD) is defined as "quantified environmental data for a product, with pre-determined parameters, based on the ISO 14040 series of standards, which mat be supplemented by other qualitative and quantitative information" [6]. With respect to this study, the environmental burdens or impacts of the Bangkok Municipal Solid Waste Sanitary Landfill would be reflected and compared through the EPD of 4 different phases, Transfer, landfill, Leachate and Biogas phase.

## 2. Methods

The method of this study is set under the scope of the received and transferred waste from the 2 different Transfer Stations, Nongkam and Tarang Transfer Stations, until the material or MSW is being disposed by the 2 different sanitary landfilling at Kampangsan landfill site. Within the phase of transferring, the amount of diesel used would be the key factor to identify the emission produced from this work process. In addition, the disposing and landfilling phase is also a crucial factor. Before landfilling the waste, the composition of the waste must be initiated; hence, the number can be converted back to the environmental burdens. Moreover, the scope of this study would extend further to the phases of leachate and Biogas, which derived from the landfills. The study on leachate and biogas would cover the pollutants or $CO_2$ emissions produced from each phases before they are being treated, in this case, we would find the actual and exact environmental burdens that are generated by the raw resources and not yet being treated. The $CO_2$ emission can be calculated based on the Intergovernmental Panel on climate change (IPCC) guideline.

The theoretical framework derives from the studies and understanding from the texts is set to be the standard of proper landfilling process. On the other hand, the solid waste management of BMA case study: Sub-contractors (Group 79 Co., Ltd. and Wassaduphan Co., Ltd.) landfills, is an "On Site Research" for practical framework. Beside, by adopting PSR 2003:3 [19], which defines the requirements, based on environmental parameters must also be considered within the LCA study of MSW Sanitary Landfill Management under the scope of transferring, disposing and treating leachate and biogas.

## 3. Results and discussions

### 3.1 Site description

The sites are located within the same area of Kampangsan district, Nakhon Pathom province. The 2 different sites are managed by Thai operator, Group 79 Co, Ltd. (**Case Study I)** and Wassaduphan Co, Ltd **(Case Study II)** The area is located in a less to non community zone, high ground above the sea-level, deep underground water table, dry and unfertile soil, etc.

**Case Study I.** The Group 79, Co., Ltd. Landfill site is located at 39 Moo.8, Tumbol Tungbua, Kampangsan District, Nakhon Pathom Province, 73000**.** The daily incoming waste for Group 79 site is at the average of 2700 tons per day; starting from March 2005.

**Case Study II.** Wassaduphan Co., Ltd. site is located at 49 Moo.8, Tumbol Tungbua, Kampangsan District, Nakhon Pathom Province, 73000**.** The Wassaduphan site started operated since March 2004 and is receiving waste at around 2000 tons per day.

The major description of each site can be determined through the characteristic of the waste contained or the waste composition. In **Table 1**, the waste compositions of the two case studies, Group 79 Landfill as Case I and Wassaduphan as case II, are shown, whereby the values are slightly different from each other, due to the fact that the sources of waste are from different area. Both samples were taken at the delivery of waste on site; hence, the quick decomposition of putrescible materials has no effect with the result.

The waste is characterized by direct sampling during the field site investigation at the final disposal site area, before landfilling. Both case studies samples were collected from monthly data for the past three consecutive years (2006, 2007, and 2008). The result shows that the compositions of waste in 2 different areas of Bangkok Municipality are very much alike. The only two major different would be Organic matter and Wood, which might be because of the number of fresh market and national park within the area.

Table 1 Composition of waste disposed in Landfills

| Waste Composition (%) | Case study | |
|---|---|---|
| | Case I | Case II |
| Organic matter | 43.99 | 38.19 |
| Plastic material | 20.92 | 20.96 |
| Iron/metal | 0 | 0 |
| Glass | 1.34 | 1.20 |
| Paper | 10.06 | 14.6 |
| Wood | 8.26 | 18.23 |
| Textile | 14.13 | 5.86 |
| Inert material | 1.27 | 0.94 |

### 3.2 Transport phase

**Case Study I.** The receiving waste from Nongkam station is roughly at 3,000 tons per day, where the distance is about 86 kilometers. According to this case study, the trailers required to perform the task are 48 trucks.

**Case Study II.** The incoming daily waste for Tarang station is roughly at 2,000 tons per day, where by the distance is at around 135 kilometers, whereby, the amount of semi-trailers needed are 39 trucks.

As the matter of fact, the impact from transferring phase shall be calculated by diesel consumed by the hauling trucks as shown in **Table 2** below.

The important cause of variation for the Carbondioxide produced is based on fuel consumption. The distance of the route back and forth parallel with the weight that need to be carried are different for both case studies. Case I required lesser hauling distance, but more trip for the truck to carry 2,700 tons of waste, which in fact produce slightly more $CO_2$ emission rather than the 2,000 tons flat for Case II.

Table 2 $CO_2$ produced from diesel consumption during transferring phase

| Case Study | Yearly average $CO_2$ produced (Ton $CO_2$) | | |
|---|---|---|---|
| | 2006 | 2007 | 2008 |
| Case I | 18,510,724 | 18,372,120 | 17,565,753 |
| Case II | 17,281,346 | 17,604,326 | 17,305,521 |

### 3.3 Landfill phase

Sanitary landfill is landfill that has physical barriers such as liners and leachate collection systems, and procedures to protect the public from exposure to the disposed wastes. The term sanitary landfill normally refers to those where municipal solid waste is disposed of, as well as other wastes high in organic material [12].

With the concern toward environmental suitability of the surrounding condition of the landfills area, group 79 and Wasaduphan Co., L.td. have implemented their frame work regarding theoretical. Before the landfill can start the operation, a lot of effort is needed in the preparation phases. The process starts from the daily transportation of the waste from Bangkok Municipality. Next important item is choosing suitable land. Then we need to excavate down to certain levels and compaction for both the landfill and leachate treatment ponds. Then, leachate collection system must be carried out. Further, HDPE liner must be put down and joined with special machine before checking for leakage on both landfill and leachate treatment ponds. After that we have to put Geo-net and Geo-textile to prevent any sharp object from piercing down the liners at this stage only for the landfill. Also, the HDPE collection pipe for landfill gas is lay out and covered with rock and sand [11].

After landfill has been conducted and ready to be operated, as any other activities, during the process of landfill the 2 resources used would be electricity and waster. The main water and electric usage would be based on office work rather than on-site activities. The Table 3 below shows the Water consumption in term of cubic meter. Thus far, the electricity usage can be converting back to $CO_2$ emission as shown in Table 4 below.

Due to the fact that the amount of waste at Group 79 site or case I is greater than the other site, the consumption of water for dusting, planting and general usage would be greater respectively.

Table 3 Yearly water consumption rate in Cubic meter

| Case Study | Average Water Consumption (Cubic meter) | | |
|---|---|---|---|
| | 2006 | 2007 | 2008 |
| Case I | 5,331 | 4,863 | 5,448 |
| Case II | 2,997 | 2,965 | 3,230 |

Even though the amount of waste is lesser in Case study II site, but the number of electricity usage appear to be greater; the reason behind this is because both landfill operations share a single operator’s team and field office, which located at Wassaduphan or Case II site. Therefore, the number of electricity usage or the number of the $CO_2$ produced from electricity usage would be much more significant on the Case study II site.

Table 4 Yearly $CO_2$ produced from electricity usage

| Case Study | Yearly average $CO_2$ produce from Electricity usage (Ton $CO_2$) | | |
|---|---|---|---|
| | 2006 | 2007 | 2008 |
| Case I | 1,152,499 | 2,887,611 | 3,563,495 |
| Case II | 2,779,553 | 3,113,274 | 2,720,723 |

Even though the amount of waste is lesser in Case study II site, but the number of electricity usage appear to be greater; the reason behind this is because both landfill operations share a single operator’s team and field office, which located at Wassaduphan or Case II site. Therefore, the number of electricity usage or the number of the $CO_2$ produced from electricity usage would be much more significant on the Case study II site.

**3.4 Leachate phase**

The leachate treatment system contains 14 HDPE lined linear treatment ponds which provide the company with various jobs of treatments. The leachate treatment capacity of treatments. The leachate treatment capacity of each case study is at 2000 cubic meter per day of leachate. The leachate will enter first the anaerobic then aerobic treatment. After that the leachate will enter maturation pond then wetland and lastly to the storage pond.

**Case Study I.** The leachate produced from the landfill is pumped from the bottom of the landfill and hurl to the “leachate collection canal”. Within the “leachate collection canal” the sludge would get settle to the bottom of the pond and the leachate would be over-flowed toward systematic Stabilization Pond, which start from Facultative Ponds, follow by Aerobic Ponds, which are all lined-up in linear sequence. Last treatment pond to arrive is the Constructed Wetland, which is the quality alteration process by biological treatment. After all kinds of treatment ponds, the treated leachate would be discharged to the gigantic storage pond and use for other purposes. During this period of time, leachate only circulates within the first stage of the treatment system, which is Stabilization pond. In fact, the measurement under table 3 shows the present condition of leachate, which is not yet completely treated

**Case Study II.** The leachate treatment system is exactly identical with the earlier case study 1. The only differ among the two is the composition of MSW, which came from different area, which consequence in the diverse results of the measurement in each parameters.

The **Table 5** below shows the laboratory test results of incoming or untreated leachate collected at the initial pond before entering the treatment system.

**3.5 Biogas phase**

Throughout the lifespan of the MSW, the gas generation process has its own characteristic during each stage. The most common containments of the gases are primarily Methane, Carbon Dioxide, Ammonia, Nitrogen, Hydrogen Sulphide and traceable amount of Non-methane organic compounds, etc. After the MSW has been landfilled, the biological reactions slowly begin under the 2 different phases. The first phase takes place in the atmospheric air, which is near by the surface of the landfill whereby the natural organic compounds are oxidized aerobically. The second phase emerges within the landfill anaerobically and can be divided into 3 stages. The first, fermentative bacteria would hydrolyze the organic compound into soluble molecules. Within the second stage, the molecules are converted by bacteria to carbon dioxide, hydrogen and organic acids; the primary acids produced are acetic, propionic, butyric acid and also ethanol. The last stage is basically where the methane is formed by methanogenic bacteria, by breaking down of acids to carbon dioxide and methane or by the reduction of carbon dioxide with hydrogen.

**Case Study I**. According to the study of Group 79 Co., Ltd., the generation of the gases would firmly initiate within the $3^{rd}$- $4^{th}$ year and tend to increase as time comes. The collection system

Table 5 Leachate laboratory test results on 26 different parameters

| Parameter | Unit | Average 2006 | | Average 2006 | | Average 2006 | |
|---|---|---|---|---|---|---|---|
| | | Case I | Case II | Case I | Case II | Case I | Case II |
| pH | | 8.03 | 8.17 | 8.16 | 8.1 | 8.03 | 8.2 |
| EC | μmho/cm | 20,861 | 24,316 | 14,133 | 13,965 | 24,183 | 23,753 |
| Color | Color unit | - | - | - | - | - | - |
| Temperature | $^{o}C$ | 32.93 | 31.83 | 29.63 | 32.13 | 30.97 | 30.20 |
| TSS | mg/L | 403.33 | 246.00 | 673.33 | 231.33 | 387.33 | 176.67 |
| TDS | mg/L | 14,788 | 13,993 | 14,736 | 9,650 | 14,080 | 13,569 |
| Chloride | mg/L | 4,255 | 4,366 | 4,041 | 5,139 | 3,967 | 4,315 |
| Sulphate | mg/L | 3.97 | 14.92 | 5.53 | 30.83 | 3.83 | 25.33 |
| BOD | mg/L | 1,242 | 210 | 1,296 | 119 | 2,056 | 113 |
| COD | mg/L | 4,202 | 1,612 | 3,771 | 1,639 | 4,235 | 1,517 |
| Nitrate | mg/L | 36.47 | 23.37 | 32.85 | 11.07 | 27.01 | 16.69 |
| Ammonia | mg/L | 1,628 | 909 | 3,881 | 555 | 1,887 | 895 |
| Total Phosphate | mg/L | 39.07 | 33.40 | 36.3 | 32.03 | 32.77 | 32.73 |
| Alkalinity | mg/L | 8,028 | 5,981 | 12,309 | 5,505 | 8,747 | 6,447 |
| Arsenic | mg/L | 0.25 | 0.39 | 0.57 | 0.44 | 0.24 | 0.18 |
| Cyanide | mg/L | - | - | - | - | - | - |
| Phenols | mg/L | 3.23 | 1.19 | 3.86 | 1.16 | 2.33 | 0.90 |
| Chromium Hexavalent | mg/L | - | - | - | - | - | - |
| Nickel | mg/L | 0.39 | 0.57 | 0.42 | 0.30 | 0.32 | 0.25 |
| Zinc | mg/L | 1.19 | 0.40 | 1.45 | 0.13 | 0.63 | 0.17 |
| Cadmium | mg/L | - | - | - | - | - | - |
| Copper | mg/L | - | - | 0.05 | - | - | - |
| Lead | mg/L | - | - | - | - | - | - |
| Manganese | mg/L | 3.63 | 0.49 | 1.07 | 0.31 | 1.67 | 0.17 |
| Mercury | mg/L | 0.04 | 0.063 | 0.02 | 0.046 | 0.0096 | 0.018 |
| Sodium | mg/L | 6,569 | 3,948 | 5,468 | 3,212 | 5,302 | 2,900 |

would be built in the horizontal plan on every 3 layers or 9 meters of the landfill. The first installation system starts in the 5th layer of the landfill with 8 inches diameter main pipeline and 6 inches diameter collection pipelines. The collected gas, if enough, would be utilized for the electricity generation, if not, would be burnt by flaring system. The measured gas parameters are Ammonia, Hydrogen Sulphide, Methane and Carbon Dioxide, which are stated as the following Table 6.

**Case Study II**. The work procedure of the Wassaduphan Co., Ltd. is again exactly identical with the first Case Study, however, the amount and the composition of the gases might be dissimilar due to the variation in the amount and composition of the MSW.

**4. Conclusion**

Today, product-related environmental issues are playing an important role within the strategic planned out for business sectors. Such developments required business sectors, companies or organizations to recruit all vital information about environmental aspects of products and services, which in return would provide such sectors to be able to place the information in the context and make their own decision. Under the sense of sustainable development, the goal of EPD is to provide relevant, verified and comparable information to meet the various needs within an organization including within environmental management systems (EMS), for Eco-design, and in green procurement, etc.

Precisely speaking, Environmental Product Declaration represents a verifiable and accurate way to show the environmental aspects of products or services, view from a comprehensive life cycle perspective 'from cradle-to-grave'. It is defined as 'quantified environmental data for a product, with pre-determined parameters, based on the ISO 14040 [7] series of standards, which may be supplemented by other qualitative and quantitative information [16]. The information contained in the EPD, developed using Life Cycle Assessment (LCA), are exclusively informational in nature, and the declaration contains no criteria for assessment, preferability or minimum levels to be met. In fact, it is not

Table 6: Biogas laboratory test result on 3 different parameters

| Parameter | Unit | Average 2006 | | Average 2007 | | Average 2008 | |
|---|---|---|---|---|---|---|---|
| | | Case I | Case II | Case I | Case II | Case I | Case II |
| Ammonia | mg/m3 | 0.18 | 0.27 | 0.31 | 0.24 | 0.28 | 0.29 |
| Hydrogen Sulphide | mg/m3 | 0.001 | 0.008 | 0.002 | 0.007 | 0.001 | 0.001 |
| Methane | ppm | 15.83 | 13.70 | 18.04 | 16.54 | 28.80 | 25.65 |

possible to rely on the studied result to determine the ‘best product’ or ‘best method’ for waste treatment, but it is possible to identify the lowest impact product or service for each resource usage and impact category.

**5. Acknowledgement**

Great acknowledgements and thank you for the kind support on materials, lab test results, funding and other needed information regarding the landfills to the sites owner, Group 79 Co., LTD and Wassaduphan Turakit Co., Ltd.

**7. References**

[1] Borghi, A.D., Binaghi, L., Borghi, M.D. and Gallo, M. (2007) The Application of the Environmental Product Declaration to Waste Disposal in a Sanitary Landfill, *International Journal Life Cycle Assessment*, vol. 12(1), pp. 40-49.

[2] Department of Environment, *Waste Management*. Thailand, Bangkok Metropolis Administration, Available online: http://203.155.220.239/subsite/index.php?strOrgID=001054

[3] Department of Public Cleaning, *Waste Management*. Thailand, Bangkok Metropolis Administration. Available online: http://203.155.220.217/dopc/

[4] Tchobanoglous, G., Theisen, H. and Vigil, S.A. (1993). Integrated Solid Waste management, International Edition, McGraw-Hill, Singapore.

[5] Global Finest Inc, Convert Waste Oils, Crude Oils & Plastic Recyclables into EN590 Diesel, (May 12th 2008) Available online: http://www.globalfinest.com/tech/

[6] International EPD Consortium (IEC), None profit organization, The International EPD, Stockholm, Sweden, Available online: http://www.environdec.com/pageId.asp?id=100

[7] ISO 14040. (1997). Environmental Management - Life-cycle assessment – Principles and Framework, International Organization for Standardization.

[8] Themelis, N. J. and Ulloa, P.A. (2006) Methane Generation in Landfills, Earth Engineering Center and Department of Earth and Environmental Engineering, Columbia University.

[9] Paul, T. and Williams. (2005). Waste Treatment and Disposal, John Wiley & Sons Co., Ltd., England.

[10] Pollution Control Department. (1992) *Waste Management*, Pollution Control Department, Thailand, Available online: http://www.pcd.go.th/

[11] Taken from: Ms. Pantip Chancharuenkit, Site Manager of Group 79 Co, Ltd. and Wassaduphan Co, Ltd. Kampangsan District, Nakhon Pathom Province.

[12] The Wikimedia Foundation, Inc, Wikipedia dictionary: (February 20th 2008), Available online:http://en.wikipedia.org/wiki/Thermal_depolymerization.

[13] ISOTR 14025. (2000) Environmental labels and declarations – Type III environmental labeling. Geneva: ISO; 2000.

[14] Environmental product declarations, EPD: (May 12th 2008) Available online: http://www.environdec.com

[15] Steen, B., Garling, A., Umrell, A.M. and Sanne, K. (2007). Development of interpretation keys for environmental product declarations, Chalmers University of Technology, Environmental System Analysis.

[16] ISO (2003): ISO CD 14025.1: Environmental Labels and Declarations – Type III Environmental Declarations – Principles and procedures. International Organization for Standardization

[17] Del borghi A., Binaghi L., Forte A., Fabbiani V. and Maggi G. (2003). Environmental Product Declaration for Waste Collection, Transport and Landfilling – A Case Study PA Waste Management Concepts and Strategies Sardinia, *Ninth International Waste Management and Landfill Symposium*, pp 555-556

[18] Del Borghi A., Soracco B., Fabri A., Ruello A. and Gallo M. (2001). Environmental Declaration of Services: LCA applied to various biological treatments of urban landfill leachate. Proceedings 9th SETAC Europe LCA Case Studies Symposium, Noordwijkerhout, The Netherlands, 14-15 November 2001.

[19] PSR 2003:3 Product – Specific Requirements (PSR) for preparing an environmental product declaration (EPD) for Product Group Collecting and disposal service of Municipal Solid Waste (MSW) in a sanitary landfill The Swedish Environmental management Council Version 1.0 2003-05-28: Available from: http://www.environdec.com/psr/e psr0303.pdf

[20] California Integrated Waste Management Board, *Collecting Your Own Solid Waste Characterization Data: CIWMB Uniform Waste Disposal Characterization Method,* California, USA: Available online: http://www.ciwmb.ca.gov/WasteChar/YourData.htm#Step5