DUMPSITE TOXICITY ASSESSMENT AND POTENTIAL FOR REHABILITATION: A CASE STUDY AT MAUNG PATHUM DUMPSITE, THAILAND

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ABSTRACT
The condition of Maung Pathum dumpsite in Pathumthani province, Thailand was investigated for potential rehabilitation and material recovery. Analysis of solid wastes and leachate samples from the dumpsite showed that the waste is stabilized, mainly consisting of soil fraction (69-75%). The result of toxicity characteristics leaching procedure (TCLP) revealed that the soil fraction was not hazardous and potential to be reused as landfill cover material. Moreover, soil fractions of particle size <10 mm and <2 mm have potential to be used as compost material after supplementing P and K. However, the leachate quality does not comply with the criteria of a typical stabilized landfill and the heavy metals concentration is higher than the Thai Effluent Standard. This may be due to the infiltration of young leachate from the waste newly dumped at the top of the pile. The calorific values of waste samples indicate that except for wet organic materials it can be reused as refuse derived fuel (RDF).

INTRODUCTION
Open dumping is a common method of municipal solid waste (MSW) disposal in Asian countries. Uncontrolled and irresponsible dumping leads to severe environmental contamination and if inappropriately addressed, it could seriously affect the environment. Moreover, land space for waste dumping expands rapidly as demanded by an enormous amount of solid waste generation. Thus, an urgent need to solve the associated disposal problems, to recover resources, and conserve space for future disposal is crucial.

The common features of existing dumpsites in Asia can be described by improper site investigation and lack of control over the type of waste entering the site; non-engineered design without waste confinement; and lack of proper planning, on-site monitoring, and control measures (ARRPET, 2004; Ball and Denhann, 2003). The uncontrolled disposal, weak features of dumpsites (without liner, leachate collection or landfill gas control), and the presence of hazardous waste components creates considerable environmental health nuisance. The co-disposal of hazardous waste from industries and hospitals containing toxic substances are commonly found in typical dumpsites in Asia (ARRPET, 2004) making it necessary to rehabilitate the old dumpsites to minimize the extent of toxic compounds in the environment.

Strange (1998) suggested that a landfill needs to be 15 years old before a successful mining project can be performed. Landfill mining technology is a preferred approach for conservation of landfill space, reduction of pollutants, dumpsite rehabilitation, recovery of valuable materials as RDF, and reduction of waste management (Hogland et al. 1997). Van Der Zee et al., (2004) stated that landfill mining is a process of waste excavation by using a conventional mining technology to recuperate valuable resources from landfills. Importantly, before conducting this technique, the condition of solid waste has to be investigated to determine the level of stabilized waste. In Asia, there is an urgent need to restore the existing dumpsites and promote engineered landfilling techniques.

MATERIALS AND METHODS

Site Description

The Maung Pathum dumpsite, operated by Maung Pathum Municipality, is located at Amphur Maung, Pathumthani province in Thailand. This dumpsite is operated for the past 20 years. Figure 1 shows the location map of the existing dumpsite and the sampling points. Currently, half of the dumpsite area is used as a temporal dumping station by stacking new waste at the top of the old pile. The sampling is conducted in the other half part of the dumpsite (figure 1). The height of dumpsite pile is 2.2 m above ground level and the volume of waste pile including a part below the ground level is 15,000 m^3. The depth of dumped waste below ground level is 1.5-2 m. The leachate from this dumpsite is collected in a long narrow pond adjacent to the dumpsite. Moreover, it is located in the middle of a rice field and most of the land area in this municipality is used for agricultural purposes.

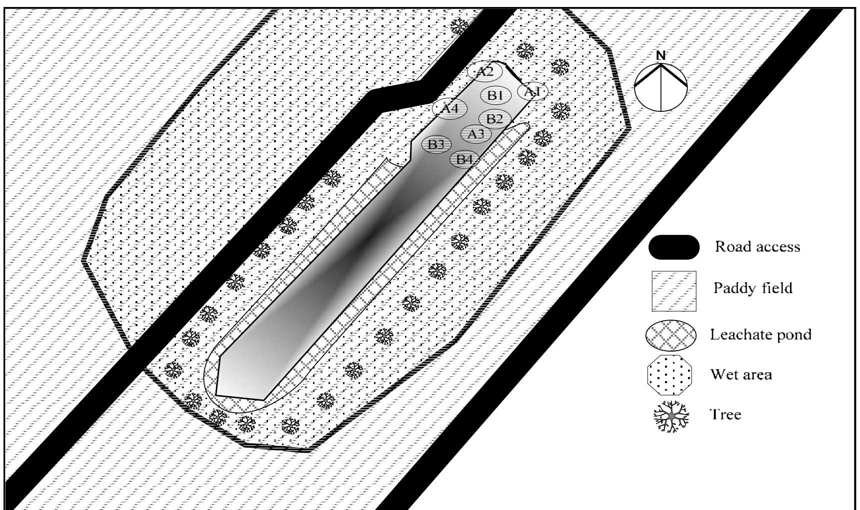

FIGURE 1: LOCATION MAP OF THE DUMPSITE

Waste Sampling and Analyses

Representative solid waste samples were collected using Augur and Backhoe excavation equipments; these samples were designated as sample A and B, respectively. In this study, backhoe sampling is considered as bulk sampling due to large amount of waste can be collected. Leachate samples were collected from bored holes where solid wastes were taken.

Waste composition: Representative solid waste bulk samples were randomly collected in the dumpsite by using backhoe equipment. The bulk wastes are allowed to dry and segregated into combustibles, non-combustibles, and soil fractions. Furthermore, the waste was classified into individual components such as wet organic, textile, wood, plastics, rubber and leather, metal, glass, and stone.

Physical-chemical characteristics: Total solids (TS), volatile solids (VS), moisture content (MC), and ash content of waste samples was determined based on standard method. The total organic carbon (TOC) was analyzed by using Walkley-Black method.

Heavy metals concentration: Heavy metals such as Hg, Cd, Pb, Cr, Ni, Zn, and Cu were analyzed in solid waste samples by using TCLP analysis adopted from method 1311 of U.S.EPA (1992). The results of TCLP analysis determine the degree of hazardousness of waste by comparing with TCLP limits.

Characterization of leachate: The leachate samples were analysed for pH, BOD (biochemical oxygen demand), COD (chemical oxygen demand), NH_4-N, cations and anions. Similarly, heavy metals as analyzed for solid waste samples were also determined in leachate. The analyses were conducted according to the analytical procedures of standard methods in APHA et al. (1998).

Soil fraction analyses: Soil fraction of size less than 25 mm and 2 mm was analyzed for hydraulic conductivity based on Constant-head method which is one of the many methods used by U.S. EPA for solid waste analysis. The objective of this test is to investigate the potential of soil fraction to be used as landfill barrier material. In addition, soil fraction of <10 mm and <2 mm were analyzed for pH, N, P, K, and heavy metals. The results were compared with Thai guideline. Heavy metals result was compared with Thai soil standard.

Calorific value of waste: The calorific value measurement was conducted in each fraction of combustible wastes such as plastics, wood, textile, rubber and leather, and wet organic fraction. In addition, a mixed of combustible and segregated waste (without organic fraction) are also subjected to analysis based on the British standard No BS 4379 with Cussons Bomb Calorimeter. This is to investigate the potential of the waste to be used as refuse derived fuel (RDF).

RESULTS AND DISCUSSIONS

Solid waste

The average percentage of waste composition from this dumpsite is shown in Figure 2. The result is mainly comprised of soil fraction (69-75%) with low organic content (0.3%-2.7%). This soil fraction is marginally higher than that reported for the Kodungaiyur dumpsite (only 55-65%) in India (Kurian et al., 2003). The characteristic of excavated waste with high soil fraction and low organic content indicate that the dumped waste is stabilized. Thus, the results of waste composition indicate that the waste in this dumpsite has a potential for mining to recover soil fractions that can be used as landfill cover material.

Table 1 represents the solid waste characteristics at Maung Pathum dumpsite and some dumpsites in India (Perunkudi and Kodungaiyur dumpsites). The moisture content in wastes from Maung Pathum dumpsite is less than that in Indian wastes and the variation is less. For other parameters such as ash content, TOC and bulk density, waste from Maung Pathum is more variable than Indian waste. In addition, considering the TOC concentration of wastes, the waste at Maung Pathum Dumpsite appear to be younger than the wastes dumped at Perunkudi dumpsite due to higher TOC values.

The result of physical-chemical analyses of solids waste from 8 sampling locations (A1, A2, A3, A4, B1, B2, B3, and B4) is in the range of 12-33% (MC), 67-88% (TS), 11-49% (VS), 52-88% (ash content), and 7-40% (TOC). The VS and TOC results are quite similar, because they both measure the organic matter contained in a waste. The observed high variation of VS and TOC values represent that the waste composition and age at any given point are different. Moreover, most of the sampled locations (A2, A3, A4, and B2) suggest that the waste is stabilized due to its low VS (11-24%), TOC (7-20%) and high ash content (76-89%) compared to the other sampling locations. Table 2 shows that the heavy metals concentration of the waste is below the TCLP regulatory level. Thus, the solid waste in this dumpsite can be considered as non-hazardous wastes.

Leachate

Leachate characteristic is another indicator to assess the characteristics of dumped waste. Table 3 represents the leachate quality of a typical stabilized landfill and the Maung Pathum dumpsite.

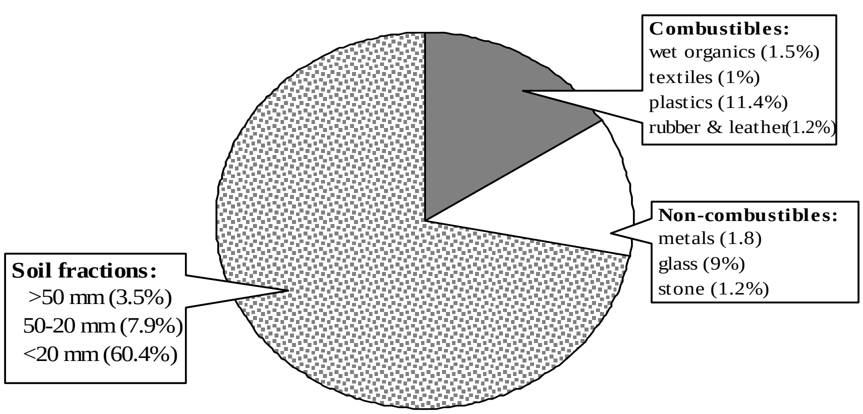

FIGURE 2: DISTRIBUTION OF WASTE COMPONENTS IN DUMPSITE

TABLE 1: SOME CHARACTERISTICS OF SOLID WASTES BETWEEN MAUNG PATHUM AND INDIAN DUMPSITE

Particulars	Maung Pathum Dumpsite		Perunkudi dumpsite[a]		Kodungaiyur dumpsite[a]	
	Min	Max	Min	Max	Min	Max
Moisture content (%)	12.1	33.4	19	52	15	46
Ash Content (%)	52.0	88.7	84.2	93.7	77	91
TOC (%)	2.3	39.7	3.02	7.88	-	-
Bulk Density	738.9	1,726.9	745*	1,185*	853*	1,254*

*mean dry bulk density

[a] ARRPET (2004)

TABLE 2: HEAVY METALS IN TCLP EXTRACTS OF SOLID WASTES

Sample	Hg (µg/L)	Cd (mg/L)	Pb (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cu (mg/L)
B1	7.7	0.6	1.0	1.6	1.9	5.1	1.1
B2	1.8	0.6	0.9	2.6	1.2	5.0	0.6
B3	4.0	0.6	0.8	2.8	1.5	3.2	0.6
B4	4.4	0.2	0.5	3.2	1.3	5.6	0.4
A1	4.7	0.7	BDL	2.0	1.6	4.9	0.3
A2	3.2	0.6	BDL	2.9	1.3	4.1	BDL
A3	3.9	0.7	1.2	3.5	1.5	5.6	1.1
A4	3.7	0.4	1.1	4.0	0.3	6.0	0.4
TCLP regulatory level (b)	200	10.4	5	5	20	250	25

[b] PSS (2001) BDL: below detection limit

TABLE 3: QUALITY OF LEACHATE FROM A TYPICAL STABILIZED LANDFILL AND THE MAUNG PATHUM DUMPSITE

Parameters	Unit	Typical stabilized landfill (c)	Maung Pathum dumpsite
pH	-	6.6-7.5	7.2-7.6
BOD	mg/L	100-200	465-1268
COD	mg/L	60-80	1800-58000
NH_4-N	mg/L	20-40	277-784
K^+	mg/L	50-400	10-695
Na^+	mg/L	100-200	493-970
Cl^-	mg/L	100-400	1399-2174
Ca^{2+}	mg/L	100-400	32-906
Mg^{2+}	mg/L	50-200	111-1291
PO_4^{3-}	mg/L	5-10	0-8.8
SO_4^{2-}	mg/L	20-50	85-198

[c] Tchobanoglous et al (1993)

Most of the analyzed parameters (BOD, COD, NH_4-N, Na^+, Cl^-, Mg^{2+}, and SO_4^{2-}) exhibited great difference from the typical stabilized landfill leachate. The high concentration of Maung Pathum leachate is due to the percolated leachate from the dumped fresh wastes. Thus, in this case the leachate quality is not a sufficient basis to consider the waste as stabilized or not because of newly dumped waste at the top of the pile.

Table 4 exhibits the results of heavy metals analysis expressed in terms of average value from the different sampling points in Maung Pathum dumpsite and the results from Perunkudi and Kodungaiyur dumpsites in

India are included for the purpose of comparison. Hg and Cu in the leachate of Maung Pathum dumpsite are comparatively higher than Perunkudi and Kodungaiyur dumpsites.

Moreover, Figure 3 shows the leachate heavy metals concentration and the Thai effluent standard. The leachate heavy metal content has mostly exceeded the standard. Thus, the strong leachate concentration emphasizes the necessity for dumpsite rehabilitation to prevent the further extent of contamination. Moreover, the newly dumped waste at the top portion of Maung Pathum dumpsite influence the overall result of leachate heavy metal concentration.

exhibited lower heavy metal concentration than the Thai soil standard for reclaimed soil. Whereas soil samples <10 mm match the fertilizer standard except for Hg concentration. This may indicate that the soil is potential to be used as soil cover for landfill and for other purposes such as landscaping or city greening purposes.

Nutrient level in soil samples was conducted in particle size <10 mm as determined a general guideline to evaluate the potential of soil for agricultural application as compost material or vegetative soil.

TABLE 4: HEAVY METALS IN LEACHATES FROM MAUNG PATHUM, PERUNGKUDI, AND KODUNGAIYU DUMPSITES

Dumpsite	Hg (µg/L)	Cd (mg/L)	Pb (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cu (mg/L)
Maung Pathum (Thailand)	22.0	1.4	70.4	13.1	11.4	96.9	176.5
Perunkudi (India) [(d)]	3.4	14.9	403.9	86.1	350.0	114.5	73.7
Kodungaiyur (India) [(d)]	12.4	71.4	159.8	4.1	379.6	168.1	136.4

[d] Kurian et al. (2003)

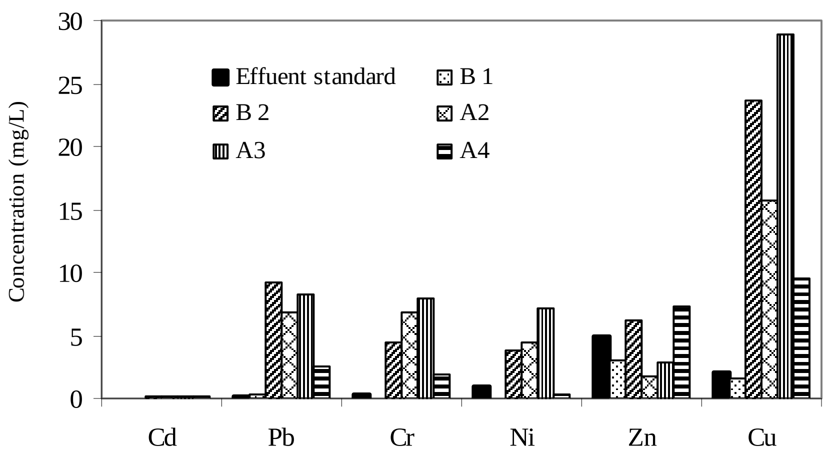

FIGURE 3: HEAVY METALS IN LEACHATE FROM MAUNG PATHUM DUMPSITE AND THE THAI EFFLUENT STANDARD

Soil fractions

The heavy metal concentration in soil fraction of particle size less than 10 mm and 2 mm were compared with Thai standard to assess the soil quality for reuse. Table 5 illustrates the heavy metal content in soil bulk samples and the Thai standard for reclaimed soil and fertilizer for agricultural applications. The sampled soil fractions

The nutrient in soil fractions of <10 mm and <2 mm were determined and the results did not comply with the set Thai guideline for compost material, particularly the P and K content while the pH condition and N fairly conform to the Thai guideline (Table 6). The low nutrient content may be due to the organic matter degradation in soil. According to Golueke (1997), degradation of organic material decreases the nutrient contained in soil while prevents foul odor, however appropriate amount of nutrients in soil is necessary if it is to be used for agricultural purposes. Thus, this soil fraction may contain organic matter that had undergone extensive degradation or maybe the nutrient is dissolved in leachate. Thus, these soil fractions could be used as compost material or for landscaping purposes after improving the P and K content.

Soil fraction of particle size less than 25 mm and 2 mm from bulk samples were analyzed to obtain the hydraulic conductivity. The result of measurement shows a value in the range of 0.026-0.068 and 0.0025-0.0078 cm/s, respectively. According to Tchobanoglous et al. (1993), the landfill clay barrier should have a maximum saturated hydraulic conductivity of $1x10^{-5}$ cm/s in order to prevent rain and leachate infiltration. However, the results do not comply with the requirement. Thus, soil fractions cannot be used as a soil barrier in landfills. Nevertheless, it can be used as a vegetative landfill cover alternative to control the rainfall infiltration into the waste (Victor et al., 2001).

TABLE 5: HEAVY METAL IN MINED WASTE AND THE THAI STANDARDS

Soil sample	Hg (mg/kg)	Cd (mg/kg)	Pb (mg/kg)	Cr (mg/kg)	Ni (mg/kg)
< 10 mm	4.7	2.3	105.4	251.3	43.3
< 2 mm	18.8	0.8	133	41.2	267.7
Thai guideline for reclaimed soil [(e)]	23	37	400	300	1600
Thai fertilizer standard (Sludge) [(f)]	2	5	500	300	-

[e] NEB (2004)
[f] Department of Agriculture Standard, Thailand (2005)

TABLE 6: pH AND NUTRIENT CONTENT OF WASTE SOIL FRACTIONS AND THE THAI GUIDELINES

Sample	pH	N (%)	P (%)	K (%)
<10 mm	8.0	0.8	0.1	0.04
<2 mm	7.6	0.6	0.1	0.03
Organic fertilizer Thai guideline [(g)]	5.5-8.5	1.0	0.5	0.5

[g] Department of Agriculture Standard, Thailand (2005)

Combustible fraction

EURITS (European Union for Responsible Incineration and the Treatment of Special Waste) has determined the calorific value of recovered waste for fuel across Europe and it is about 15 MJ/kg (Gendebien et al. 2003). Table 7 shows the approximate calorific values of the waste fractions. The results showed that most of the waste fractions except the organic portion have a calorific value of more than 18 MJ/kg. This suggests that all combustible waste fractions except the organics have potential to be recovered as RDF. Nevertheless, extensive waste segregation (separating wet organics) would improve the calorific value of recovered waste.

TABLE 7: CALORIFIC VALUE OF MINED WASTE

Sample	Calorific value (MJ/kg)
Plastic	29.7
Wood	18.2
Textile	20.7
Rubber and leather	22.2
Wet organic	13.5
Combustible wastes	25.0
Segregated wastes	32.3

CONCLUSION

The waste condition in Maung Pathum dumpsite is in a state feasible for waste mining or rehabilitation. High soil fractions (69-75%) and low organic content (0.3-2.7%) in black-colored waste appearance without offensive odor revealed that the waste is stabilized. High fractions of combustible waste material mainly consisting of plastics were also exhibited. Moreover, the solid waste analysis showed low VS and TOC with high ash content. The heavy metal concentration in solid waste was below the TCLP regulatory level suggesting that the waste has potential for reuse as landfill cover material or for landscaping purposes. The waste soil fractions of <10 mm and <2 mm can be potentially reused as compost material for agricultural purposes but the P and K content needs to be supplemented. Moreover, the hydraulic conductivity test showed that the waste soil fractions (<25 mm and <2 mm) are not suitable to be used as a material for landfill barrier instead it can be used as landfill cover. The quality and heavy metal concentration of leachate in this dumpsite is below the leachate characteristics of typical stabilized landfill and does not meet the effluent standard for heavy metal. This is due to the leachate infiltration of fresh waste dumped at the top of the pile. Thus, dumping fresh waste should be avoided in order to allow for proper waste stabilization. The strong leachate characteristics also suggest that the dumpsite needs to be rehabilitated to prevent the further extent of contamination. Nevertheless, the recovered segregated combustibles (without wet organics) improve the calorific value of waste and potential to be used as RDF.

ACKNOWLEDGEMENT
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Dumpsite Toxicity Assessment and Potential for Rehabilitation: A Case Study at Maung Pathum Dumpsite, Thailand

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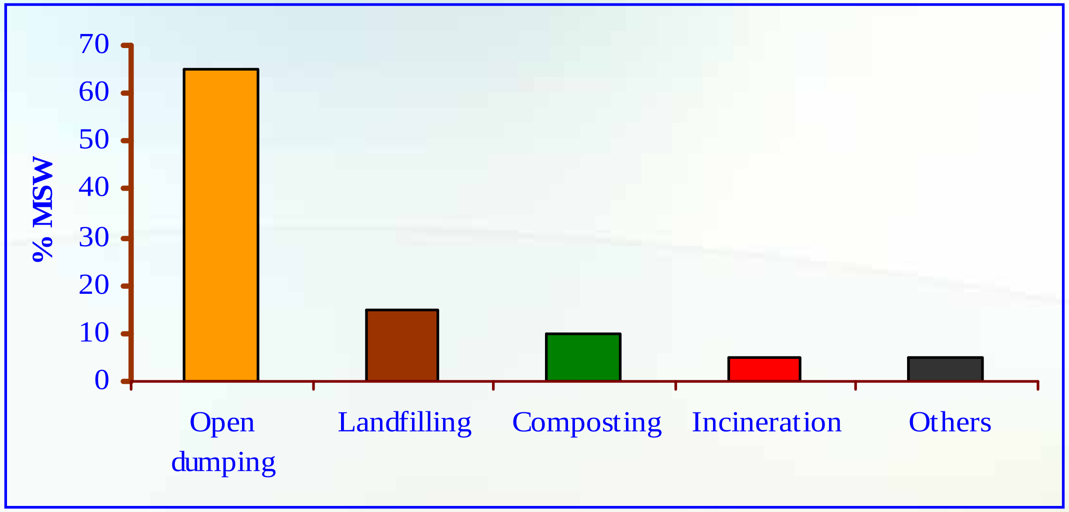
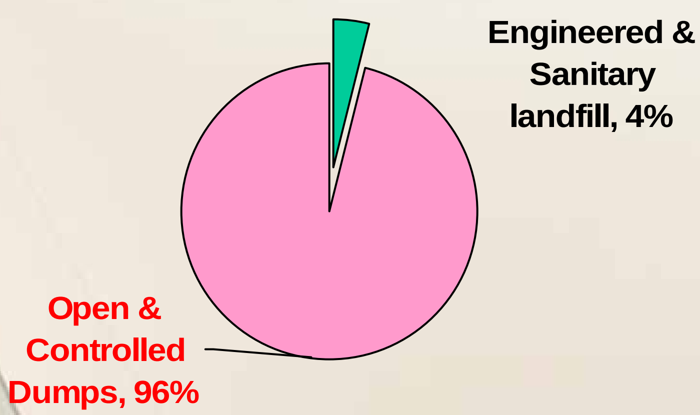
Background

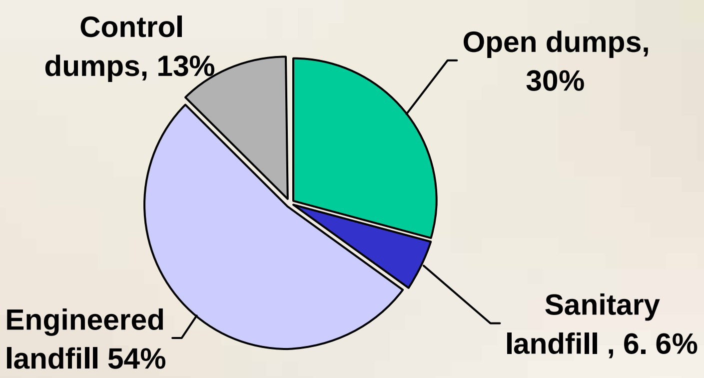
Open dump is a predominant solid waste disposal system in Thailand



Practical in Tambon Municipalities



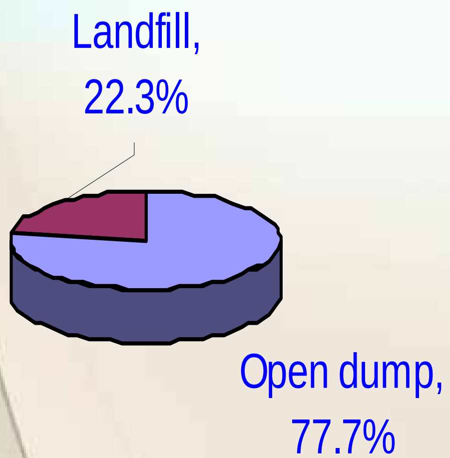
Practical in Provincial Capital

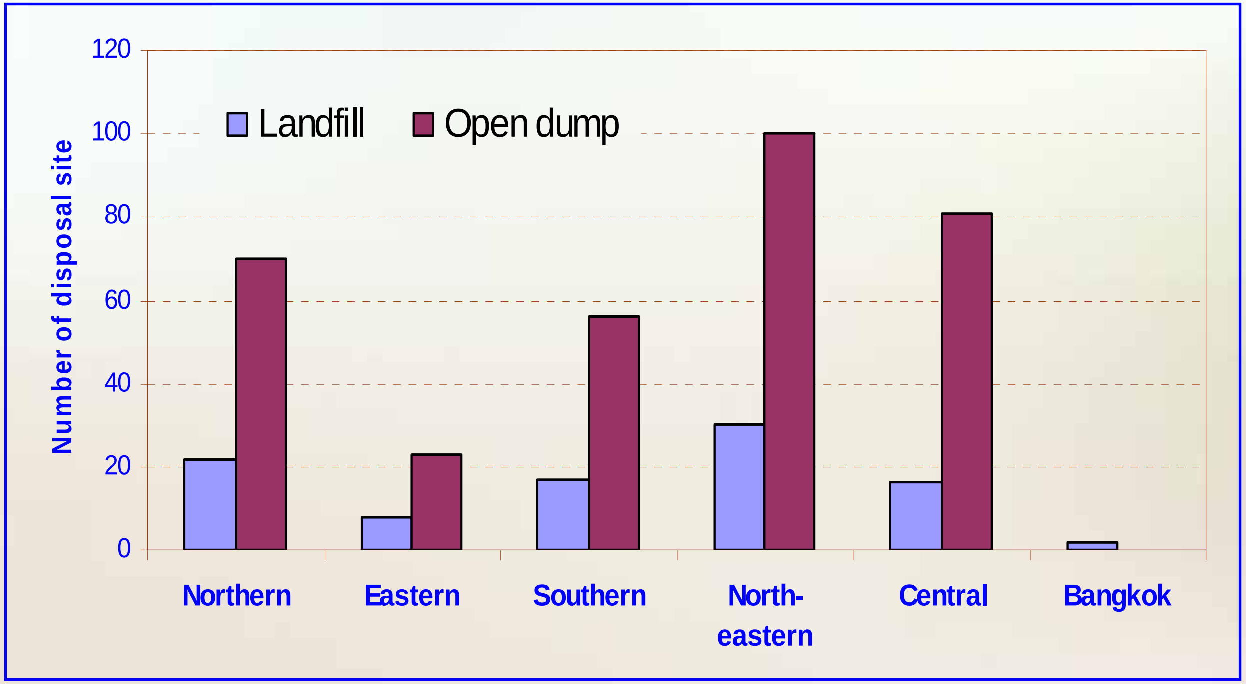


Background

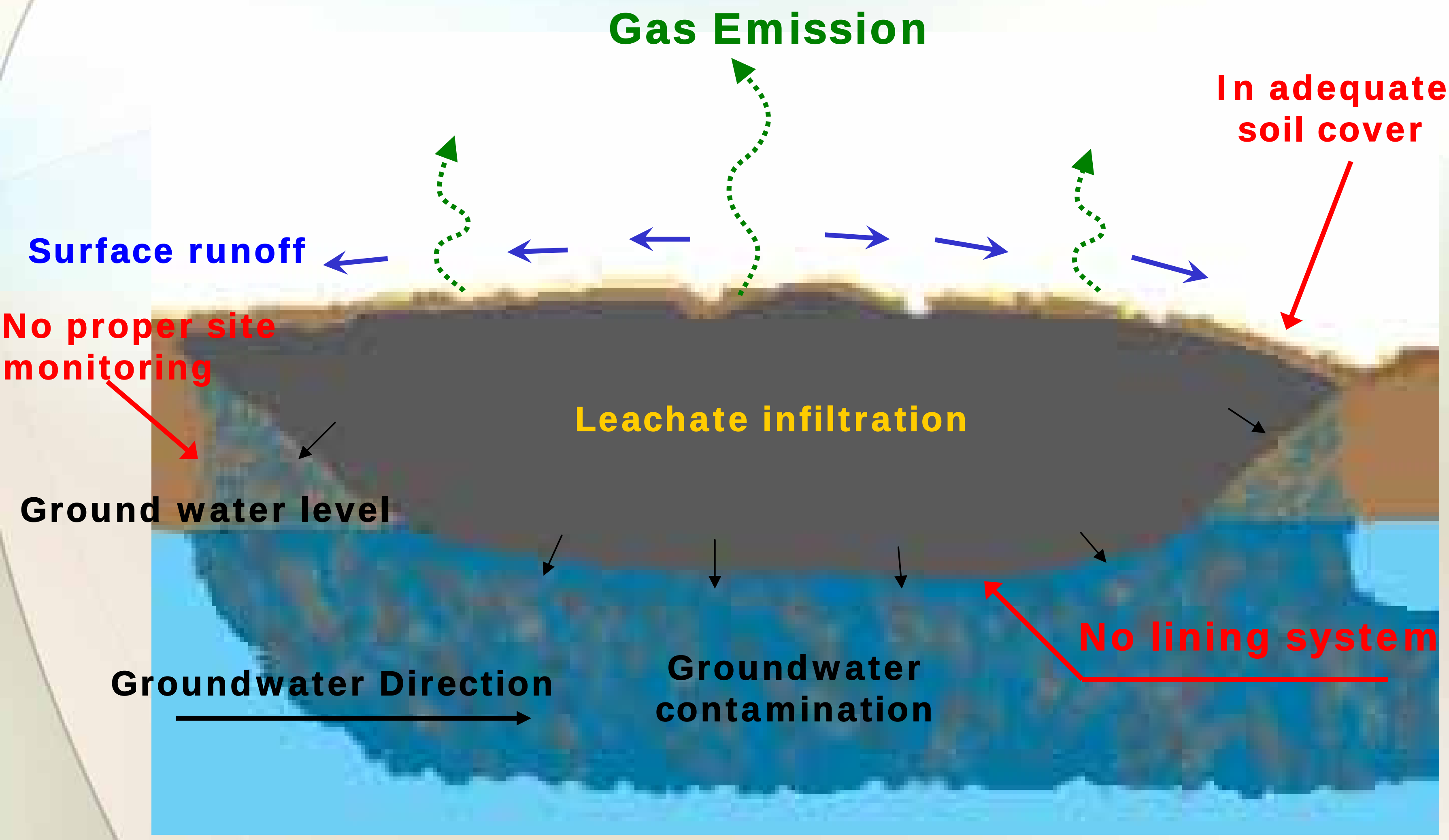
In most regions in Thailand, open dumping is commonly practiced.

The recent survey study showed that more than out of 425 disposal sites, 330 sites are open dumps

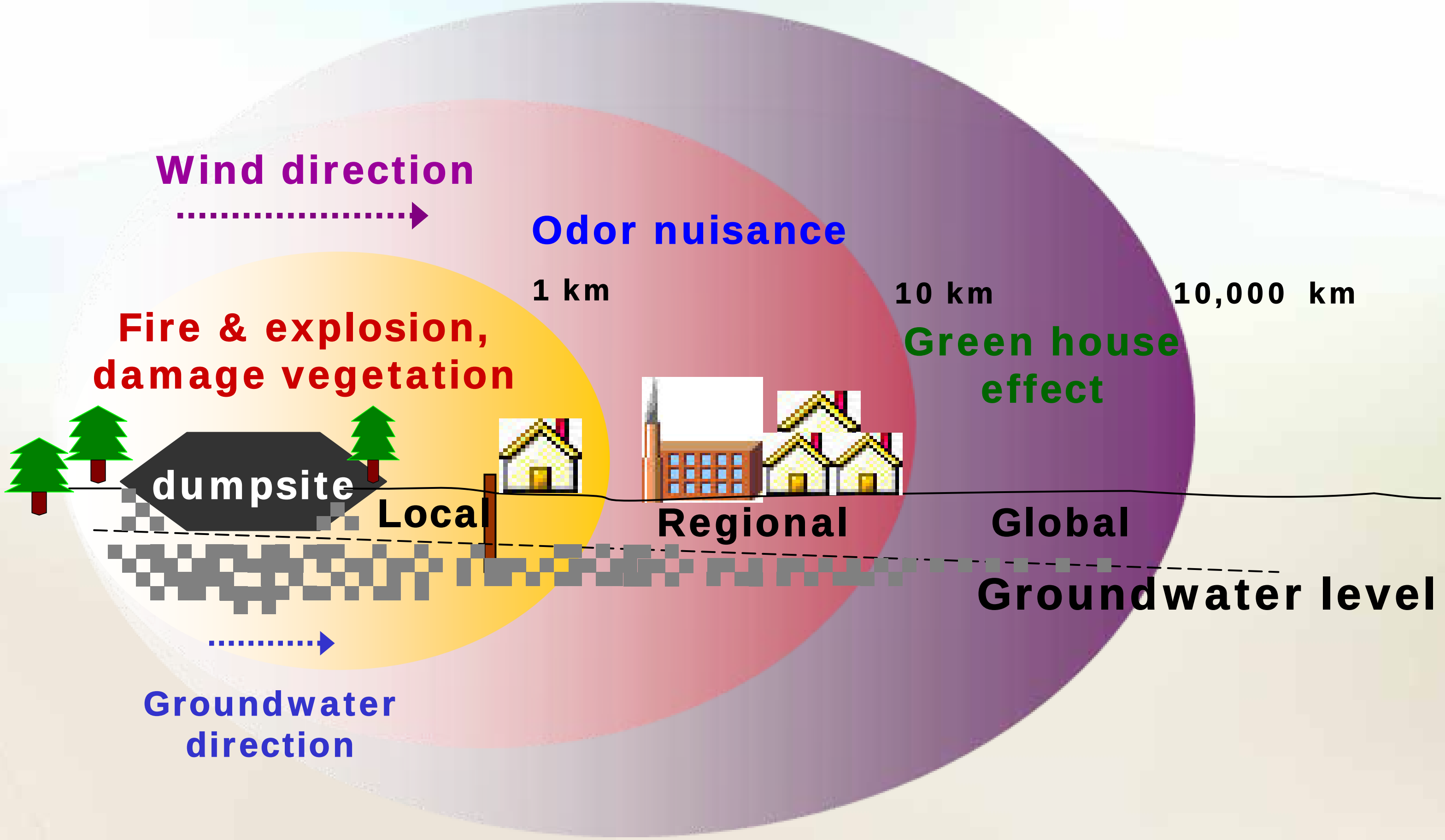




Dumpsites as Unsustainable Waste Disposal



Dumpsites as Unsustainable Waste Disposal



Objective of the Study

1. To evaluate potential for "Dumpsite rehabilitation and landfill mining"

2. To determine physical-chemical characteristics of dumped waste

3. To verify the feasibility of reusing mined waste

   - soil daily cover, soil
   - compost material
   - Fuel (RDF)

4. To determine level of toxicants: heavy metals

   - in dumpsite
   - in surrounding environment

Methodology Diagram

Preliminary Walk through Survey at Dumpsites

Survey, Map, Measure Size, Snapshot selected areas at Dumpsite

Determination of hazardous level

- **In solid waste by using TCLP analysis**
- **In leachate of bored holes at dumpsite**
- **In surrounding environment like surface water and soil**

Sampling: Solid Waste, Leachate , Soil and Water

Determination of dumpsite mining feasibility

- **Determine waste composition**
- **Determine some physical chemical characteristics of solid waste**
- **Determine some characteristics of reusable waste ie. calorific value, hydraulic conductivity, nutrients**

Data Analysis

Methodology Diagram

Data Analysis

Determination of hazardous level

- In solid waste

  Compare with TCLP regulatory level

- In leachate in dumpsite

  Compare with Thai effluent standard

- In surrounding environment

  Compare with Thai soil and surface water standard

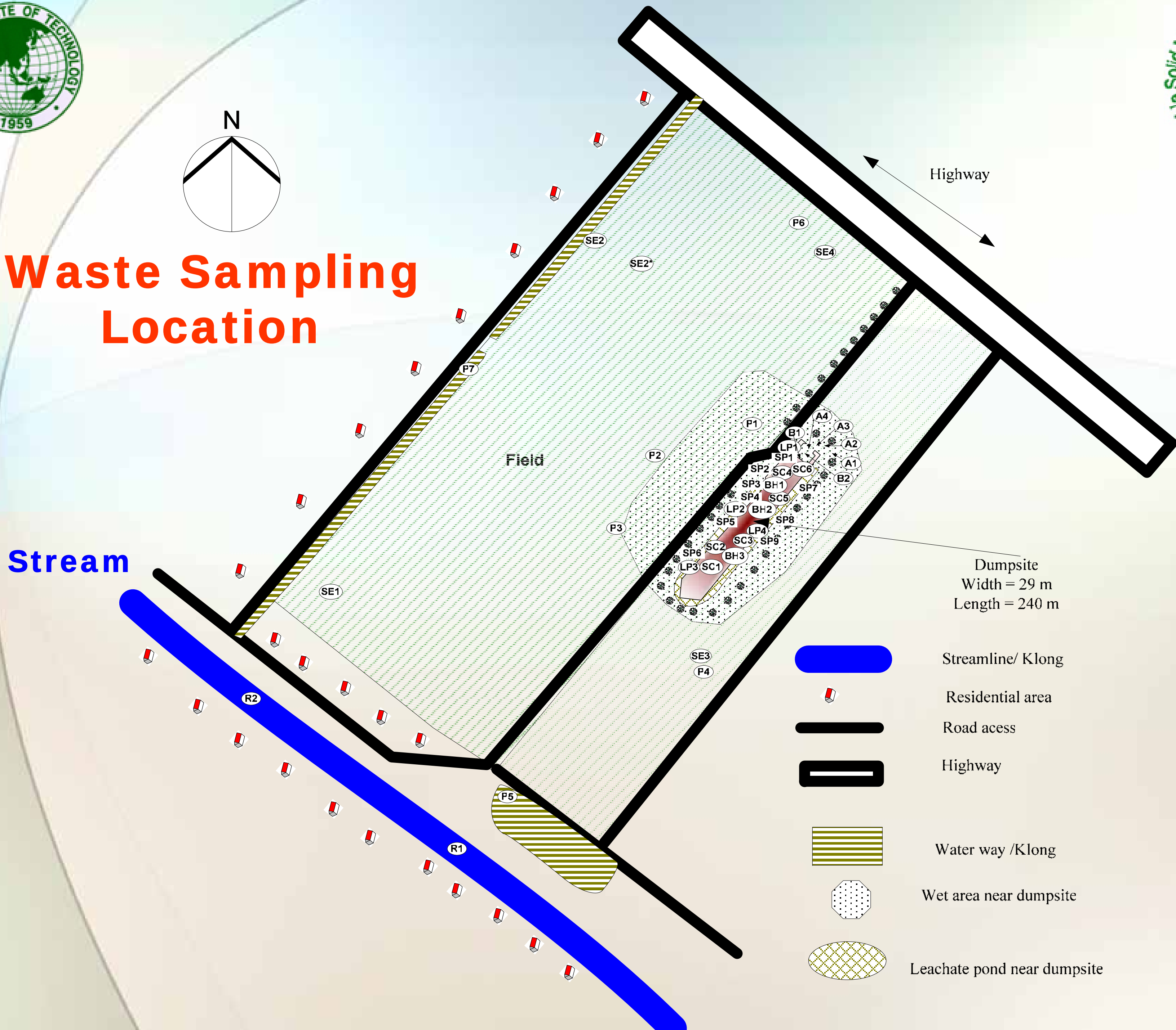
Determination of dumpsite mining feasibility

- Evaluate amount of reusable waste
- Compare physical-chemical characteristic of waste with typical stabilized waste
- Compare quality of reusable waste with typical product

Risk caused from dumpsite and Potential of Landfill Mining Method for Dumpsite Rehabilitation

Waste Sampling Location

Dumpsite toxicity assessment and potential for rehabilitation:
A case study at Maung Pathum Dumpsite, Thailand



Results of TCLP (heavy metal) Analysis in Waste Samples

	Hg (µg/L)	Cd (mg/L)	Pb (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cu (mg/L)
Results in range	1.8- 7.7	0.2- 0.7	0-1.2	2.0-4.0	0.3-1.9	1.2-6.0	0-1.1
*TCLP Limit**	*200*	*1*	*5*	*5*	*20*	*250*	*25*

** source: PSS, 2001*

- **All collected waste samples were non-hazardous wastes**
- **Cd and Cr near to TCLP standard limit**

Results of Determination dumpsite mining feasibility: leachate

Leachate

	Typical stabilized waste [a]	Maung Pathum	Typical new waste [a]
BOD	100-200	470-1,300	2,000-3,000
COD	60-80	1,800-58,000	3,000-60,000
NH_4-N	20-40	100-200	10-800
pH	[illegible]	[illegible]	[illegible]
Ca²	[illegible]	[illegible]	[illegible]
Mg	[illegible]	[illegible]	[illegible]
K^+	[illegible]	[illegible]	[illegible]
Na	[illegible]	[illegible]	[illegible]
Cl^-	100-400	1,400-2,170	200-3,000

Even some char. were similar to new waste, may caused from new waste above, this waste is stabilized waste based on characteristics of solid waste itself

[a] source: Tchobanoglous, G. et al. (1993)

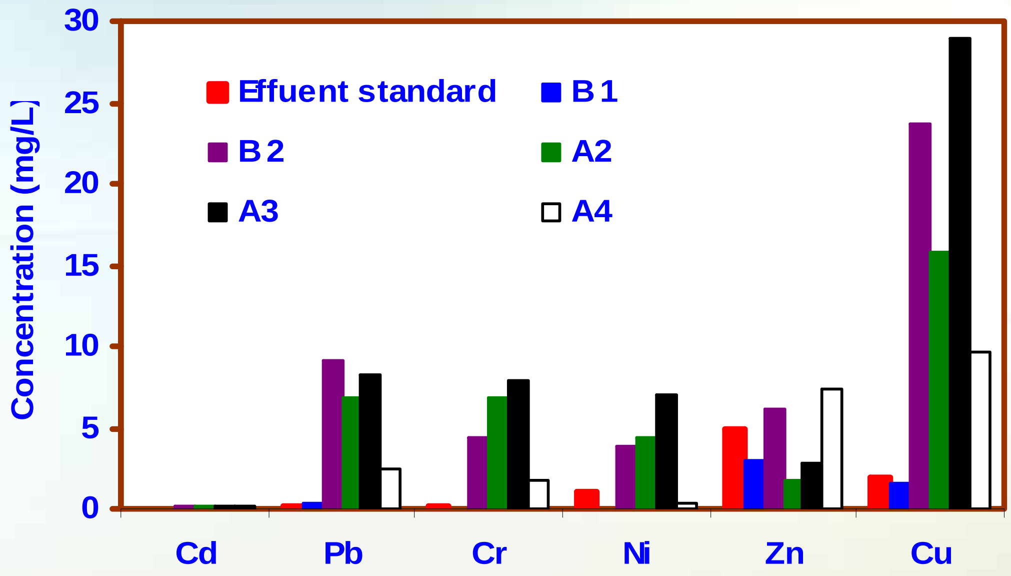
Results of Determination level of hazardousness : in leachate

General Parameter	Leachate from Maung Pathum dumpsite	Effluent standard	Typical stabilized waste*
pH	7.2-7.6	5.5-9.0	6.6-7.5
COD (mg/L)	1,800-58,000	120-240	60-80
BOD (mg/L)	465-1,268	60-520	100-200
TDS	4,100-8,900	3,000-5,000	-
NH_4-N	277-784	-	20-40

- COD, BOD and TDS were higher than standards
- Other parameters, regulatory levels were not determined i.e. NH_4-N
- COD, BOD, and NH_4-N concentration suggest that leachate does not belong to a stabilized waste

Results of Determination level of hazardousness : in leachate

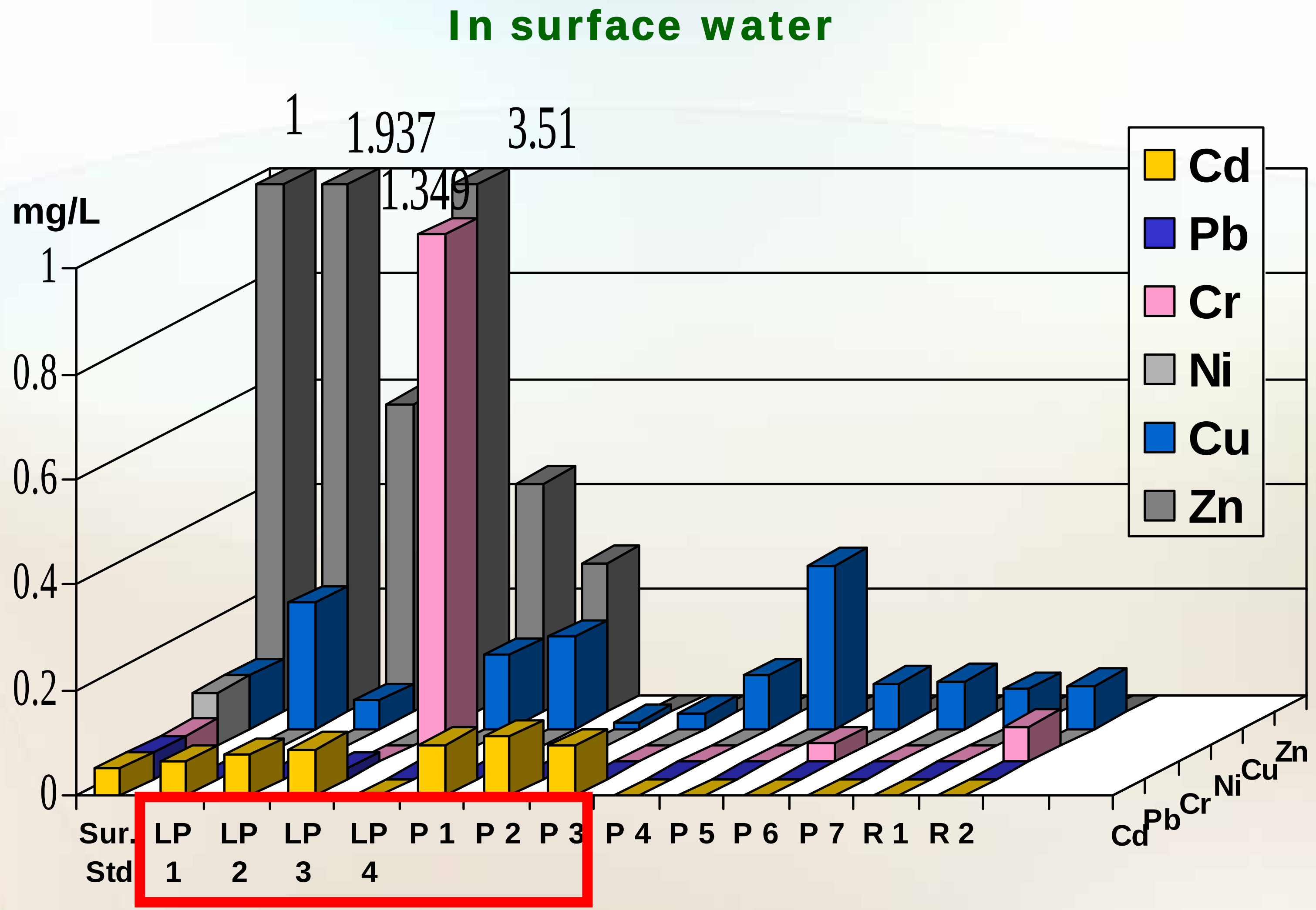
The leachate heavy metal concentration mostly exceeded the Thai Effluent Standard



Dumpsite	Hg (µg/L)	Cd (mg/L)	Pb (mg/L)	Cr (mg/L)	Ni (mg/L)	Zn (mg/L)	Cu (mg/L)
Maung Pathum	22.0	1.4	70.4	13.1	11.4	96.9	176.5
Perunkudi*	3.4	14.9	403.9	86.1	350.0	114.5	73.7
Kodungaiyur*	12.4	71.4	159.8	4.1	379.6	168.1	136.4

** Source: Kurian et al. (2003)*

Results of Determination level of hazardousness in term of heavy metal: in surrounding environment



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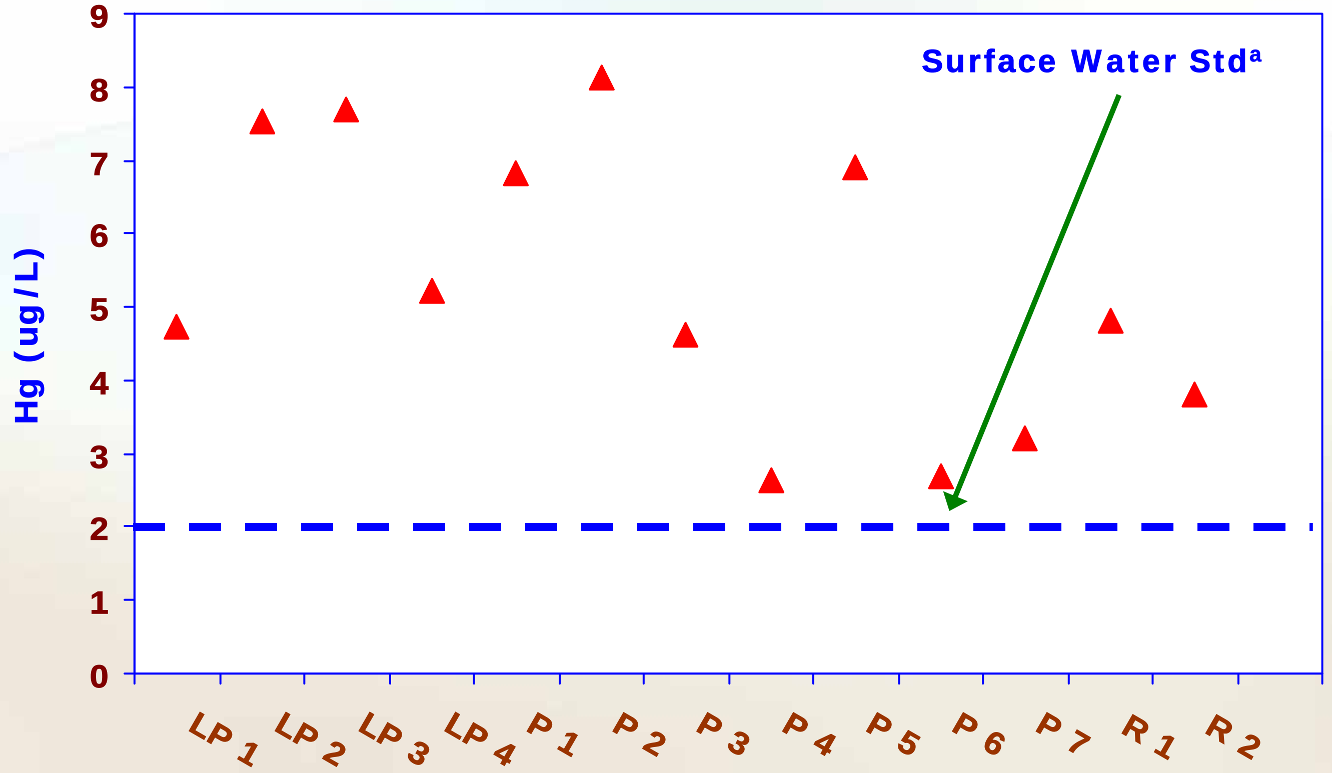
Results of Determination level of hazardousness in term of heavy metal: in surface water in surrounding environment

In surface water



[a] source: NEB (1994)

The risk of heavy metals appear in surface water sources, especially those closer to the dumpsite

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Results of Determination level of hazardousness in term of heavy metal: in surrounding environment

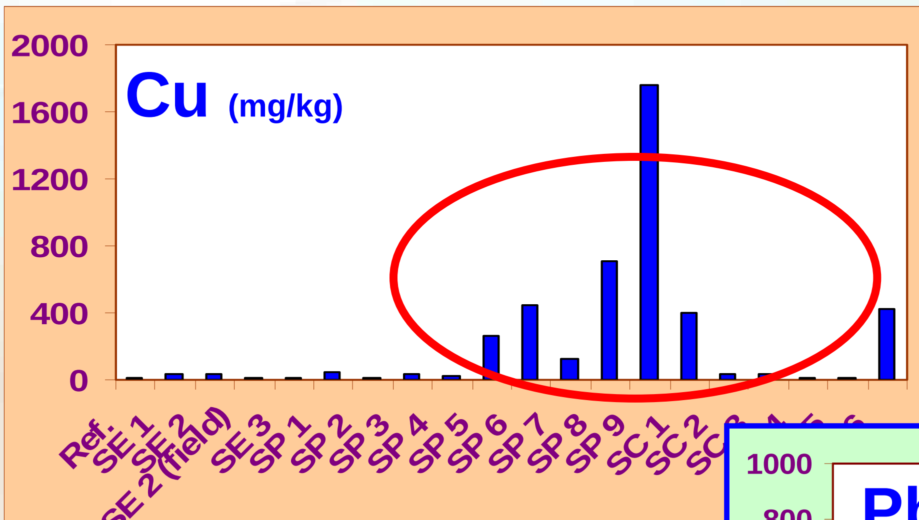
In soil

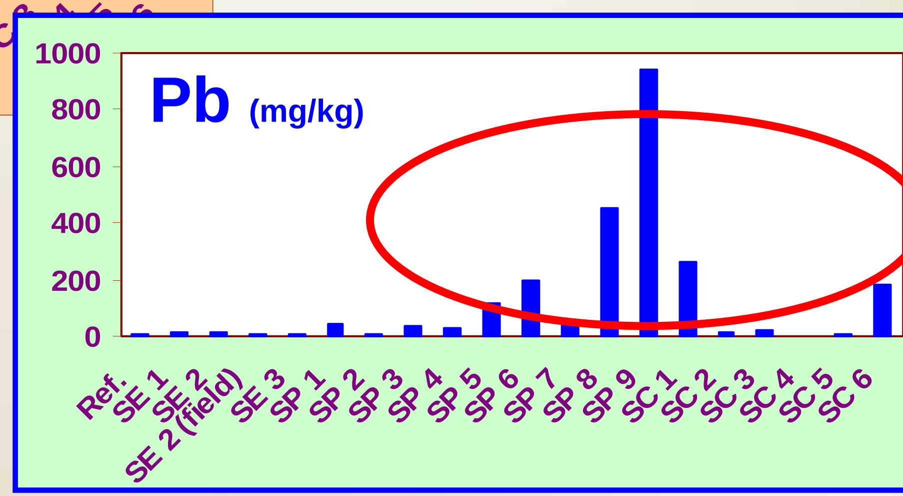
Heavy Metal	Maung Pathum (mg/kg)	England Standard (mg/kg)
Hg	0.8-3.6	0-1
Cd	BDL-3.2	1-3
Pb	4-944	35
Cr	0.7-162	0-100
Ni	3-287	-
Zn	3-289	140
Cu	8-1,757	280

Results of Determination level of hazardousness in term of heavy metal: in surrounding environment

In soil

Although, almost samples, concentration < std, Is it safe?





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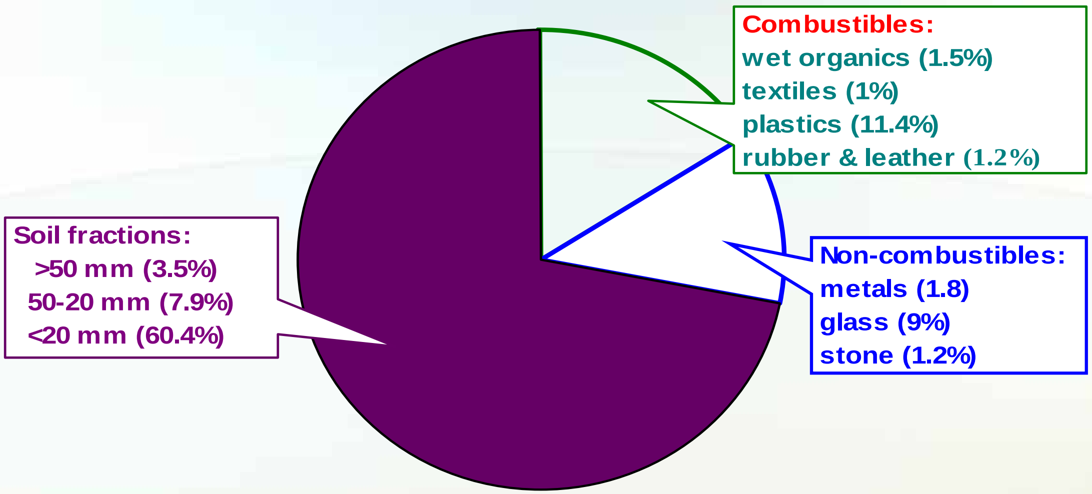
Determination of Dumpsite Mining Feasibility: Waste Composition



Waste Fraction	Maung Pathum (Thailand)	Perunkudi (India)	Kodungaiyur (India)	Fiborna (Sweden)
Combustible	15.9%	39.4%	3.5%	28.3%
Non-combustible	12.1%	19.5%	28.8%	27.4%
Soil fraction	60.2%	40.1%	67.8%	55%
Others	11.6%	1%	-	-

Determination of Dumpsite Mining Feasibility: Waste Characteristics

Solid waste

Parameters	Maung Pathum (Thailand)	Perunkudi (India)	Kodungaiyur (India)
MC (%)	12-33	19-52	15-46
TS (%)	67-88	81-48	85-54
VS (%)	11-50		
TOC (%)	2-40	3-8	-
Ash (%)	52-88	84-94	77-91
Bulk density	740-1730	740-1190	850-1250

Based on waste composition and physical characteristics, suggest that the waste is a stabilized waste due to low VS and TOC, with high ash content and the waste is mainly consist of soil

Results of Determination dumpsite mining feasibility: characteristics of reusable waste

Soil fraction (size < 20 mm)

- Daily cover → Hydraulic conductivity
- Size < 10 mm for compost materials → Nutrients and HM.
- Size < 2 mm for agriculture soil → Nutrients and HM.

For soil daily cover

- The results Ksat were in range 0.0078-0.026 cm/s

picture

But typical value for MSW landfill is 1x10[-5]

That mean only this fraction low quality, should modify → vegetation?

Results of Determination dumpsite mining feasibility: characteristics of reusable waste

For compost material and agriculture soil (cont')

	Maung Pathum		Thai	Canada Compost standard [b]	England Standard [c]
	Size <10mm	Size <2mm	Soil/Compost [a]		
Hg	1-8	15-23	23	0.8	0-1
Cd	1-4	BDL-0.8	37	3	1-3
Pb	1-210	80-190	400	150	35
Cr	150-350	30-60	300	210	0-100
Ni	5-45	230-280-	1,600	62	-
Zn	42	210-330	-	500	140
Cu	310-350	1,420-1,480	-	100	280

Unit: mg/kg [a] *source: Land Development Department, Thailand,* [b] *source: Ministry of Agriculture and Food, Canada,* [c] *source: Nguyen Ngoc Quyenh et al.*

Results of Determination dumpsite mining feasibility: characteristics of reusable waste

For compost material and agriculture soil

	Maung Pathum		Thai Guideline	Typical at Scotland [a]
	Size <10mm	Size <2mm		
pH	8.1	7.7	6-7.5	8-85
N (%)	0.8	0.6	1	0.4-3.5
P (%)	0.1	0.1	1	0.1-1.8
K (%)	0.04	0.03	0.5	0.2-2.5
TOC (%)	19	20	-	24-80

[a] source: REMADE (2001)

Amount of substantial element need to be improved for reusing as compost material

Results of Determination dumpsite mining feasibility: characteristics of reusable waste

For compost material and agriculture soil (cont.)

conclusion:

- **For compost material (size <10mm)**

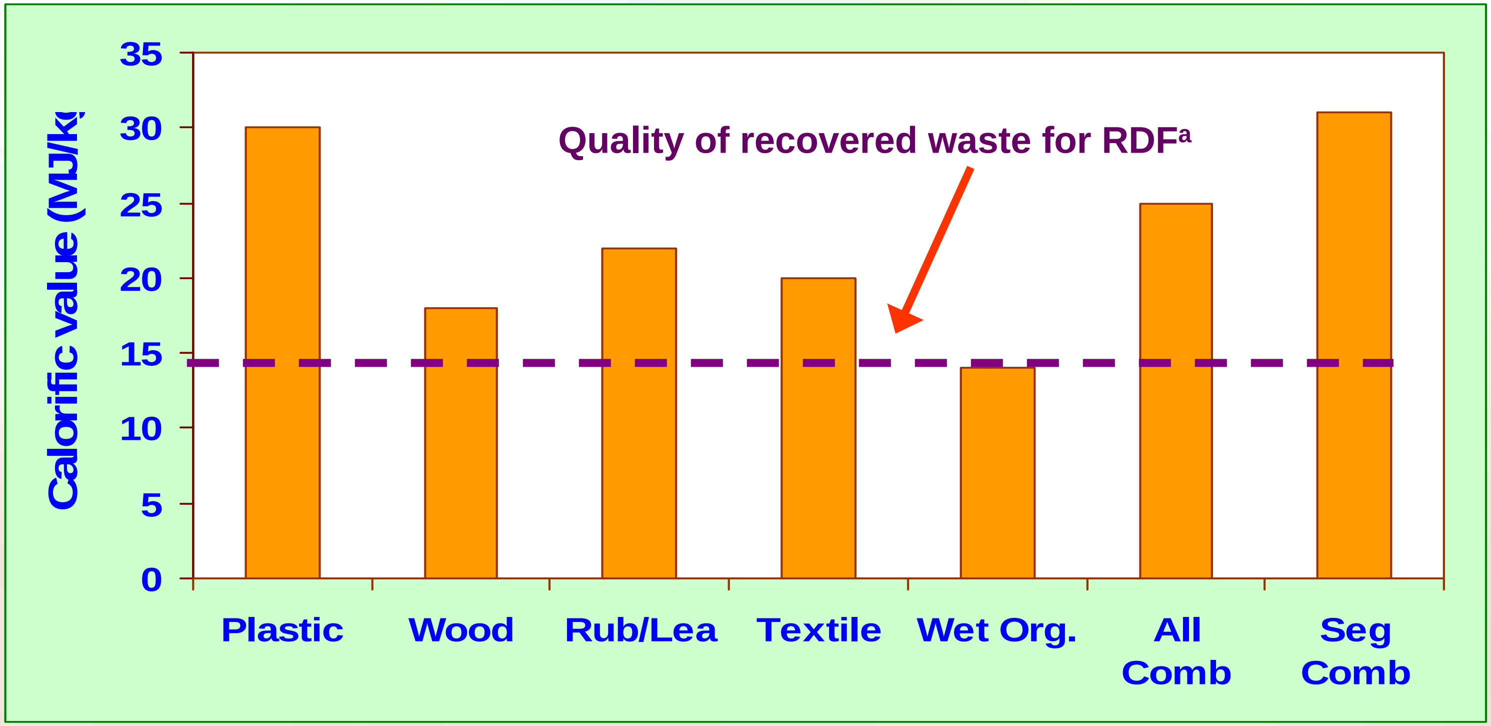
  This fraction can be used as compost materials after supplementing nutrients and treat Cr contamination, however, when compared with Canada compost standard, risk from almost HM exist in this fraction

- **For agriculture soil (size <2mm)**

  This fraction can be used as agriculture soil, however, when compared with England soil standard, risk of almost HM exist. Nevertheless, this fraction can be used safely for non-agriculture purposes.

Results of Determination dumpsite mining feasibility: characteristics of reusable waste

For Refused Derive Fuel



[a] source: Gendebien, A. et al., 2003

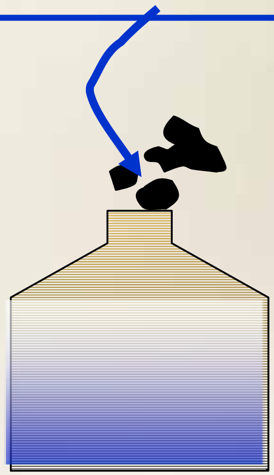
All waste except organic waste can reused as RDF raw material

Recommendations

- Experimenting the clean up method to be used to treat HM. in fine fraction, and possibility to growth plant
- Experimenting practical soil cover design by reusing soil fraction. In addition, investigate probability to sell mined waste in to existing market
- Determination of hazardous level of hardly degradable organic compounds like pesticides in municipal solid wastes

Photograph: TCLP

Grinded waste and Extraction Fluid 1



Photograph: Solid Waste Sampling

Dumpsite toxicity assessment and potential for rehabilitation:
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Photograph: Leachate Sampling

Photographs: Sampling in Surrounding Environment

Photographs: Waste Characterization

Photographs: Dumpsite

Photograph: Hydraulic conductivity set-up