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Characteristics of municipal solid waste and leachate from selected landfills in Malaysia

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Abstract. This paper describes the general features of three Municipal Solid Waste (MSW) landfills in Malaysia, the MSW composition in these landfills and the leachate characteristics. Typical of most Asian countries (except Japan), the MSW comprised 60-90 % organic waste, mainly garbage or agro-industrial waste, with 3 to 18 % plastic waste. Detailed evaluation of the landfill leachate revealed that the concentrations of Na, K and Cl are exceptionally high and thus some form of pretreatment of the leachate before biological treatment is suggested. Urban wastes from the city of Kuala Lumpur (KL) and adjacent satellite town of Petaling Jaya (PJ) contribute higher pollution parameters in the leachate compared to the suburban landfill in Sabak Bernam (SB).

Abstrak. Kertas ini menghuraikan sifat-sifat am tiga isian tanah sisa pepejal munisipal dalam Malaysia, kandungan sisa pepejal munisipal dan ciri-ciri larut lesapan dari isian tanah ini. Seperti dikebanyakan negara, di Asia (kecuali Jepun), sisa pepejal munisipal mengandungi 60-90% sisa organik, khasnya sisa makanan atau sisa industri pertanian, dan 3 hingga 18% sisa plastik. Penilaian teliti larut lesapan isian tanah menunjukkan bahawa kepekatan Na, K dan Cl adalah terlalu tinggi dan akibatnya praolahan larut lesapan diperlukan sebelum pengolahan biologi digunakan. Sisa bandar dari bandaraya Kuala Lumpur (KL) dan bandar satelit Petaling Jaya (PJ) mengeluarkan parameter pencemaran yang lebih tinggi dalam larut lesapan berbanding dengan larut lesapan dari isian tanah luar bandar iaitu di Sabak Bernam (SB).

Introduction

Waste generation

There are 230 municipal dumping sites in Peninsular Malaysia, an average of 1.8 dumping sites per municipal council [1] to accommodate the bulk of the municipal solid waste (MSW) generated. Malaysians generate about 6 million tonnes of MSW per year, or about 15,000 tonnes daily. Of the latter, 12,000 tonnes are domestic waste and the rest is commercial waste. The urban population, which is almost 50% of the total population of 20 million people in Peninsular Malaysia, generates about 3 million tonnes of domestic refuse annually. The average per capital generation is 1.00 kg/day, however the per capital rate varies between 0.27 kg/day in the rural areas to as high as 1.2 kg/day in some urban centers.

Leachate

The liquid contained in the waste itself, liquid produced during the decomposition process, as well as water that seeps through the ground cover and flows out of the municipal landfill is known as leachate. The characteristics of the leachate depend on the nature of the waste, the stage of stabilization, age of the landfill, composition of waste disposed, size of fill and degree of compaction, the moisture content of the untreated waste, degree of rainwater infiltration, temperature and analytical procedures [2,3,4,5,6,7,8]. The composition of the leachate varies greatly within individual landfill over time, as well as, among different landfills.

Landfills

The leachate characterization in this communication is confined to three landfills; hence a brief description of these landfills is in order.

Taman Beringin Landfill, Jinjang, KL.

This 16-year-old landfill, which is situated at the northern periphery of the capital city of Kuala Lumpur, is used to dispose the municipal solid waste from the city. Situated on a 40-acre piece of ex-mining land, it handles about 1800-2000 tonnes with 1000 lorries commuting daily. The bulk of the waste (49%) comes from domestic source, while industrial (non-hazardous) waste accounts for 24%, municipal waste is 2%, construction waste is 9% and others about 16%. The landfill does not have facilities for gas collection, however recently a couple of aeration ponds were constructed to treat the leachate before disposal.

Air Hitam Landfill, Puchong, MPSJ.

This is the only modern sanitary landfill in Malaysia with both gas collection and leachate collection and treatment facilities. The bulk of the MSW from the satellite town of Petaling Jaya, which is adjacent to the city of Kuala Lumpur, is disposed in this landfill, which is 5 years old. Commissioned in 1995, the landfill was constructed at a cost of RM 30 million (1US$ = RM 3.80) over a 42-ha piece of ex-agricultural area. The landfill has a capacity to receive 1500 to 2000 tonnes daily but the average daily collection currently is 1000 tonnes of which 80% is domestic waste.

Sabak Bernam Landfill

This small landfill, 10 acres in size, is mainly for the municipal and agricultural wastes generated from Sabak Bernam district. This site commenced operation in 1993. The weight of waste disposed into this landfill could not be determined accurately since there is no weighbridge, but the estimated average is 52 tonnes per day (with a range of 50-60 tonnes).

Materials and Method

Waste composition determination

The waste volume was determined from randomly selected lorries at the landfill site. The waste from larger lorries (10-tonne) was divided into four quarters and one quarter or 100 kg samples were analyzed for components.

Leachate analysis

pH and Conductivity

These were measured directly using combination probes for pH and conductivity and recorded using meter (Model No. 8033)

Total Suspended Solids (TSS)

Leachate TSS was determined by filtering the leachate using glass fibre filter and weighing the filter paper before and after filtration.

Biochemical Oxygen Demand (BOD)

BOD was determined using BOD bottles incubated for 5 days at 20°C. The dissolved oxygen (DO) before and after incubation was measured using DO meter YSI Model 57 and the BOD was computed from the difference in DO value.

Chemical Oxygen Demand (COD)

COD was determined using dichromate reflux method using potassium dichromate, silver nitrate and sulphuric acid in a TECATOR COD digestion unit. The excess dichromate was titrated with 0.1M ferrous ammonium sulphate. COD was calculated based on the difference in dichromate levels.

Total Organic Carbon (TOC)

TOC was analysed using TOC analyzer (Shimadzu 5000 Model).

Total – N

Total – N was determined using Kjeldahl method.

Heavy Metal Determination

The concentration of the heavy metals in the leachate was determined using the Inductivity Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) Model Baired 2000. Leachate samples were collected in High Density Polyethylene bottles, which contained 1mL concentrated Nitric acid to prevent sorption of the metals. The samples were stored at 4°C prior to analysis. The leachate was filtered through 0.45μm Millipore filter before ICP analysis.

Alkalinity, Hardness, Chloride and Sulphate were determined using Hanna Instruments HI 4817 Test Kit.

Results and Discussion

Waste Composition

About 60-75 % (vol) of the municipal waste in KL and PJ is organic, putrescible waste and paper while in Sabak Bernam Landfill, the bulk of the waste (65%) is agro-based (Table 1). Being a fast developing country, plastic component in the Municipal waste is also a high 10-16 % in the urban waste, while the smaller towns outside the Klang Valley generate less plastic and paper waste. The bulk of the agro waste in the Sabak Bernam landfill comes from the numerous oil palm and coconut processing mills in this area. Putrescible waste forms only 20% of the waste in Sabak Bernam while in KL and PJ it is 30 to 45% of the total.

Leachate Characteristics

The type of waste disposed into a landfill is one of the main factors that influence the composition of the leachate formed. This phenomenon is evident in this research too. In terms of almost all the parameters analyzed (Table 2) the leachate from Sabak Bernam landfill is of lower (pollution) strength. The COD is 2 –3 times lower in SB landfill when compared to the landfills in KL or PJ, and this lower COD is due to the lower amount of putrescible waste disposed in the SB landfill. Also the agro waste, which is mainly fibrous in nature, takes a much longer time to degrade and hence the leachate formed will have lower quantity of pollution parameters, as is seen here. Data obtained shows that the Malaysian landfill leachate generally contains high quantities of Na, K and Chloride when compared to data reported [8,9,10]. For example, for mature landfills above 10 years old, typical concentrations of Na, K and Cl are 100-200, 50-400 and 100-400 mg/L [8] whereas in this analysis the concentrations of Na, K, Cl were 1500 to 5640, 400-1940 and 875-2900 mg/L,respectively in the mature landfill in Taman Beringin. Similar concentrations were also recorded in the other two landfills, although they are less than 10 years old.

Alkalinity in mature landfills is usually below 1000 mg/L while data obtained in this study indicates a nine fold increase in two landfills (KL and PJ), and only new landfills, below one year old generally record such high alkalinity levels [11]. Such high levels of salt concentrations with high alkalinity and hardness, makes the biological treatment of landfill leachate extremely difficult. The only sanitary landfill (in Puchong) uses extended aeration to treat the leachate but most often the effluent characteristics do not meet the Department of Environment (DOE) standard guidelines for wastewater release into the environment.

The high salt concentration in the leachate could be attributed to the large quantity of garbage in the municipal waste. The characteristics of the garbage in turn reflect that the food waste disposed in Malaysia is of high salt concentration.

Heavy metal concentration in the leachate (Table 2) was comparatively low and after biological treatment, the effluent contained metals within DOE limits that it did not cause much concern for leachate management or disposal into monsoon drains.

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Table. 1. Municipal waste composition (% vol)

Waste Type	Urban Waste in Malaysia	Kuala Lumpur	Petaling Jaya	Sabak Bernam
Paper & paper products	29.5	30	27	2
Vegetable & putrescible garbage	32	46	36.5	20
Plastic & rubber	18	10	16.4	3
Agricultural	-	-	-	65
Metal	4.3	4.6	3.9	2
Glass & Ceramic	4.9	3.0	3.1	1.5
Textile	3.4	2.3	3.1	0.5
Wood	7.0	3.2	7.0	-
Others	0.9	0.9	3.0	6

Table 2. Characteristics of landfill leachate

	Taman Beringin, landfill, KL	Air Hitam, landfill, MPSJ	Sabak Bernam landfill
Years in operation	16	5	7
Alkalinity	3750 - 9375	1540 - 9000	1200-1550
Hardness	211 – 1200	314 - 672	310-850
PH	7.85 – 8.75	7.6 – 8.84	7.95-8.10
Conductivity µS	8.80 – 35.4	8.64- 33.50	8.10-16.20
Chloride	875 - 2875	1625 - 3200	420-1820
Sulfate	40 - 79	18.5 - 110	36-52
TSS	420 - 1150	410 - 1250	111.60-920
TS	10300 – 13680	13930 - 15380	-
COD	1960 - 5500	1724 – 7038	1250-2570
BOD	562 - 1990	1120 –1800	726-1210
Total-P	6 - 28	6 – 22	5.8-17.2
Total-N	104 - 1014	131 – 930	-
Amm.N	2.1 - 47	1.88 – 32.00	3.1-8.0
Total-C	1380 - 2573	1610 - 2890	1230-2060
Ca	28 - 376	47 - 177	110-440
Ba	0 – 0.3	0.01 – 0.13	-
K	402 - 1940	719 - 1818	540-980
Ni	0 – 0.60	0.13 – 0.95	-
Cd	0 – 0.15	0.0001 – 0.23	0-0.001
Cu	0.15 – 0.46	0.05 – 0.49	0-0.02
Fe	3.2 – 17.42	3.6 – 15.7	2.0-8.6
Pb	0 – 3.45	0 – 5.37	0-0.03
Na	1530 - 5640	2616 - 5660	1287-1670
Mg	31 - 109	41 - 105	55-96
Al	1.13 – 33.1	1.4 – 6.6	-
Zn	1.0 – 4.70	1.0 – 5.4	1.4-2.0
Cr	0.04 – 0.70	0.24 – 0.94	-

(All in mg/L expect otherwise stated; 3 replicate samples taken over a 5-month period)