B-48 Development of Synthetic Leachate Generated from Landfills in Southeast Asia

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1. Introduction

Open landfill is a popular method for solid waste treatment in Southeast Asia. However, those landfills are mostly non-engineered facilities, resulting in emission of polluted leachate to environment. The complicated and changeable nature of the leachate composition hinders systematic and reproducible research and development of effective leachate treatment processes. So as to reduce such a difficulty, we attempt to develop synthetic landfill leachates as a helpful tool for modeling and evaluating the treatment processes. Related literatures were collected to build a water quality database of leachate in Southeast Asia. Based on the review, synthetic leachates of Southeast Asia were proposed in this study.

2. Typical degradation of wastes in landfills

Normally, the waste degradation process in a landfill consists of aerobic, acetogenic, and methanogenic phases. The aerobic phase is very short due to the limited supply of oxygen in the landfill and the high amount of biochemical oxygen demand (BOD) of solid wastes. The acetogenic phase lasts for several years, while volatile fatty acids (VFAs) are produced, which lowers pH in leachate, thus contribute to solubilizing inorganic materials. Ammonium is also accumulated in leachate by degradation of organic nitrogen. During the methanogenic phase, VFAs are converted to methane and carbon dioxide. Humic substances are also formed by the biodegradation of dead plant components such as lignin. The color of humic substances such as humic acids and fulvic acids are dark brown to black and they are highly resistant to additional biodegradation.

3. Leachate with different landfill age

Table 1 lists the composition of leachate from Southeast Asia with different age periods of landfill: young (< 5 years), medium (5–10 years), and old (> 10 years). The leachate composition was considered in four categories: organic matters, inorganic macro components, heavy metals and xenobiotic organic compounds. The ratio of BOD to chemical oxygen demand (COD) represents the biodegradability of leachate. Table 1 exhibits that the value of the BOD/COD ratio is high in the young leachate and low in the old leachate. Inorganic components excepting sulfide in all leachate are at high levels, especially chloride, sodium and calcium. The amounts of heavy metals are relatively low (mostly < 10 mg/l), whereas iron in young landfills, manganese in medium landfills, and zinc in both landfills are high.

Table 2 shows typical concentrations of xenobiotic organic pollutants in leachate in Southeast Asia. Volatile organic compounds in petroleum derivatives and endocrine-disrupting chemicals are frequently found in leachate. There are not enough data to classify their concentrations by landfill age. The range of detected xenobiotic organic compounds depends on landfills and surrounding environment.

4. Development of synthetic leachate

Since the aerobic phase in a landfill lasts only a few days, synthetic leachate simulating this phase was not tried. Hence, synthetic leachates of the acetogenic phase and the methanogenic phase were developed based on the results of the reference review, which is listed in Table 3.

Acetate and propionate are typical VFAs found in leachate. Humic acids as the main color component in leachate are available on several chemical companies but its composition depends on the product. Ammonium is a main inorganic nitrogen in leachate. The concentrations of

Table 1. Leachate compositions with different landfill age in Malaysia [1–36], Thailand [37–41], Indonesia [38, 42] and Vietnam [43, 44].

	Young	Medium	Old		Young	Medium	Old
Physicochemical parameters				***Inorganic macro components (mg/l)***			
Temprature (°C)	29–33	29–34	23–32	Sulfide	–	0.30–0.82	–
Color (Pt-Co)	–	1690–7475	130–8180	Sulphate	–	1.6–110	1.5–207
Turbidity (NTU)	–	67–4500	50–690	Sulfur	138–1165	–	20–229
pH	3.9–8.6	6.6–8.8	7.0–9.4	Chloride	682–5500	324–3650	228–3802
TS (g/l)	–	4.5–11	0.45–10	Aluminum	0.03–401	–	0–2.6
TSS (g/l)	0.10–6.7	0.01–2.2	0.002–1.1	Potassium	434–793	530–1819	44–1932
Conductivity (mS/cm)	–	3.9–28	6.6–28	Sodium	89–2269	1460–2179	81–2453
ORP (mV)	–	12–13	–	Calcium	418–3752	121–1600	13–1900
Alkalinity as $CaCO_3$ (g/l)	1.9–14	5.7–16	1.1–24	Magnesium	194–776	25–294	14–36533
Dissolved organic matter				***Heavy metals (mg/l)***			
DO (mg/l)	–	–	0.03–4.1	Cadmium	0–0.04	0.05–7.0	0–0.33
COD (g/l)	1.1–81	0.60–51	0.10–23	Chromium	0–5.0	0.16–0.50	0–3.6
BOD (g/l)	0.80–91	0.07–27	0.04–13	Copper	0–1.6	0.05–7.0	0–4.6
BOD/COD	0.68–0.95	0.04–0.35	0.02–0.15	Iron	1.9–560	0.60–98	0–134
TOC (g/l)	6.3–24	0.04–0.99	0.07–12	Manganese	11–38	0.60–540	0–25
TP (mg/l)	0.13–97	8.0–43	0–190	Nickel	0.11–1.8	1.0–4.9	0.01–1.3
PO_4-P (mg/l)	–	38–290	–	Molybdenum	–	–	0–0.03
TKN (mg/l)	476–2940	1440–2191	63–2688	Lead	0–0.64	1.0–13	0–42
TN (mg/l)	131–1800	100–1800	85–2637	Zinc	0–21	0–828	0–676
NO_3-N (mg/l)	0–92	1.0–7900	0–16				
NO_2-N (mg/l)	0–2.0	0.30–270	0–1.0				
NH_4-N (mg/l)	86–2440	0.09–4329	8.0–3125				

TS: total solids; TSS: total suspended solids; ORP: oxidation reduction potential; DO: dissolved oxygen; COD: chemical oxygen demand; BOD: biochemical oxygen demand; TOC: total organic carbon; TP: total phosphorus; PO_4-P: phosphate; TKN: total Kjeldahl nitrogen; TN: total nitrogen; NO_3-N: nitrate nitrogen; NO_2-N: nitrite nitrogen; NH_4-N: ammonia nitrogen.

Table 2. Concentration of xenobiotic organic compounds found in leachate in Malaysia [12, 19, 20, 36] and Thailand [37, 41].

Compounds	Concentration (μg/l)
Total phenols	350–10500
Bisphenol A	6.0–9200
Trichloroethylene	0.33–2790
2,6-Di-tert-butylphenol	185–247
2,6-Di-tert-4methyl-butylphenol	173–196
Ethyl phthalate	130–195
Butyl phthalate	275–384
Bis (2-ethylhexyl) phthalate	146–276
Toluene	0.10–65
m,p-xylene	0.05–64
o-xylene	0.09–27
N-Butyl benzenesulfonamide	0.10–150
t-Butyl phenol	0.40–44
Benzene	0.08–3.1
Ethyl benzene	0.19–3.5
2 Ethyl toluene	0.01–0.13
1,2,3 Trimethyl benzene	0.01–0.64
1,2,4 Trimethyl benzene	0.02–1.4
1,3,5 Trimethyl benzene	0.03–0.85

Table 3. Composition of synthetic leachate.

	Acetogenic	Methanogenic
Physicochemical parameters		
pH	5.5–6.5	7.0–8.0
Dissolved organic matter (g/l)		
Sodium acetate	0–65	0–6.8
Sodium propionate	0–12	0–3.5
Sodium humate	0–1.9	0–19
Inorganic macro components (mg/l)		
NH_4Cl	290–7070	590–9400
KH_2PO_4	0–430	0–840
KCl	570–3760	570–3760
$CaCl_2 \cdot 2H_2O$	370–13870	180–6940
$MgCl_2 \cdot 2H_2O$	80–3800	80–3800
Heavy metals (mg/l)		
$CdCl_2 \cdot 2.5H_2O$	0–14	0–1.0
$K_2Cr_2O_7$	0–17	0–8.5
$FeCl_3 \cdot 6H_2O$	0–2690	0–670
$MnCl_2 \cdot 4H_2O$	0–145	0–70
$NiCl_2 \cdot 6H_2O$	0–25	0–8.0
$Pb(NO_3)_2$	0–25	0–70
$ZnSO_4 \cdot 7H_2O$	0–100	0–30

Concentrations of xenobiotic organic compounds can be set according to Talbe2.

those chemicals highly depend on the age of leachate. The concentrations of potassium, calcium, and manganese were set equivalently in the young and the old leachates. The concentrations of heavy metals in the young leachate were set to be higher than those in the old leachate. Among the heavy metals found in leachate, cadmium, chromate, nickel, lead, and zinc are highly toxic. Those organic and inorganic concentrations determine BOD and COD concentrations and the pH value of the leachates. The amounts of xenobiotic organic compounds can be set according to Table 2, depending on the purpose of researches using these synthetic leachates. In addition, a difficulty in the leachate treatment in Southeast Asia is attributed to its changeable characteristics depending on precipitation and evaporation in the monsoon climate. The synthetic leachates should be diluted and concentrated for simulating those in the rainy season and the dry season, respectively.

These synthetic leachates would be used for research and development of the leachate treatment processes, such as aerobic and anaerobic biological processes, advanced oxidation processes, membrane separations, and constructed wetlands.

5. Conclusion

The result of this study supplied a useful database of composition and characteristics of leachate in Southeast Asia with different landfill ages. Depending on these information, the young and the old synthetic leachates of Southeast Asia were developed for further researches.

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