Leachate treatment
from municipal solid waste landfill in Indonesia

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ABSTRACT

Leachate is a fluid from the external water that enter into the landfill waste, dissolve and rinse the dissolved materials, including organic matter resulted from decomposition in biological process. Generally, Leachate has characteristic such as high content of organic materials concentration, specially for young leachate, high in nitrogen content and electrical conductivity, sometimes contains high concentration of heavy metals, pH neutral to acid, light brown to black in colorthat is difficult to be eliminated, and bad smell. Leachate is one of the sources of pollution that have a serious impact on the environment. Chemical Oxygen Demand (COD) and (Biochemical Oxygen Demand(BOD) content of fresh leachate could reach 45,000 mg/l and 30,000 mg/l respectively. Existing condition for leachate treatment in Indonesia is usually done only by using stabilization ponds with relatively long retention time, but the result of the treatment often was not satisfy.

These researchs were conducted in laboratory scales. Coagulation-flocculation process can be an alternative pre-treatment process in for leachate treatment, reducing its organic loading for the next treatment units. With the efficient coagulant dose of alum (500 mg/L), or Poly Aluminium Chloride (PAC) dose of 300 mg/L, the total COD removal efficiency is 36.14%. and 29.79% respectively. If the optimum pH is used (pH = 8), for these coagulant concentration of alum and PAC, the total COD removal efficiency are 43.41% and 40.18% respectively.

For biological treatment, the Sequencing Batch Reactor (SBR) with aerobic treatment process as a secondary or tertiary treatment of leachate treatment plant is used. SBR operational system consists of five stages: filling, reaction, settle, draw, and idle phases. In reaction (react) phase, the contact between the organic material and microorganisms will take place during this period and high biodegradation of COD was expected in this process. This study used the aerobic SBR reactor with a volume of 5 L and the filling time of 2 hours with a variation of the reaction time of 2, 4 and 8 hours and COD concentrations of 3000-3500 mg / l. The results of this study indicate that the increase of reaction time affects COD reduction. The optimum degradation of wastewater occurs in achieving a removal efficiency of 79.19% for leachate treatment with reaction time of 8 hours.

For the final treatment which is appropriate for Indonesia, high efficiency, easy to operated and cheap, constructed wetland system is used. The main purpose of this study was to compare the removal efficiency of non metallic and metallic parameters present in leachate by using Constructed

wetland system and to know the capability of this treatment to treat leachate continuously. The laboratory research was conducted on subsurface flow constructed wetland system which was operated in vertical and horizontal flow. The reactor was planted with Cyperus papyrus, with detention time of 9 days. Horizontal reactor was operated at a flow rate of 3 liters/day while vertical reactor was operated at a flow rate of 2 liters/day. The results showed that highest efficiency for COD, BOD, TKN, TSS and color consecutive were 95.75%, 89.08%, 85.33%, 92.24%, and 99%. All of them was reached by vertical reactor. For metallic removal efficiency, the reduction of Fe, Cu and Zn in wetland with vertical flow was 95%, 97% and 98%, while in wetland with horizontal flow the removal efficiency of Fe, Cu and Zn reduction was 91%, 98%, 98% respectively. Metals in constructed wetland systems accumulate in the soil and absorbed by plants (roots, stems and leaves). Moreover, Cyperus papyrus had the impact to optimization of pollutants removal and constructed wetland with Cyperus papyrus as the vegetation is a sustainable treatment for leachate.

KEYWORDS

leachate treatment, coagulation-flocculation, SBR, wetland, Cyperus papyrus.

Practical Research and Education
of SWM Based on Partnership between University
and Governments Asia and Pacific Countries

Leachate Treatment from Municipal Solid Waste Landfill in Indonesia

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Outline

- Back Ground
- Leachate Treatment in Indonesian Landfill
- Research at ITB for Leachate Treatment
- Conclusion

BACK GROUND (1)

LEACHATE :

Fluid from the external water enter into the landfill waste, dissolve and rinse the dissolved materials, including organic matter decomposition resulted in biological process

BACK GROUND (2)

Characteristics of leachate :

- BOD and COD concentration : high at the beginning
- High nitrogen content
- Electrical conductivity : high
- Heavy metals : sometimes in high concentration
- pH : neutral to acid
- Colors : difficult to be eliminated, light brown to black
- Bad smell

Leachate move to the bottom by its gravity, bring the pollutant, both suspended and dissolved matter

BACK GROUND (3)

Final Disposal Pollution

Environmental pollution

Esthetic Decreasing

Social Conflict

Final Disposal management required for leachate treatment

Expensive !!!

Efficient and cheap Leachate Treatment

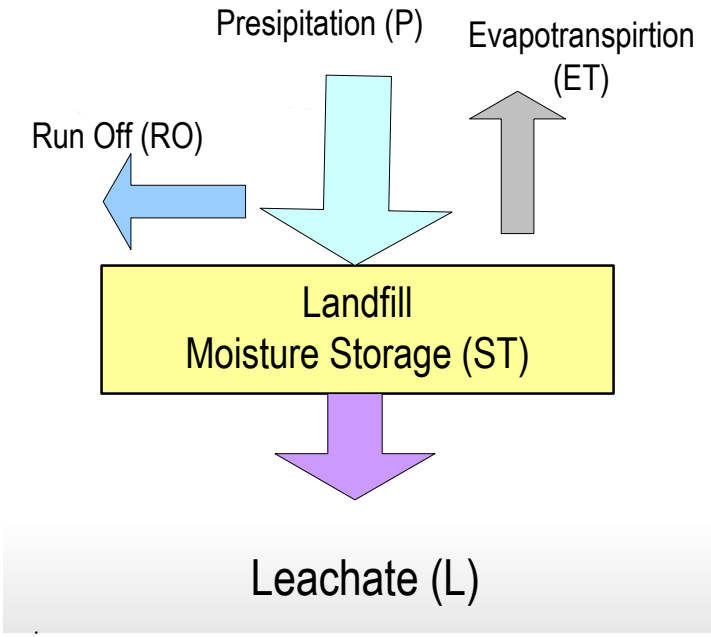
Leachate Treatment

BACK GROUND (4)

Water balance in Landfill

Generally, leachate contains organic and inorganic substances in a high concentration, especially for young landfill

Landfill needs a good leachate treatment



Leachate percolation
L = P - RO - ET - ST

Leachate Generation

LEACHATE TREATMENT IN INDONESIAN LANDFILL (1)

Leachate characteristics

No	Parameter	Unit	Leachate Characteristics				
			Bogor	Cirebon	Jakarta	Bandung *	Effluent Std
1	pH	-	8	7	7.5	7.96	6-9
2	N-NH4	mg/l	649	395	799	924	-
	N-NO2	mg/l	0.075	0.225	0.35	8.74	-
3	EC	µS/cm	24,085	12,480	13,680	17650	-
4	Alcalinity	mg/l $CaCO_3$	-	-	-	9350	-
5	TSS	mg/l	-	-	-	640	400
7	Total COD	mg/l	28,723	13,575	6,839	4618	300

* Last sampling at Sarimukti FDS

LEACHATE TREATMENT IN INDONESIAN LANDFILL (2)

Effluent standard

No	Parameter	Unit	Sandard
1	TDS	mg/L	4.000
2	TSS	mg/L	400
3	pH	-	6 – 9
4	Ammonia	mg/L as $N\text{-}NH_3$	5
5	Nitrat	mg/L as $N\text{-}NO_3$	30
6	Nitrit	mg/L as$N\text{-}NO_2$	3
7	BOD	mg/L	150
8	COD	mg/L	300

LEACHATE TREATMENT IN INDONESIAN LANDFILL (3)

Stabilization pond: typical leachate treatment

- **Leachate's characteristics were dominated by the concentration of organic components with Chemical Oxygen Demand (COD) between 4000 – 30000 ppm**
- **Currently, the existing condition of landfill's leachate treatment done only by using stabilization ponds**

Why stabilization pond ?

- **Indonesia has enough available sunlight,**
- **Treatment is simple and relatively cheap**

LEACHATE TREATMENT IN INDONESIAN LANDFILL (4)

LEACHATE

BOD = 2.000 – 10.000 ppm
COD = 4.000 – 30.000 ppm

TREATMENT

Existing condition : **Stabilization ponds**

Relatively long retention times

LEACHATE TREATMENT IN INDONESIAN LANDFILL (5)

Problems appear :

- Leachate treatment use anaerobic stabilization ponds / aerobic only, and color is difficult disappear
- Allowing the leachate installation as it is without control
- Sometimes leachate treatment plant is run only when there is a visit
- Less / no attention from landfill management - considered expensive

RESEARCH AT ITB FOR LEACHATE TREATMENT (1)

Coagulation and flocculation process

Can be one of the alternatives for leachate's pre-treatment process

Jar-test (laboratory test)

Coagulant : Alum & PAC

Dose

50	
100	
300	
500	
1000	
1500	
2000	mg/l
2500	
3000	
3500	
4000	
4500	

⟷

pH
9,25
9
8,5
8
7,5
7

RESEARCH AT ITB FOR LEACHATE TREATMENT (2)

Coagulation and flocculation process

Initial Characteristics

No	Parameter	Unit	Sample			Quality Standard
			1	2	3	
1	pH	-	7,91	7,96	9,26	6 – 9
2	Turbidity	NTU	130	160	321	-
3	Conductivity	µS/cm	15100	17650	24500	-
4	Alcalinity	mg/L $CaCO_3$	7933	9350	11700	-
5	TSS	mg/L	490	640	1270	400
6	TDS	mg/L	9943	10680	16710	4000
7	Total COD	mg/L	4498	4618	10800	300

RESEARCH AT ITB FOR LEACHATE TREATMENT (3)

Coagulation and flocculation process

Dose used in this research → **EFFICIENT DOSE**

- High dose → inefficient :
  - Did not give significant increase on total COD removal e
  - High Cost :
    - Purchasing
    - Sludge treatment

PAC Alum

Effluent → Potentially toxic to microorganisms

RESEARCH AT ITB FOR LEACHATE TREATMENT (4)

Coagulation and flocculation process

RESULTS:

- The **high dose** for alum is 4500 mg/L with a total COD removal efficiency of 52.1%. Meanwhile, the high dose of PAC is 3500 mg/L with a total COD removal efficiency of 54.28%.

- However, **the high dose is inefficient** because the numbers are very high and the volume of sludge generated is also very high.

- **Efficient dose** of alum is 500 mg/L with a total COD removal efficiency of 36.14%. Efficient dose of PAC is 300 mg/L with a total COD removal efficiency of 29.79%.

- The **optimum pH** for alum and PAC is 8 and using the efficient dose of alum and PAC with the total COD removal efficiency are 43.41% and 40.18% respectively.

RESEARCH AT ITB FOR LEACHATE TREATMENT (5)

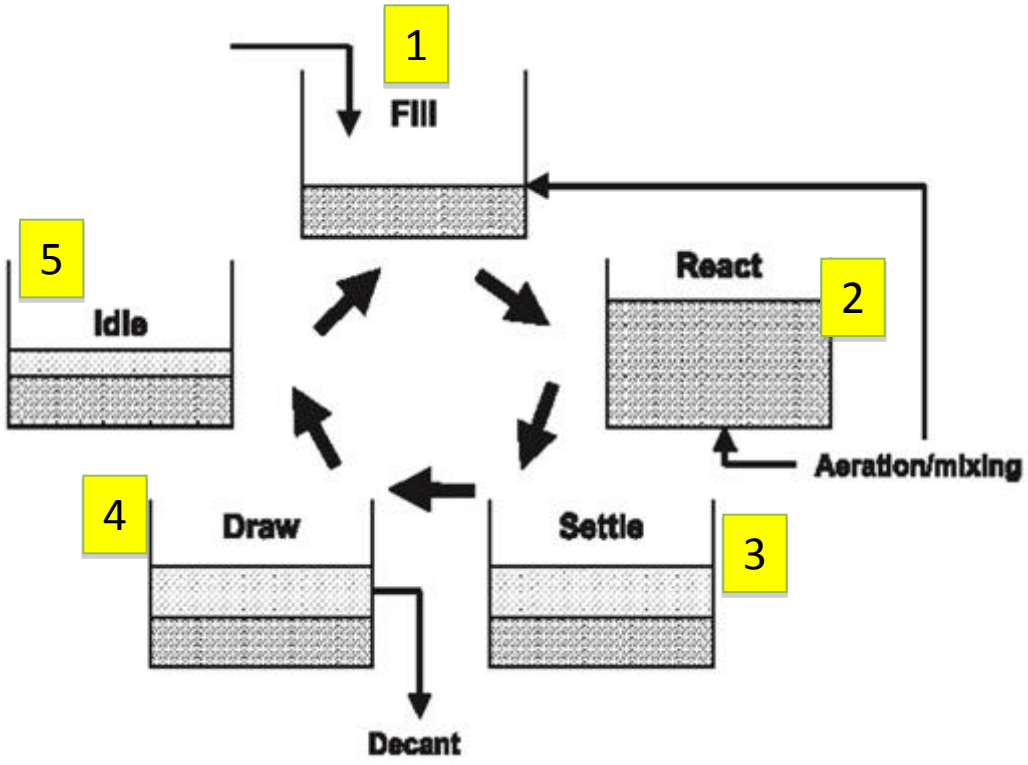
SBR (sequencing bed reactor)

Advantages :
the process of equalization of biological process and settling stage , occurs in a single tank with the time sequence.

The main process of SBR:

1. Fill the waste to the reactor
2. React: mixing by aerator
3. Settle for some hours
4. Draw: separate supernatant and sludge.
5. Idle: sludge is used for the next stage (stabilization phase)

---- And Fill again



RESEARCH AT ITB FOR LEACHATE TREATMENT (6)

SBR (sequencing bed reactor)

Reaction phase

Generally, the reaction phase conducted to give enough time to the microorganisms to contact and degrade organic matter

It is the core phase in the cycle of SBR in degrading organic matter

Adsorption of organic matter that occurs during periods of contact will be used as a reserve of organic matter when the condition without substrate (famine).

RESEARCH AT ITB FOR LEACHATE TREATMENT (7)

SBR (sequencing bed reactor)

Overall efficiency of aerobic SBR performance

Variation code	influent	efluent	Efficiency (%)
A2	3185.82	746.11	76.58
A4	2946.08	724.38	75.41
A8	3177.09	661.09	79.19
B2	1644.0	364.10	77,85
B4	1614.62	617.57	61.75
B8	1646.85	508.26	69.14

Result :
COD removal : 70 – 80%

Code A2: 3000-3500 mg/l, 2 hours reaction time
Code A4: 3000-3500 mg/l, 4 hours reaction time
Code A8: 3000-3500 mg/l, 8 hours reaction time
Code B2 : 1500-2000 mg/l, 2 hours reaction time
Code B4: 1500-2000 mg/l, 4 hours reaction time
Code B8: 1500-2000 mg/l, 8 hours reaction time

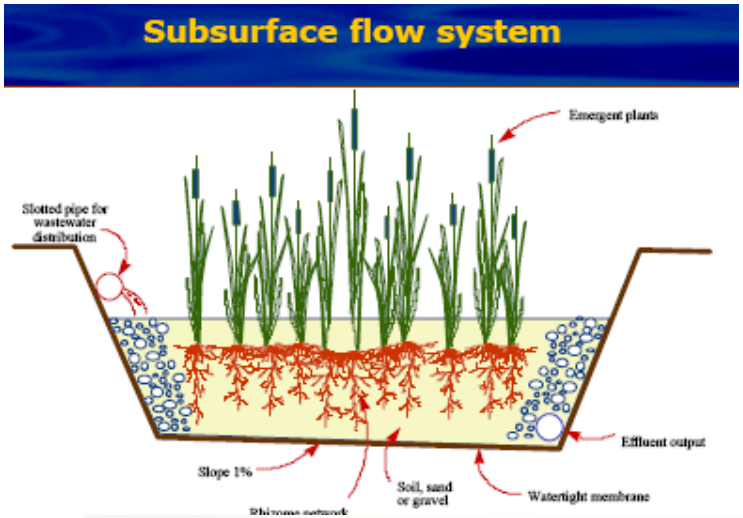
RESEARCH AT ITB FOR LEACHATE TREATMENT (8)

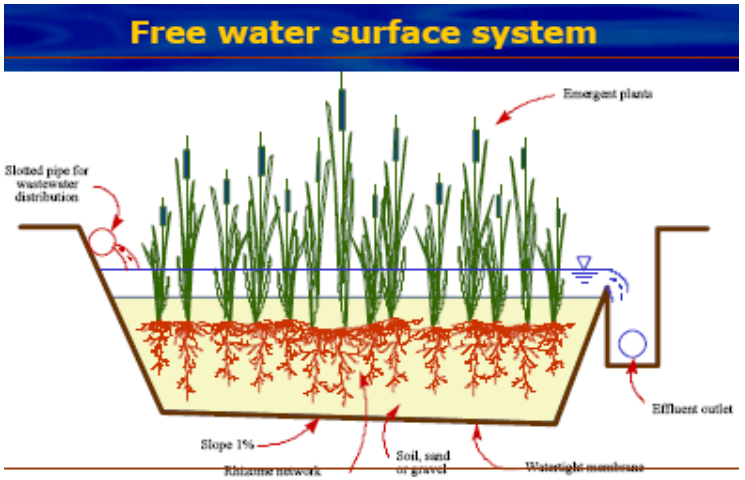
SBR (sequencing bed reactor)

Leachate treatment using SBR aerobe by varying the reaction time provides the best results for the COD removal of 3000-3500 mg / l with a reaction time of 8 hours : efficiency up to 79%.

RESEARCH AT ITB FOR LEACHATE TREATMENT (9)

Wetland





RESEARCH IN ITB FOR LEACHATE TREATMENT (10)

Wetland

Advantages:

- Cost of investment, operation, and maintenance is cheaper.
- Operation and maintenance easy
- Efficiency is high enough.
- Relatively tolerant of different levels of pollutant concentrations
- Absorb heavy metals that can not be treated conventionally.
- Suitable developed in small settlements, agricultural areas
- Indirect benefits such as supporting the ecological functions of rain, habitat for wildlife and recreation areas.

Disadvantages :

- Need large areas of land.
- Criteria for the design and operation remains unclear.
- Possibility of developing the disease vectors such as mosquitoes

RESEARCH IN ITB FOR LEACHATE TREATMENT (11)

Wetland

Laboratory scale:
Used as final Treatment

Aquatic plants (ex. Cyperus papyrus)
Plant age ± 2 months
Plant height 30-40 cm

Removal efficiency of Fe, Cu and Zn in:
Wetland horizontal flow: 91%, 98%, 98%
Wetland vertical flow: 95%, 97% and 98%.

Metals in constructed wetland systems accumulate in the soil and absorbed by plants. (Roots, stems and leaves.)

RESEARCH IN ITB FOR LEACHATE TREATMENT (12)

Wetland

Influent Leachate

Effluent from wetland

Horizontal reactor

Blank Reactor

Vertikal reactor

Result of leachate treated by wetland

CONCLUSION

Besides of using Stabilisation ponds, there are many alternative treatments that can be applied in treating leachate :

- Coagulation-flocculation as pre- treatment
- Sequencing bed reactor (SBR)- as biological treatment
- Wetland as tertiary treatment