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Influence of Waste Age on Landfill Leachate Quality

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***Abstract*—The influence of waste age on the characteristic of leachate from a landfill site where young and mature waste cells were investigated over a period of six years to evaluate the impact of waste age on quality of leachate generated. Results of the study revealed that the leachate quality is affected by waste age due to its impacts to bacterial growth and chemical reaction in the waste mass of landfill.**

***Index Terms*— leachate, sanitary landfill, bacterial growth, chemical reaction landfill, waste age**

I. Introduction

Leachate is the liquid percolation that drains through the waste in the landfill varies widely depend on waste type and the waste age (Christensen et al., 1994; Lema et al., 1988; Lu et al., 1985; Pohland and Harper 1985). Typically, the leachate can be characterized into three major groups as shown in Table 1. The three major groups are mainly organic matters, inorganic matters and xenobiotic organic compounds. Beside these, other compounds are also likely present in the leachate such as arsenate, barium, borate, cobalt, lithium, mercury, selenate and sulfide however in small quantity and of less significant level.

TABLE 1 Pollutants In Leachate

Group of Pollutants In Leachate		Components
1	Organic matters	Acids, alcohols, aldehydres and others usually quantified as COD (Chemical Oxygen Demand), BOD (Biochemical Oxyegn Demand), DOC (Dissolved Organic Carbon), Other Volatile fatty acid and refractory compound include fulvic-like and humic like compounds
2	Inorganic matters	Sulfate, chloride, ammonium, calcium, magnesium, sodium, potassium , hydrogen carbonate, iron and manganese and heavy metal like lead, nickel, copper, cadmium, chromium and zinc
3	Xenobiotic organic compounds	Aromatic hydrocarbon, phenols, chlorinated aliphatics, pesticides and plastizers include PCB, Dioxin, PAH, etc

Leachate quality is significantly influence by the waste age or length of time after waste fill. It is reported that leaching quality achieved at maximum after two or three years and decline subsequently (McBean et al, 1991; Lu et al., 1985). Also there is reporting that leachate from young landfill will be high in BOD and COD and decline subsequently to level off after 10 years (Akyurek, 1995).

The purpose of this paper is to study the influence of waste age on quality of leachate leaching out from sanitary that yield various pollutants that pose environmental pollution to soil and groundwater.

II. Material And Method

The leachate data used in this study was obtained from the performance results of a landfill site at Toronto over a period of five years and fifteen years for the young age and mature age part of landfill respectively. The leachate composition was typical of both young and mature landfills. The landfill is deposited with wastes of solid, non-hazardous, industrial, commercial and institutional waste from municipalities and business.

The parameters evaluated include carbonaceous parameters such as BOD, COD and DOC, nitrogeneous parameters include ammonia, nitrate, nitrite, TKN and other parameters include alkalinity, calcium, chloride, conductivity, hardness, iron, magnesium, pH, phenols, phosphorus, sodium, sulphate and total suspended solids.

Characteristic of leachate are analyzed statistically in term of linear regression on performance data obtained over the period of five and fifteen years for young and mature landfill.

III. Result And Discussion

In this study, landfill of both young and mature waste cells that are designed with a typical engineered hydraulic trap as shown in Fig. 1 to contain and collect leachate to minimize groundwater impact. The young and old waste cells if are in operation of five and fifteen years respectively.

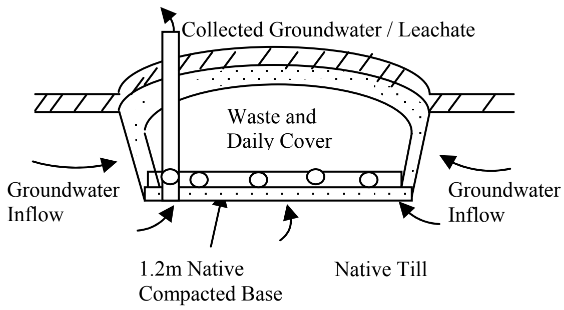

Fig. 1 Landfill with Hydraulic Trap

Data of carbonaceous pollutants in leachate of young waste cell of landfill is depicted in Table 2 and Fig. 2.

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The mean value for BOD, COD and DOC is 2031.62, 3641.2 and 1240 mg/l with standard deviation of 2754.85, 3949.71 and 1421.41 mg/l respectively. Maximum and minimum BOD, COD and DOC values obtained are 6350, 9600 and 3490 mg/l and 13.1, 226 and 90 mg/l respectively. The value of BOD and COD obtained is correlated well to the reported BOD and COD ranges of 4000-40,000 mg/l and 6,000-60,000 mg/l respectively for acetonogenic leachate typically from young landfill (Ehrig, 1983, 1988). This observation suggests that the performance data obtained from the young landfill of five years which is still experiencing the acetogenic phrase at the landfill that is still active. Higher organic matter content is expected in this leachate due to generation of dissolved and solubilized organic matter.

TABLE 2 CARBONACEOUS POLLUTANT CONCENTRATION IN LEACHATE FROM YOUNG LANDFILL CELL

Parameter	Maximum value	Minimum Value	Mean	Standard Deviation
BOD (mg/l)	6350	13.1	2031.62	2754.85
COD (mg/l)	9600	226	3641.2	3949.71
DOC (mg/l)	3490	90	1240	1421.41
BOD:COD Ratio	0.66	0.05	0.31	0.29
pH	6.80	5.92	6.52	0.35

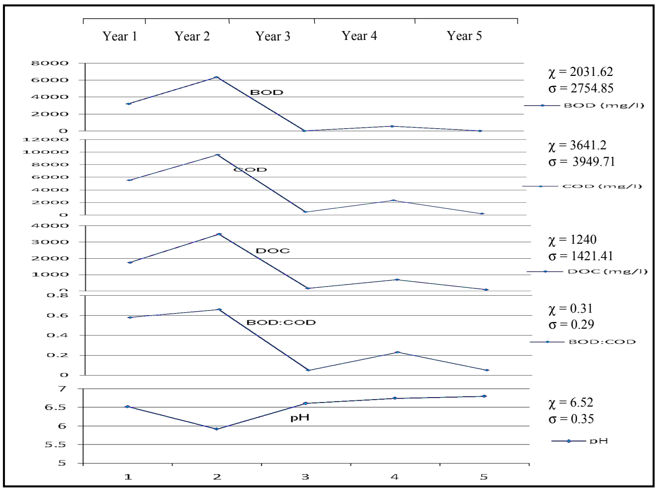

Fig. 2 Carbonaceous Pollutant Concentration in Leachate from Young Landfill Cell

On the other hand, data of carbonaceous pollutant in leachate of landfill over fifteen years is depicted in Table 3 and Fig. 3. The mean value for BOD, COD and DOC is 195.83, 875.44 and 290.28 mg/l with standard deviation of 202.45, 256.80 and 167.14 mg/l respectively. Maximum and minimum BOD, COD and DOC values obtained are 870, 1510 and 650 mg/l and 61.90, 409 and 137 mg/l respectively. The values of BOD and COD achieved are well correlated to the reported value of BOD and COD ranges of 20-550 mg/l and 500-4500 mg/l respectively for methanogenic leachates (Ehrig, 1983, 1988) which further suggest that mature leachate produce lower organic matter content with clear indication that efficient degradation of dissolved organic matter can be well achieved.

TABLE 3 CARBONACEOUS POLLUTANT CONCENTRATION IN LEACHATE FROM MATURE LANDFILL CELL

Parameter	Maximum value	Minimum Value	Mean	Standard Deviation
BOD (mg/l)	870	61.90	195.83	202.45
COD (mg/l)	1510	409	875.44	256.80
DOC (mg/l)	650	137	290.28	167.14
BOD/COD Ratio	0.57	0.05	0.20	0.14
pH	7.38	6.27	5.72	2.64

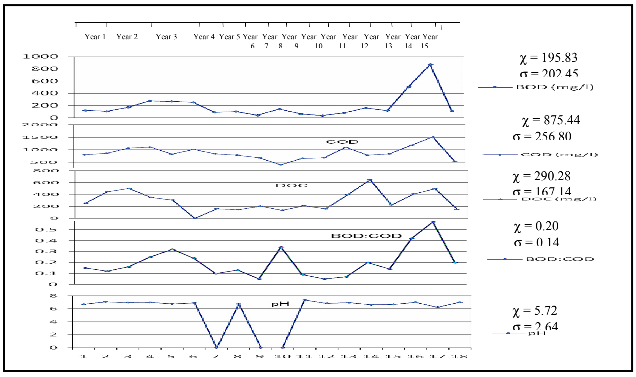

Fig. 3 Carbonaceous Pollutant Concentration in Leachate from Mature Landfill Cell

Performance data of nitrogeneous pollutants in leachate of young waste cell of landfill is illustrated in Table 4 and Fig. 4. The mean value for ammonia, nitrite, nitrate and TKN is 288.6, 1.8, 1.8 and 474.80 mg/l with standard deviation of 196.57, 0.45, 0.45 and 347.33 mg/l respectively. Maximum and minimum values for ammonia, nitrite, nitrate and TKN are 520, 2, 2, 880 mg/l and 103, 1, 1 and 162 mg/l respectively. The presence of ammonia and organic nitrogen are mainly due to their generation from decomposition of organic matters which are stable in anaerobic condition thus explained the presence of high percentage of soluble nitrogen compounds found in the leachate (McBean et al, 1995).

TABLE 4 NITROGENOUS POLLUTANT CONCENTRATION IN LEACHATE FROM YOUNG LANDFILL CELL

Parameter	Maximum value	Minimum Value	Mean	Standard Deviation
Ammonia (mg/l)	520	103	288.60	196.57
Nitrite (mg/l)	2	1	1.8	0.45
Nitrate (mg/l)	2	1	1.8	0.45
TKN (mg/l)	880	162	474.80	347.33

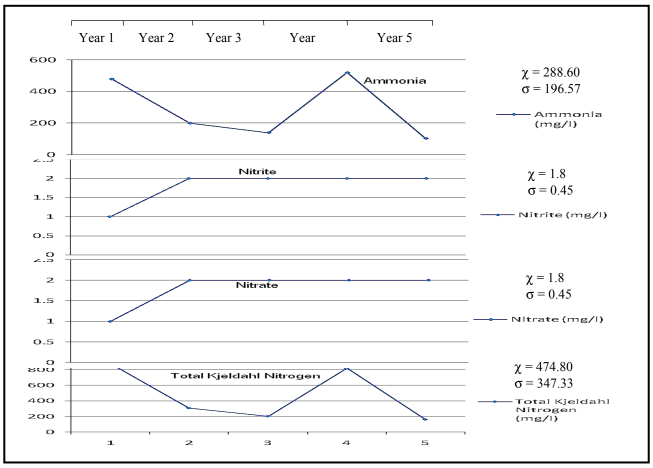

Fig. 4 Nitrogeneous Pollutant Concentration in Leachate from Young Landfill Cell

On the other hand, nitrogeneous pollutants in leachate of the mature waste cell landfill is shown in Table 5 and Fig. 5. The mean value for ammonia, nitrite, nitrate and TKN is 260.03, 0.72, 0.73 and 304.46 mg/l with standard deviation of 102.73, 0.78, 0.77 and 118.29 mg/l respectively. Maximum and minimum values for ammonia, nitrite, nitrate and TKN are 523, 2, 2 and 663 mg/l and 78.50, 0.10, 0.10 and 90.30 mg/l respectively. It is reported that the range of ammonia nitrogen concentration spread from 200 to 2000 mg/l showing no decreasing trend in concentration with time. It is also believed that ammonia is mainly released from the decomposition of organic matter such as protein (Robinson, 1995; Burton and Watson-Craik, 1998). Thus ammonia appear to be a good indication of organic nitrogen in the leachate.

TABLE 5 NITROGENOUS POLLUTANT CONCENTRATION IN LEACHATE FROM MATURE LANDFILL CELL

Parameter	Maximum value	Minimum Value	Mean	Standard Deviation
Ammonia (mg/l)	523	78.50	260.03	102.73
Nitrite (mg/l)	2	0.10	0.72	0.78
Nitrate (mg/l)	2	0.10	0.73	0.77
TKN (mg/l)	663	90.30	304.46	118.29

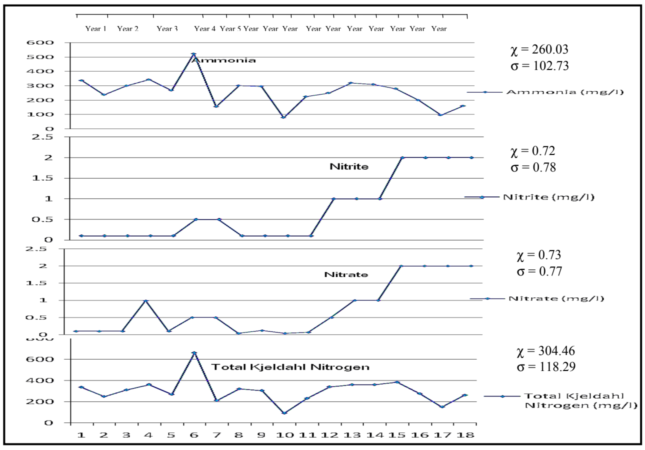

Fig. 5 Nitrogeneous Pollutant Concentration in Leachate from Mature Landfill Cell

Data of other pollutants in leachate of the new waste cell landfill is depicted in Table 6 and Fig. 6. The mean value of calcium, chloride, iron, magnesium, sodium, sulfate and phenol is 421.40, 893.80, 32.11, 153.60, 764.20, 196.80 and 783.60 mg/l with standard deviation of 415.16, 466.29, 36.90, 27.75, 450.31, 180.53 and 757.6 mg/l respectively.

TABLE 6 OTHER POLLUTANT CONCENTRATION IN LEACHATE FROM YOUNG LANDFILL CELL

Parameter	Maximum value	Minimum Value	Mean	Standard Deviation
Calcium (mg/l)	1060	126	421.40	415.16
Chloride (mg/l)	1410	322	893.80	466.29
Iron (mg/l)	73.80	3.84	32.11	36.90
Magnesium (mg/l)	179	118	153.60	27.75
Sodium (mg/l)	1370	279	764.20	450.31
Sulfate (mg/l)	509	40	196.80	180.53
Phenol (mg/l)	1720	3	783.80	757.633

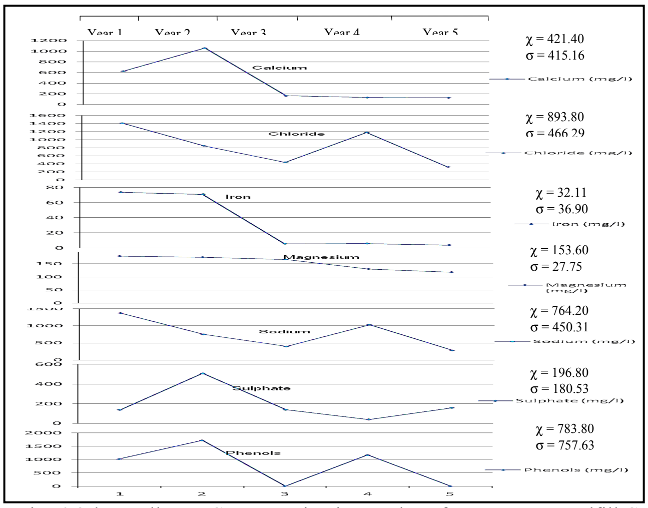

Fig. 6 Other Pollutant Concentration in Leachate from Young Landfill Cell

Also, data of other pollutants over fifteen years from the mature waste cell is depicted in Table 4.10 and Fig. 7. The mean value for calcium, chloride, iron, magnesium, sodium, sulfate and phenol is 181.91, 735.06, 11.24, 132.79, 688, 81.73 and 175.44 mg/l with standard deviation of 85.54, 235.58, 8.30, 36.88, 253.61, 175.46 and 274.41 mg/l respectively. There is observed difference of these parameters between acenogenic phase and methanogenic phase likely due to the effects of sorption, complexation and precipitation. Decreasing trend in concentration with time of these pollutants could be also due to washout by leaching as reported in some study (Ehrig 1983, 1988).

TABLE 7 OTHER POLLUTANT CONCENTRATION IN LEACHATE FROM MATURE LANDFILL CELL

Parameter	Maximum value	Minimum Value	Mean	Standard Deviation
Calcium (mg/l)	405	62.40	181.91	85.54
Chloride (mg/l)	1100	275	735.06	235.58
Iron (mg/l)	32.5	2.92	11.24	8.30
Magnesium (mg/l)	215	75.70	132.79	36.88
Sodium (mg/l)	1030	297	688	253.61
Sulfate (mg/l)	771	7.03	81.73	175.46
Phenol (mg/l)	951	1	175.44	274.41

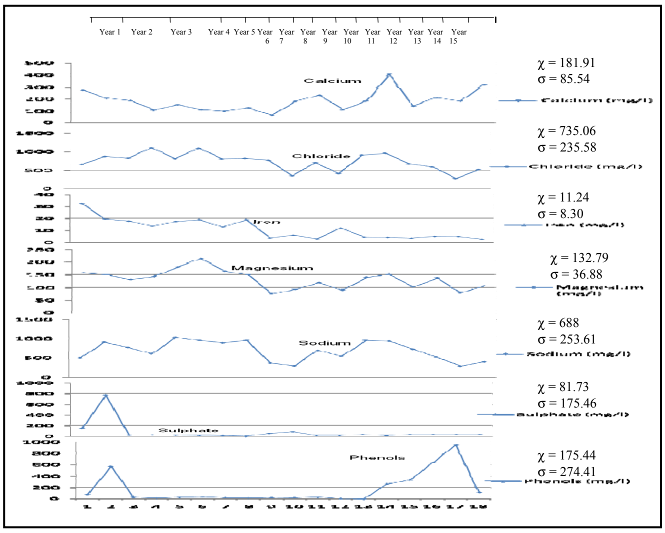

Fig. 7 Other Pollutant Concentration in Mature Age Leachate Sampling Point

IV. CONCLUSION

Leachate generation in sanitary landfill is a complex combination of physical, chemical and biological processes whereby waste age has impact to performance of landfill that generate leachate. Results reveal that leachate quality correlates well with the waste age. This is largely due to microbial degradation of both organic and inorganic constituents in the waste experience different exposure of acetogenic and methanogenic phases.

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REFERENCES

[1] Qasim S.R. and ChiangW, Sanitary Landfill Leachate, Technomic Publishing Co., Inc. Lancaster, 1994.

[2] Lu J.C.S., et al., Td, Leachate from Municipal Landfills Production and Management, Noyes Publication, Park, Ridge, 1985.

[3] Kjeldsen, P. and Christophersen, M., Composition of leachate from old landfills in Denmark, Waste Manag. Res., 19, 24-256, 2001.

[4] Kjeldsen, P., Barlaz, M., Rooker, A., Baun, A., Ledin, A. and Christensen, T., Present and Long-Term Composition of MSW Landfill Leachate : A Review. Critical Reviews in Environmental Science and Technology, 32, No. 4, 2002.

[5] Ehrig, H.-J., quality and quantity of sanitary landfill leachate, Waste Manag. Res., 1, 53, 1983.

[6] Johansen O.J. and Carlson D.A. Characterization of Sanitary Landfill Leachates, Water Research, 10:1129-1134, 1976.

[7] Ritzkowski M., Heyer, K.-U, Stegmann, R. (2003) : Insitu aeration of Old landfills : Carbon Balances, temperatures and settlements. Proceedings of Sardia, 2003-Ninety International Waste Management and landfill Symposium, Cagliari, Italy, 06-10.10.2003.

[8] Barlaz, M.A., Ham, R.K. and Shaefer, D.M., Methane Production from Municipal Refuse: A Review of Enhancement Techniques and Microbial Dynamics, CRC Crit. Rev. Environ. Contr., 19, 6, 557,

[9] Bookter and Ham R.K., stabilization of solid waste In Landfills, Journal of Environmental Engineering, 108(6) : 1089(1982).

[10] Chian, E.S.K., and DeWalle, F.B., Characterization of Soluble organic matter in leachate. Environ Sci. Techol., 11, 158, 1977

[11] Christensen, T.H., Kjeldsen, P., Albrechtsen, H-J., Heron, G., Nielsen, P.H., Bjerg, P.L., and Holm, P.E., Attenuation of landfill leachate pollutants in aquifers, Crift. Rev. Environ. Sci. Technol, 24, 119, 1994.

[12] Pohland, F.G. Harper, S.R., Chang, K.C. Dertien, J.T. and Chain. E.S.K. Leachate generation and control at landfill disposal sites, Water Pollution Resources Journal Canada, 20(3): 10-24, 1985.

[13] Akyurek, M., Trends in landfill leachate characteristics, Presented at the Eighteenth International Madison Waste Conference, Department of Engineering Professional Development, Madison, 1995.

[14] Burton. S.Q. and Watson-Craik, I.A., Ammonia and nitrogen fluxes in landfill sites: applicability to sustainable landfillinf, Waste Manag:Res., 16, 41, 1998.

[15] Kruempelbeck, I. and Ehrig, H.-J., Long-term behavior of municipal solid waste landfill in Germany, in Sardinia 99, Seventh International Waste Management and Landfill Symposium, 4-8 October, S. Margherita di Pula, Cagliari, Proceedings vol.. I, Christensen, T.H., Cossu, R., and Stegmann, R. Eds., CISA – Environmental Sanitary Engineeging Centre, Cagliari, Italy, 1999, 27.

[16] Sulfita, J. Gerba, C. Ham, R. Palmisano, A. Rathje, W. and Robinson, J. The world's largest landfill, Environmental Science & Technology, 26(8): 1486-1495, 1992.