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Effect of Temperature on Performance of a Sanitary Landfill

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Abstract. The effect of temperature on the characteristic of leachate from a mature landfill site was investigated over a period of six years to evaluate the impact of climatic temperature on quality of leachate generated. Results of the study revealed that the leachate quality is affected by climatic temperature due to its impacts to bacterial growth and chemical reaction in the waste mass of landfill.

Keywords: temperature, leachate, sanitary landfill, bacterial growth, chemical reaction

1. Introduction

Leachate can be generated by several potential sources include gravity drainage, ponded water, rain, infiltration and groundwater inflow. Leachate generation that caused water pollution was not gaining much attention until 1965 when leachate causing harmful impact to water course was studied in depth (1-4).

Leachate percolateing waste above groundwater and table causes contaminant to migrate to groundwater. The transfer of contaminants is subject to a combination of physical, chemical and biological processes from the waste to the percolating leachate and thus made composition of leachates from different waste fills having similar characteristics (5-6).

Leachate temperature in landfill is affected by climatic temperature due to fluctuation of ambient temperature as temperature poses impact to bacterial growth and chemical reaction. Bacterial growth is constraint by particular individual bacterial optimum growth temperature and any temperature change will retard growth due to its enzyme deactivation and cell wall rupture. Beside this, temperature also poses impact to solubility of many compounds to increase or decrease that affect the quality of leachate. It is also reported that numerous compounds in leachate such as $CaCO_3$ and $CaSO_4$ show decrease in solubility as temperature increase (7-10).

The purpose of this paper is to study the effect of temperature on quality of leachate generated from a sanitary landfill.

2. 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 6 (six) years spread from 2004 to 2009. The leachate composition was typical of a mature landfill. The landfill is deposited with wastes of solid, non-hazardous, industrial, commercial and institutional waste from municipalities and business.

The parameters were evaluated in terms of pH, TSS (Total Suspended Solids), BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand) and DOC (Dissolved Organic Carbon), TKN (Total Kjeldahl Nitrogen), ammonia, nitrite and nitrate.

Characteristic of leachate are analyzed statistically in term of linear regression on performance data obtained over the period of six years.

3. Results and Discussion

In this study, landfill that is designed with an engineered hydraulic trap as shown in Figure 1 to contain and collect leachate to minimize groundwater impact.

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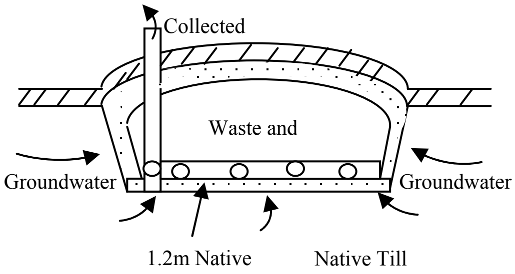

Fig. 1: Landfill with Hydraulic Trap

Correlation relationship of leachate concentration to temperature is evaluated in terms of pH, TSS, BOD, COD, DOC, ammonia, nitrate, nitrite, TKN and phenols.

From the analysis as shown in Figure 2, the equation for a straight line forced through the data with pH = 6.555 + 0.01701 Temperature. The r^2 value also depicts that 10% of the total variation about the pH mean is explained by the regression line. The confidence interval for the slope show that with 95% confidence the data value for the slope lines somewhere between -0.01864 to 5.708.

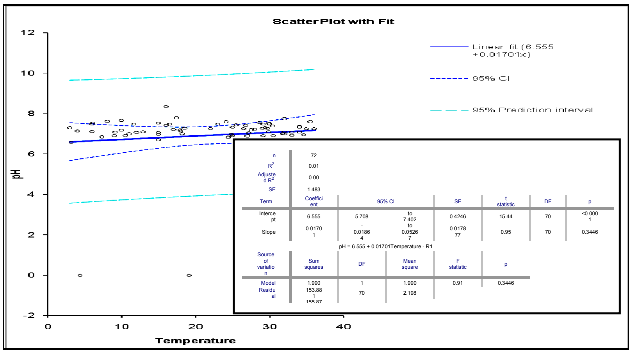

Fig. 2: pH of Leachate Versus Temperature

The correlation of TSS to temperature is shown in Figure 3 with the equation of TSS = 39.45 + 1.107 Temperature. The r^2 value obtained shows 10% of the total variation about the temperature mean is explained by the regression line. The confidence interval for the slope shows that 95% confidence extend from – 2.161 mg/L to 117.06 mg/L

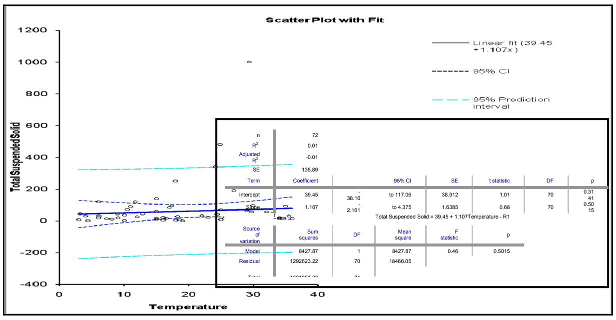

Fig. 3: Total Suspended Solid of Leachate Versus Temperature

Figure 4 depicts the correlation of BOD to temperature illustrating the equation of BOD = 475.8 – 10.89 Temperature. The r^2 value shows that about 30% of the total variation about the temperature mean is explained by the regression line. The confidence interval for the slope shows that with 95% confidence the data value for the slope lines somewhere between 197.4 mg/L to 754.1 mg/L. The correlation coefficient was statistically high and significant different from zero. The negative value indicates that there is an inverse relationship between BOD and temperature i.e. higher temperature show a lower BOD value.

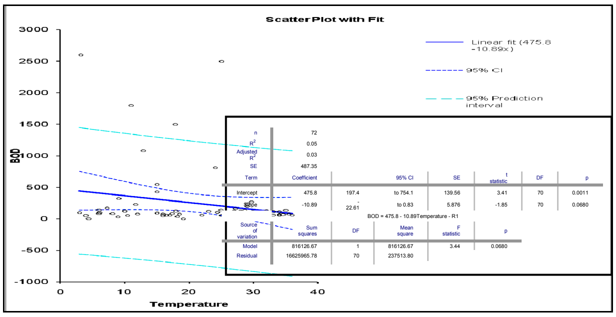

Fig. 4: BOD of Leachate Versus Temperature

The correlation of COD to temperature shows likewise to BOD correlation to temperature as depicted in Figure 5. The equation of COD = 1222 – 12.8 Temperature with r^2 of 20%. The confidence interval spread from 745 mg/L to 1700 mg/L. Negative slope also illustrate an inverse relationship between COD and temperature.

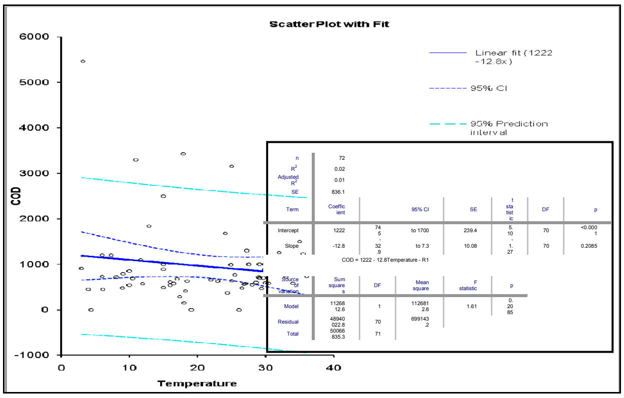

Fig. 5: COD of Leachate Versus Temperature

Figure 6 again illustrate the similar trend like BOD and COD for correlation of DOC to temperation. The equation of DOC = 351 – 2.015 Temperature is obtained with r^2 value of 10%. The 95% confidence interval spread form 210 mg/L to 492 mg/L with negative correlation coefficient reveal that there is an inverse relationship to lower DOC values at higher temperature.

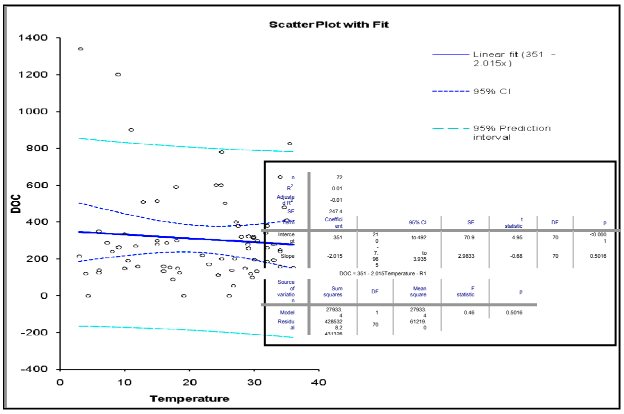

Fig. 6: DOC of Leachate Versus Temperature

Figure 7 depicts the correlation of ammonia to temperature. The equation obtained is Ammonia = 164.4 + 2.98 Temperation with r^2 value of 10%. The 95% confidence interval spreads from 113.3 mg/L to 215.5 mg/L.

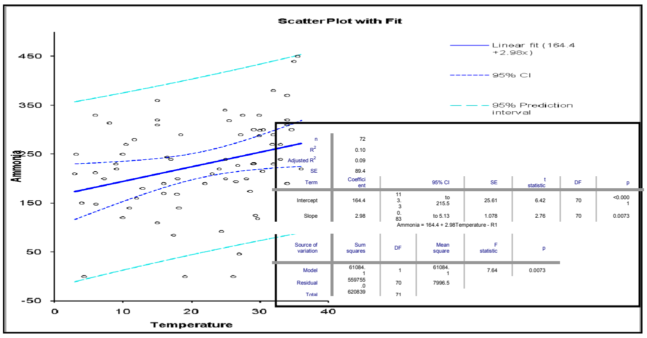

Fig. 7: Ammonia of Leachate Versus Temperature

The correlations of nitrate and nitrite in the leachate to temperature are shown in Figures 8 and 9 respectively. The equations obtained are Nitrate = 1.096 + 0.0111 Temperature and Nitrite = 1.154 + 0.0114 Temperation with r^2 values of 2% and 3% respectively. The respective 95% confidence interval spreads between 0.671 mg/L to 1.521 mg/L and 0.767 mg/L to 1.541 mg/L. Also, the correlation equation of TKN = 219.8 + 3.72 Temperation is obtained with r^2 values of 7%. The 95% confidence interval spreads between 145.1 mg/L to 294.5 mg/L.

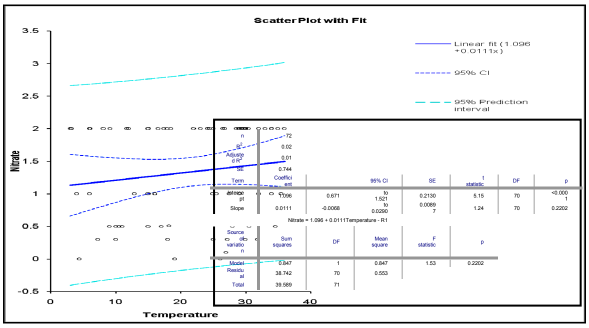

Fig. 8: Nitrate of Leachate Versus Temperature

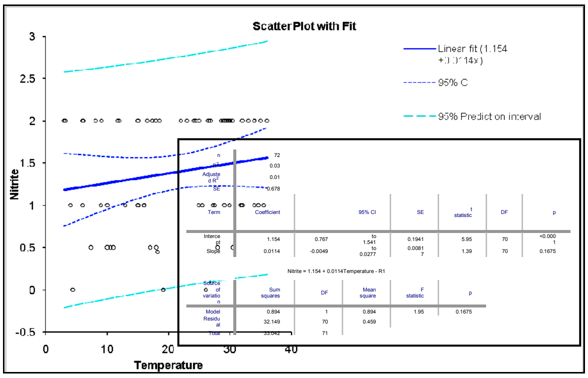

Fig. 9: Nitrite of Leachate Versus Temperature

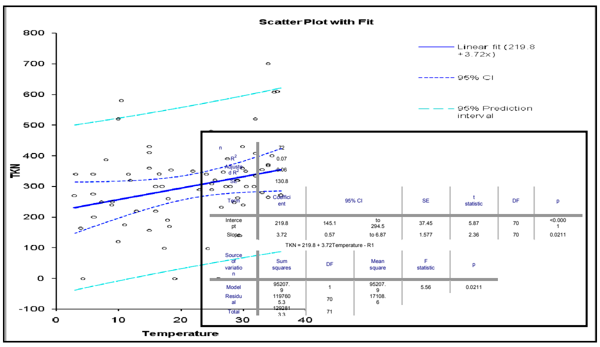

Fig. 10: Total Kjeldahl Nitrogen of Leachate Versus Temperature

Figure 11 depicts the correlation of Phenol = 330.8 – 5.5 temperation with r^2 value of 7%. The 95 confidence interval spreads from 219.4 mg/L to 442.1 mg/L.

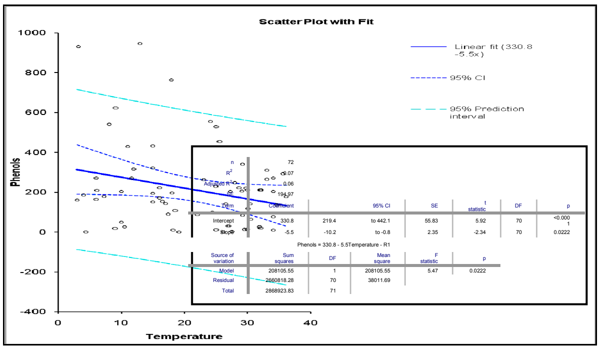

Fig. 11: Phenols of Leachate Versus Temperature

From the data evaluation as depicted in Figures 2 to 11, all properties evaluated with r^2>0.1 revealed that there is some degree of significance of correlation relationship of leachate to temperature in the environment. This can be explained by the active decomposition rate in the waste due to high temperature that facilitates both biological and chemical reaction inside the waste mass.

4. Conclusion

Leachate generation in sanitary landfill is a complex combination of physical, chemical and biological processes whereby climatic condition particularly temperature has impact to performance of landfill that generate leachate. The result of study reveals that temperature is largerly an incontrollable factor that influenced leachate quality of the sanitary landfill mainly due to temperature reaction on bacterial growth and chemical reaction in the waste mass.

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