

# Characterization of Acetogenic and Methanogenic Leachates Generated from a Sanitary Landfill Site

Aik Heng Lee, Hamid Nikraz, Yung Tse Hung

**Abstract**—Decomposition processes take place in landfill generate leachates that can be categorized mainly of acetogenic and methanogenic in nature. BOD:COD ratio computed in this study for a landfill site over a 3 years duration revealed as a good indicator to identify acetogenic leachate from methanogenic leachate. Correlation relationships to predict pollutant level taking into consideration of climatic condition are derived.

**Keywords**—Acetogenic Leachate, Methanogenic Leachate, BOD:COD Ratio.

## I. INTRODUCTION

LANDFILLS are major sources of groundwater and land contamination that can cause adverse impacts to the environment. Perforation of pollutants due to waste disposal which passes through as leachate if not properly handled will diffuse through the landfills and contaminate soils and groundwater if left unchecked. The constituents of leachate can be categorized into four types namely organic matter, inorganic matter, heavy metal and xenobiotic organic compounds [1].

The extent of contamination from the leachate depends on the type of control measures used in landfill. Nevertheless, pollutants in the leachate of different composition have different impacts on the environment. Even under controlled conditions such as those of a well planned and well managed landfill, leachate may percolate or penetrate through natural ground and may still contaminate groundwater and ultimate contaminate fresh water supplies over time. The environmental impact is most significant particularly those landfills without integration of engineering controls such as liners and leachate collection system.

The content of leachate generated from most landfill is subject to several factors such as climatic condition, infiltration and waste type. As leachate percolates through waste strata layers that undergo various decomposition high amounts of both organic matter and inorganic matters are found to be higher than those in groundwater [2]-[3].

Both temperature and water content in landfill will affect the rate of waste decomposition which is usually lower in dry

weather condition. Dissolved organic matter in leachate consists of various organic and inorganic constituents. Higher organic matter is anticipated in acetogenic phase whereas inorganic matter is lower in methanogenic phase due to lower dissolved organic matter and higher pH [4]-[8].

Leachate content generated from waste landfill can be broadly categorized as organic matters, inorganic matter, xenobiotic organic compounds and other compounds due to various conditions such as weather, infiltration, gravity drainage and groundwater inflow. The strength of leachate is depend on decomposition processes comprising of biological and chemical reactions which vary from pH and high concentration of biodegradable organic pollutant in early methanogenic phase to high pH and lower concentration of biodegradable organic content in later methanogenic phase.

The purpose of this paper is to study the impact of temperature and precipitation on landfill performance that yield various pollutant removal experiencing both acetogenic and methanogenic phases.

## II. MATERIALS AND METHOD

Performance data from a landfill site in Toronto, Canada was evaluated over a period of 3 years to assess the range of pollutant in the leachate. The performance data is depicted in Table 1.

The dissolved organic matters were evaluated in terms of BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand) and DOC (Dissolved Organic Carbon). The inorganic matters such as ammonia, calcium, chloride, iron, magnesium, sodium and sulfate of the landfill leachate were evaluated and xenobiotic organic compounds such as phenols were also evaluated. Statistical study using regression analysis to establish correlation relationship to evaluate pollutants from landfill that are leached out from this traditional waste landfill using clay liner taking into consideration of basic properties and factors influencing landfill performance include climatic conditions such as temperature and precipitation and also the organic content of leachate in terms of BOD:COD ratio.

## III. RESULTS AND DISCUSSIONS

As water passes through waste strata layer in landfill it triggers and activates decomposition due to present of microorganisms. The decomposition can be defined in two

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phases, firstly soluble organic matter produced due to aerobic decomposition or acetogenic phase and secondly methane and carbon dioxide produce due to anaerobic decomposition or methanogenic phase.

acidic and high ammonia concentration. Such aggressive nature of leachate prompts dissolution of other components in wastes resulting in high concentration of iron, magnesium, zinc and calcium.

TABLE I  
PERFORMANCE DATA OF LANDFILL SITE

Parameter	Year	Month	1	2	3	4	5	6	7	8	9	10	11	12
Temperature	1	2	30.5	19.2	25	27.5	31.8	30.5	29.5	29.1	27.2	35	30	
	2	19	7.3	12.9	28	43.9	34.6	35.0	34	32	40.1	19.1	4.4	
	3	11	4	15	25	27	27	31	31	35	32	42	15	37
	4	15	4	11.3	23	25.1	28.4	30.0	29.4	29.7	24.4	17.4	4.1	
Leach	1	20	18	18	17	17	17	17	17	17	17	17	17	17
	2	14.2	15	14.2	0	0.4	2.1	11.4	13	4.4	0.3	13.3	15.2	
	3	11	11	15	4	0	0	12	11	0	0	0	0	15
	4	17	25	27	7	0	0	7	11	0	0	0	0	13
Precipitation	1	10	10	10	10	10	10	10	10	10	10	10	10	10
	2	71.30	69.50	38.50	58.50	14.90	73.50	18.50	179.60	244.50	41.50	154.80	65.10	
	3	45.5	45.5	55.9	44.0	40.0	48.9	76.5	84.2	74.2	47.0	20.3	45.5	
	4	45.4	45.5	54.7	44.0	40.0	48.9	76.5	84.2	74.2	47.0	20.3	45.5	
BOD:COD ratio	1	0.01	0.06	0.16	0.09	0.01	0.06	0.06	0.06	0.06	0.13	0.19	0.16	
	2	0.01	0.01	0.02	0.02	0.16	0.09	0.06	0.06	0.06	0.13	0.19	0.16	
	3	0.21	0.11	0.14	0.09	0.13	0.09	0.12	0.08	0.27	0.29	0.09	0.13	
	4	0.05	0.05	0.05	0.05	0.08	0.14	0.08	0.08	0.14	0.08	0.11	0.11	
5	0.22	0.12	0.11	0.19	0.09	0.11	0.11	0.09	0.39	0.27	0.08	0.22		
Performance Data	1	2200	2200	1600	2800	4500	2200	3200	3200	3200	3200	2800	2800	
	2	2200	2200	1600	2800	4500	2200	3200	3200	3200	3200	2800	2800	
	3	2200	2200	1600	2800	4500	2200	3200	3200	3200	3200	2800	2800	
	4	2200	2200	1600	2800	4500	2200	3200	3200	3200	3200	2800	2800	
Alkalinity	1	2000	2000	1600	2800	4500	2200	3200	3200	3200	3200	2800	2800	
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	4	2000	2000	1600	2800	4500	2200	3200	3200	3200	3200	2800	2800	
Ammonia	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
BOD	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
COD	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Calcium	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Chloride	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Conductivity	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
DOC	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Hardness	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Iron	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Magnesium	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Nitrate	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Nitrite	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
pH	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Phenols	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Phosphorus	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Sodium	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	280	450	220	320	320	320	320	280	280	
	3	200	200	160	280	450	220	320	320	320	320	280	280	
	4	200	200	160	280	450	220	320	320	320	320	280	280	
Sulphate	1	200	200	160	280	450	220	320	320	320	320	280	280	
	2	200	200	160	28									

waste due to high temperature that facilitates both biological and chemical reaction inside the mass.

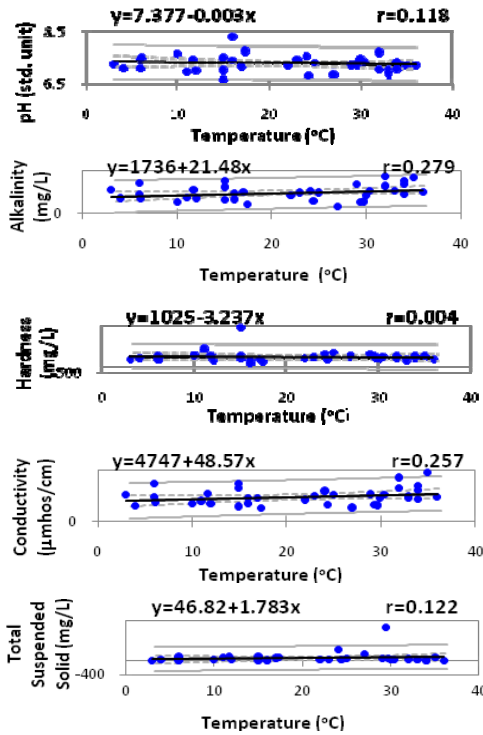


Fig. 2 Physical Properties of Leachate Versus Temperature

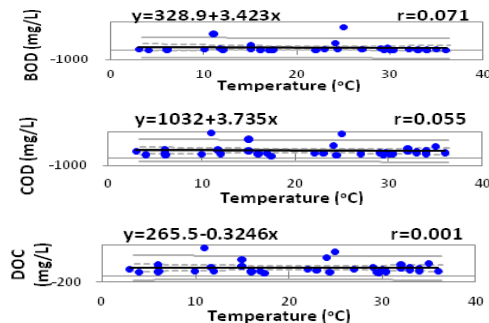


Fig. 3 Dissolved Organic Matters of Leachate Versus Temperature

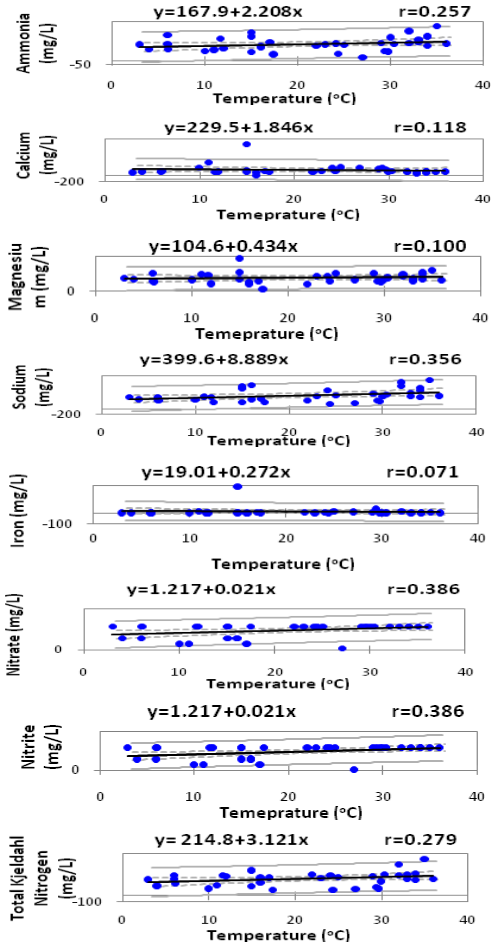
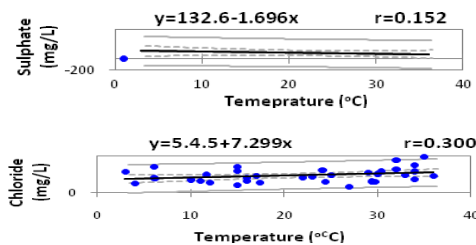


Fig. 4 Inorganic Matters of Leachate Versus Temperature

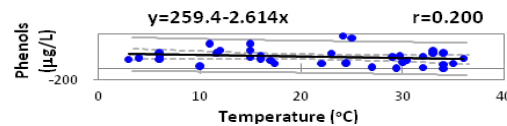


Fig. 5 Xenobiotic Organic Compounds of Leachate Versus Temperature

Figures 6 to 9 depict the correlation relationship of leachate concentration to precipitation. Results illustrate that all physical properties ( $r > 0.114$ ) except pH ( $r = 0.077$ ); all dissolved organic matters ( $r > 0.257$ ); all inorganic matters ( $r > 0.118$ ) except ammonia ( $r = 0.077$ ) and xenobiotic organic compound of phenol ( $r = 0.339$ ) are relatively quite correlated to precipitation as excessive precipitation is likely to slow down decomposition rate in the waste environment which leachate is percolated through.

BOD:COD ratio is also evaluated to established the correlation relationship to leachate concentration obtained from the landfill. Figures 10 to 13 depict the correlation relationship of leachate concentration to BOD:COD ratio.

Results reveals that all physical properties ( $r > 0.146$ ) except total suspended solid ( $r = 0.045$ ); dissolved organic matters ( $r > 0.633$ ); inorganic matter ( $r > 0.118$ ) except iron ( $r = 0.063$ ) and xenobiotic organic compound ( $r = 0.688$ ) are correlated significantly to BOD:COD ratio computed for the leachate concentration obtained for the landfill in this study.

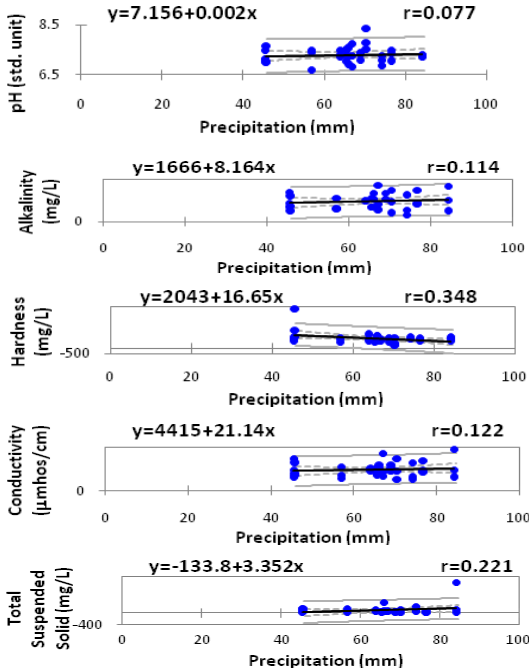


Fig. 6 Physical Properties of Leachate Versus Precipitation

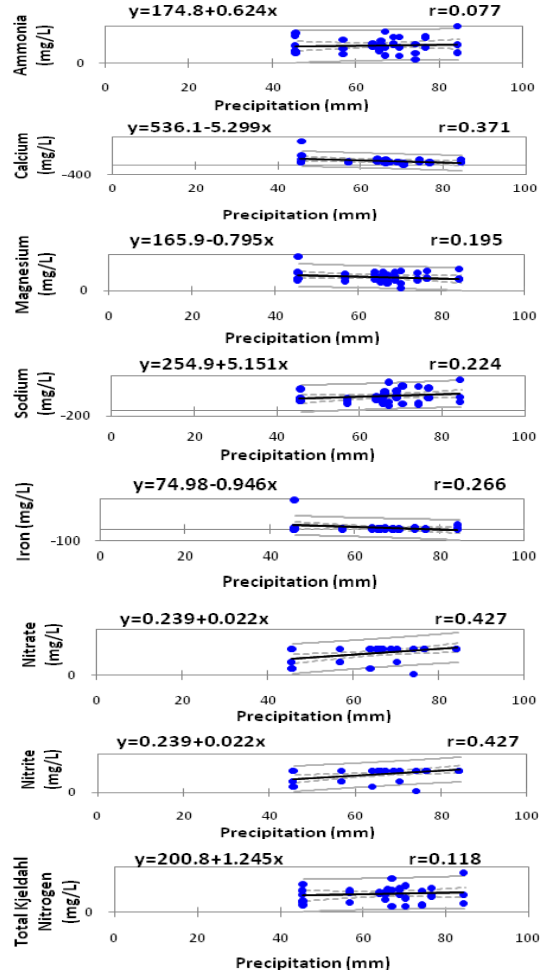


Fig. 8 Inorganic Matters of Leachate Versus Precipitation

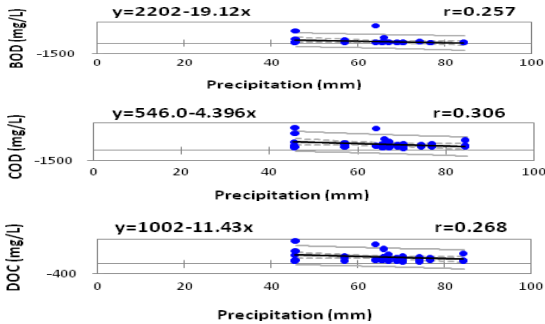


Fig. 7 Dissolved Organic Matters of Leachate Versus Precipitation

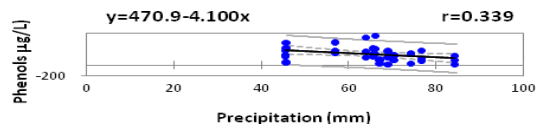
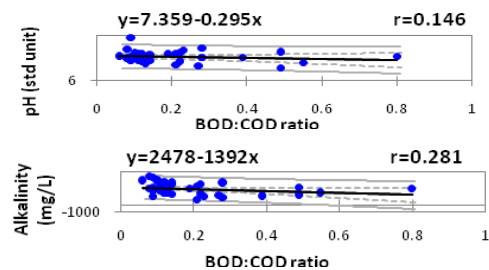
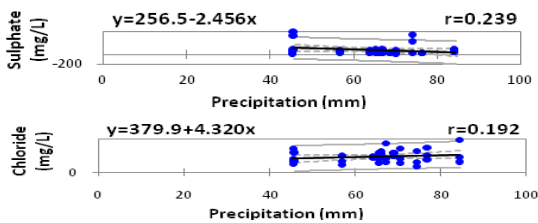


Fig. 9 Xenobiotic Organic Compounds of Leachate Versus Precipitation



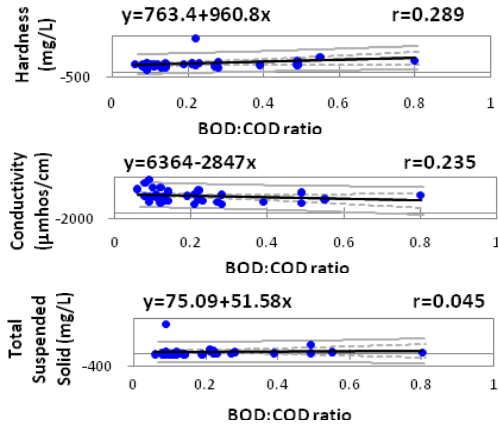


Fig. 10 Physical Properties of Leachate Versus BOD:COD Ratio

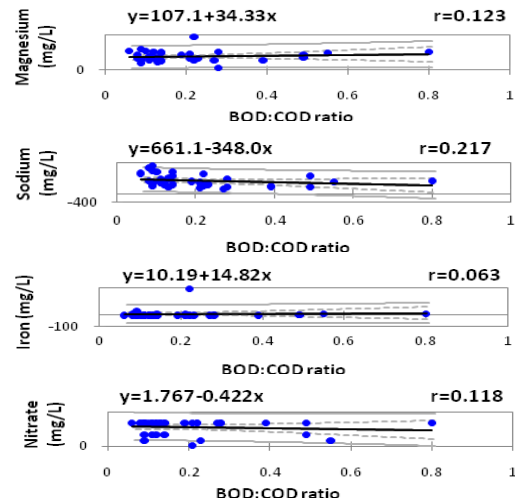


Fig. 12 Inorganic Matters of Leachate Versus BOD:COD Ratio

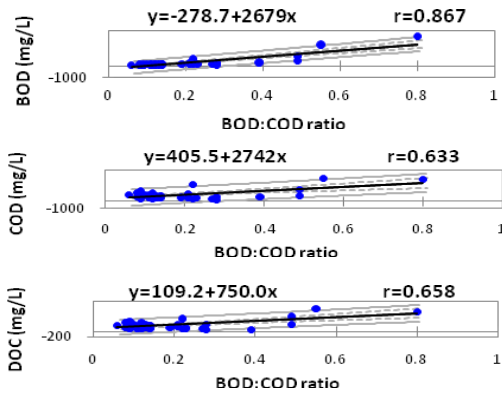


Fig. 11 Dissolved Organic Matters of Leachate Versus BOD:COD Ratio

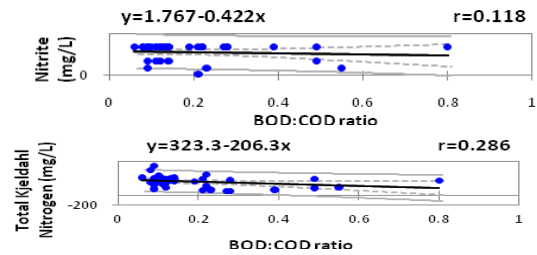
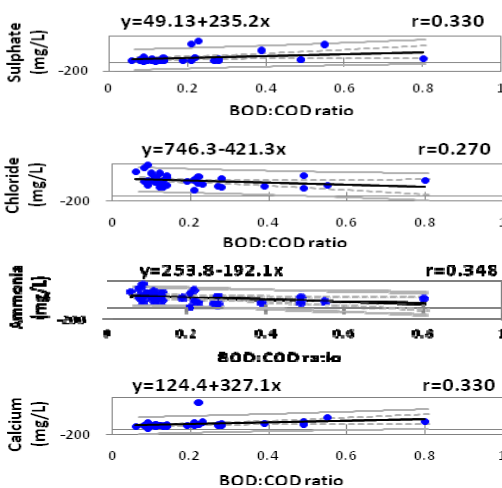


Fig. 13 Xenobiotic Organic Compounds of Leachate Versus BOD:COD Ratio



IV. CONCLUSION

The study concluded that in an actively decomposing waste landfill, leachate generated can be characterized as acetogenic and methanogenic and BOD:COD ratio of leachate is a good indicator to illustrate the degree of stabilization in landfill. The BOD:COD ratio of leachate computed indicate if sufficient biological and chemical decomposition as well as biodegradation are carried out under changing ambience conditions in the landfill body. It is referred that decreasing BOD:COD ratio is taken as an indicator of degradation of organic substrate due to decomposition.

Acetogenic leachates are typically characterized by its high BOD value and high BOD:COD ratio due to rapid hydrolysis of insoluble organic matters that make it readily degradable. On the other hands, methanogenic leachates are characterized by its relatively low BOD values and low ratios of BOD:COD due to the active dissolution of soluble organic matters present as well as inorganic matter, sulphate, chloride and calcium.

The study also reveals that the waste decomposition in landfill is influenced by climatic condition such as temperature and precipitation based on correlation relationship established. The intensity of decomposition is observed to be significantly affected by amount of precipitation and the temperature inside the landfill mass. Rises in temperature accelerate decomposition while precipitations slow down decomposition to anaerobic condition.

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