

## **Relating climatic parameters with leachate chemistry and its association with river water quality**

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### **Introduction**

Increased solid waste generation due to rapid urbanization and industrialization is a major problem in the world (Golomeova et al. 2013). Landfilling is the most common disposal method of municipal solid waste (MSW) in developing countries, even though majority of these landfills are not properly managed, and pose a serious threat to the environment due to leachate run-off which contaminates the nearby ground water and surface water bodies (Kjeldsen 1993).

The quantity and quality of leachate is influenced by various factors and climatic conditions are one of these governing factors (Chu et al. 1994; Johansen & Carlson 1976). Hence this study was carried out focusing on the impact of climatic parameters on leachate quality and its association with the Mahaweli river water quality which has not yet been further studied. Meantime two main objectives were fulfilled during the process of reaching the main target. They were, investigating seasonal variation of leachate chemistry and Mahaweli river water quality and developing correlation between climatic parameters, leachate chemistry and Mahaweli river water quality.

### **Materials and methods**

Landfill leachate, river water samples and ground water samples were collected from the leachate drain of the Gohagoda landfill, four locations along the Mahaweli river- two upstream and two downstream points from where leachate drain to the river and from two wells within the landfill. Weekly sampling was carried out for a period of two months and sample preservation, storage and analysis were performed according to Standard Methods (APHA, 1999). Daily temperature and rainfall data were collected from Horticultural Crop Research and Development Institute (HORDI) Gannoruwa and the statistical computations were performed with MINITAB version 17.0.

## Results and Discussion

All the measured leachate and water quality data are summarized in Table 1. As the first step, primary leachate characteristic values were being compared with the past studies (Wijesekara et al.) and with the recommended standards of tolerance limits for discharge of effluent for inland surface waters by the Central Environmental Authority (CEA). Alkaline pH value represented the methanogenic stage of the landfill (More than 10y of operation) and exceed the CEA value. TDS and EC values of the leachate were very high ( $1.33 \times 10^3$  mg/L &  $2.05 \times 10^3$   $\mu$ s/cm) compared to other sites. Dissolved Oxygen showed a very low value (0.09 mg/L) at the leachate drain owing to the anaerobic conditions and oxidisable organic matter related components are measured as BOD and COD. Both of these components were exceeding the CEA values. BOD:COD ratio was stated as 0.911 representing acidogenic condition which contrast with the above results. It is obvious that the uncontrolled dumping of the waste can produce leachate with various ages due to the irregular degradation pattern of the refuse material. (Wijesekara et al).

According to the study,  $5.24 \times 10^{-2}$  mg/L of TOC is present in the Gohagoda leachate once more endorse the high organic concentration of the leachate. Nitrate-nitrogen (63.33mg/L) and Phosphate (23.67mg/L) concentrations have exceeded the CEA limits. The nitrate of the leachate is mainly from biological sources, human and animal excreta accounting for a large percentage of the total nitrogen load. Furthermore, Cadmium concentration was below the SLS standards

First step of assessing the impact of leachate on river water quality was based on ANOVA tests. Significant difference in any of the parameters between river water upstream (U1 & U2) and downstream (D1 & D2) of the point where leachate entered the river were checked. According to the results TOC showed significant differences among all locations at 5 % probability level ( $P < 0.05$ )

Furthermore, correlation analysis was performed in order to study the impact of leachate (L) on river and ground water quality (D1, D2, W1, W2 & M). High positive correlation ( $0.5 < r < +1$ ) was obtained between Inorganic Carbon (L-M), Phosphate (L-W1), Ammonia (LD2 & LW2), Cd (LD2-LM). This can further confirm the observation obtained from the ANOVA table which pointed out that there was an impact of leachate on downstream water quality. Dissolve Oxygen concentration of leachate had a weak positive correlation ( $0 < r < 0.5$ ) with all the interested points (L, M, D1, D2, W1, W2). Similar relationship was obtained for Nitrate, Ammonia, IC, TOC and Cadmium between leachate and Well 1. Well 2 showed the same pattern of relationship for IC, TOC and Phosphate. D1 and leachate showed weak positive relationship of IC and D2 showed for Phosphate. All other relationships were highly or weakly correlated.

Correlation between climatic parameters and leachate chemistry was studied using Pearson Correlation. According to the Pearson correlation, pH has a high positive correlation with the temperature and a weak positive correlation with the rain fall. Dilution occur at the rainy days may cause the weak positive correlation with the rain fall. At the same Electrical conductivity and the total dissolved solids show a strong positive relationship with the temperature and these two parameters show weak negative relationship with the rainfall. According to the literature,

(Maqbool et al.2011) low DO values were reported at high temperature which contrasts with correlation results obtained from the present study.

Rest of the parameters (COD,BOD,TC,TN,IC,TOC Phosphate,Nitrate,Ammonia and Cadmium) shows a negative correlation with the temperature. TC,TN,IC,TOC,Phosphate,and Ammonia shows a negative relationship with the rainfall most probably due to dilution.

### **Conclusions.**

The concentrations of Gohagoda landfill leachate components in the primary leachate were higher than CEA standard values and most of these parameters were similar to the past studies. According to the results obtained from the Pearson correlation Analysis and the ANOVA table, no significant impact on Mahaweli river water was caused by the Gohagoda leachate and this is most probably based on the dilution Few of the leachate parameters were effected from the temperature and rainfall, yet a comprehensive study should be carried out encountering all other climatic parameters(wind pattern, solar radiation) in order to develop a broad view.

### **References**

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Table 01. Summary of the leachate river water and ground water quality data

Parameter	Unit	(L)	(M)	(U1)	(U2)	(D1)	(D2)	(W1)	(W2)
pH		8.57±0.3 8.36-8.96	7.99±0.3 7.6-8.4	7.66±0.6 6.97-8.48	7.78±0.5 7.33-8.68	7.76±0.4 7.06-8.53	7.77±0.6 7.37-8.62	6.81±0.4 6.31-7.66	7.57±0.7 6.96-8.62
Electrical Conductivity	µs/cm	2.05*10 <sup>3</sup> ±3.24*10 <sup>3</sup> 1.53*10 <sup>3</sup> ±2.42*10 <sup>3</sup>	1.62*10 <sup>3</sup> ±1.7*10 <sup>3</sup> 52-5110	64.2±26.7 11.2-96.0	73.24±29.3 46.7-135	67.33±12.04 53-83.3	88±18.19 61.8-114.6	3.88*10 <sup>3</sup> ±3.5*10 <sup>3</sup> 3.27*10 <sup>3</sup> -4.48*10 <sup>3</sup>	5.36*10 <sup>3</sup> ±1.3*10 <sup>3</sup> 2.94*10 <sup>3</sup> ±6.18*10 <sup>3</sup>
Dissolved Oxygen	mg/L	0.09±0.4 0.06-0.16	3.61±3.3 0.55-4.66	7.66±0.3 7.28-8.43	7.61±0.2 7.31-7.96	7.61±0.2 7.31-7.96	7.5±0.4 7.11-8.23	5.26±1.9 7-18	6.24±1.1 4.2-7.44
Total Dissolved Solids	mg/L	1.33*10 <sup>3</sup> ±2.2*10 <sup>3</sup> 9.9*10 <sup>3</sup> -1.6*10 <sup>4</sup>	7.5*10 <sup>3</sup> ±1.1*10 <sup>3</sup> 1.33*10 <sup>3</sup> -3.37*10 <sup>3</sup>	48.5±13.4 31.4-74.0	53.59±19.0 31.7-89.1	53.59±19.0 31.7-89.1	54.83±15.28 35.8-76.1	2.56*10 <sup>3</sup> ±2.1*10 <sup>3</sup> 2.15*10 <sup>3</sup> -2.96*10 <sup>3</sup>	4.18*10 <sup>3</sup> ±6.6*10 <sup>3</sup> 3.78*10 <sup>3</sup> -5.79*10 <sup>3</sup>
Sulphate	mg/L	11±16.4 0-40	1±0.76 0-2	0.88±0.8 0-2	1±0.6 0-2	1±0.6 0-2	2±1 1-3	3.5±2 04-Jul	37.75±1.75 35-40
Phosphate	mg/L	23.67±6.4 15-32	14.49±9.8 0.66-25	0.23±0.1 0.07-0.37	0.24±0.1 0.1-0.53	0.51±0.7 0.19-2	0.25±0.01 0.23-0.27	0.44±1.4 0.17-0.61	3.43±8.31 0.14-24
Nitrate-Nitrogen	mg/L	63.33±17.5 40-90	55.38±24.72 Mar-90	1.13±0.4 0.4-1.7	0.98±0.2 0.5-1.2	6.94±0.5 0.3-1.6	1.22±0.3 0.8-1.5	1.47±0.87 1-3.6	6.84±1.27 4.3-7.9
Ammonia-Nitrogen	mg/L	1.35*10 <sup>3</sup> ±8.6*10 <sup>2</sup> 1.1*10 <sup>2</sup> -2.8*10 <sup>3</sup>	3.99*10 <sup>3</sup> ±5.5*10 <sup>2</sup> 1.86-1370	0.65±0.6 0.4-1.7	3.08±6.9 0.13-20	0.42±0.4 0-1	1.01±1.6 0.17-3	1.89±4.5 0.08-13	0.63±0.16 0.43-0.9
Total Nitrogen		14*10 <sup>3</sup> ±8.6*10 <sup>3</sup> 3.37*10 <sup>3</sup> -2.35*10 <sup>3</sup>	3.41*10 <sup>3</sup> ±3.6*10 <sup>3</sup> 44.19-460.5	2.1±1.4 0.96-4.93	6.20±11.7 1.19-30.17	13.16±32.9 2.28-85.91	4.15±6.9 3.66*10 <sup>3</sup> -1.8*10 <sup>3</sup>	1.85±4.9 0.45-3.34	6.86±3.04 1.69-9.76
Cadmium		4.1*10 <sup>3</sup> ±2.4*10 <sup>3</sup> 1.8*10 <sup>3</sup> -8.2*10 <sup>3</sup>	3.4*10 <sup>3</sup> ±2.2*10 <sup>3</sup> 1.3*10 <sup>3</sup> -1.9*10 <sup>3</sup>	2.4*10 <sup>3</sup> ±1.3*10 <sup>3</sup> 3*10 <sup>3</sup> ±2.4*10 <sup>3</sup>	2.3*10 <sup>3</sup> ±1.4*10 <sup>3</sup> 1*10 <sup>3</sup> -4.5*10 <sup>3</sup>	1.4*10 <sup>3</sup> ±1.4*10 <sup>3</sup> 1*10 <sup>3</sup> -2.4*10 <sup>3</sup>	3*10 <sup>3</sup> ±1*10 <sup>3</sup> 8-1.8*10 <sup>3</sup>	1.6*10 <sup>3</sup> ±1.9*10 <sup>3</sup> 8-1.4*10 <sup>3</sup>	3.4*10 <sup>3</sup> ±2.2*10 <sup>3</sup> 7*10 <sup>3</sup> ±4*10 <sup>3</sup>
BOD	mg/L	433.16±53.9 266-573	157*10 <sup>3</sup> ±1.8*10 <sup>3</sup> 13-465		7.25±4.98 43525	6.62±1.2 4-8		31.12±39.1 8.59-119.3	11.63±8.86 5-33
COD	mg/L	474.83±2.2*10 <sup>3</sup> 9311-5840							
Total Organic Carbon	mg/L	523.9±47.73 18.5-952.1	4.98*10 <sup>2</sup> ±3.7*10 <sup>2</sup> 1.39*10 <sup>2</sup> -1.14*10 <sup>3</sup>	3.62±1.1 2.57-5.87	12.72±11.61 3.33-31.25	1.88±1.7 4.4*10 <sup>2</sup> -4.75	7.34±7.01 2.56-21.42	19.34±39 2.37-16.32	9.94±11.54 2.21-33.14
Total Carbon	mg/L	3.16*10 <sup>3</sup> ±2.2*10 <sup>3</sup> 9.31*10 <sup>3</sup> -5.84*10 <sup>3</sup>	1.36*10 <sup>3</sup> ±1.5*10 <sup>3</sup> 167.2-402.1	8.02±1.9 3.19	23.09±24.88 3.19	10.06±3.69 6.62-16.13	13.63±10.8 5.4-35.3	10.35±4.9 2.37-16.32	40.66±15.3 7.74-63.24
Inorganic carbon	mg/L	1.73*10 <sup>3</sup> ±1.2*10 <sup>3</sup> 5.37*10 <sup>3</sup> -3.3*10 <sup>3</sup>	2.29*10 <sup>3</sup> ±4.2*10 <sup>2</sup> 28.1-1076	4.11±1.2 2.84-6.63	10.36±16.13 3.39-46.91	4.07±1.15 1.88-5.32	6.28±4.08 2.84-13.86	10.35±4.93 2.37-16.32	33.2±12.2 5.52-44.55