International Research Journal of Environmental Sciences ISSN 2319–1414
Vol. **9(4),** 24-37, October **(2020)** *Int. Res. J. Environmental Sci.*

Flow of water through soil columns as influenced by cassava wastewaters application

J.A. Osunbitan[1] and O.A. Akinyele[2*]
[1]Department of Agricultural and Environmental Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria
[2]Department of Agricultural and Bio-Environmental Engineering, Federal College of Agriculture, Ibadan, Nigeria
seunakinyele.oa@gmail.com

Available online at: www.isca.in, www.isca.me
Received 5th November 2019, revised 1st September 2020, accepted 5th October 2020

Abstract

This study investigated the effects of cassava wastewater and soil types on the flow rate through saturated soil columns. This was with a view to examine the vertical movement of trace elements from the wastewater in the columns of soil. The experiment for column leaching was carried out using three different types of soil (Iwo, Apomu, Egbeda) plus four variable levels of cassava wastewater (0, 6, 12, and 18ml). The samples of soil were compressed to 1.50g/cm^{3}bulk density in order to simulate the soil bulk density obtained at the soil collection site. The soil columns were saturated with de-ionized water after which the various levels of cassava wastewater were added. The columns were then left for 24 hours to allow for the adsorption of the trace elements in the wastewater to soil particles. After a day period of adsorption, each soil column was leached with 1767.1cm^3 (translating to 10cm depth) of de-ionized water and the leachate flow rate monitored every 2 minutes. The depth of leachate was measured and the flow rate calculated. The results showed that the flow rate was higher at 12ml of effluent for Iwo and Egbeda while Apomu was slower at almost all the four levels of the wastewater applied. Flow through the columns of Iwo soil rises faster than that of the other two soils. The result also showed that the average total leachate of 88.99, 99.86, and 100.87ml of water flowed through the columns containing Apomu, Egbeda and Iwo soils respectively. On the average, the time to peak of 13.71, 25.90 and 28.07 minutes were observed for Iwo, Apomu and Egbeda soils respectively. Two-way ANOVA shows that there are significant differences among the three soil types ($F = 22.585$, $df = 2$, $P < 0.05$), the four levels of cassava wastewater ($F = 4.568$, $df = 3$, $P < 0.05$) and the interaction between the soil types and cassava wastewater ($F = 14.702$, $df = 6$, $P < 0.05$) on the time to peak flow. The ANOVA results also showed no significant variations among the soil types ($F = 4.768$, $df = 2$, $P < 0.05$), but significant differences among the levels of cassava wastewater ($F = 11.107$, $P < 0.05$) and the interaction between the soil types and cassava wastewater ($F = 3.806$, $df = 6$, $P < 0.05$) on the total leachate. However, the Post-Hoc Test (using Tukey HSD) for multiple comparisons also shows that the soil types and all the levels of cassava wastewater are significant different in their effects on the time to peak flow rate. It can be seen that cassava wastewater on the agricultural soils will affect the flow rate of water through the soil profile hence there is need for proper treatment of the effluent before discharge into the environment.

Keywords: Cassava, wastewater, soil column, flow rate, leachate, environment.

Introduction

Cassava *(manihotesculentacrantz)* is a major staple crop in many tropical areasespecially most developing countries and it is recognized to be the most significant among root and tuber crops.Cassava belongs to the family *Euphorbiaceae*, a plant from North-East Brazil, and the tubers are relatively rich in carbohydrates with leaves as cheap and good sources of protein and minerals in the human food. It is generally recognized to be a main source of carbohydrate having Africa as the largest centre of production[1-3]. Cassava is a key staple food in Nigeria thus produces great volumes of waste which create environmental nuisance in the region[4-6]. With the increasing industrial production of cassava products such as starch and cassava flour, these wastes would be more challenging in future. The high carbohydrate content of cassava makes it a staple food item especially for the lower income earners in most countries, especially Africa and Asia[7,8]. Cassava is identified to be one of the mostessential food crops in the world. It was reported that, in the tropics, the roots and leaves of the plant serve as avital source of calories and income[9]. Almost 600 million people in Africa, Asia and Latin America depend solely on cassava crop for their daily food and incomes[9]. In Africa, cassava production has shown a multiple increase over the last fifty years: from about 30 to above 120million tons/year[10].

In Nigeria, cassava is processed into different food products such as garri, starch, lafun flour, fufu, etc., several of which are fermented products[11]. Amidall the cassava products, garri is recognised to be the most common in Nigeria because its production is done on small, medium and large scales[12]. The processing of cassava into various products comprises: peeling, washing, grating/grinding, dewatering (pressing), pulverizing, and frying, while wastewater is extracted as a results of all those processes mentioned[1]. The tubers of cassava are peeled and the peels make the first phase of the solid waste. Then, the tubers are grated and dewatered and effluent (wastewater) is obtained. Likewise, after dewatering, the cassava semi-solid solution is then sieved and the ungrated fibres are thereby discharged as the final solid waste. With the increasing acceptance of new appropriate technologies for gaari and other cassava products, which could likewise be applied on a large scale, the future would experience larger processing plants for cassava while the handling of waste may become a major concern[13].

It was reported that much effluents and solid wastes are generated and released into the environment during cassava processing, and soil is one of the major recipients of these effluents[14]. As these effluents infiltrate into the soil, the remnants on the surface of the soil are eroded easily by rainfall run-off into a nearby stream. These effluents contain hydrogen cyanide (HCN) that is very poisonous to human lives. Considering the long term and short term basis, the presence of these wastes in the soil can alter the quality of water and chemical properties of soil[15,16]. Cassava processing releases solid and liquid filtrates which are harmful in the environment[17].It was observed specifically that raw cassava and its peels contain around 114.7 to 159.6 and 360.05 to 509.51 mg/kg of cyanide, respectively[18]. The cooked cassava cyanide was also assessed to be about 6.79 to 24.91mg/kg[19]. The cassava cyanide contents contaminate the soil mostly during processing[20]. The fate and the movement of the wastewater components in the soil are influenced by various factors such as: constituents' adsorption characteristics to soil particles; soil organic matter content; soil pH; and constituent loading rate[15].

Several developments have revealed that there is little concern in the resulting effects of cassava wastewater on the immediate environment. This is mainly because majority of the products of cassava that discharge these effluents (wastewaters) are processed in the rural areas. As these poisonous and damaging wastes continuously being released into the environment, there would be adverse effect on lives of human and animal, crop yield, natural and soil ecosystems[20]. It is therefore necessary to be aware of the spreading of these trace elements in the soil in order to moderate their damaging effects on soil, groundwater and environment. Hence, the main objectives of this research are to examine the effect of cassava wastewater and soil types on the water flow rate using the soil column and to determine the time to peak flow rate of water through the soil types as affected by the cassava wastewater.

Methodology

Soil collection and preparation: The experiment was carried out with three different soil types which are categorized as: Iwo, Apomuand Egbeda Types. The soil samples were collected from the Teaching and Research Farm of Obafemi Awolowo University to the depth of 40cm at interval of 8cm depth with shovels and packed inside sacks, before being taken to the soil laboratory for the column leaching experiment. Twelve PVC pipes (50cm long and 15cm diameter) were employed to hold the samples for each soil type. The effluent was collected as its being discharged through the grating of cassava mesh that is positioned under a screw press during the production of garri. The collected soil samples were sun dried to almost 6% moisture content and the soils thereafter were pulverized to remove the plant stems and roots and then homogenized by sieving off the clumps and gravel using 2mm sieve. Soil columns were prepared with the collected soils for the column leaching experiment using the above-mentioned PVC pipes. The twelve (12) columns were filled with the dried soils to a 1.50 g/cm^3 bulk density with four (4) columns for each soil type. 10.6 kg of each soil series was compacted to 40 cm depth of the soil column to simulate the soil bulk density of $1.50 g/cm^3$ which is the soil bulk density at the site of soil collection.

Experimental set-up: The experimental design is 3x4 factorial arrangements while the considering factors are soil types (Iwo, Apomu, Egbeda) as well as cassava effluents (0ml as control, 6ml,12ml,18ml). Table-1 shows the choice of treatments and their levels of application as carried out in this experiment. The samples of effluents were measured directly into the soil columns that is already saturated, from the top and permitted to leach through the columns. Four (4) volumes (0, 6, 12, and 18 ml) were used for the four (4) columns with each soil type respectively. A funnel and a plastic beaker were positioned at the end of each column to receive leaching fluids from the soil columns as shown in Figure-1. The experiment was run for seven times at two (2) days interval. Each column was saturated with de-ionized water to a depth of 10cm above the soil inside, after which the various levels of cassava wastewater were added. The columns were then left for 24 hours to allow for the adsorption of the trace elements in the wastewater to soil particles. After a day period of adsorption, each column was saturated with de-ionized water and the leachate flow rate monitored every 2 minutes. The depth of leachate was measured and the flow rate calculated.

Data analysis: In order to better understand the effects of the different treatments, the experimental data were subjected to statistical analysis using Two-way analysis of Variance (2-way ANOVA) to compare variations in the treatments while the post-hoc test was also done to further compare and check the levels of significance and variations among the parameters.

Results and discussion

Flow rate of water through the soil columns: The method of soil column used in this research signifies an interpretation of the natural processes. Table-2 shows some of the properties of the three soil types used for the experiment which explained that Iwo type is sandy loam while Apomu is characterized with loamy sand soil and Egbeda series is sandy clay loam. This actually reflected in the further results obtained when the cassava wastewater and water was applied during the experiments. From Figures-2, 11 the flow through the soil columns for the three soil types and cassava wastewater levels of application first increases with time to a peak value after which the flow starts to decline for the seven events of leaching.

Table-1: Treatments and Application Levels

Experimental Run	Soil Types	Volume of Cassava Effluents (ml)
1	Iwo	0
2	Iwo	6
3	Iwo	12
4	Iwo	18
5	Apomu	0
6	Apomu	6
7	Apomu	12
8	Apomu	18
9	Egbeda	0
10	Egbeda	6
11	Egbeda	12
12	Egbeda	18

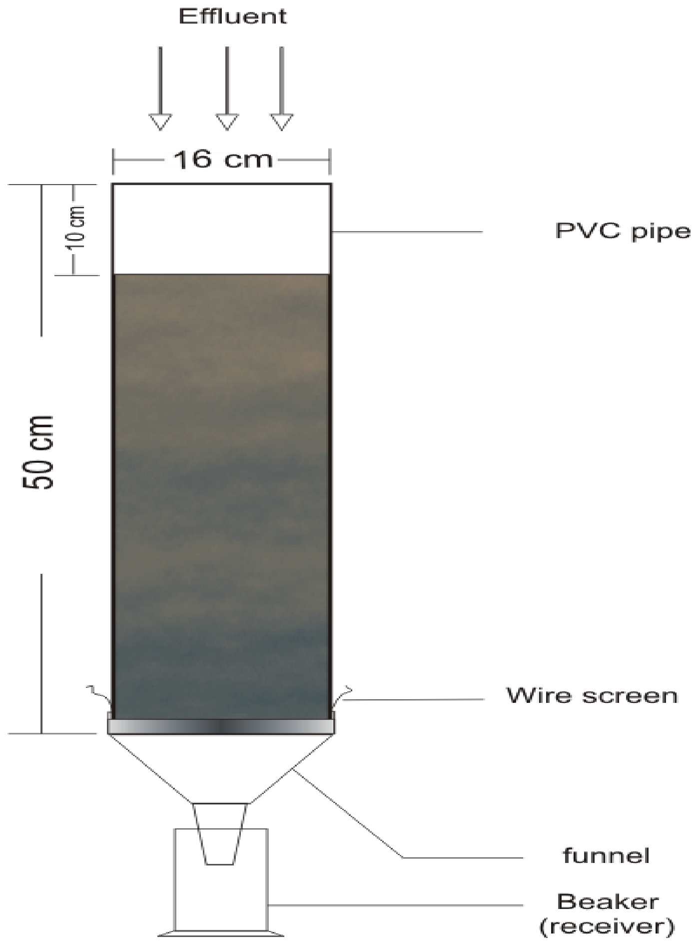

Figure-1: Soil Column Set-up.

Table-2: Physical and Chemical Properties of the Soil Types.

Property	Iwo Series		Apomu Series		Egbeda Series	
	0 - 20cm	20 – 40cm	0 – 20cm	20 – 40cm	0 – 20cm	20 – 40cm
Textural Classification	Sandy Loam	Sandy Loam	Loamy Sand	Loamy Sand	Sandy Clay Loam	Sandy Clay Loam
pH	5.40	5.30	4.48	4.65	5.82	5.64
Cation Exchange Capacity (cmol./kg)	4.2	3.6	7.75	5.75	13.25	7.00
Electrical Conductivity (mmhos/cm)	0.054	0.032	0.058	0.029	0.04	0.034
Organic Carbon Content (%)	1.60	1.18	1.72	1.16	2.10	1.85
Sand (%)	80	77	78.5	82.5	68.0	70.0
Silt (%)	5	5	12.0	7.0	10.0	10.0
Clay (%)	15	18	9.5	10.5	22.0	20.0

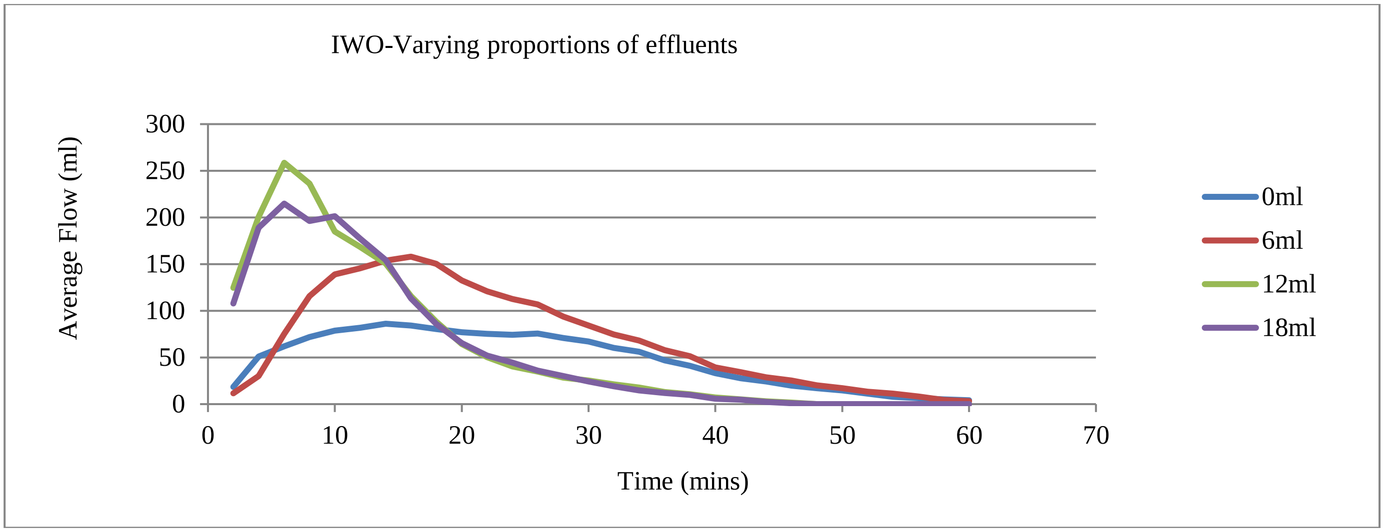

Figure-2: Average Flow with Time for Varying Proportions of Effluents.

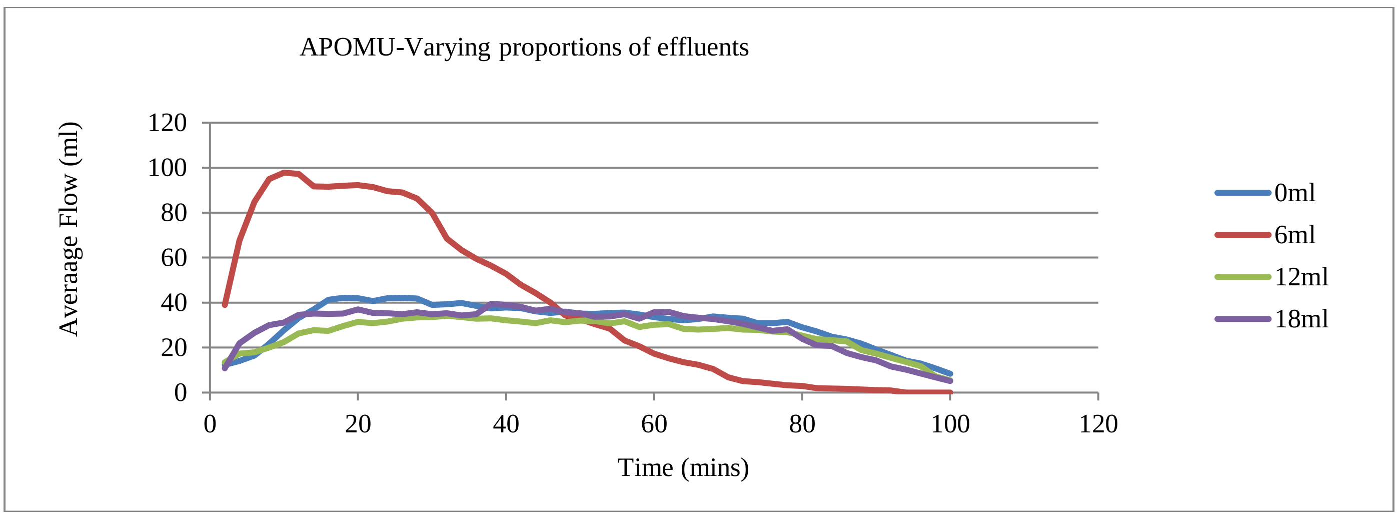

Figure-3: Average Flow with Time for Varying Proportions of Effluents.

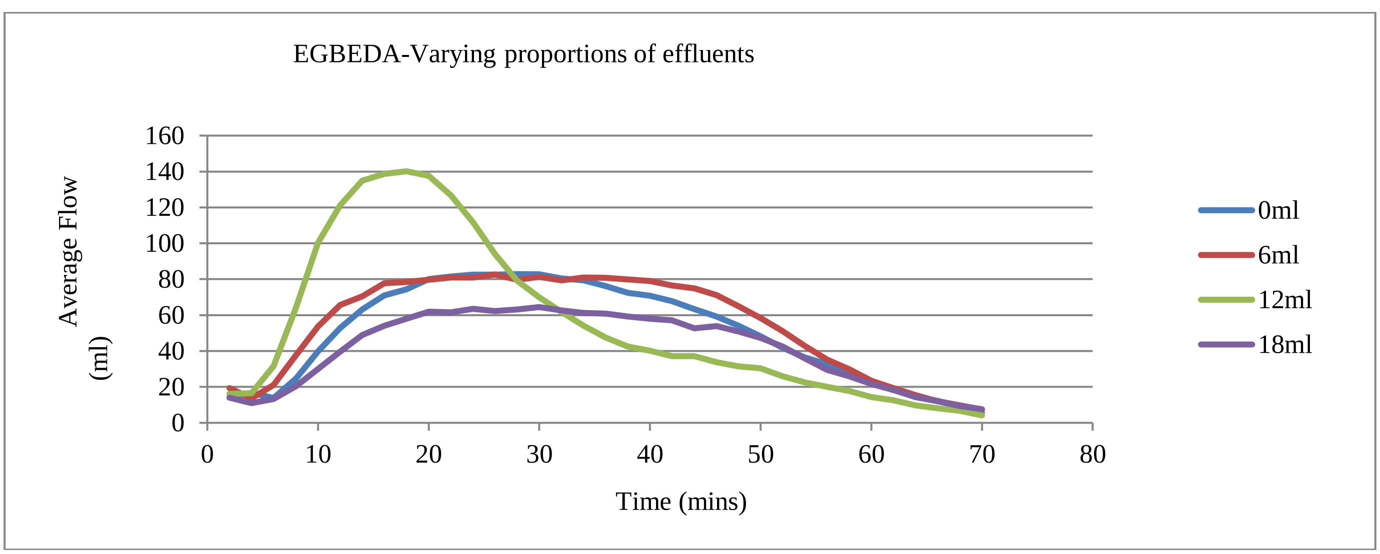

Figure-4: Average Flow with Time for Varying Proportions of Effluents.

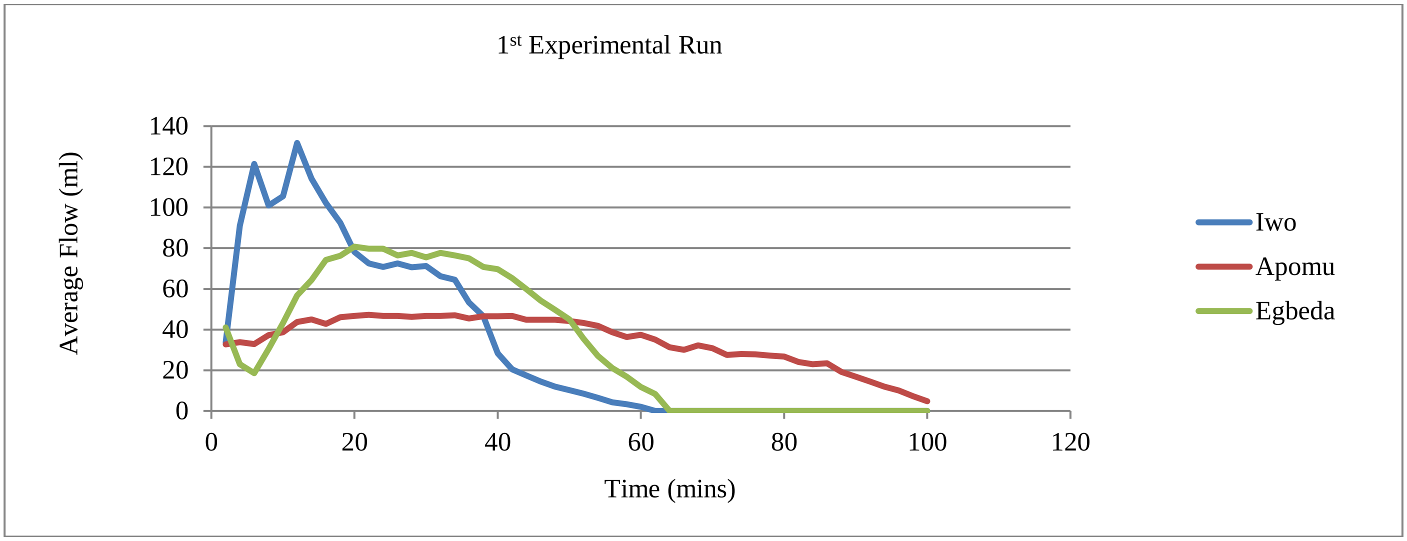

Figure-5: Average Flow Rate for Each of the Soil Series.

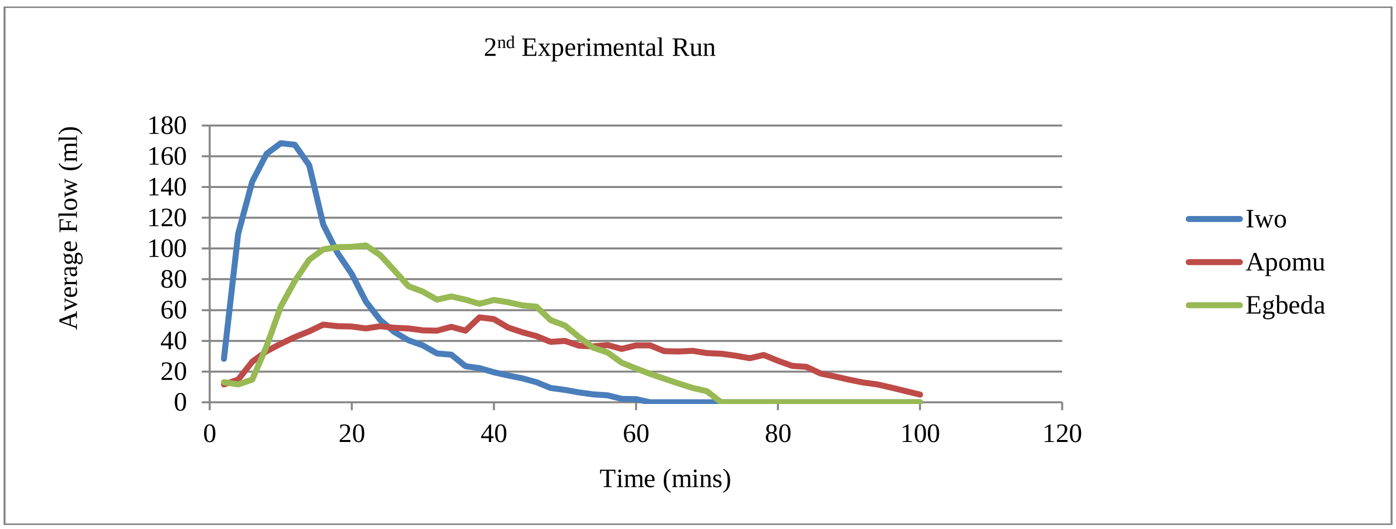

Figure-6: Average Flow Rate for Each of the Soil Series.

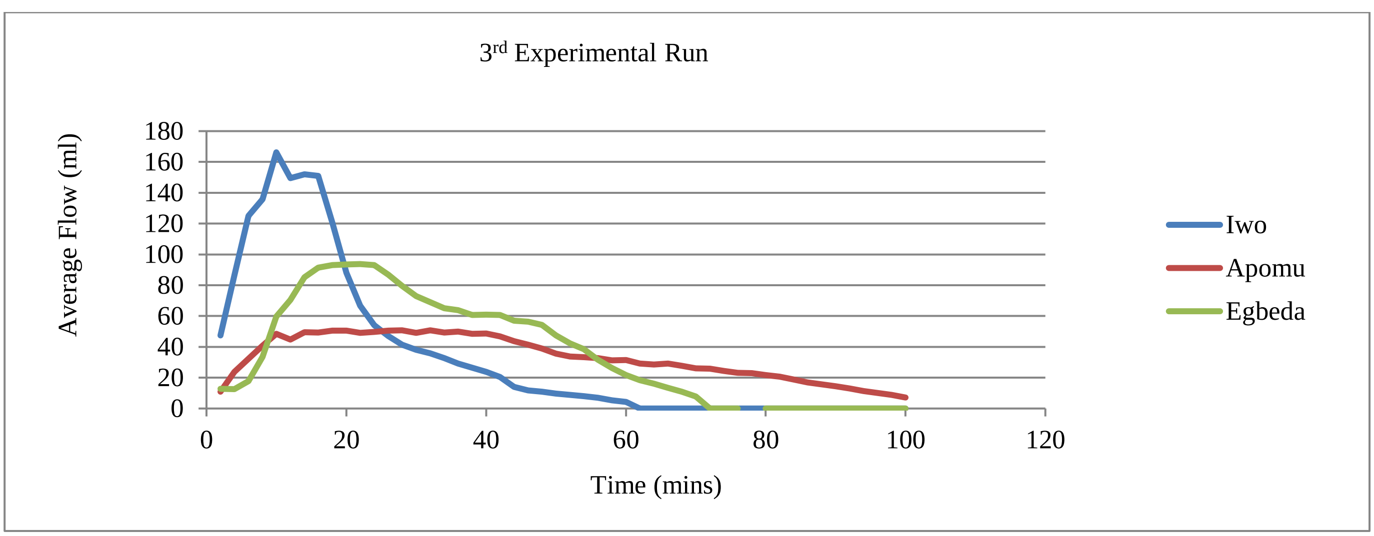

Figure-7: Average Flow Rate for Each of the Soil Series.

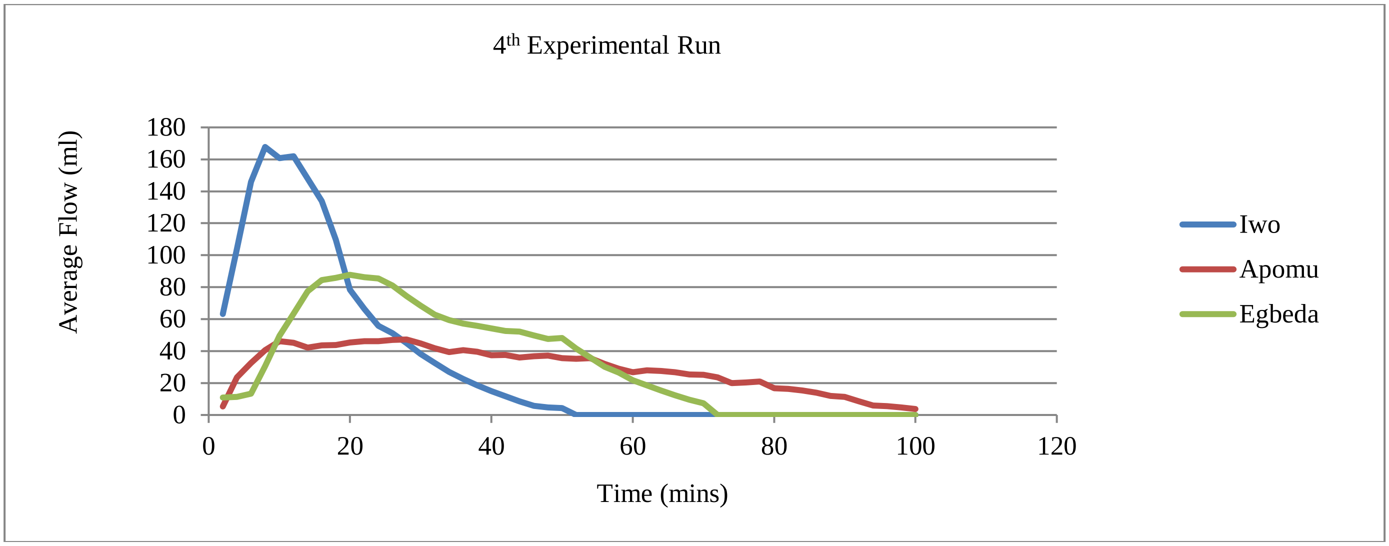

Figure-8: Average Flow Rate for Each of the Soil Series.

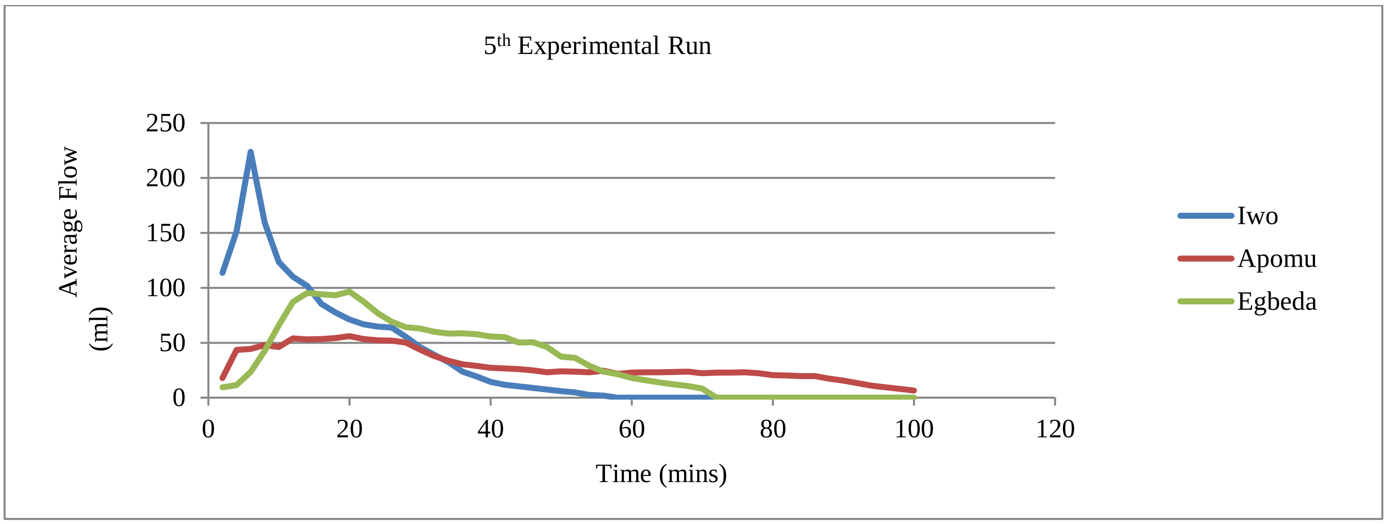

Figure-9: Average Flow Rate for Each of the Soil Series.

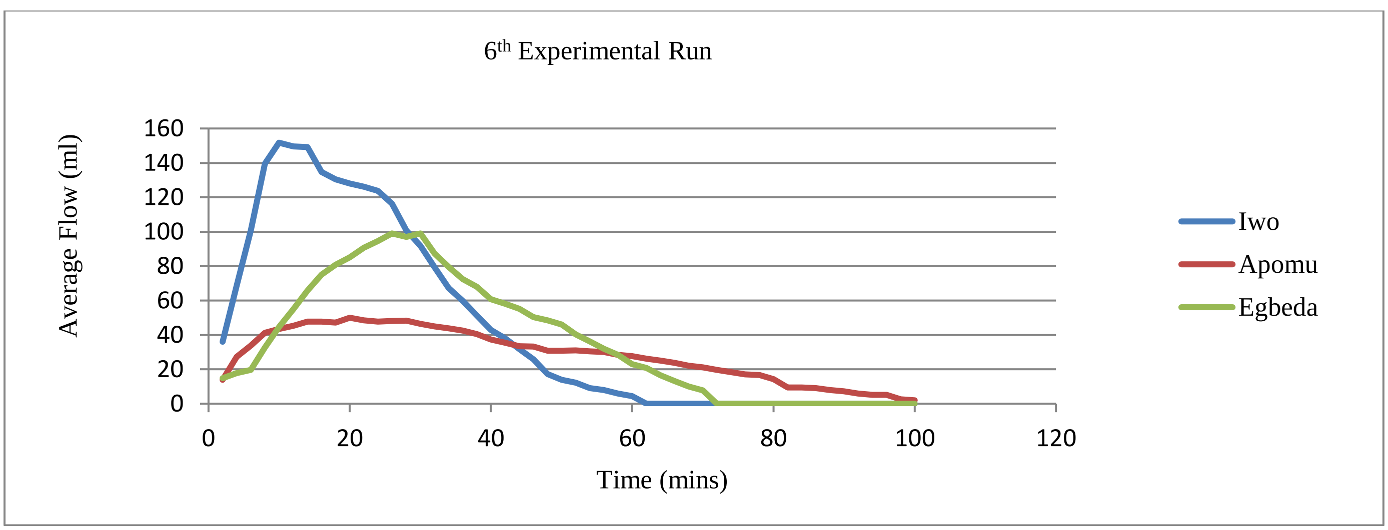

Figure-10: Average Flow Rate for Each of the Soil Series.

Time to Peak Flow Rate: The time to peak flow varies with the soil type, level of wastewater application and the irrigation events. Table-3 shows time to peak flow of leaching water through the three soil types considered at the different levels of cassava wastewater application for the seven leaching events. From the table, the minimum time to peak flow of 4 minutes occurred during the first, fifth and seventh leaching events through the columns containing Apomu soil of 18ml waste water, Apomu soil of 6ml and Iwo soil of 12ml wastewater respectively. This is likely to be due to the fact that Apomu soil is more sandy in nature than the remaining two soil types considered. Sandy soil because of the larger pores, which will allow easy flow of water or any other solute through it, thereby recording faster time to peak of flowing water. In other words, the maximum time to peak flow of 62 minutes occurred during the second leaching event through the soil column containing Apomu soil treated with 12ml wastewater. This is also simply because the nature of the soil type is sandy, thereby allowing easy flow of water. From Figure-12, which shows the profile plot of time to peak flow through the soil types as affected by cassava wastewater, it can be observed at 0ml of cassava effluent; the estimated marginal means of peak flow rate were 21.43, 25.14, and 28.57 for Iwo, Apomu and Egbeda soils respectively. Also, the estimated marginal means of peak flow rate at 6 ml were 18.00, 8.86, 27.43 while at 12ml, 8.00, 49.43, 22.86 and at 18 ml of cassava wastewater, we have 7.43, 20.29, 33.43; all respectively for Iwo, Apomu and Egbeda. It was observed further that the minimum mean value of peak flow rate was 7.43 which occurred at Iwo Soil of 18ml cassava wastewater while the maximum mean value of peak flow rate was 49.43 which occurred at Apomu Soil of 12ml of cassava wastewater. However, from Figure-13 which shows the profile plot of time to peak flow through the three soil types, it was observed that estimated marginal means to peak flow through the soil types were 13.71, 25.93 and 28.07 for Iwo, Apomu and Egbeda respectively.

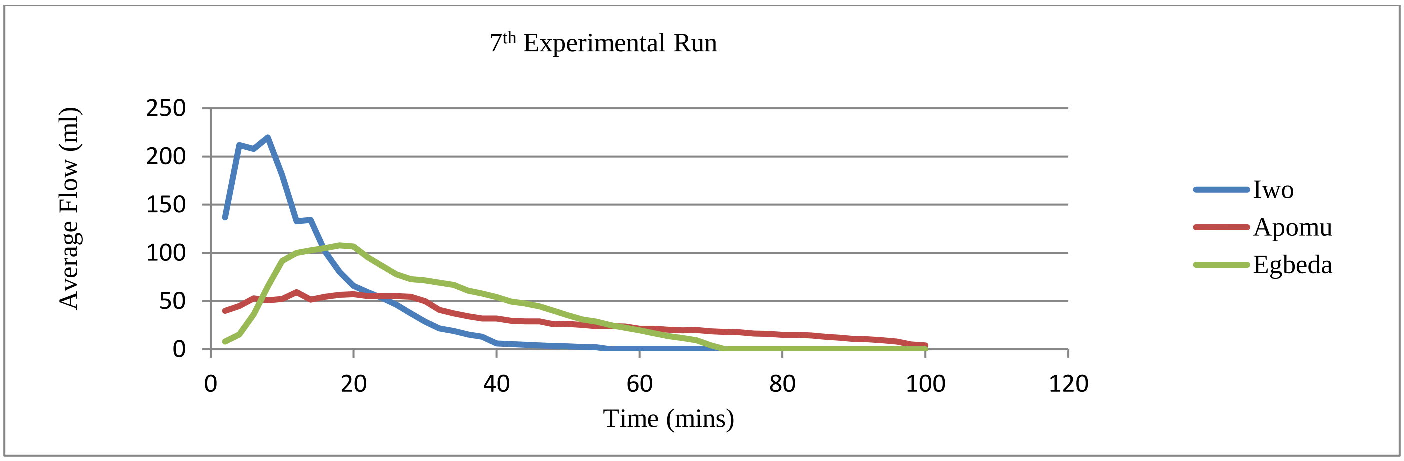

Figure-11: Average Flow Rate for Each of the Soil Series.

Table-3: Time to Peak Flow for the Seven Leaching Events.

Soil Type	Cassava Wastewater (ml)	Time to Peak Flow (mins)						
		1	2	3	4	5	6	7
Iwo	0	30	26	14	18	26	26	10
	6	30	16	10	16	14	26	14
	12	12	8	10	8	6	8	4
	18	6	6	10	6	6	10	8
Apomu	0	42	16	26	28	20	24	20
	6	12	12	10	10	4	8	6
	12	46	62	48	56	50	32	52
	18	4	38	16	36	20	20	8
Egbeda	0	24	46	32	22	28	28	20
	6	16	40	18	30	38	26	24
	12	32	44	16	16	12	30	10
	18	20	40	36	50	20	30	38

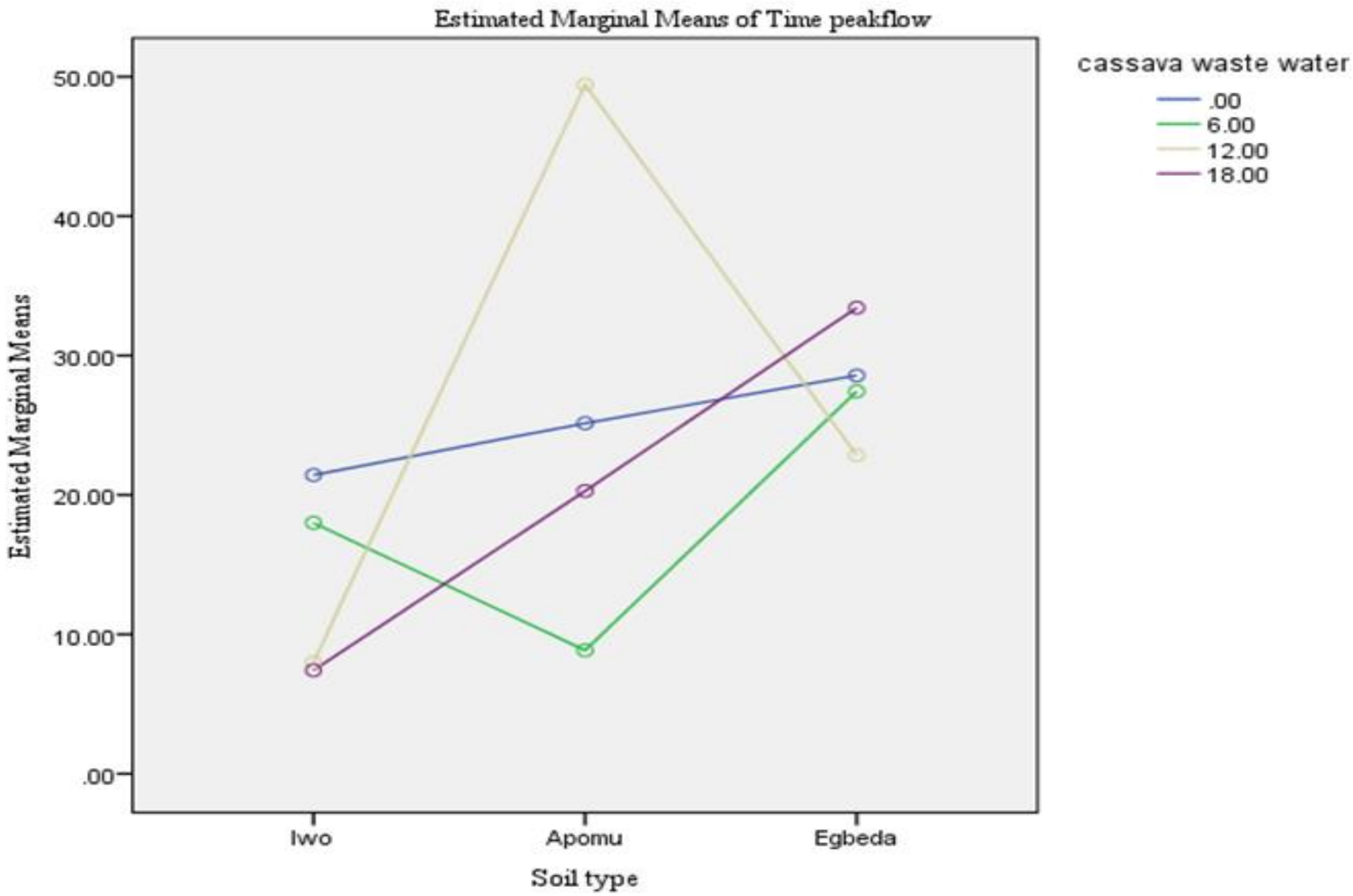

Figure-12: Time to Peak Flow through the Soil Types as affected by Cassava Wastewater.

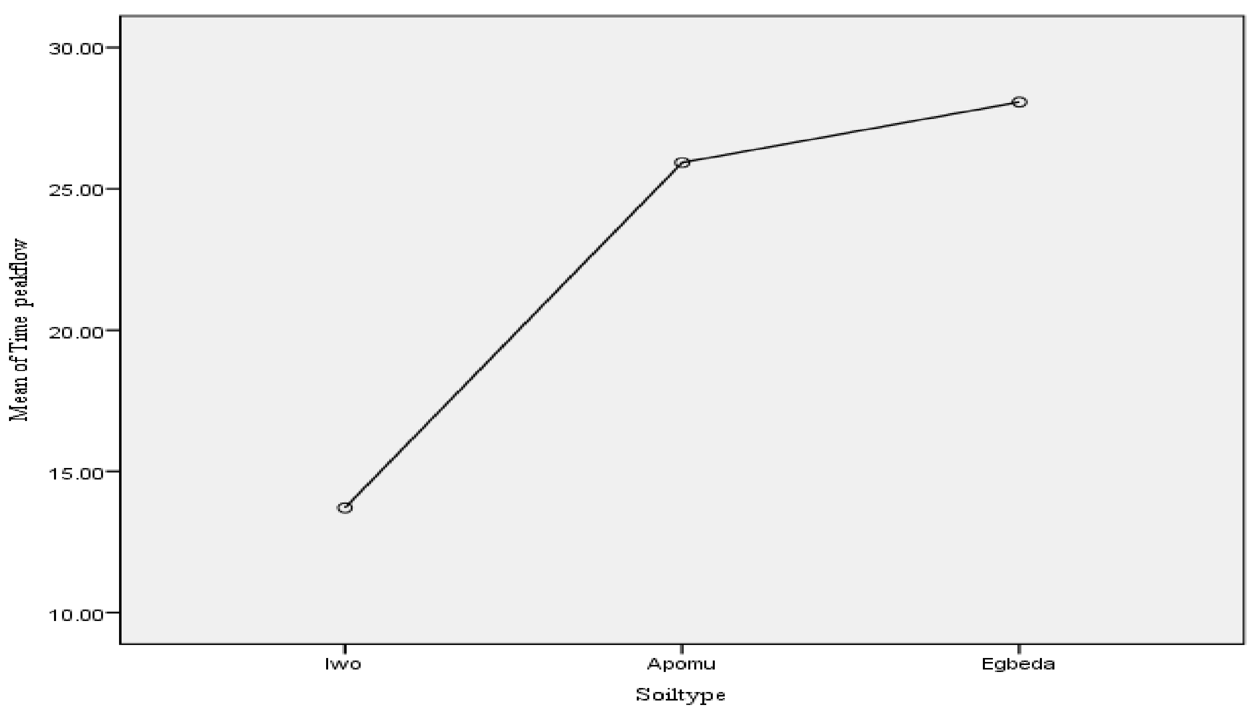

Figure-13: Time to Peak Flow through the Three Soil Types.

Effect of Cassava Wastewater on Peak Flow Rate: The different levels of cassava wastewater vary with the irrigation events and the soil type for the seven leaching events of the experiment. The addition of effluents caused the flow to reach the peak in Iwo and Egbeda. From the Table-3, the maximum time (62 minutes) to peak flow rate occurred at 12ml waste water of Apomu soil and the minimum time (4 minutes) to peak flow rate occurred at 6ml and 18ml waste water of Apomu soil. Comparing the average of the four level of wastewater for each leaching event, it shows that the flow is fluctuating which shows that the cassava wastewater has significant effect on the peak flow rate.Two-way ANOVA in Table-4 reveals that there are significant variations among the levels of cassava wastewater on time to peak flow (F = 4.568, df = 3, P < 0.05).

This therefore suggests that the application of cassava wastewater on the soil really impacted on the flow rate of water.

Effect of Soil Type on Peak Flow Rate: The soil type varies with the different levels of cassava wastewater, the irrigation events and time to peak flow for the seven leaching events. From Table-3, it was observed that for most Iwo, the peak flow occurred earlier compared to Apomu that occurred late due to slow mobility of water. It reveals that the leaching rate can be affected by the time allotted for the flow to take place. Though, Iwo soil has larger micro pores that are not clogged by cassava effluent (wastewater) and it rapidly attains its peak flow faster than Apomu and Egbeda. Two-way ANOVA in Table-4 reveals that there are significant differences among the three soil types on time to peak flow (F=22.585, df = 2, P< 0.05).This therefore suggests that the soil types were significantly influenced by the cassava wastewater applied to determine the time to peak flow.

Effect of Interaction between Soil Type and Cassava Wastewater on Peak Flow Rate: It can be further observed from the ANOVA analysis (Table-4) that the interactions between the three soil types and the cassava wastewater are significant on time to peak flow (F=14.702, df=6, P<0.05), which shows that there are significant variations among the soil types and the levels of cassava wastewater. However, the Post-Hoc Test (using Tukey HSD) for multiple comparisons (Table-5) further shows that there are significant differences when comparing Iwo soil with Apomu and Egbeda soils. Moreover, there is significant variation comparing Apomu with Iwo while there is no significant difference when comparing Apomu and Egbeda. Similarly, there is significant difference when comparing Egbeda with Iwo while there is no significant variation comparing Egbeda with Apomu. Generally, it can be observed from the test that the multiple comparisons of the three soil types reveals mostly significant variations among the soil types. However, the Post-Hoc Test for multiple comparisons (Table-6) among the four levels of cassava wastewater application reveals that majorly, there are no significant differences when comparing the four application levels except the comparison of 6ml effluent application with 12ml, and likewise 12 ml with 6ml effluent application with the same value (P = 0.009).

Table-4: Effect of Soil Type, Effluent and Interactions between Soil Type and Effluent.

Dependent Variable: Time to peak flow					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	53733.714[a]	12	4477.810	60.214	.000*
Soil Type	3359.143	2	1679.571	22.585	.000*
Cassava Wastewater	1019.048	3	339.683	4.568	.006*
Soil Type*Cassava Wastewater	6560.095	6	1093.349	14.702	.000*
Error	5354.286	72	74.365		
Total	59088.000	84			
a. R Squared = .909 (Adjusted R Squared = .894)					

Note: Statistics is significant at P < 0.05*.

Table-5: Post-Hoc Test (using Tukey HSD) for Multiple Comparisons of the three Soil Types.

Dependent Variable: Time to peak flow						
(I) Soil Type	(J) Soil Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Iwo	Apomu	-12.2143*	2.30473	.000*	-17.7298	-6.6988
	Egbeda	-14.3571*	2.30473	.000*	-19.8727	-8.8416
Apomu	Iwo	12.2143*	2.30473	.000*	6.6988	17.7298
	Egbeda	-2.1429	2.30473	.623	-7.6584	3.3727
Egbeda	Iwo	14.3571*	2.30473	.000*	8.8416	19.8727
	Apomu	2.1429	2.30473	.623	-3.3727	7.6584

Based on observed means. The error term is Mean Square (Error) = 74.365. *The mean difference is significant at the .05 level. Statistics is significant at $P < 0.05$*.

Table-6: Post-Hoc Test (using Tukey HSD) for Multiple Comparisons of the Three Soil Types.

Dependent Variable: Time to peak flow						
(I) Cassava Wastewater	(J) Cassava Wastewater	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0.00	6.00	6.9524	2.66128	.052	-.0469	13.9517
	12.00	-1.7143	2.66128	.917	-8.7136	5.2850
	18.00	4.6667	2.66128	.304	-2.3327	11.6660
6.00	0.00	-6.9524	2.66128	.052	-13.9517	.0469
	12.00	-8.6667*	2.66128	.009*	-15.6660	-1.6673
	18.00	-2.2857	2.66128	.826	-9.2850	4.7136
12.00	0.00	1.7143	2.66128	.917	-5.2850	8.7136
	6.00	8.6667*	2.66128	.009*	1.6673	15.6660
	18.00	6.3810	2.66128	.087	-.6184	13.3803
18.00	0.00	-4.6667	2.66128	.304	-11.6660	2.3327
	6.00	2.2857	2.66128	.826	-4.7136	9.2850
	12.00	-6.3810	2.66128	.087	-13.3803	.6184

Based on observed means. The error term is Mean Square (Error) = 74.365. *. The mean difference is significant at the .05 level. Statistics is significant at $P < 0.05$*.

Total Leachate: The cumulative leachate for the seven leaching events depends on the soil type, different level of wastewater application and the irrigation events. Table-7 shows the total leachate of leaching water through the three soil types considered in the experiment at different levels of cassava wastewater application for the seven leaching events. From the table, the minimum cumulative leachate of 519.64mm occurred at the leaching events of Apomu soil treated with 12 ml cassava wastewater and the maximum cumulative leachate of 768.78 mm occurred at the leaching events of Egbeda treated with 12 ml cassava wastewater. This is likely due to the fact that Egbeda is clayey in the nature than the remaining two soil types. Due to the smaller pores, the soil will not allow easy flow of water or any other solute through it, thereby recording the maximum total leachate. From Figure-14, which shows the profile plot of total leachate through the soil types as affected by cassava wastewater, it can be observed at 0ml of cassava effluent, the estimated marginal means of total leachate were 80.91, 87.12 and 99.35 for Iwo, Apomu and Egbedasoils respectively. Also, the estimated marginal means of total leachate at 6ml were 118.04, 112.71, 108.38 while at 12ml, 104.77, 74.23, 109.83 and at 18ml of cassava wastewater, we have 99.68, 81.91, 81.89; all respectively for Iwo, Apomu and Egbeda. It could be seen at 0ml, the flow was increasing, while at 6ml and 18ml, it was decreasing except at 12ml, the flow decreased greatly and later increased. It was noticed further that the minimum mean value of total leachate was 74.23 which occurred at Apomu Soil of 12ml cassava wastewater while the maximum mean value of total leachate was 118.04 which occurred at Iwo Soil of 6ml of cassava wastewater. However, from Figure-15 which shows the profile plot of total leachatethrough the three soil types, it was observed that estimated marginal means of total leachate for the three soil types were 100.85, 88.99 and 99.86 for Iwo, Apomu and Egbeda respectively. It could be seen at Iwo soil, the flow increased and decreased greatly at Apomu and later increased at Egbeda.

Effect of Cassava Wastewater on Total Leachate: The cassava wastewater of different volume (0, 6, 12 and 18ml) varies with the total leachate leached through the soil columns for the seven leaching events. This is shown in Table-4. It was observed that the minimum total leachate occurred at 12 ml waste water of Apomu soil and the maximum at 12 ml wastewater of Egbeda. This shows that the leachate or rate of leaching through the soil columns is enhanced by the wastewater application at different levels for the three soil types. When comparing the averages of different volume of cassava wastewater for the seven leaching events, it can be inferred that wastewater have significant effect on the leaching rate. Two-way ANOVA in Table-8 shows that there are significant differences among the levels of cassava wastewater on total leachate ($F = 11.107$, $df = 3$, $P < 0.05$). This therefore suggests that the application of cassava wastewater on the soil really impacted on the total leachate.

Table-7: Total Leachate for the Seven Leaching Events.

Soil Type	Cassava Wastewater (ml)	Total Leachate (ml)							Total Leachate (ml)
		1	2	3	4	5	6	7	
Iwo	0	66.72	82.17	80.47	89.33	77.25	86.04	84.4	566.38
	6	134.6	105.48	111.88	103.96	109.16	152.88	108.82	826.78
	12	95.3	94.4	101.01	93.57	109.13	122.21	117.76	733.38
	18	85.34	98.95	95.47	93.8	88.68	140.17	95.38	697.79
Apomu	0	109.78	112.19	98.83	82.48	70.06	72.52	63.97	609.83
	6	109.78	108.03	114.59	131.74	107.78	106.56	110.52	789
	12	99.15	87.01	64.97	52.85	66.38	89.92	59.36	519.64
	18	75.18	80.52	97.75	66.18	92.72	53.82	107.21	573.38
Egbeda	0	109.16	98.55	100.81	81.09	96.88	90.46	118.53	695.48
	6	123.42	119.4	117.91	105.71	97.93	96.6	97.7	758.67
	12	59.76	99.85	108.6	113.38	118.27	143.91	125.01	768.78
	18	83.87	101.13	79.51	77.58	71.47	82.31	77.36	573.23

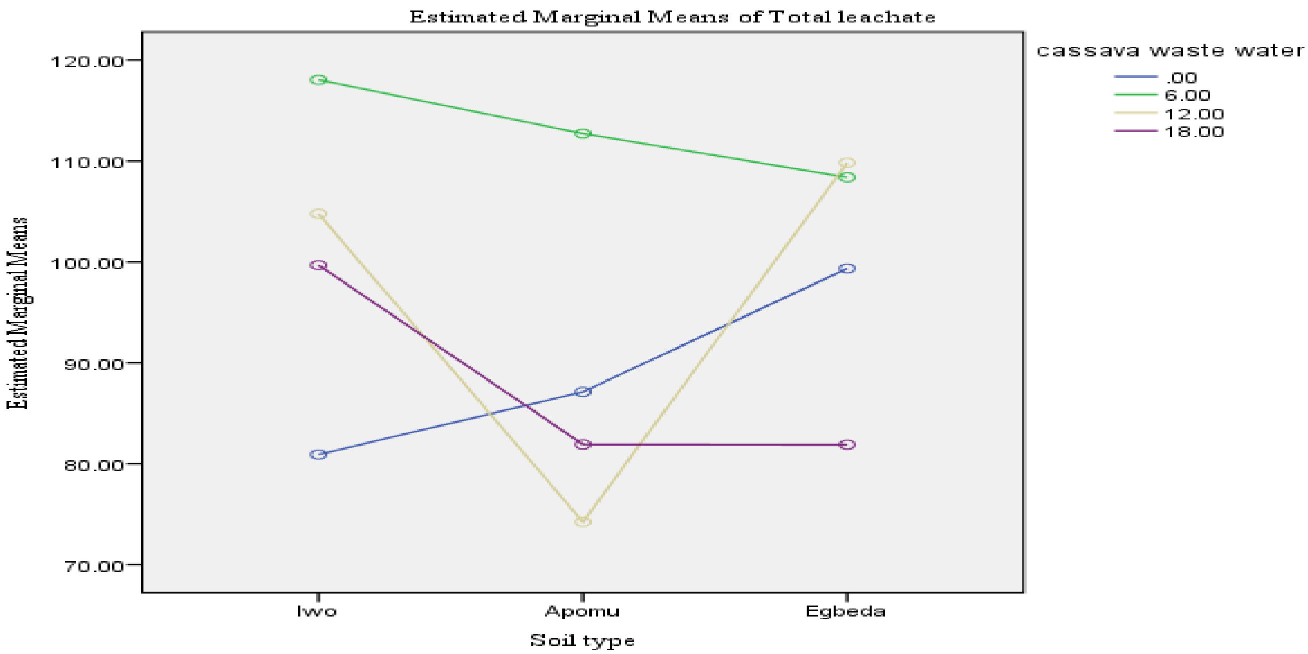

Figure-14: Total Leachate through the Soil Types as affected by Cassava Wastewater.

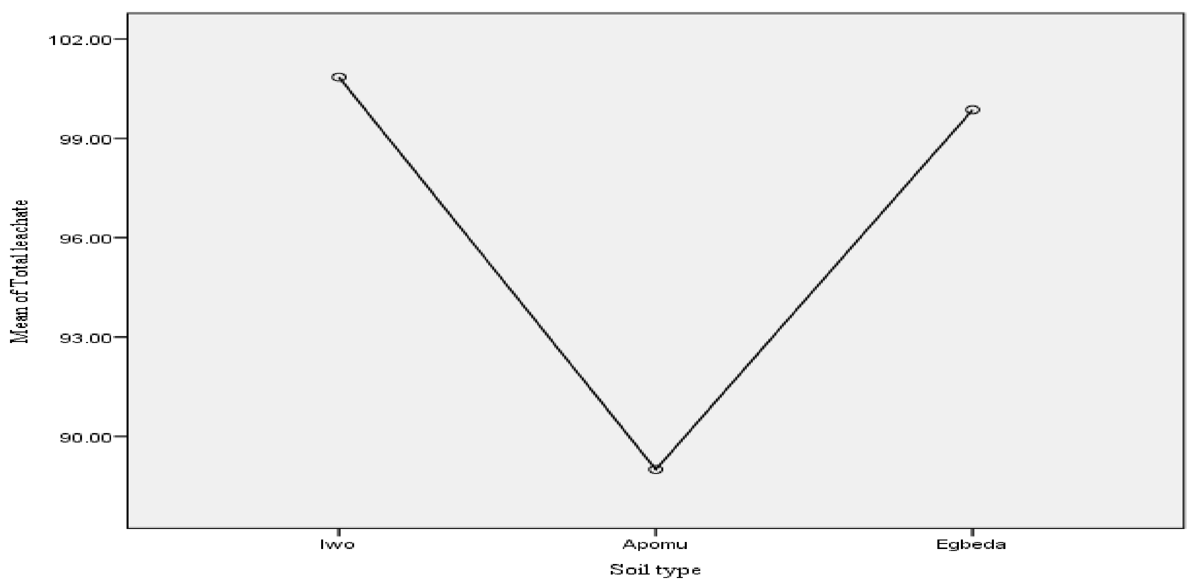

Figure-15: Total Leachate through the Soil Types.

Effect of Soil Type on Total Leachate: The three soil types depend on the total leachate through the soil columns and the different volumes of cassava waste water. It was observed from the Table-4 that, water leached out quickly at Iwo compared to the two remaining soils. The flow was also faster at 6 ml of Apomu and some for Egbeda. This is likely due to the sandy nature of Apomu and coarse nature of Iwo, so water is expected to leach out faster compare to Egbeda that is clayey in nature. Two-way ANOVA in Table-8 reveals that there are no significant variations among the three soil types on the total leachate ($F = 4.768$, $df = 2$, $P < 0.05$). This therefore suggests that the soil types were not significantly influenced by the cassava wastewater applied to determine the total leachate.

Effect of Interaction between Soil Type and Cassava Wastewater on Total Leachate: It can be observed further from the ANOVA analysis (Table-8) that the interactions between the three soil types and the cassava wastewater are significant on total leachate ($F = 3.806$, $df = 6$, $P < 0.05$), which shows that there are significant differences among the soil types and the levels of cassava wastewater.

Table-8: Effect of Soil Type, Effluent and Interactions between Soil Type and Effluent.

Dependent Variable: Total Leachate					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Model	800053.422[a]	12	66671.119	262.308	.000*
Soil Type	2423.582	2	1211.791	4.768	.011
Cassava Wastewater	8469.601	3	2823.200	11.107	.000*
Soil Type* Cassava Wastewater	5803.713	6	967.286	3.806	.002*
Error	18300.316	72	254.171		
Total	818353.739	84			
a. R Squared = .978 (Adjusted R Squared = .974)					

Note: Statistics is significant at P < 0.05*

Conclusion

The research showed that the starchy nature of the effluent have serious effects on the flow rate for Iwo, Apomu and Egbeda soils. Iwo was discovered to have the highest flow being that it has more micro pores that are not clogged by the cassava effluent to reach its peak. The flow rate for the three soil types and levels of cassava wastewater increases with time to a peak value after which the flow started to fall for the seven leaching events. The soil type and cassava wastewater have significant effects on the peak flow rate and cumulative leachate for all the events. Thus, in the area predominantly dominated by cassava without considering treatment of wastewater, Iwo soil series will be at high danger of contamination of underground water. As for Apomu, which is naturally sandy in nature, it was observed that flow was slow for 12ml and 18ml cassava wastewater addition. The reason might be due to the fact that the soil micro and macro pores might have been blocked by starch in the cassava wastewater.

Acknowledgement

The Authors express their gratitude to the management of Obafemi Awolowo University, Ile-Ife for releasing the facilities to be used and the supports to carrying out this research successfully.

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