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Research Article

Modeling Void Ratio Influences on Shigella Transport in Heterogeneous Grave Depositions

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Abstract

The study examined the transport of Shigella in heterogeneous gravel formation, this is to monitored the migration of Shigella in two different ways, monitoring of the contaminants at vertical direction were increase in in concentration with respect to change in depth and monitoring the concentration influenced by variation of gravel porosities, these two dimension were carried out, it was observed that the transport of Shigella in vertical direction experienced exponential growth rate to the optimum level recorded at ninety meters, this can be attributed to deposition of micronutrients that may increase the population rate of Shigella, this increase the concentration of the contaminant to the optimum depth, while that of porosity influences experienced variation of soil consolidation, decrease in porosity where high consolidation is observed experienced high concentration of Shigella, while increase in soil porosity decrease the concentration of Shigella at different location as observed from the study, the predictive values were subjected to model validation, and both parameters developed best fits correlation, the study has express the influenced from variation of soil porosity under fluctuation of soil consolidation in the study. It has also expressed the growth rate of Shigella influenced by variation of micronutrients in the formation; experts will definitely fine this study useful in monitoring and evaluation of microbial transport in soil and water environment.

Keywords: Modeling; Porosity shigella Transport; Sand gravel formation

Introduction

The reaction from 1996 Amendments on Safe Drinking Water Act, including the U.S. Environmental Protection Agency (USEPA) that are the developer of Ground-Water Rule (GWR). This will always protect users of public ground-water supplies from viral contamination [1-6]. Due the fact that total coliform bacteria are normally applied an indicator of the possibility or probable existence of pathogenic contamination from microbial pathogens, several groundwater suppliers applied the absence of coliform as justification for not disinfecting source water. Despite the inherent complications related with the identification of viruses in water, disease epidemics have been attributed to specific episodes of viral pollution in ground water [3-7]. There has been a suggestion as viral indicators. Coliphages are a bacterial virus that is known to infect the coliform bacterial group. Most of these coliphages that are superficially similar to the enteric viruses, they are known to share symmetrical structures, morphologies, and sizes, they also have similar half-lives in natural waters [8-10]. Some coliphages, precisely infect “male” strains of Escherichia coli (E. coli), or “male-specific” coliphages, they are normally found in human feces, this has been identified in huge numbers in human wastewater [11].

- Outbreaks of viral etiology have been documented in waters that met coliform criteria for drinking purposes [12-16].
- Viruses may be considerably more resilient in the environment than coliforms [17,18].
- The infectious dose of many viral diseases is considerably lower than that observed for enteric bacterial disease [19-21].

Theoretical Backgrounds

Nomenclature:

C	=	Shigella Concentration
A(x)	=	void Ratio /Permeability of Soil
B(x)	=	Velocity of Flow

C-n-[α1x] = void ratio of soil

x = Depth

$$\frac{dc}{dx} + A_{(x)}\, C_d + B_{(x)}\, C_d^n = 0 \quad \text{.....................(1)}$$

Transform the above Bernoulli's Equation to a linear first order DE gives:

$$\frac{dk}{dx} + (1-n)k = (1-n)\, B_{(x)}$$

Let I.F = $\ell^{-\alpha x_{1x}}$ ………………………….…. **(2)**

Use I.F to Solve (2) above

Hence, the general Solution becomes:

$$C_d^{1-n} = -\frac{B}{A} + Ce^{-\alpha_1 x} \quad \text{……………………… (3)}$$

Materials and Method

Standard laboratory experiment where performed to monitor Shigella using the standard method for the experiment at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition of the lithology at different locations, this samples collected at different location generated variations at different depths producing different Shigella concentration through column experiment, from the pressure flow at different strata, the experimental result were compared with the theoretical values for the validation of the model.

Results and Discussion

Results and discussion are presented in tables including graphical representation for Shigella concentration (Tables 1-7).

Table1: Predictive and experimental values of shigella concentration at different depth.

Depth [M]	Predictive Values [Conc. Mg/L]	Experimental Values [Conc. Mg/L]
3	0.030077637	0.03
6	0.060155274	0.06
9	0.090232911	0.09
12	0.120310548	0.12
15	0.150388185	0.15
18	0.180465822	0.18
21	0.210543459	0.21
24	0.240621096	0.24
27	0.270698733	0.27
30	0.30077637	0.33
33	0.330854007	0.33
36	0.360931644	0.36
39	0.391009281	0.39
42	0.421086918	0.42
45	0.451164555	0.45
48	0.481242192	0.48
51	0.511319829	0.51
54	0.541397466	0.54
57	0.571475103	0.57
60	0.60155274	0.62
63	0.631630377	0.63
66	0.661708014	0.66
69	0.691785651	0.69
71	0.711837409	0.71
74	0.741915046	0.74
77	0.771992683	0.77
80	0.80207032	0.84
83	0.832147957	0.83
86	0.862225594	0.86
89	0.892303231	0.89
90	0.90232911	0.93

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Table 2: Predictive and experimental values of shigella concentration at different depth.

Depth [M]	Predictive Values [Conc. Mg/L]	Experimental Values [Conc. Mg/L]
3	0.024625489	0.0246
6	0.049250977	0.0492
9	0.073876466	0.0738
12	0.098501954	0.0984
15	0.123127443	0.123
18	0.147752931	0.1476
21	0.17237842	0.1722
24	0.197003908	0.1968
27	0.221629397	0.2214
30	0.246254885	0.246
33	0.270880374	0.2706
36	0.295505862	0.2952
39	0.320131351	0.3198
42	0.344756839	0.3444
45	0.369382328	0.369
48	0.394007816	0.3936
51	0.418633305	0.4182
54	0.443258793	0.4428
57	0.467884282	0.4674
60	0.49250977	0.492
63	0.517135259	0.5166
66	0.541760747	0.5412
69	0.566386236	0.5658
71	0.582803228	0.5822
74	0.607428717	0.6068
77	0.632054205	0.6314
80	0.656679694	0.656
83	0.681305182	0.6806
86	0.705930671	0.7052
89	0.730556159	0.7298
90	0.738764655	0.738

Table 3: Predictive and experimental values of shigella concentration at different depth.

Depth [M]	Predictive Values [Conc. Mg/L]	Experimental Values [Conc. Mg/L]
3	0.020161645	0.0201
6	0.04032329	0.0402
9	0.060484934	0.0603
12	0.080646579	0.0804
15	0.100808224	0.1005
18	0.120969869	0.1206
21	0.141131513	0.1407
24	0.161293158	0.1608
27	0.181454803	0.1809
30	0.201616448	0.201
33	0.221778092	0.2211
36	0.241939737	0.2412
39	0.262101382	0.2613
42	0.282263027	0.2814
45	0.302424671	0.3015
48	0.322586316	0.3216

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51	0.342747961	0.3417
54	0.362909606	0.3618
57	0.38307125	0.3819
60	0.403232895	0.402
63	0.42339454	0.4221
66	0.443556185	0.4422
69	0.463717829	0.4623
71	0.477158926	0.4757
74	0.497320571	0.4958
77	0.517482215	0.5159
80	0.53764386	0.536
83	0.557805505	0.5561
86	0.57796715	0.5762
89	0.598128794	0.5963
90	0.604849343	0.603

Table 4: Predictive and experimental values of shigella concentration at different depth.

Depth [M]	Predictive Values [Conc. Mg/L]	Experimental Values [Conc. Mg/L]
3	0.014936114	0.015
6	0.029872228	0.032
9	0.044808341	0.045
12	0.059744455	0.065
15	0.074680569	0.075
18	0.089616683	0.093
21	0.104552797	0.105
24	0.11948891	0.122
27	0.134425024	0.135
30	0.149361138	0.155
33	0.164297252	0.165
36	0.179233365	0.183
39	0.194169479	0.195
42	0.209105593	0.212
45	0.224041707	0.225
48	0.238977821	0.243
51	0.253913934	0.255
54	0.268850048	0.275
57	0.283786162	0.285
60	0.298722276	0.322
63	0.31365839	0.315
66	0.328594503	0.333
69	0.343530617	0.345
71	0.353488026	0.355
74	0.36842414	0.374
77	0.383360254	0.385
80	0.398296368	0.423
83	0.413232481	0.415
86	0.428168595	0.435
89	0.443104709	0.445
90	0.448083414	0.455

Citation: Nwaoburu AO, Eluozo SN. Modeling Void Ratio Influences on Shigella Transport in Heterogeneous Grave Depositions. Glob J Eng Sci. 2(2): 2019. GJES.MS.ID.000535. DOI: 10.33552/GJES.2019.02.000535.

Table 5: Predictive and experimental values of shigella concentration at different depth.

Depth [M]	Predictive Values [Conc. Mg/L]	Experimental Values [Conc. Mg/L]
3	0.009059211	0.009
6	0.018118422	0.018
9	0.027177633	0.027
12	0.036236844	0.036
15	0.045296055	0.045
18	0.054355266	0.054
21	0.063414477	0.063
24	0.072473688	0.072
27	0.081532899	0.081
30	0.090592109	0.091
33	0.09965132	0.099
36	0.108710531	0.108
39	0.117769742	0.117
42	0.126828953	0.126
45	0.135888164	0.135
48	0.144947375	0.144
51	0.154006586	0.153
54	0.163065797	0.162
57	0.172125008	0.171
60	0.181184219	0.182
63	0.19024343	0.189
66	0.199302641	0.198
69	0.208361852	0.207
71	0.214401326	0.213
74	0.223460537	0.222
77	0.232519748	0.231
80	0.241578959	0.242
83	0.25063817	0.249
86	0.259697381	0.258
89	0.268756591	0.267
90	0.271776328	0.275

Table 6: Predictive and experimental values of shigella concentration at different depth.

Depth [M]	Predictive Values [Conc. Mg/L]	Experimental Values [Conc. Mg/L]
3	0.005494689	0.0054
6	0.010989378	0.0108
9	0.016484068	0.0162
12	0.021978757	0.0216
15	0.027473446	0.0273
18	0.032968135	0.0324
21	0.038462824	0.0378
24	0.043957514	0.0432
27	0.049452203	0.0486
30	0.054946892	0.0542
33	0.060441581	0.0594
36	0.06593627	0.0648
39	0.07143096	0.0702
42	0.076925649	0.0756
45	0.082420338	0.0812
48	0.087915027	0.0864

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51	0.093409716	0.0918
54	0.098904406	0.0972
57	0.104399095	0.1026
60	0.109893784	0.1082
63	0.115388473	0.1134
66	0.120883162	0.1188
69	0.126377851	0.1242
71	0.130040978	0.1278
74	0.135535667	0.1332
77	0.141030356	0.1386
80	0.146525045	0.1443
83	0.152019734	0.1494
86	0.157514424	0.1548
89	0.163009113	0.1602
90	0.164840676	0.1621

Table 7: Variation of shigella concentration at different depth.

Soil porosity	0.23	0.25	0.27	0.3	0.35	0.4
3m	0.03008	0.02463	0.02016	0.01494	0.00906	0.00549
6m	0.06016	0.04925	0.04032	0.02987	0.01812	0.01099
9m	0.09023	0.07388	0.06048	0.04481	0.02718	0.01648
12m	0.12031	0.0985	0.08065	0.05974	0.03624	0.02198
15m	0.15039	0.12313	0.10081	0.07468	0.0453	0.02747
18m	0.18047	0.14775	0.12097	0.08962	0.05436	0.03297
21m	0.21054	0.17238	0.14113	0.10455	0.06341	0.03846
24m	0.24062	0.197	0.16129	0.11949	0.07247	0.04396
27m	0.2707	0.22163	0.18145	0.13443	0.08153	0.04945
30m	0.30078	0.24625	0.20162	0.14936	0.09059	0.05495
33m	0.33085	0.27088	0.22178	0.1643	0.09965	0.06044
36m	0.36093	0.29551	0.24194	0.17923	0.10871	0.06594
39m	0.39101	0.32013	0.2621	0.19417	0.11777	0.07143
42m	0.42109	0.34476	0.28226	0.20911	0.12683	0.07693
45m	0.45116	0.36938	0.30242	0.22404	0.13589	0.08242
48m	0.48124	0.39401	0.32259	0.23898	0.14495	0.08792
51m	0.51132	0.41863	0.34275	0.25391	0.15401	0.09341
54m	0.5414	0.44326	0.36291	0.26885	0.16307	0.0989
57m	0.57148	0.46788	0.38307	0.28379	0.17213	0.1044
60m	0.60155	0.49251	0.40323	0.29872	0.18118	0.10989
63m	0.63163	0.51714	0.42339	0.31366	0.19024	0.11539
66m	0.66171	0.54176	0.44356	0.32859	0.1993	0.12088
69m	0.69179	0.56639	0.46372	0.34353	0.20836	0.12638
71m	0.71184	0.5828	0.47716	0.35349	0.2144	0.13004
74m	0.74192	0.60743	0.49732	0.36842	0.22346	0.13554
77m	0.77199	0.63205	0.51748	0.38336	0.23252	0.14103
80m	0.80207	0.65668	0.53764	0.3983	0.24158	0.14653
83m	0.83215	0.68131	0.55781	0.41323	0.25064	0.15202
86m	0.86223	0.70593	0.57797	0.42817	0.2597	0.15751
89m	0.8923	0.73056	0.59813	0.4431	0.26876	0.16301
90m	0.90233	0.73876	0.60485	0.44808	0.27178	0.16484

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Figures 1-7 explain the behavior of the system in terms of growth rate of Shigella in heterogeneous grave depositions, the figures experienced linear trend under exponential condition, the transport of the microbes observed increase with respect to depth, but the concentration were observed in different rates, the simulation express the behavior of Shigella migration in gravel deposition, these condition were expressed from various figures as it explained the influence of heterogeneous structure of the formation to be insignificant from the observed effect on the rate of concentration, because it express linear growth rate to the optimum depth, increase in concentration with respect to increase in depth were observed from all the figures, the experimental values compared favorably well with the predictive values, the optimum rate of concentration recorded at ninety meters, but the rate of concentration varies based on the porosity depositions of gravel in the study location, figure seven observed the rate of porosity variation with respect to variation of concentration in different depositions and locations, the figure experienced consolidation of porosity variation in the lithe structures of the formation, thus the concentration observed increase at high consolidation of the porosity, but suddenly decrease in concentration were it experienced decrease in consolidation thus high increase in porosity of the formation. The figure explained the influenced from soil porosity in various deposition of the formation.

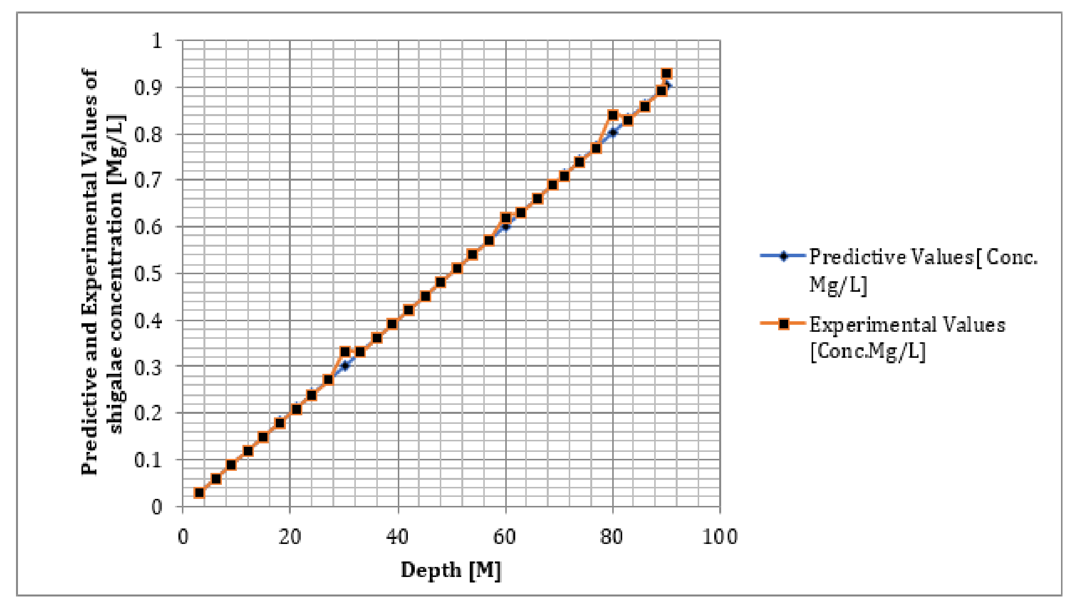

Figure 1: Predictive and experimental values of shigella concentration at different depth.

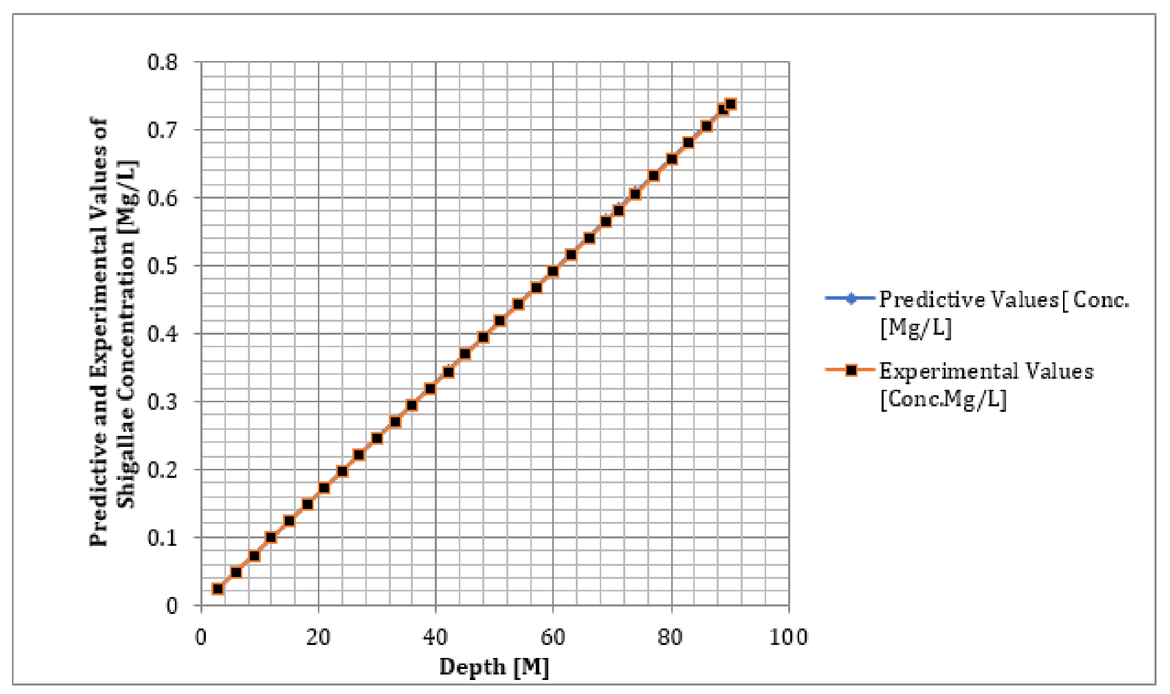

Figure 2: Predictive and experimental values of shigella concentration at different depth.

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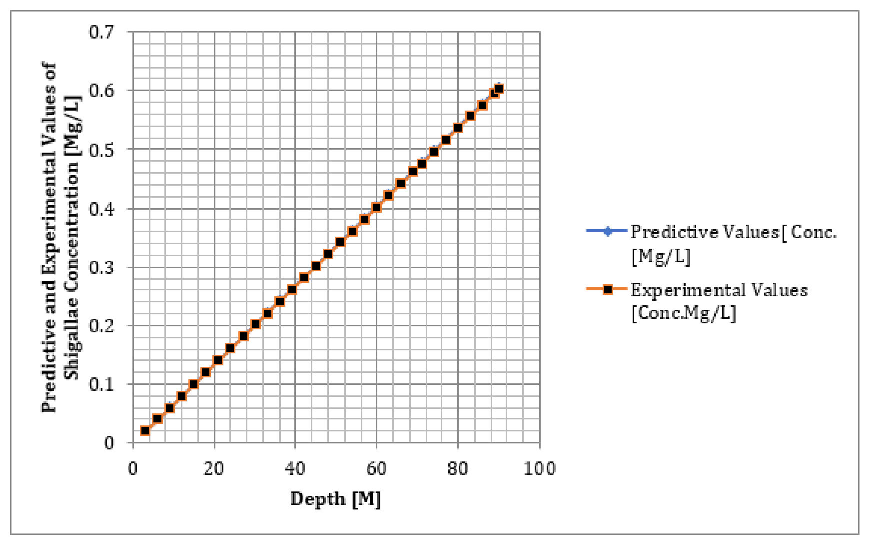

Figure 3: Predictive and experimental values of shigella concentration at different depth.

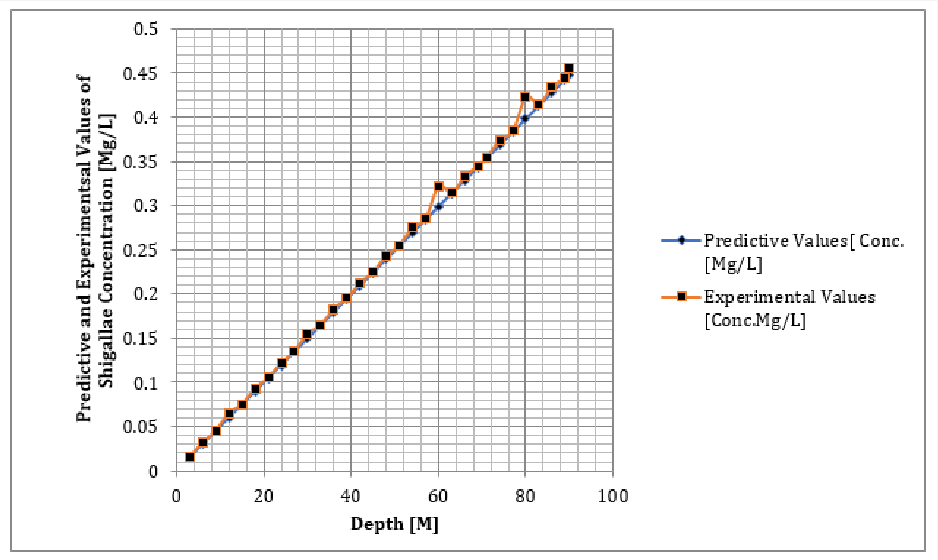

Figure 4: Predictive and experimental values of shigella concentration at different depth.

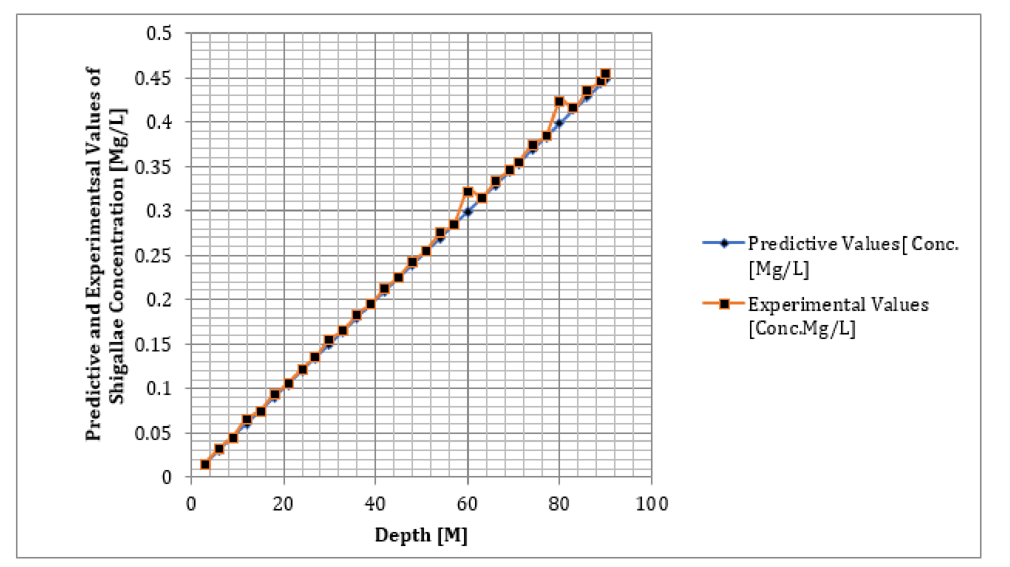

Figure 5: Predictive and experimental values of shigella concentration at different depth.

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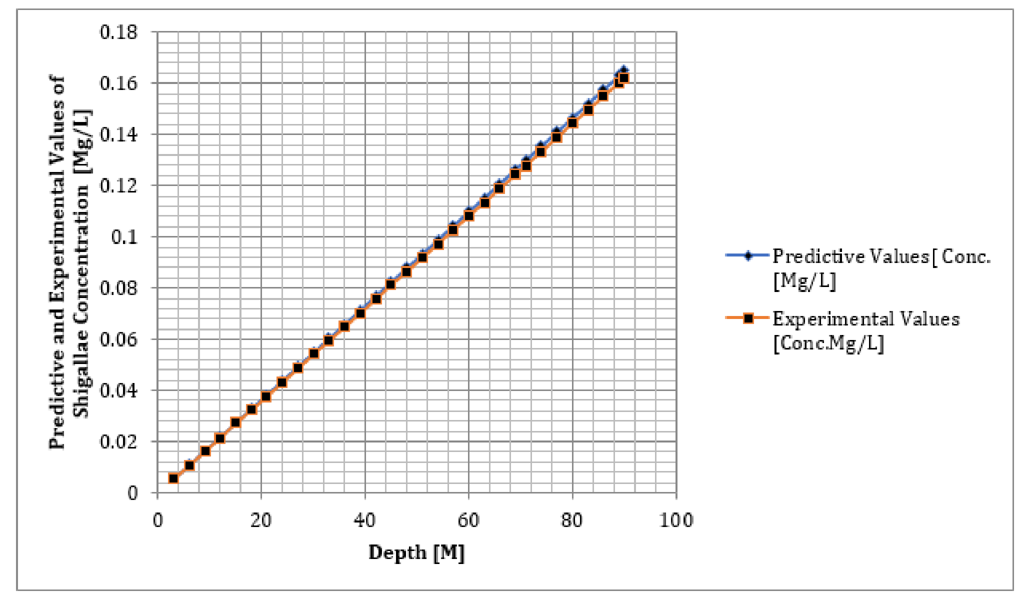

Figure 6: Predictive and experimental values of shigella concentration at different depth.

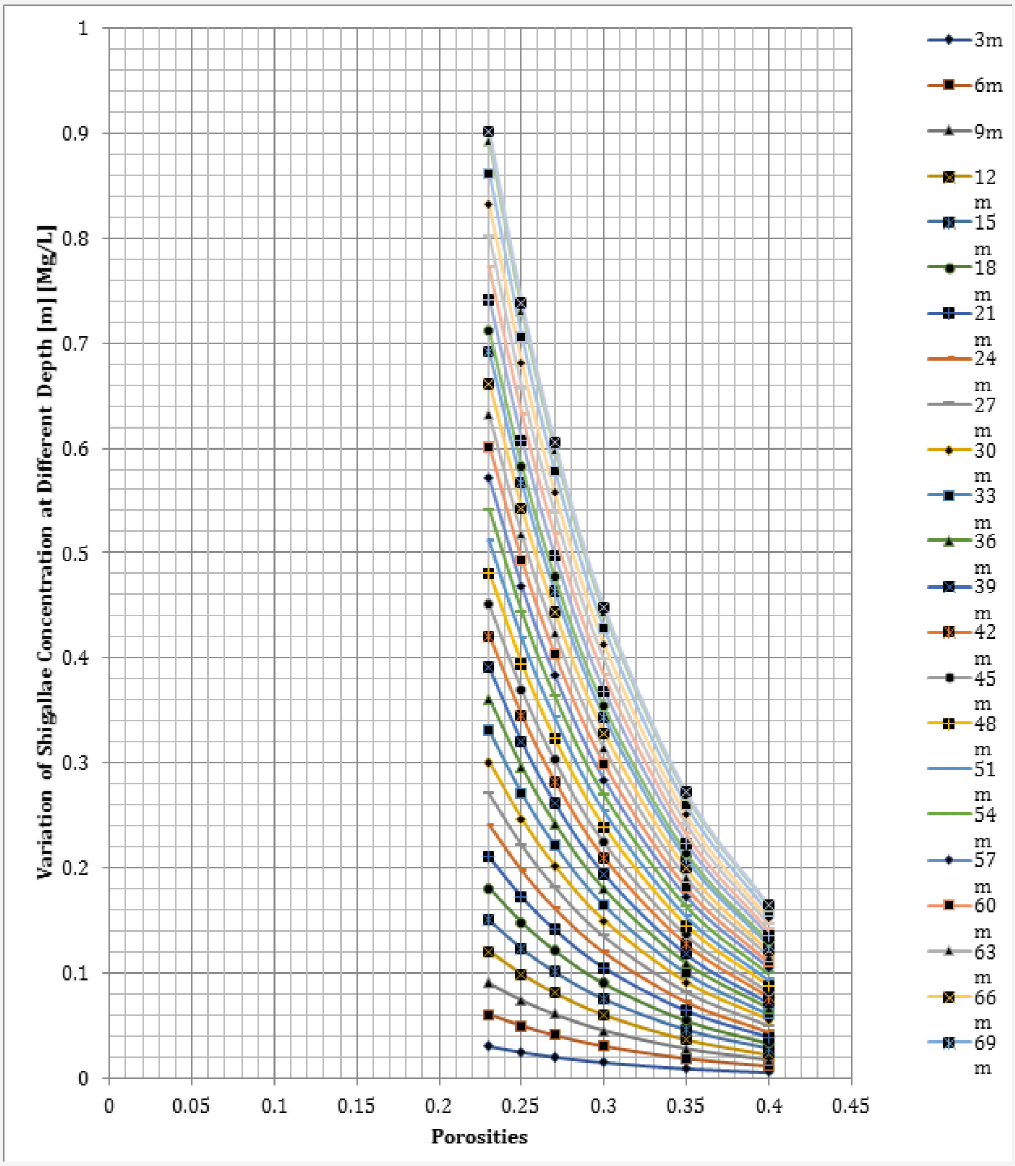

Figure 7: Variation of predictive values of Shigella concentration influenced by depositions of the formations.

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Conclusion

The study expresses the effect of porosities in various depositions of gravel, the transport of Shigella were monitored to determine the effect of porosity on the deposition and transport of the microbes in such heterogeneous gravel formation. The study expresses the variation of soil porosity in different condition monitored in the system, the transport rate was from three to ninety meters depth, linear trend was observed in the study, but with different concentration. Monitoring the effect of porosity on the migration of Shigella on variation of porosity with respect to concentration is based on the rate of the formation consolidation. decrease in soil porosity generated higher concentration at three meters, but when the porosity of the soil experienced decrease in it consolidation thus high porosity, decrease in concentration were observed, despite exponential growth rate were the optimum concentration were recorded at ninety meters, when the concentration were monitored in terms of variation influences of porosity, the concentration experienced lower concentration recorded at [0.40] while the highest concentration were observed at porosity rate of [0.23] these has explained the behavior of the transport in two dimension increase in concentration based on increase in depth, this could be attribute to deposition of micronutrients, while high to low concentration are based on the influences from variation of soil porosity in gravel depositions. The study has expressed the behavior of Shigella in terms of transport were micronutrient are deposited, it has also explained the influenced from variation of soil porosity in Shigella depositions on gravel formations.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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