Trends in Civil Engineering and
its Architecture

DOI: 10.32474/TCEIA.2021.04.000182

ISSN: 2637-4668

Research article

Mathematical Modeling of Dispersion Coefficient and Particle Density Bacterial Influence on *Campylobacter spp* Transport In Surface Water Environment

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Received: January 04, 2021 **Published:** January 22, 2021

Abstract

Particle density bacterial and dispersions of *Campylobacter* deposition was monitor in surface water environment, the transport of these microbes were observed to decrease with respect to change in distance at various monitored locations, dispersion of the contaminant at initial point of discharge were examined in the study environment, this was influenced through the migration of the contaminant at various station point of discharge, it was based on the heterogeneous velocity in the surface water environment. Despite the application of one dimensional flow transport, the study experience the impact of dispersion as decrease in concentration were observed in all the figures, the spread of the contaminant are based on the velocity of flow subjecting it to fast spread of *Campylobacter* in surface water environment, particle density bacterial influence was also examined in its different dimensions, the particle densities of the bacterial was through transient frequencies, while another was through a microfluidic channel of flow in surface water, thus the distribution of a population and its heterogeneous size particle were based on difference carrier fluids, these also affected the concentration through heterogeneous velocities of surface water flows at different station point, the decrease in the transport system were monitored based on these two predominant parameters in the simulation, the generated parameters of concentrations at different stationed point of transport ranged from 24.38700365-3.422646182, 21.54119013- 3.170336995, 23.47218199-3.56121468, 19.59794838-2.705873785, 14.78899765-1.873477905, 12.58403842-1.536910683. the study has express the behaviour of the system in terms of its rapid decrease of *Campylobacter* based on these factors, the concentration implies that the surface water Pollution should be subjected to clean up to reduce the rate of contamination to the minimum required standard, this will definitely make the surface water environmentally friendly. The study is imperative because it has expressed the rate of these two predominant parameters that can influenced the spread and the deposition of *Campylobacter* in surface water environment.

Keywords: Mathematical Modeling, Dispersion Coefficient Density Bacterial and *Campylobacter* Transport

Introduction

Pathogens group of this type of species were *Vibrio Cholera* are from has such causes cholera, this has been observed to infect numerous human settlements, over millions of people each year Nelson et al., 2009 [1] Eluozo Afiibor 2018 [2]). For instance, records of the implementation of a suitable quantify to prevent the transmission of water borne pathogens (Colwell, 1996 [3]; Okun 1996 [4], Eluozo and Oba 2018 [5], Pandey 2012 [6]). Studies carried out in the Year past the application of geographic techniques has shown the spread and epicenter of cholera, this perception resulted to the locating of contaminated water body, because that it was observed to be responsible for spreading of the disease. Diseases such as Water borne (i.e., diarrhea, gastrointestinal illness) such rate are caused by various microbes such as bacteria, viruses, and protozoa, there are various reasons for numerous outbreaks as it stated by (Craun et al., 2006 [7] Eluozo and Ezeilo 2018 [8], Pandey 2012 [6]). Nigeria as a developing nation such as other Africa nations, waterborne diseases infect millions of people (Fenwick, 2006 [9]). *Cryptosporadium*, *E. coli* O157:H7, V. Cholera, and *Salmonella* was observed to be the fundamental outbreaks in this environment (Craun et al., 2006 [7], Eluozo and Ezeilo 2018a [10], Eluozo and Ezeilo 2018b [11], Eluozo and Ezeilo 2018c [12]). It was noted that in the mid late 18th century; cholera, diseases have infected high percentage millions of people around the globe (Colwell, 1996 [3]). More so , in relative conditions, there are current research studies carried out such as Diffey (1991) [13], Brookes et al. 2004 [14] Eluozo and Ezeilo 2018d [15], Jamieson et al.(2004) [16], Gerba and Smith (2005) [17], Gerba and McLeod (1976), John and Rose (2005) [18], Hipsey et al. 2008 [14] Eluozo and Afiibor 2018b [19], Eluozo and Afiibor 2018a [2]), and Pachepsky and Shelton (2011) [20] these there is a comprehensive research the has thoroughly reviewed the current advancement in this area, precisely, freshwater and estuarine sediments. However, these research studies have developed some other areas that has not been done to improve on the existing works, numerous research is on specific water bodies, examples of these are research studies carried out by, John and Rose (2005) [18] it focuses on ground water, Brookes (2004) [14], other works carried out focuses on reservoirs and lakes, and Jamieson et al. 2004 [16], Eluozo and Amadi 2019a [21], Amadi and Eluozo 2019b [22] while others focuses on agriculture watershed.

Theoretical Background

Governing equation

$$\frac{dc}{dx} + \beta(x)K = A(x) \tag{1}$$

Nomenclatures

C = Concentration Campylobacter SPP

B = Particle density of bacterial

K = Dispersions. Velocity of flow

A = Fluid Density

X = Distance

Multiplying the equation through by $C[x]$, we have:

$$C(x)\frac{dC}{dx} + C(x)\beta(x)K = C(x)A(x) \tag{2}$$

Let $P(x) = C(x)\beta(x)$ (3)

Then Equation (2), we have:

$$C(x)\frac{dC}{dx} + C(x)\beta(x)K = C(x)A(x) \tag{4}$$

$$C(x)\frac{dC}{dx} + P(x)K = C(x)A(x) \tag{5}$$

$$C(x)P^1 + P(x)K = C(x)A(x) \tag{6}$$

$$C(x)P^1 = C(x)A - P(x)K \tag{7}$$

Differentiate 2nd term on the left hand side of (6) with respect to x, we have

$$K\frac{dC}{dx} = C(x)A(x) - C(x)P^1 \tag{8}$$

$$\frac{dC}{dx} = \frac{1}{K}\left[C(x)A(x) - C(x)P^1\right] \tag{9}$$

$$\frac{dC}{dx} = \frac{C(x)}{K}\left[A(x) - P^1\right] \tag{10}$$

Applying separation of variables, by dividing through by C(x) and cross multiply by dx, gives:

$$\frac{1}{C(x)}dC = \frac{1}{K}\left[A(x) - P^1\right]dx \tag{11}$$

$$\frac{1}{C(x)}dC = \frac{1}{K}\left[A(x) - P^1\right]dx \tag{12}$$

$$\frac{1}{C(x)}dC = \left(\frac{A(x)}{K} - \frac{P^1}{K}\right)dx \tag{13}$$

$$\int\frac{1}{C(x)}dC = \int\left(\frac{A(x)}{K} - \frac{P^1}{K}\right)dx + \eta \tag{14}$$

$$\ln C(x) = \int A(x)dx - \int\frac{P^1}{K}dx + \eta \tag{15}$$

$$\ln C(x) = \frac{1}{K}\left[Ax - P^1\right]x + \eta \tag{16}$$

$$\text{h}\ C(x) = \left(\frac{A(x)}{K} - \frac{P^1}{K}\right)x + \eta \tag{17}$$

Taking exponent of the both side of the equation

$$C(x) = \ell^{\left(\frac{A(x)}{K} - \frac{P^1}{K} + \eta\right)} \tag{18}$$

$$C(x) = D\ell^{\frac{1}{K}\left(Ax - P^1 x\right)} \tag{19}$$

Materials and Method

Standard laboratory experiment where performed to monitor *Campylobacter* using the standard method for the experiment at different sample at different station, the water sample were collected in sequences base on specification stipulated at different locations, this samples collected at different location generated variations at different distance producing different *Campylobacter* concentration through physiochemical analysis, the experimental result were compared with the theoretical values for model validation [23].

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Results and Discussion

Tables 1-6 & Figure 1-6.

Figure 1-6 explained the behaviour of *Campylobacter* Concentration in surface water environment, the study through its expression on graphical representations, shows the rate of concentration from the initial point of discharge to the final monitored distance in the study environment, the figures from various location in studied environment experienced high to low concentration, but with different concentration between the initial point source of discharge to the final monitored distance in the study area, gradual decrease with respect to change in distanced was observed in all the studied locations, the rate of decrease in concentration was observed to be attributed to the dispersion coefficient and the particle densities of the bacterial, in surface water environment, the system developed monitor the influenced based on the imperative factors in surface water environment, the variation of velocity affected the dispersions of the microbes in terms of discharge in different point source, this implies that the dispersion influence on the transport of *Campylobacter* Concentration were based on the observed heterogeneous velocities in various point source of discharge in the study environment , while the particle density bacterial are observed through its mass transient frequency through the channel flow, it is monitored based on the discharge rate of population observed in its rate of heterogeneity particle size, while particle densities measured from carried fluids through its frequencies, this implies the shapes of the microbes that also determined the densities are affected by the microfluidic channel on the variation of heterogeneous fluid velocities, this system were influenced by these parameters as observed from the study carried out, the trend of the graph despite the variation of velocities in various station point source experience the effect from particle density of the bacterial, the predictive and the experimental values in all the figures developed best fits correlation.

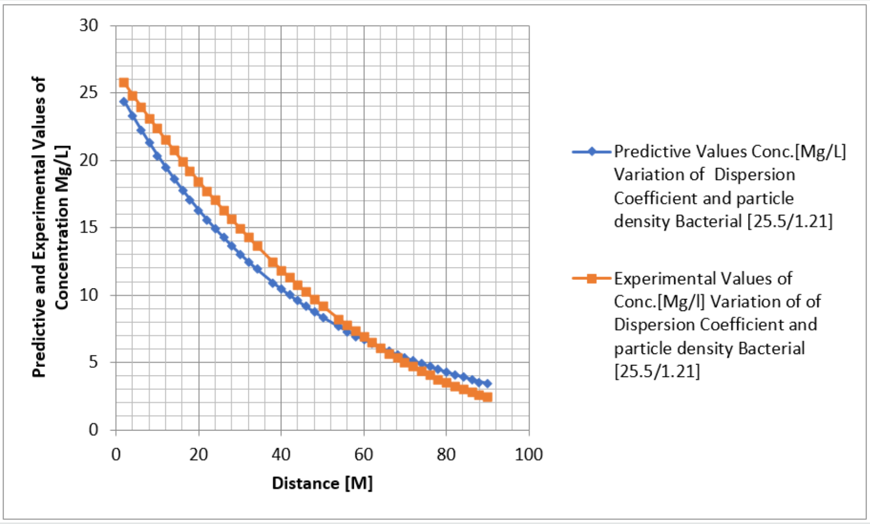

Figure 1: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

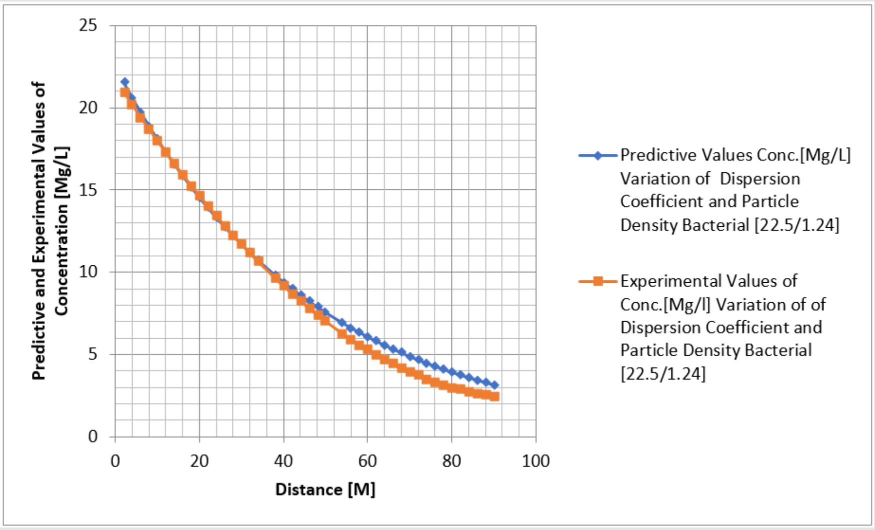

Figure 2: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

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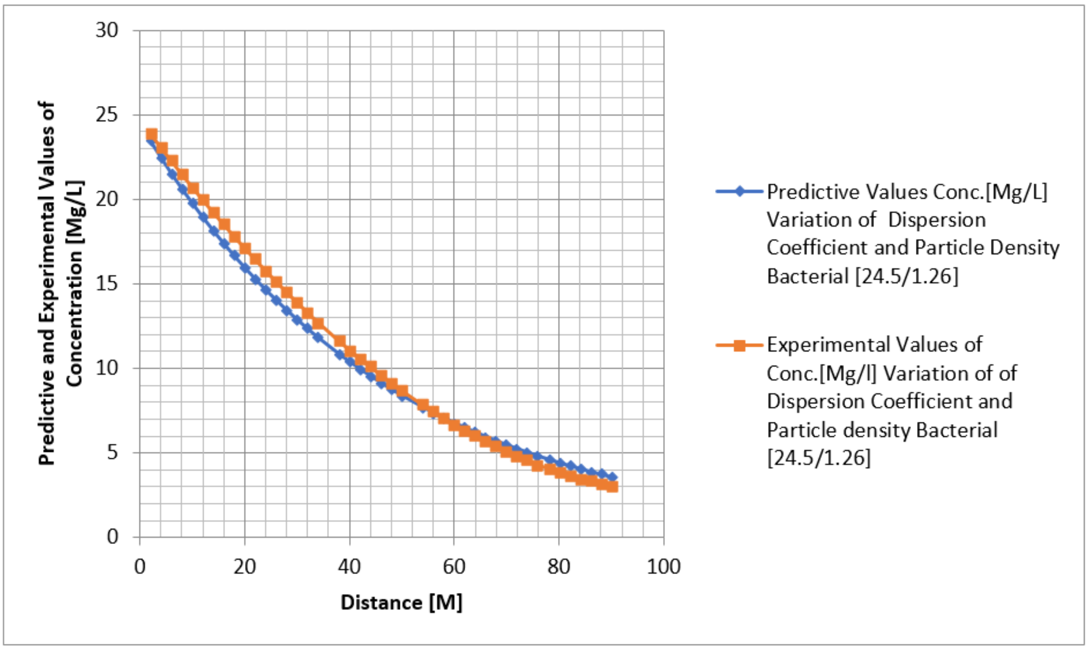

Figure 3: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

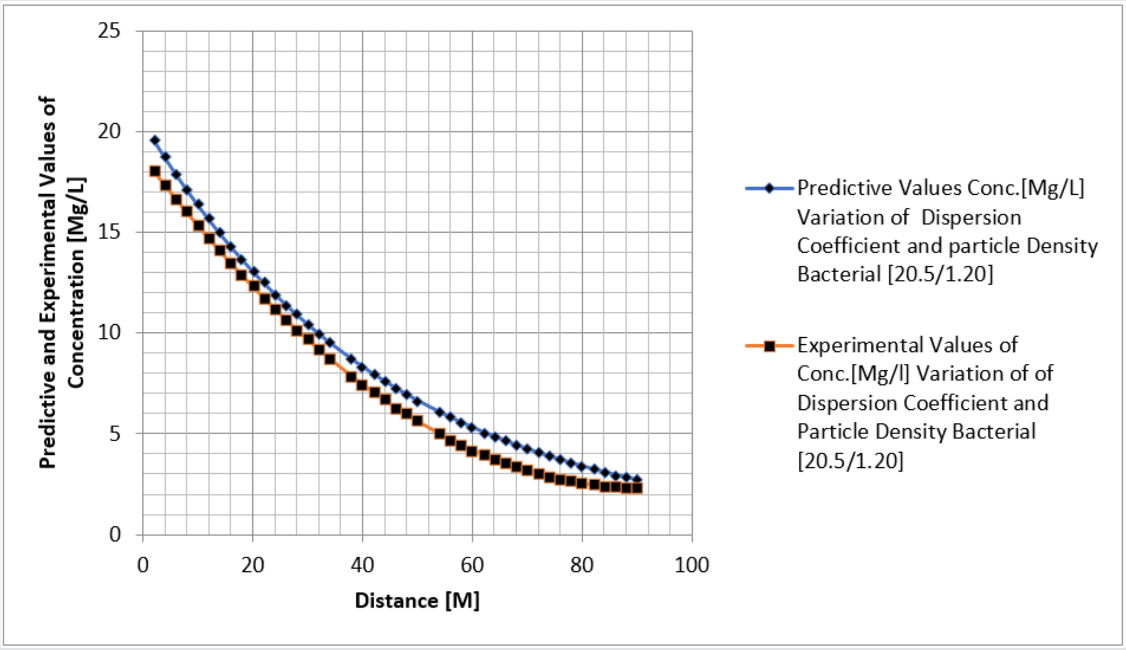

Figure 4: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

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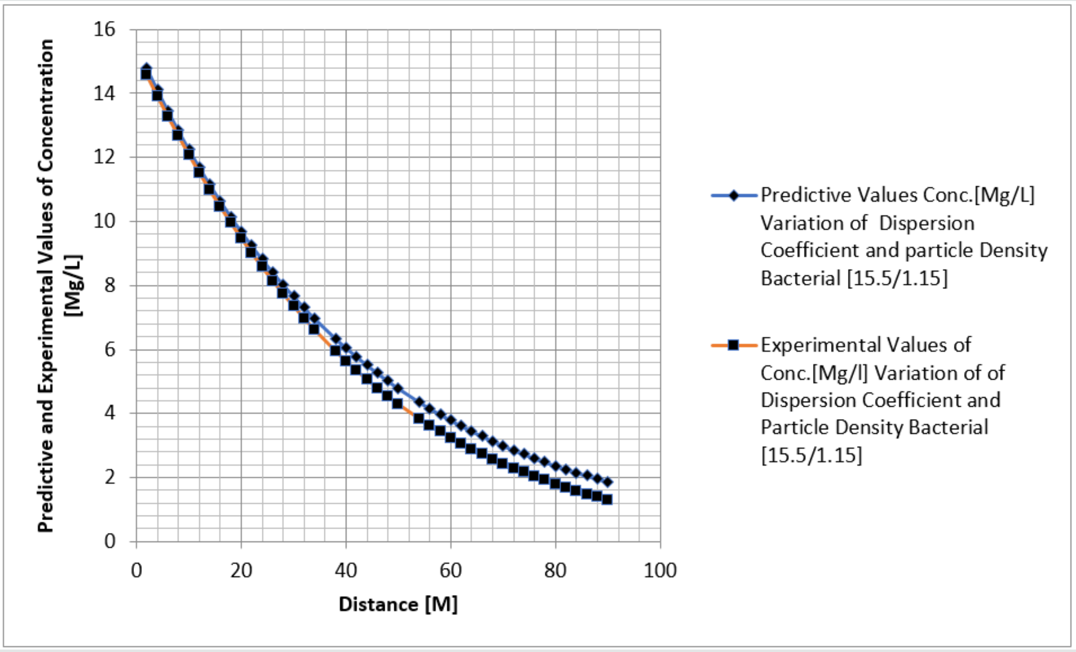

Figure 5: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

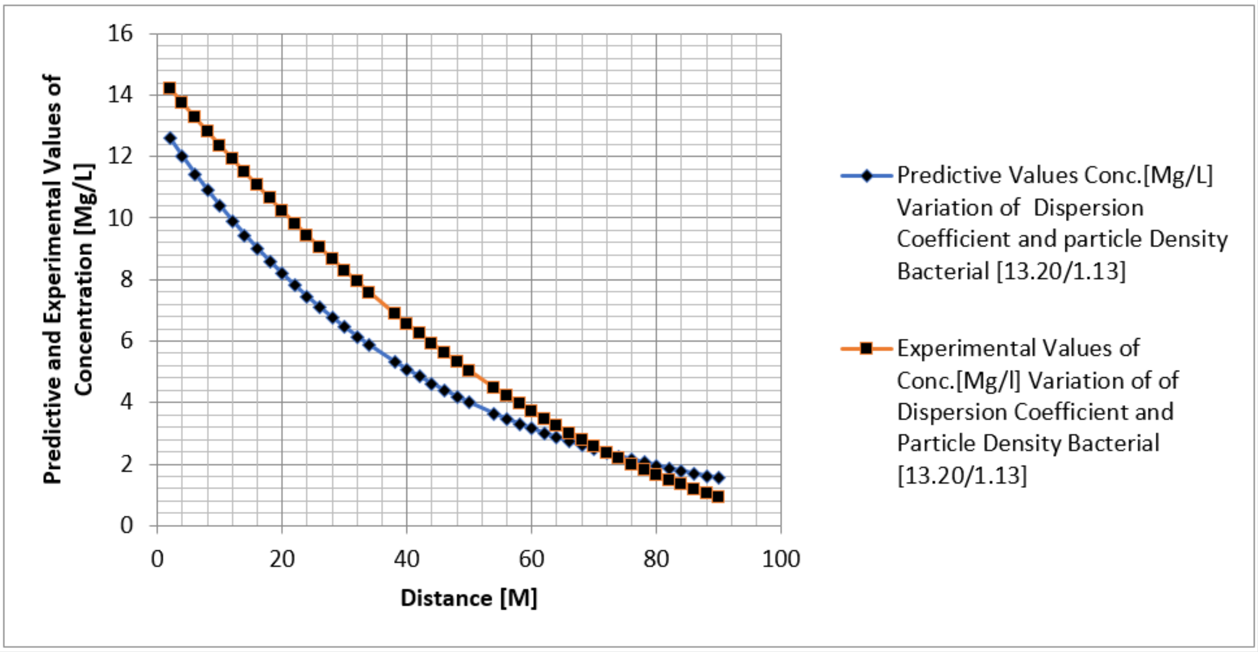

Figure 6: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

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Table 1: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

Distance [x]	Predictive Values Conc. [Mg/L] Variation of Dispersion Coefficient and particle density Bacterial [25.5/1.21]	Experimental Values of Conc. [Mg/l] Variation of Dispersion Coefficient and particle density Bacterial [25.5/1.21]
2	24.387	25.74
4	23.32259	24.866
6	22.30463	24.008
8	21.3311	23.166
10	20.40006	22.34
12	19.50966	21.53
14	18.65813	20.736
16	17.84376	19.958
18	17.06493	19.196
20	16.3201	18.45
22	15.60778	17.72
24	14.92655	17.006
26	14.27505	16.308
28	13.65199	15.626
30	13.05612	14.96
32	12.48626	14.31
34	11.94127	13.676
38	10.92162	12.456
40	10.44493	11.87
42	9.989039	11.3
44	9.553048	10.746
46	9.136087	10.208
48	8.737325	9.686
50	8.355968	9.18
54	7.642462	8.216
56	7.308892	7.758
58	6.989881	7.316
60	6.684795	6.89
62	6.393024	6.48
64	6.113988	6.086
66	5.847131	5.708
68	5.591922	5.346
70	5.347852	5
72	5.114435	4.67
74	4.891205	4.356
76	4.677719	4.058
78	4.473551	3.776
80	4.278295	3.51
82	4.09156	3.26
84	3.912976	3.026
86	3.742187	2.808
88	3.578852	2.606
90	3.422646	2.42

Table 2: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

Distance [x]	Predictive Values Conc. [Mg/L] Variation of Dispersion Coefficient and Particle Density Bacterial [22.5/1.24]	Experimental Values of Conc. [Mg/l] Variation of Dispersion Coefficient and Particle Density Bacterial [22.5/1.24]
2	21.54119	20.96
4	20.62324	20.196
6	19.7444	19.448
8	18.90302	18.716
10	18.09749	18
12	17.32629	17.3
14	16.58795	16.616
16	15.88108	15.948
18	15.20432	15.296
20	14.55641	14.66
22	13.93611	14.04
24	13.34224	13.436
26	12.77367	12.848
28	12.22934	12.276
30	11.7082	11.72
32	11.20927	11.18
34	10.7316	10.656
38	9.836461	9.656
40	9.417292	9.18
42	9.015986	8.72
44	8.63178	8.276
46	8.263948	7.848
48	7.91179	7.436
50	7.574639	7.04
54	6.942826	6.296
56	6.646966	5.948
58	6.363713	5.616
60	6.092532	5.3
62	5.832906	5
64	5.584344	4.716
66	5.346374	4.448
68	5.118545	4.196
70	4.900424	3.96
72	4.691599	3.74
74	4.491672	3.536
76	4.300265	3.348
78	4.117014	3.176
80	3.941573	3.02
82	3.773607	2.88
84	3.6128	2.756
86	3.458845	2.648
88	3.31145	2.556
90	3.170337	2.48

Table 3: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

Distance [x]	Predictive Values Conc. [Mg/L] Variation of Dispersion Coefficient and Particle Density Bacterial [24.5/1.26]	Experimental Values of Conc. [Mg/l] Variation of Dispersion Coefficient and Particle density Bacterial [24.5/1.26]
2	23.47218	23.906
4	22.48748	23.088
6	21.54409	22.286
8	20.64028	21.5
10	19.77438	20.73
12	18.94481	19.976
14	18.15005	19.238
16	17.38862	18.516
18	16.65914	17.81
20	15.96026	17.12
22	15.2907	16.446
24	14.64922	15.788
26	14.03466	15.146
28	13.44589	14.52
30	12.88181	13.91
32	12.34139	13.316
34	11.82365	12.738
38	10.85241	11.63
40	10.39713	11.1
42	9.960957	10.586
44	9.543077	10.088
46	9.142728	9.606
48	8.759175	9.14
50	8.391712	8.69
54	7.702387	7.838
56	7.379258	7.436
58	7.069685	7.05
60	6.7731	6.68
62	6.488956	6.326
64	6.216733	5.988
66	5.95593	5.666
68	5.706069	5.36
70	5.466689	5.07
72	5.237352	4.796
74	5.017636	4.538
76	4.807137	4.296
78	4.605469	4.07
80	4.412262	3.86
82	4.22716	3.666
84	4.049823	3.488
86	3.879926	3.326
88	3.717156	3.18
90	3.561215	3.05

Table 4: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

Distance [x]	Predictive Values Conc. [Mg/L] Variation of Dispersion Coefficient and particle Density Bacterial [20.5/1.20]	Experimental Values of Conc. [Mg/l] Variation of Dispersion Coefficient and Particle Density Bacterial [20.5/1.20]
2	19.59795	18.062
4	18.73559	17.36
6	17.91118	16.674
8	17.12304	16.004
10	16.36958	15.35
12	15.64928	14.712
14	14.96067	14.09
16	14.30236	13.484
18	13.67302	12.894
20	13.07138	12.32
22	12.4962	11.762
24	11.94634	11.22
26	11.42067	10.694
28	10.91813	10.184
30	10.43771	9.69
32	9.978421	9.212
34	9.539346	8.75
38	8.718305	7.874
40	8.334678	7.46
42	7.967931	7.062
44	7.617322	6.68
46	7.282141	6.314
48	6.961708	5.964
50	6.655376	5.63
54	6.082555	5.01
56	5.814908	4.724
58	5.559037	4.454
60	5.314425	4.2
62	5.080577	3.962
64	4.857019	3.74
66	4.643298	3.534
68	4.438981	3.344
70	4.243655	3.17
72	4.056923	3.012
74	3.878408	2.87
76	3.707749	2.744
78	3.544598	2.634
80	3.388627	2.54
82	3.239519	2.462
84	3.096972	2.4
86	2.960698	2.354
88	2.830419	2.324
90	2.705874	2.31

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Table 5: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

Distance [x]	Predictive Values Conc. [Mg/L] Variation of Dispersion Coefficient and particle Density Bacterial [15.5/1.15]	Experimental Values of Conc. [Mg/l] Variation of Dispersion Coefficient and Particle Density Bacterial [15.5/1.15]
2	14.789	14.56392
4	14.11061	13.91136
6	13.46334	13.28184
8	12.84576	12.67488
10	12.25651	12.09
12	11.69429	11.52672
14	11.15786	10.98456
16	10.64604	10.46304
18	10.15769	9.96168
20	9.691748	9.48
22	9.247177	9.01752
24	8.822998	8.57376
26	8.418278	8.14824
28	8.032122	7.74048
30	7.663679	7.35
32	7.312138	6.97632
34	6.976722	6.61896
38	6.351342	5.95128
40	6.059999	5.64
42	5.78202	5.34312
44	5.516792	5.06016
46	5.263731	4.79064
48	5.022277	4.53408
50	4.7919	4.29
54	4.362363	3.83736
56	4.162257	3.62784
58	3.971329	3.42888
60	3.78916	3.24
62	3.615347	3.06072
64	3.449507	2.89056
66	3.291274	2.72904
68	3.1403	2.57568
70	2.996251	2.43
72	2.858809	2.29152
74	2.727673	2.15976
76	2.602551	2.03424
78	2.483169	1.91448
80	2.369264	1.8
82	2.260583	1.69032
84	2.156887	1.58496
86	2.057948	1.48344
88	1.963548	1.38528
90	1.873478	1.29

Citation: Ezeilo FE, Eluozo SN. Mathematical Modeling of Dispersion Coefficient and Particle Density Bacterial Influence on *Campylobacter spp* Transport In Surface Water Environment. Tr Civil Eng & Arch 4(2)- 2021. TCEIA.MS.ID.000182. DOI: 10.32474/TCEIA.2021.04.000182.

Table 6: Predictive and Experimental Values of *Campylobacter* Concentration at Different Distance.

Distance [x]	Predictive Values Conc. [Mg/L] Variation of Dispersion Coefficient and particle Density Bacterial [13.20/1.13]	Experimental Values of Conc. [Mg/l] Variation of Dispersion Coefficient and Particle Density Bacterial [13.20/1.13]
2	12.58403842	14.208
4	11.99681992	13.734
6	11.43700325	13.268
8	10.90330972	12.81
10	10.39452034	12.36
12	9.909472976	11.918
14	9.447059747	11.484
16	9.006224457	11.058
18	8.585960197	10.64
20	8.185307046	10.23
22	7.803349876	9.828
24	7.439216262	9.434
26	7.09207449	9.048
28	6.761131657	8.67
30	6.44563186	8.3
32	6.144854468	7.938
34	5.858112479	7.584
38	5.324145492	6.9
40	5.075700867	6.57
42	4.8388496	6.248
44	4.613050704	5.934
46	4.397788431	5.628
48	4.192571105	5.33
50	3.996929991	5.04
54	3.632609799	4.484
56	3.463098582	4.218
58	3.301497395	3.96
60	3.147437126	3.71
62	3.000565889	3.468
64	2.860548214	3.234
66	2.727064291	3.008
68	2.599809228	2.79
70	2.478492365	2.58
72	2.362836602	2.378
74	2.252577772	2.184
76	2.147464032	1.998
78	2.047255295	1.82
80	1.951722673	1.65
82	1.860647963	1.488
84	1.77382314	1.334
86	1.69104989	1.188
88	1.612139151	1.05
90	1.536910683	0.92

Conclusion

The study of *Campylobacter* transport in surface water environment has been carried out applying modeling and simulation; the study expressed the behaviour of the *Campylobacter* transport in terms of influence from dispersion coefficient and particle densities of the bacterial in study area. The application of one dimensional flow system monitored the rate of migration at different point source of discharge, these are based on the predominant parameters that was monitored in the surface water environment, despite the application of one dimensional flow transport system, the dispersions in various location of discharge was examined to determine its rates of concentration at different station point of discharge, the dispersion on the contaminant are basically from the heterogeneity of the velocities that experience variations in various point sources, this condition examined affected the concentration of the contaminant in these stations point of discharge, the variation level of concentration were observed to experience some negative impact on it decrease with respect to change in distance, while that of the particle densities of the bacterial was through transient frequencies, while another was through a microfluidic channel of flow in surface water, thus the distribution of the population in heterogeneous size particles based on difference carrier fluids. These were also affected based on the heterogeneous velocities of surface water flows at different station point, these two predominant parameters examined has expressed in detail there impacts on the decrease of the contaminant with respect to change in distance, the study has definitely determined the impacts of these two parameters in *Campylobacter* transport in surface water environment.

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DOI: 10.32474/TCEIA.2021.04.000182

Citation: Ezeilo FE, Eluozo SN. Mathematical Modeling of Dispersion Coefficient and Particle Density Bacterial Influence on *Campylobacter spp* Transport In Surface Water Environment. Tr Civil Eng & Arch 4(2)- 2021. TCEIA.MS.ID.000182. DOI: 10.32474/TCEIA.2021.04.000182.