

Research article

MODEL PREDICTION ON ARSENIC MIGRATION IN HOMOGENEOUS VOID RATIO PENETRATING UNCONFINED BED IN OBIO-AKPOR, RIVERS STATE OF NIGERIA

Eluozo, S. N¹ and Afiibor, B.B²

¹Subaka Nigeria Limited, Port Harcourt, Rivers State of Nigeria
Director & Principal Consultant, Civil & Environmental Engineering,
Research & Development

E-mail: Soloeluzo2013@hotmail.com

E-mail: solomoneluzo2000@yahoo.com

²Department of Mathematics and Computer Science
Rivers State University of Science and Technology, Nkpolu Port Harcourt

E-mail: afiibor4bony@yahoo.com

Abstract

Predicting the rate of concentration and migration of arsenic at various formations were methods of monitoring and evaluation of arsenic concentration in the study area. The rate of pollution from arsenic deposition has cause lots of unhealthy environmental conditions polluting soil and water environments. Such situation has generated lots of ill health generating and numerous deaths; the investigation was carried out previously, but could not provide any better solution, several recorded ill health calls for serious concern, thorough investigation on comprehensive level were carried out, predominant arsenic was discovered, homogeneous void ratio were confirmed to predominantly deposit in the study area. The rate of concentration were represented graphically expressing rapid increase of arsenic in all the figures, this conditions implies that homogeneous void ratio percentage are very high where the micropores deposited through the level of disintegration from the porous predominant deposited porous rocks in the deltaic formations. Predictive model from expressed equation were generated and resolved, it produces theoretical values, the data were compared with experimental values, both parameters compared favourably well expressing model validation for the study environment

Keywords: model prediction, arsenic migration, homogenous void ratio and unconfined bed

Introduction

The soil surface is subjected to vast inputs of energy from rainfall, runoff, wind, and solar radiation as well as a wide range of human and biotic inputs. Some of this energy is intercepted and absorbed by plants that use solar energy, soil nutrients, and atmospheric carbon for photosynthesis. By contrast with plants, soil is incapable of absorbing the large energy fluxes in a constructive manner and when the soil surface is exposed, the results can be highly degrading. Particularly in the case of energy from rainfall and runoff causing water erosion, the operative processes are destructive, both to soil structure, and to its capacity to sustain biomass growth (Lal, 1998; Starr et al 2000). Rainfall impact and the shearing forces of runoff disintegrate soil aggregates (Yoder, 1936; Le Bissonnais and Arrouays, 1997) and transport fertile topsoil along with plant nutrients and organic matter away from eroded soil landscapes (Rogers, 1941; Massey and Jackson, 1952; Lal, 1980; Zebisch, et al., 1995; Starr et al 2000). Some of the soil, nutrients, and organic carbon are redistributed across the landscape and some are transferred to aquatic ecosystems (Lal, 1995; Stallard, 1998), where they contribute to eutrophication (Vezejak, et al., 1998; Frielinghaus and Vahrson, 1998), anoxia (Vezejak, et al., 1998), turbidity (Wass, et al., 1997; Riley, 1998), greenhouse gas emissions (Lal, 1995), and general water quality degradation before a part of them are eventually stored in sediments. The role of soil organic carbon (SOC) in stabilizing aggregates (Tisdall and Oades, 1982; Elliott, 1986; Kay, 1998) and thereby reducing the susceptibility to erosion (Yoder, 1936; Piccolo, et al., 1997) is fairly well established. Improved aggregate stability is but one of the many positive aspects of sequestering carbon in soil that also include reduced greenhouse gasses in the atmosphere and improved soil quality (Lal, 1997). These qualities have led to serious consideration of managing arable lands for soil carbon sequestration (Sharpenseel, 1997; Lal, et al., 1998a, b). Given the intense interest of both scientists and policy makers in SOC sequestration, it is important to improve the cursory and qualitative understanding of the principal factors and processes that affect its rate and magnitude within soil and terrestrial/aquatic ecosystems. An example of such a process with poorly understood implications for the pools and fluxes of carbon is accelerated soil erosion Starr et al 2000.

2. Materials and method

Soil samples from several different borehole locations, were collected at intervals of two and three metres each (2- 3m). Soil sample were collected in five different locations, applying insitu method of sample collection, the soil sample were collect for analysis, standard laboratory analysis were collected to determine the rate of deposition at various formation, the result were analyzed to determine the rate of arsenic concentration between the unconfined bed through column experiment in the study area.

3. Results and Discussion

Results and discussion from the expressed figures through the theoretical generated values are presented in tables and figures, the expression explain the rate of concentration through graphical representation for every condition assessed in the developed model equations.

Table: 1 Comparison of predictive and experimental values of Arsenic at Different Depths

Depths [M]	Predictive Values	Experimental values
3	11.43	12.66

6	23.94	24.44
9	36.45	34.66
12	48.97	49.88
15	61.48	60.99
18	73.99	73.88
21	86.5	86.88
24	99.02	98.34
27	111.52	112.21
30	124.04	123.67

Table: 2 Comparison of predictive and experimental values of Arsenic at Different Time

Time [Per Day]	Predictive Values	Experimental values
10	12.42	12.66
20	23.93	24.44
30	36.41	34.66
40	48.96	49.88
50	61.46	60.99
60	73.97	73.88
70	86.49	86.88
80	98.99	98.34
90	111.51	112.21
100	124.01	123.67

Table: 3 Comparison of predictive and experimental values of Arsenic at Different Depths

Depths [M]	Predictive Values	Experimental values
3	11.69	12.66
6	23.83	24.44
9	36.61	34.66
12	49.07	49.88
15	61.53	60.99
18	73.99	73.88
21	86.44	86.88
24	98.91	98.34
27	113.36	112.21
30	123.82	123.67

Table: 4 Comparison of predictive and experimental values of Arsenic at Different Time

Time [Per Day]	Predictive Values	Experimental values
----------------	-------------------	---------------------

10	11.68	12.66
20	24.13	24.44
30	36.58	34.66
40	49.03	49.88
50	61.48	60.99
60	73.93	73.88
70	86.38	86.88
80	102.23	98.34
90	115.03	112.21
100	127.83	123.67

Table: 5 Comparison of predictive and experimental values of Arsenic at Different Time

Time [Per Day]	Predictive Values	Experimental values
10	12.63	12.66
20	25.43	24.44
30	38.23	34.66
40	51.03	49.88
50	63.83	60.99
60	76.63	73.88
70	89.43	86.88
80	102.23	98.34
90	115.03	112.21
100	127.83	123.67

Table: 6 Comparison of predictive and experimental values of Arsenic at Different Depths

Depths [M]	Predictive Values	Experimental values
2	2.31	2.22
4	4.85	4.88
6	7.39	7.55
8	9.93	9.44
10	12.47	12.66
12	15.01	14.45
14	17.55	17.66
16	20.09	21.11
18	22.63	22.66
20	25.17	25.88

Table: 7 Comparison of predictive and experimental values of Arsenic at Different Depths

Time Per Day	Predictive Values	Experimental values
2	2.31	2.22
4	4.85	4.88
6	7.39	7.55
8	9.93	9.44
10	12.47	12.66
12	15.01	14.45
14	17.55	17.66
16	20.09	21.11
18	22.63	22.66
20	25.17	25.88

Table: 8 Comparison of predictive and experimental values of Arsenic at Different Depths

Depths [M]	Predictive Values	Experimental values
2	2.11	2.40E+00
4	4.73	4.98E+00
6	7.35	7.47E+00
8	9.96	9.96E+00
10	12.58	1.25E+01
12	15.19	1.49E+01
14	17.81	1.74E+01
16	20.04	2.24E+01
18	23.04	2.24E+01
20	25.66	2.61E+01

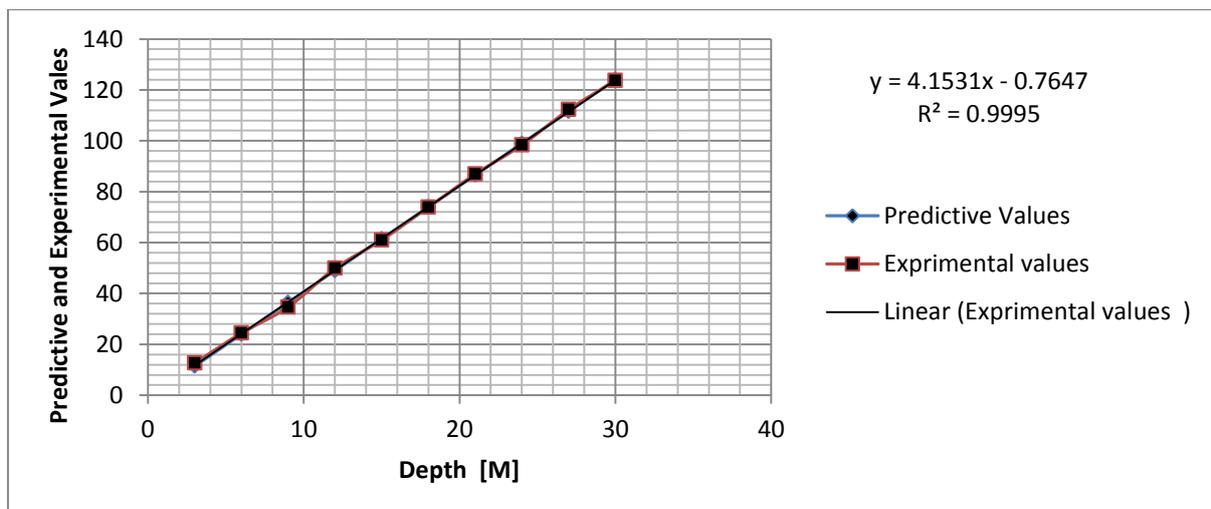


Figure 1: Comparison of predictive and experimental values of Arsenic at Different Depths

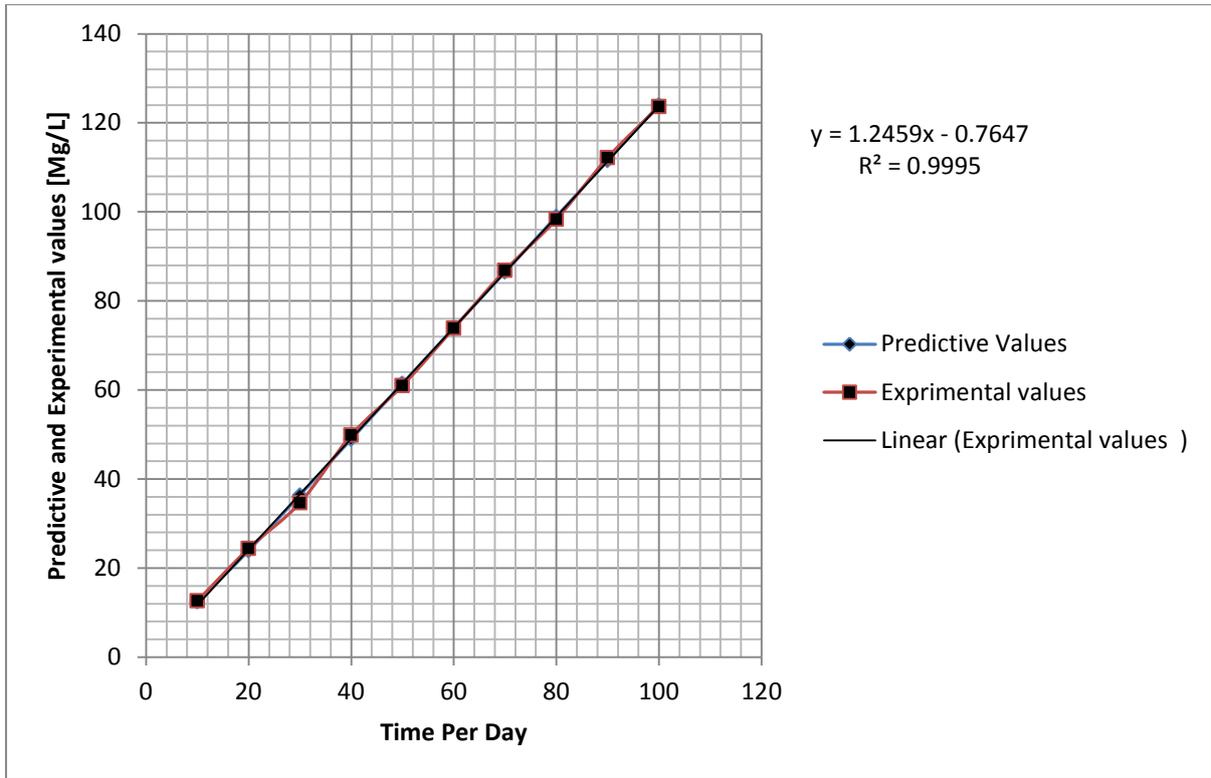


Figure 2: Comparison of predictive and experimental values of Arsenic at Different Time

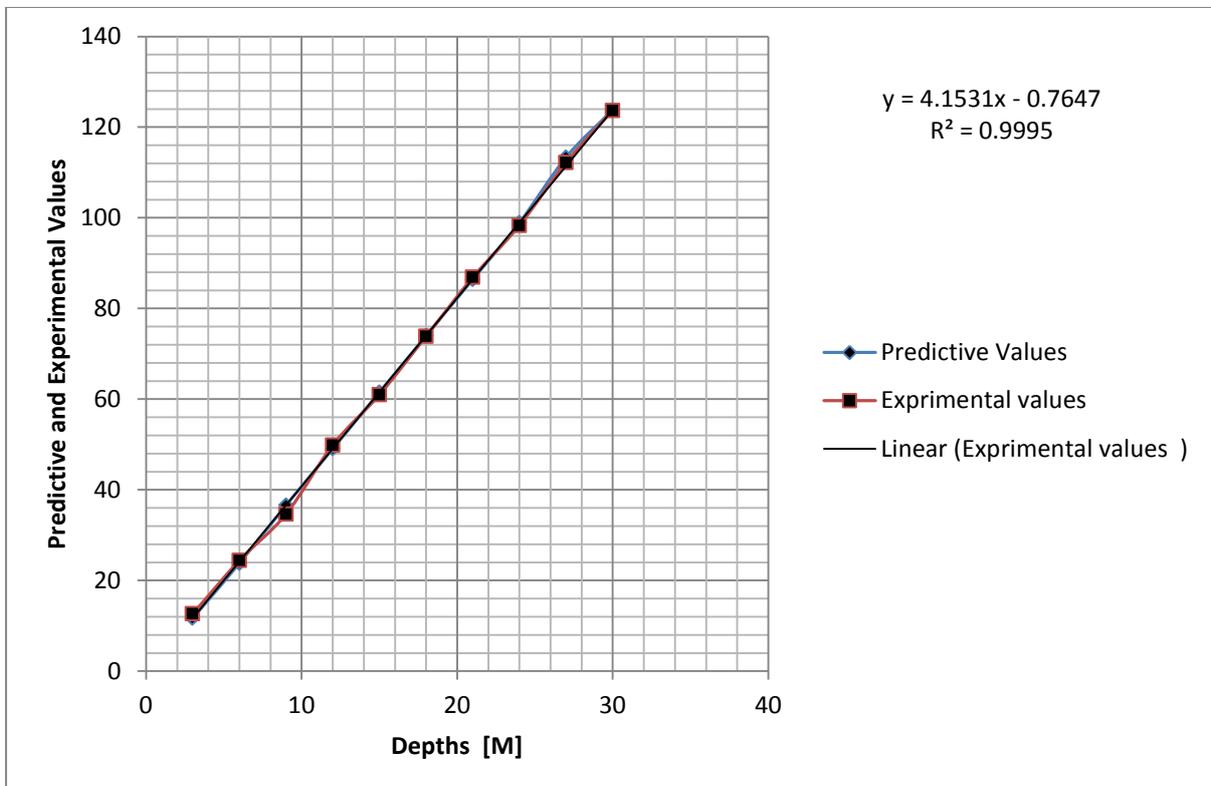


Figure 3: Comparison of predictive and experimental values of Arsenic at Different Depths

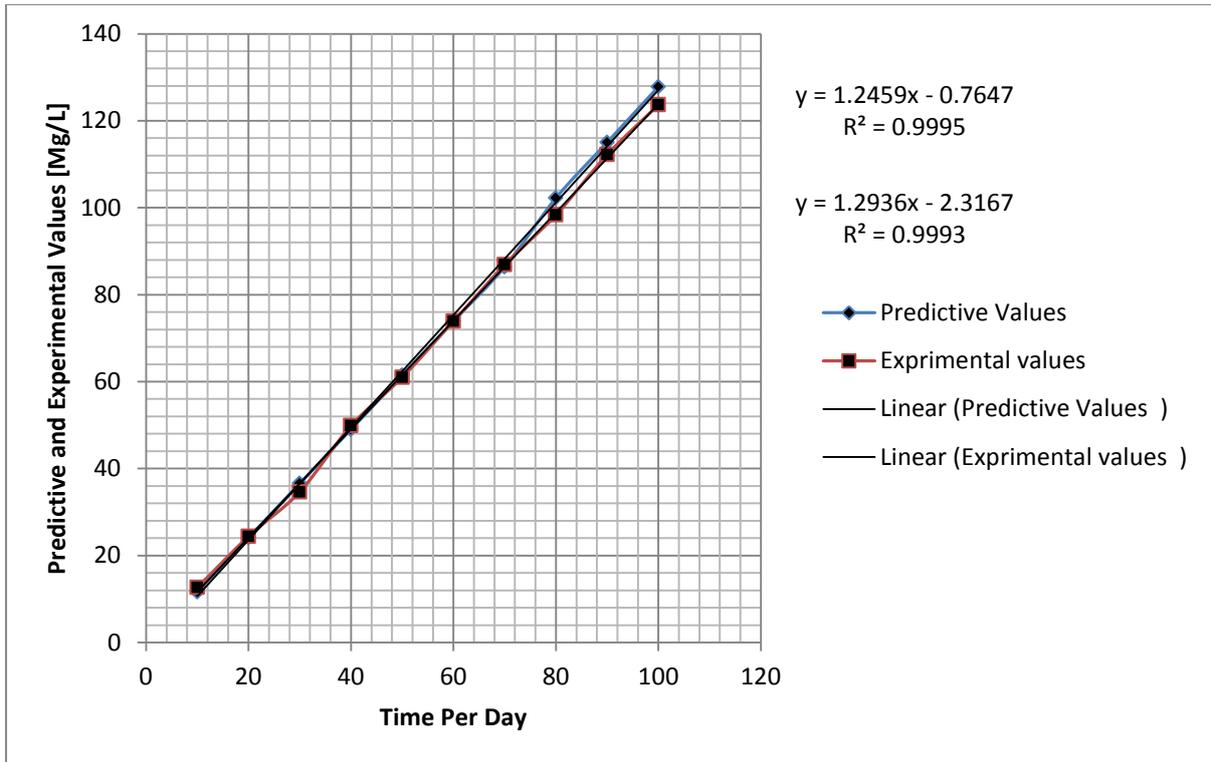


Figure 4: Comparison of predictive and experimental values of Arsenic at Different Time

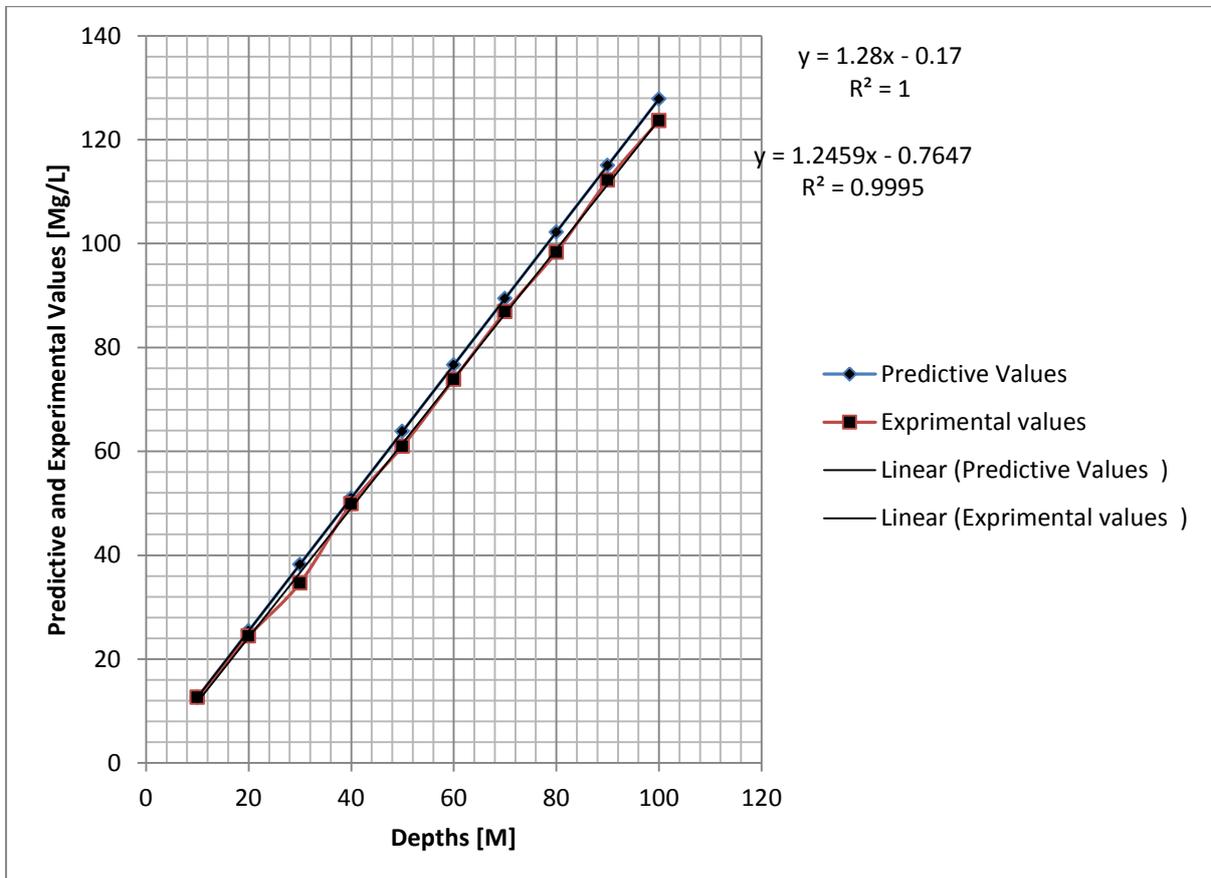


Figure 5: Comparison of predictive and experimental values of Arsenic at Different Depths

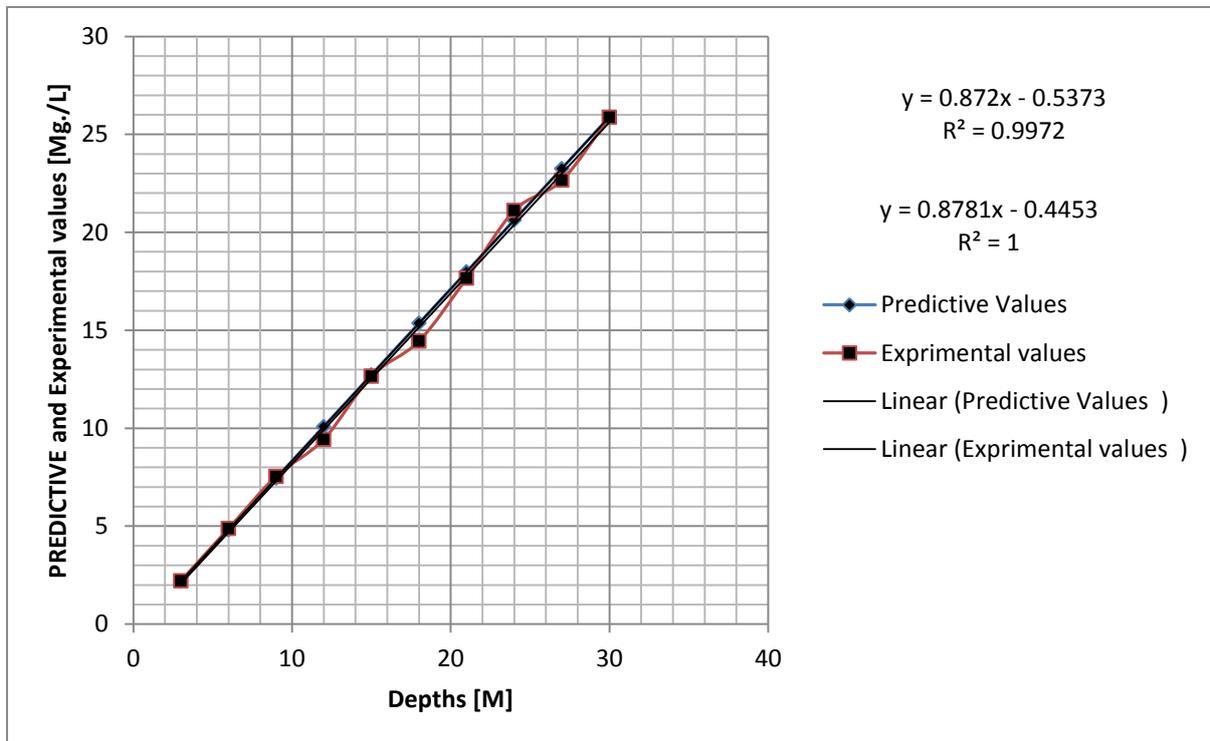


Figure 6: Comparison of predictive and experimental values of Arsenic at Different Depths

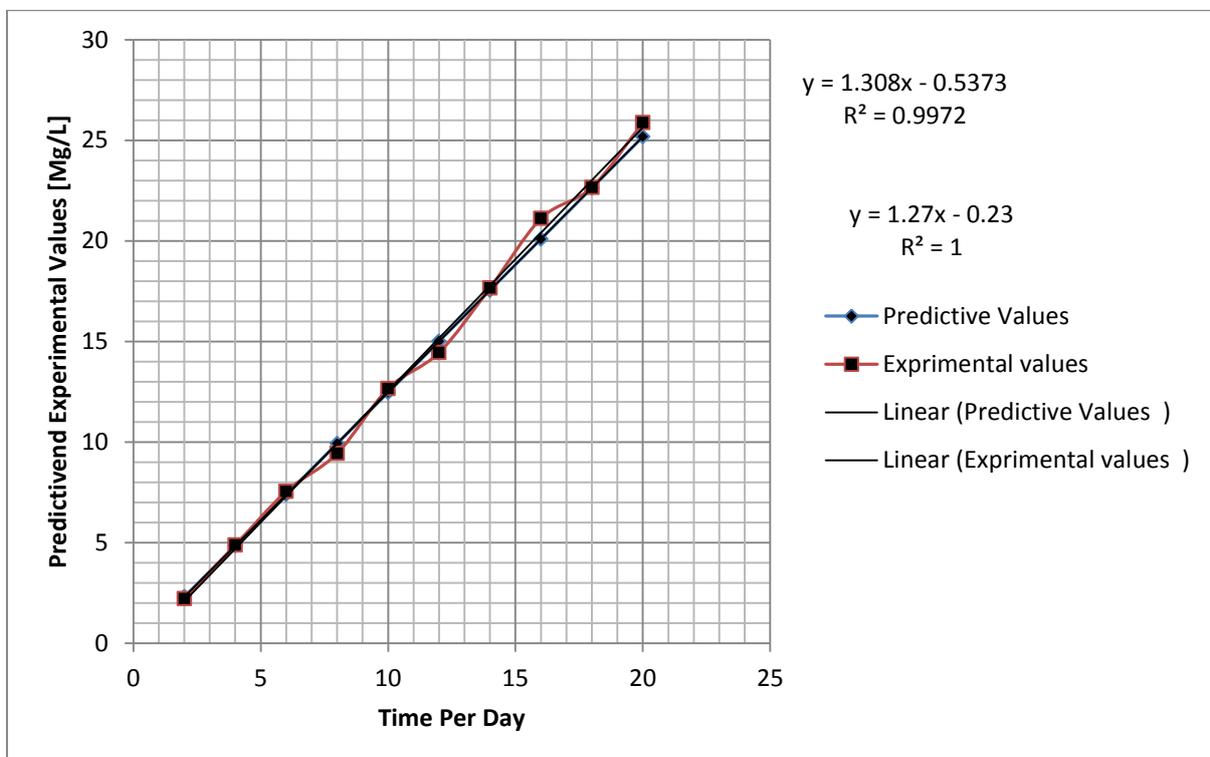


Figure 7: Comparison of predictive and experimental values of Arsenic at Different Time

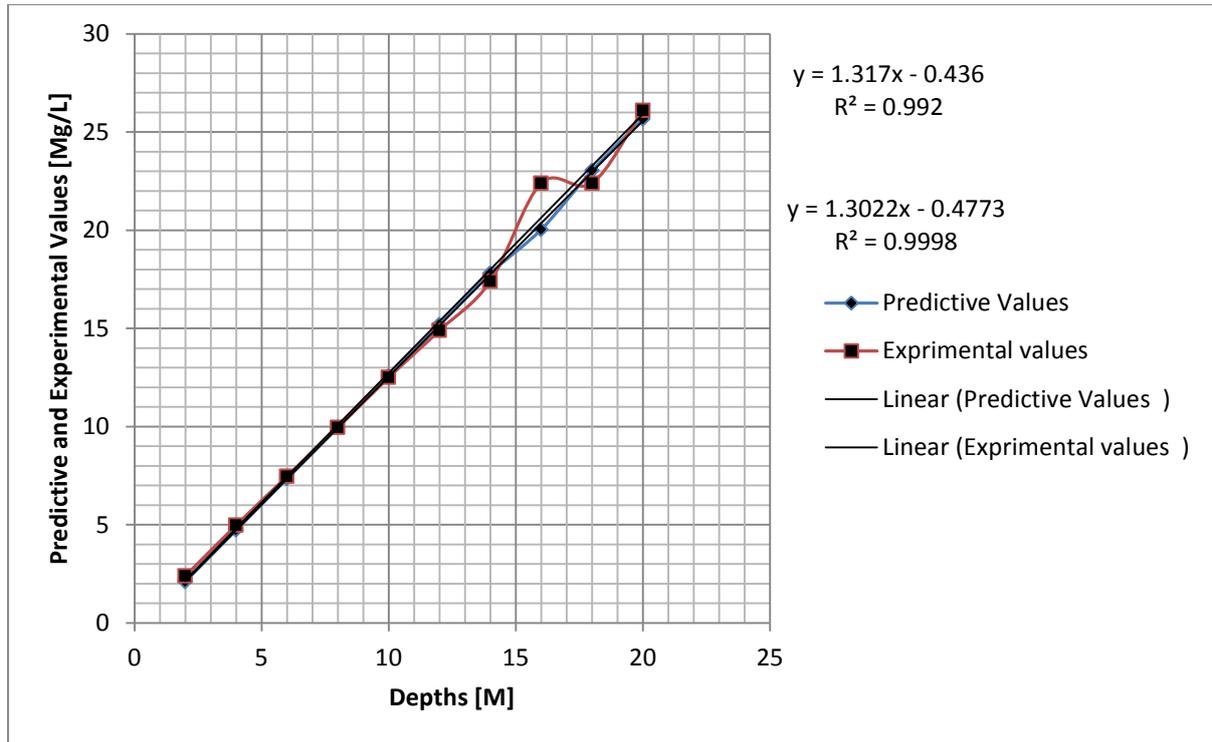


Figure 8: Comparison of predictive and experimental values of Arsenic at Different depths

Figure [1-8] shows that the concentration maintained progressive phase condition as expressed in graphical representation stated above in the study location, they are influenced by manmade activities, such condition were found to rapidly increase the deposition of arsenic, investigation carried out from risk assessment previously shows how the rapid rate of arsenic concentration were predominant in the study location, previous investigation could not provide solution to manage the contaminant polluting soil and water environment, thorough investigation was later carried out to monitor the rate of deposition and migration of arsenic in the study environment, the figures expression are influenced by these stated manmade activities, formation deposition influences was also found to pressure rapid increase of the concentration in the strata, such condition in deltaic formation implies that migration of arsenic has several pressure to accumulate within the porous medium, these situation has no doubt pollute soil and water in the environment causing serious harm to human in the study area, the experimental investigation shows the rate of arsenic concentration in aquiferous zone under the influences of homogeneous high degree of void ratio in the strata. This condition need serious attention to be addressed to avoid further pollution in the formation, the express figures generated model equations that were resolved, this derived solution produced theoretical values that were compared with other experimental data in the study area, both parameters developed a favourable fits validating the expressed model from the study environment.

4. Conclusion

The deposition of arsenic has create serious ill health in the study environment, the deposition of arsenic were investigated through risks assessment in the study area, analysis from the study location were not able to provide

solution that will prevent the spread of the contaminants, such condition call for serious concern, since the contaminants are rapidly increasing in the study environment, these factors call for thorough investigation that were able to intensively study the rate of deposition and migration of these contaminants, the study generate results on the rates of concentration at different time and depths, the values produced model equations that were thoroughly expressed to produced theoretical values for several locations, to validated the developed model, comparison with other experimental values was found necessary, both parameters were compared, and it provides favourable fits, these conditions implies that the expressed model equation can be applied for model prediction in the study environments, experts will definitely fine favour by using this conceptual tools for predicting arsenic concentration in the study area.

References

- [1] Frielinghaus, M. and Vahrson, W.-G. 1998. 'Soil translocation by water erosion from agricultural cropland into wet depressions (morainic kettle holes)', *Soil and Tillage Research*, 46, 23±30.
- [2] Lal, R. 1995. Global soil erosion by water and carbon dynamics, in pp. 131±142, R. Lal, J. Kimble, E. Levine and B. A. Stewart (eds.), *Soil Management and Greenhouse Effect*, CRC/Lewis, Boca Raton, FL.
- [3] Lal, R. 1997. 'Residue management, conservation tillage and soil restoration for mitigating greenhouse effect by CO₂-enrichment', *Soiland Tillage Research*, 43, 81±107.
- [4] Lal, R. 1998. 'Soil erosion impact on agronomic productivity and environment quality', *Critical Review of Plant Science*, 17, 319±464.
- [5] Lal, R., Kimble, J. and Follett, R. 1998a. Need for research and need for action, pp. 447±454, in R.
- [6] Lal, J. M. Kimble, R. F. Follett and B. A. Stewart (eds.), *Management of Carbon Sequestration in Soil*, CRC Press, Boca Raton,
- [7] FL.Lal, R., Kimble, J. and Follett, R. 1998b. Land use and soil C pools in terrestrial ecosystems, pp. 1±10, in R
- [8] Lal, J. M. Kimble, R. F. Follett and B. A. Stewart (eds.), *Management of Carbon Sequestration in Soil*, CRC Press, Boca Raton, FL.
- [9] Massey, H. F. and Jackson, M. L. 1952. 'Selective erosion of soil fertility constituents', *Soil Science Society of America Proceedings*, 16, 353±356.
- [10] Piccolo, A., Pietramellara, G. and Mbagwu, J. S. C. 1997. 'Reduction in soil loss from erosion-susceptible soils amended with humic substances from oxidized coal', *Soil Technology*, 10, 235±245.
- [11] Stallard, R. F. 1998. 'Terrestrial sedimentation and the carbon cycle: coupling weathering and erosion to carbon burial', *Global Biogeochemical Cycles*, 12, 231±257.
- [12] Tisdall, J. M. and Oades, J. M. 1982. 'Organic matter and water-stable aggregates in soils', *Journal of Soil Science*, 33, 141±163. Van Veen, J. A. and Paul, E. A. 1981. 'Organic carbon dynamics in grassland soils. I. Background information and mathematical simulation', *Canadian Journal of Soil Science*, 61, 185±201.
- [13] Wass, P. D., Marks, S. D., Finch, J. W., Leeks, G. J. L. and Ingram, J. K. 1997. 'Monitoring and preliminary interpretation of in-river turbidity and remote sensed imagery for suspended sediment transport studies in the Humber catchment', *Science of Total Environment*, 194±195; 263±283.

- [14] Yoder, R. E. 1936. 'A direct method of aggregate analysis and a study of the physical nature of erosion losses', *Journal of the American Society of Agronomy*, 28, 337±351.
- [15] Zobisch, M. A., Richter, C., Heiligtag, B. and Schlott, R. 1995. 'Nutrient losses from cropland in the central highlands of Kenya due to surface runoff and soil erosion', *Soil and Tillage Research*, 33, 109±116.
- [16] Riley, S. J. 1998. 'The sediment concentration-turbidity relation: its value in monitoring at Ranger Uranium Mine, Northern Territory, Australia', *Catena*, 32, 1±14.
- [17] Kay, B. D. 1998. Soil structure and organic carbon: a review, pp. 169±198 in R. Lal, J. M. Kimble, R. F. Follett and B. A. Stewart (eds.), *Soil Processes and the Carbon Cycle*, CRC Press, Boca Raton, FL.
- [18] Elliott, E. T. 1986. 'Aggregate structure and carbon, nitrogen, and phosphorus in native and cultivated soils', *Soil Science Society of America Journal*, 50, 627±633.
- [19] Le Bissonnais, Y. and Arrouays, D. 1997. 'Aggregate stability and assessment of soil crustability and erodibility: II. Application to humic loamy soils with various organic carbon content', *European Journal of Soil Science*, 48, 39±48.
- [20] Rogers, H. T. 1941. 'Plant nutrient losses by erosion from a corn, wheat, clover rotation on dunmore silt loam', *Soil Science Society of America Proceedings*, 6, 263±271.
- [21] Starr, G. C. Lal, R. Malone, R. Hothem, Dowens, . L. and Kimble J 2000; modeling soil carbon transported by water erosion processes land degradation & development land degrad. develop. 11: 83±91