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Research article

PREDICTIVE MODEL TO MONITOR THE DEPOSITION OF COPPER AND ENTERIC VIRUS ON RETARDATION PHASE IN HOMOGENEOUS FINE SAND IN ELEME, RIVERS STATE OF NIGERIA

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Abstract

Predicting the rate of copper deposition and enteric virus in the study environment has been thoroughly expressed, the model were derived through the formulated system that produced the governing equation, the study locations were found to predominantly deposit copper and enteric virus in the study environment, high deposition of porosity were the highest influential parameter considered in the study due to the geological formation of the study area. Such condition was examined to ensure that all the parameters that influence the migration process are considered in the derived model for the study. The rate of migration were found to be pressured by predominant formation characteristics, the pressure from porosity varies base on the rate of its deposition in the strata. The developed model were in phase, this is base on the geological setting including the behaviour of the microbes in the formation, since the parameters rates of concentration are determined by the structural stratification and level of contaminants generation in the study environment, experts will definitely find faivoured on the developed model as it can be applied to monitor the rate of rapid increase and deposition of the contaminants in the study area

Keywords: Predictive model copper and enteric virus, retardation phase, homogeneous fine sand

1. Introduction

Metals contamination is a persistent problem at many contaminated sites. In the U.S., the most commonly occurring metals at Superfund sites are lead, chromium, arsenic, zinc cadmium, copper, and mercury. The presence of metals in groundwater and soils can pose a significant threat to human health and ecological systems. The chemical form of the metal contaminant influences its solubility, mobility, and toxicity in ground-water systems. The chemical form of metals depends on the source of the metal waste and the soil and ground -water chemistry at the site. A detailed site characterization must be performed to assess the type and level of metals present and allow evaluation of remedial alternatives. A number of the available technologies have been demonstrated in full-scale applications and are presently commercially available. A comprehensive list of these technologies is available (U.S. EPA, 1996a). Several other technologies are being tested for application to metals-contaminated sites Treatment of metals contaminated groundwater has typically involved flushing and aboveground treatment, while treatment of contaminated solids most often has been performed by excavation followed by ex situ treatment or disposal. The most common ex situ treatment for excavated soils is solidification/stabilization. Soil consists of a mixture of weathered minerals and varying amounts of organic matter. Soils can be contaminated as a result of spills or direct contact with contaminated waste streams such as airborne emissions, process solid wastes, sledges, or leachate from waste materials. The solubility of metals in soil is influenced by the chemistry of the soil and ground water (Sposito, 1989; Evans, 1989). Factors such as pH, Eh, ion exchange capacity, and complexation/chelation with organic matter directly affect metal solubility. Surface water and groundwater may be contaminated with metals from wastewater discharges or by direct contact with metals-contaminated soils, sludge's, mining wastes, and debris. Metal-bearing solids at contaminated sites can originate from a wide variety of sources in the form of airborne emissions, process solid wastes, sludges or spills. The contaminant sources influence the heterogeneity of contaminated sites on a macroscopic and microscopic scale. Variations in contaminant concentration and matrix influence the risks associated with metal contamination and treatment options. Most published research reports have been focused on bioreduction of U(VI) by various microbial cultures at laboratory scale (e.g., Lovley et al., 1991; Lovley and Phillips, 1992a,b; Gorby and Lovley, 1992; Ganesh et al., 1997; Truex et al., 1997; Abdelouas et al., 1998; Fredrickson et al., 2000; Fredrickson et al., 2002; Holmes et al., 2002). Kinetics have been analyzed for defined or mixed cultures in laboratory (e.g., Liger et al., 1999; Spear et al., 1999, 2000). Under field conditions, U(VI) undergoes hydrological, geochemical, and biological processes in complex interaction, such as sorption/desorption, advective-dispersive transport, and microbial transformations. Uranium sorption/desorption is significantly influenced by bicarbonate concentrations and pH (Waite et al., 1994; Wazne et al., 2003). At the sorption sites, uranium competes with other ions. Since the geochemical environment may vary over the course of the experiment, simplified approaches to model U(VI) sorption, such as the assumption of a linear retardation factor, appear insufficient (Bain et al., 2001). For bioreduction of U(VI), nitrate, Fe (III) and sulfate serve as competing electron acceptors which should be considered in the simulations (e.g., Wielinga et al., 2000; North et al., 2004; Wu et al., 2005). In the presence of significant calcium concentrations, the highly stable but poorly biodegradable calcium–

uranyl– carbonate complexes should also be included in the simulation (Bernhard et al., 1996; Kalmykov and Choppin, 2000; Bernhard et al., 2001; Brooks et al., 2003).

2. Theoretical background

Risk assessment is the process of estimating the potential impact of a chemical, physical, microbiological or psychosocial hazard on a specified human population or ecological system under a specific set of conditions and for a certain timeframe. Risk assessment is intended 'to provide complete information to risk managers, specifically policymakers and regulators, so that the best possible decisions are made' (Paustenbach, 1989,). There are uncertainties related to risk assessment and it is important to make the best possible use of available information. Risk assessment may be done as a relatively rapid 'desk top' study for simple issues or may be a large and complex process where there are significant health concerns. There are numerous models of risk assessment to suit the many contexts in which risk assessments are undertaken. Even limited measures of the level of risk can be valuable for identifying complex cause and effect processes and the most efficient means of addressing the risks. It is important that assessors, users, regulators and members of the public recognize risk assessment may not always provide a compelling or definitive outcome. The deposition of copper in the environment in most cases develop negative impact of in the environments, in most condition it is normal due to improper management of the substance that develop several negative impact, therefore it is necessary to assess and monitor the rate of concentration of the substances, this substances and enteric virus were found to be predominant deposited in the study environment, both contaminants in the formation were found in the study location, this investigation were carried out through risk assessment, but this assessment could not develop effective solution, the deposition of copper and enteric virus at different direction predominantly deposit in the study environment are base on high deposition of porosity through formation characteristics observed in the study area. The direction of deposition are base on the pressure from high percentage of porosity, the parameters were found migrating base on the influences from this formation characteristics, various location deposit different variables of both parameters it will definitely reflect on the concentration of the contaminants in the system. therefore the deposition of both parameters generates different direction, but may have merge on the transportation process , the tendency of concentration fluctuating between both parameters may exhibits inhibition depending on the parameters that deposition more concentration, the developed model examined this condition as produced the derived principal equation to monitor this two direction of flow.

3. Governing equation

Nomenclature

R	=	Retardation factor [-]
C	=	Concentration of Enteric virus [cm^3/m]
D	=	Hydrodynamic Dispersion [cm^2/m]
V	=	Velocity [cm^2/sec]
μ	=	Copper [cm^3/m]

T = Time [T]

X = Distance [M]

ϕ = Porosity [-]

$$R\frac{\partial c}{\partial t} = D\phi\frac{\partial^2 c}{\partial y^2} - V\frac{\partial c}{\partial x} - \mu c\frac{\partial c}{\partial y} + \lambda(x,y) \qquad \text{……………………………} \quad (1)$$

The expression in [1] is the governing equation; the developed mathematical expression was to monitor two different contaminants at different direction of flow, there deposition and migration process of the two parameters were found to be influenced by porosity of the formation influences, the migration of enteric virus and copper in the strata can be expressed through the stated equation , the developed governing equation will be derived to generate model that will monitor the deposition of both parameters in the study area.

$$R\frac{\partial c}{\partial t} = D\phi\frac{\partial^2 c}{\partial y^2} = \lambda(x,y) \qquad \text{…………………………..} \ (2)$$

Let $C = TX$

$$\frac{\partial c}{\partial t} = T^1 X \qquad \text{…………………………..} \ (3)$$

$$\frac{\partial c}{\partial y} = TY^{11} \qquad \text{…………………………..} \ (4)$$

$$\phi T^1 + D\phi TY^{11} = \lambda \qquad \text{…………………………..} \ (5)$$

$$\phi\frac{T^1}{T} = \lambda \qquad \text{…………………………..} \ (6)$$

$$D\phi\frac{Y^{11}}{Y} = \lambda \qquad \text{…………………………..} \ (7)$$

From (6), $R\frac{dT}{T} = \lambda dt$ ………………………….. (8)

$$\int\frac{dT}{T} = \int\frac{\lambda}{f}dt \qquad \text{…………………………..} \ (9)$$

$$LnT = \frac{\lambda}{f}t + a_1 \qquad \text{…………………………..} \ (10)$$

$$T = \ell^{\frac{\lambda}{f}t + a_1} \qquad \text{.............................. (11)}$$

$$T = C_1 \ell^{\frac{\lambda}{f}t} \qquad \text{.............................. (12)}$$

$$D\phi \frac{dy}{y} = \lambda dy \qquad \text{.............................. (13)}$$

$$\int \frac{dy}{y} = \int \frac{\lambda}{D\phi} dy \qquad \text{.............................. (14)}$$

$$LnY = \frac{\lambda}{D\phi} y + a_2 \qquad \text{.............................. (15)}$$

$$Y = \ell^{\frac{\lambda}{D\phi}x + a_2} \qquad \text{.............................. (16)}$$

$$Y = C_2 \ell^{\frac{\lambda}{D\phi}y} \qquad \text{.............................. (17)}$$

But $C = TX$

$$C_1 = C_1 \ell^{\frac{\lambda}{D\phi}t} \bullet C_2 \ell^{\frac{\lambda}{D\phi}y} \qquad \text{.............................. (18)}$$

$$C_1 = C_1 C_2 \ell^{\left(\frac{t}{R} + \frac{\lambda}{D\phi}\right)\lambda} \qquad \text{.............................. (19)}$$

$$C_1 = C \ell^{\left(\frac{t}{R} + \frac{y}{D\phi}\right)\lambda} \qquad \text{.............................. (20)}$$

The tendency of migration in the overdose zone of the formations were call for concern, influences from the unsaturated were microbial activities may be more active depending on the condition of the formation, but at this phase of the transport system the condition of the substances and the microbes were found to deposit rapidly at the overdose zone in the system the expressed model in [20] are derived to monitor this condition in the stated sources.

$$R\frac{\partial c}{\partial t} = -V\frac{\partial c}{\partial x} \qquad \text{........... (2)}$$

Let $C = TX$

$$\frac{\partial c}{\partial t} = T^1 X \qquad \text{.............................. (21)}$$

$$\frac{\partial c}{\partial x} = TX^1 \qquad \text{.............................. (22)}$$

$$RT^1 X + VTX^1 = \lambda^2 \qquad \text{.............................. (23)}$$

Let $\frac{RT^1}{T} = V\frac{X^1}{X} = -\lambda^2$ .... (24)

$$\int \frac{dT}{T} = \int \frac{P^2}{R} dt \qquad \text{.............................. (25)}$$

$$LnT = -\frac{P^2}{R} t + a_3 \qquad \text{.............................. (26)}$$

$$T = \ell^{-\frac{P^2}{R} t + a_3} \qquad \text{.............................. (27)}$$

$$Y = C_3 \, \ell^{\frac{-P^2}{R} t} \qquad \text{.............................. (28)}$$

$$\frac{VX^1}{X} = -P^2 \qquad \text{.............................. (29)}$$

$$\frac{dx}{dx} + \frac{P^2}{V} x = 0 \qquad \text{.............................. (30)}$$

Auxiliary equation is

$$M^2 + \frac{P^2}{V} = 0 \qquad \text{.............................. (31)}$$

$$M = \pm i \frac{P}{V} \qquad \text{.............................. (32)}$$

$$X = ACos \frac{P}{\sqrt{V}} x + BSin \frac{P}{\sqrt{V}} y \qquad \text{.............................. (33)}$$

Combine (23) and (32), we have

$$C_2 = TX$$

$$\boxed{C_2 = C_3\, \ell^{-\frac{P^2}{R}t} \left(ACos\,\frac{P}{\sqrt{V}}t \;+\; ASin\frac{P}{\sqrt{V}}x \right)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (34)$$

The expressed model in [34] establish the deposition of the contaminants condition and its migration found in degrading the microbes , it is base on several influences, such condition that will first call to mind is change in concentration with respect to distance and depth of the soil formation, the rate of concentration may found to reduces base on this condition or other influences, the expressed model defined this condition as presented in t[34].

$$R\frac{\partial c}{\partial t} = -\frac{\partial c}{\partial y}\mu c \qquad \ldots\ldots\ldots\ldots \qquad (3)$$

Let $C_4 = TY$

$$\frac{\partial c}{\partial t} = T^1 Y \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (35)$$

$$\frac{\partial c}{\partial y} = Y^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (36)$$

$$RT^1 Y = \mu c Y^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (37)$$

$$\frac{RT^1}{T} = \mu c\frac{Y^1}{Y} = \varphi^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (38)$$

$$\frac{RT^1}{T} = \varphi^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (39)$$

$$\mu c\frac{T^1}{T} = \varphi^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (40)$$

$$Ln\;T = \frac{\varphi}{R}T + a_4 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (41)$$

i.e. $T = \ell^{\frac{\varphi^2}{R}t + a_4}$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (42)

$$T = C_4\, \ell^{\frac{\varphi^2}{R}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (43)$$

$$\mu c \frac{Y^1}{Y} = \varphi^2 \qquad \text{…………………………..} (44)$$

$$\frac{dy}{dy} - \frac{\varphi^2}{\mu c} y = 0 \qquad \text{…………………………..} (45)$$

Auxiliary equation

$$M^2 - \frac{\varphi}{\mu c} = 0 \qquad \text{…………………………..} (46)$$

$$Y = D\ell^{\frac{\varphi}{\mu c}y} + E\ell^{-\frac{\varphi}{\mu c}y} \qquad \text{…………………………..} (47)$$

Combine (43) and (47), yield

$$C_3 = TY$$

i.e. $C_3 = C_4 \ell^{\frac{\varphi^2}{R}t} \left(D\ell^{\frac{\varphi}{\sqrt{\mu c}}} + E\ell^{-\frac{\varphi}{\mu c}y} \right)$ ………………………….. (48)

$$V \frac{\partial c_4}{\partial x} = -\mu c \frac{\partial c_4}{\partial y} \qquad \text{…………} \qquad (4)$$

Let $C_5 = XY$

$$\frac{\partial c}{\partial x} = X^1 Y \qquad \text{…………………………..} (49)$$

$$\frac{\partial c}{\partial y} = XY^1 \qquad \text{…………………………..} (50)$$

$$VX^1Y = \mu c XY^1 \qquad \text{…………………………..} (51)$$

$$V \frac{X^1}{X} = K^2 \qquad \text{…………………………..} (52)$$

$$\mu c \frac{X}{X} = K^2 \qquad \text{…………………………..} (53)$$

$$Ln\ X = \frac{K^2}{\mu c} + a_5 \qquad \text{……………………………….. (54)}$$

i.e. $X = \ell \frac{K^2}{V} + a_5$ ……………………………….. (55)

$$X = C_5\, \ell^{\frac{K^2}{V}x} \qquad \text{……………………………….. (56)}$$

$$\mu c \frac{Y^1}{Y} = K^2 \qquad \text{……………………………….. (57)}$$

$$\frac{dy}{dy} = \frac{K^2}{\mu c} y = 0 \qquad \text{……………………………….. (58)}$$

Auxiliary equation

$$M^2 = \frac{K^2}{\mu c} = 0 \qquad \text{……………………………….. (59)}$$

$$Y = f\, \ell^{\frac{K}{\mu c}y} + f\, \ell^{-\frac{K}{\mu c}y} \qquad \text{……………………………….. (60)}$$

Combine (56) and (60) we have

$$C_4 = XY$$

i.e. $C_4 = C_5\, \ell^{-\frac{K^2}{V}x} \left(ACos \frac{K}{\sqrt{\mu c}} x + ASin \frac{K}{\sqrt{\mu c}} \right)$ ……………………………….. (61)

Combining (20), (38), (48) and (61)

$$C\ (x, y) = C_1 + C_2 + C_3 + C_4$$

$$C\ (x, y) = C\, \ell^{\left(\frac{t}{R} + \frac{y}{D\phi}\right)\lambda} + C_3\, \ell^{\frac{P^2}{R}t} \left(ACos \frac{P}{\sqrt{V}} + ASin \frac{P}{\sqrt{V}} t \right) +$$

$$C_4\, \ell^{\frac{\varphi^2}{R}t} \left(D\, \ell^{\frac{\varphi}{\sqrt{\mu c}}} + D\, \ell^{-\frac{\varphi}{\mu c}} \right) + C_5\, \ell^{\frac{K^2}{V}x} \left(ACos \frac{K}{\sqrt{\mu c}} + ASin \frac{K}{\sqrt{\mu c}} \right) \qquad \text{………. (62)}$$

The final model equation are expressed in [62], this expressed model defined lots of several condition considered in the system, the exponential phase dominant the developed model for the study, the rate of porosity were found to express high predominant in the formation as is defined in the derived solution, such situation has established greater influences on the developed system that generated the derived equation, the model no doubt has express different dimension of the parameters that deposit in the study area. The concept of this study is to develop model that prevent and monitor the rate of copper and enteric virus in soil and water environment, developing this model were in phases to ensure that the derived solution accommodated every defined objective and other influences that are reflected on the transport process.. Lots of human settlement has become victim of this negative impact, this call for serious action to ensure that such ugly scourge are removed or thoroughly managed in the study area.

4. Conclusion

The Behaviuor of contaminant are determined by the rate of generation through point sources and the level of management system, the study location management methods are very poor, this condition has developed high concentration of contaminant of different types, the negative impact of this pollutant has generated different types of diseases in the study location, due to mismanagement of the generated waste, it continue to increase pollution in soil and water environment. The deposition of copper and enteric virus were predominantly found in the study area, such condition call for serious concern due to high negative impact it has on human settlement, base on this condition, development of mathematical model were found appropriate, the derived model were produced through the generated system for the study, experts will definitely find the model favuorable in monitoring and evaluation including prevention of this contaminants in the study area.

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