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MATHEMATICAL MODELING TO PREDICT KLEBSIELLA PNEUMONAE TRANSPORT INFLUENCED BY POROSITY AND VOID RATIO IN SHALLOW AQUIFERS

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ABSTRACT

Mathematical model to predict the transport of klebsiella pneumonae has been developed the transport of the type microbial species where found to be a serious threat to the settlers in the study location; the microbes are influenced by the soil structural deposition, including the activities of man, the condition has resulted a lots of death trap to in many ways, the influence from porosity and void ratio are one of the major causes a high concentration of the contaminants in shallow aquifers, mathematical equation where develop considering all these source of pollution as variable in the system, this variables form the derived equation that generated a model to predict these type of microbial species in shallow aquifers the rate of transport within a short period of time in shallow aquifers, were influenced by the velocity of transport, this condition concludes that the soil marix is homogeneous in nature resulting to high degree of porosity in the study location. Hydraulic conductivity of the soil is as a result of high degree of void ratio in the study area. The model developed will certainly predict the transport from this species of microbes in the study area, and reduce the threat of human life in the study location.

Keywords: klebsiella pneumonae transport, porosity, void ratio, shallow aquifers.

1. INTRODUCTION

Indicator organisms are often used in place of disease causing pathogens because their presence is indicative of pathogen presence and indicator organisms are easier to detect. Another reason for using simple indicator tests is that pollution is often irregular. It is better to monitor drinking water frequently by means of a simple test than occasionally using more complicated direct pathogen detection tests. Indicator organisms, however, are not universal. Many studies have shown that while traditional indicators may have worked for developed countries in temperate climates, they are not necessarily appropriate for developing countries in tropical environments. There is a need to investigate the suitability of these indicators for their use in tropical environments for the detection of recent fecal contamination in drinking water supplies. Extensive research has already been carried out in this area. These indicators have different characteristics and their significance to the microbial quality of drinking water can vary depending on the monitoring region. After the most appropriate indicator organisms are identified, the methods for their detection are assessed and compared (Chian, 2002).

The WHO "Guidelines for Safe Recreational Water Environments" reviewed the scientific evidence concerning the health issues associated with using waters for recreational purposes and concluded that enteric illness, such as self-limiting gastroenteritis, and AFRI are the most frequently investigated and reported adverse health outcomes in the published literature. The Guidelines also concluded that there is an association between gastrointestinal symptoms, AFRI and indicator-bacteria concentrations in recreational waters (WHO 2003a; WHO, 2005). The Guidelines represent a consensus view and assessment among experts of the health hazards encountered during recreational water use. It includes the derivation of guideline values and explains the basis for the decision to derive or not to derive them. There are relatively few studies which report associations between indicators and other symptoms although there is limited evidence of an association between ear (Fleisher *et al*., 1996), eye (Fleisher *et al*., 1996) and skin ailments with swimming. Evidence suggests that bathing, regardless of water quality, compromises the eye's immune defenses leading to increased reporting of symptoms after bathing in marine waters. Infection could also be due to person to- person transmission (Hunter, 1998). In addition, the statistical probability of contracting an ear infection has been found to be generally lower than for gastrointestinal illnesses which are associated with higher Thermo tolerant coliform concentrations (WHO, 2003a). Several studies have found that symptom rates were more frequent in lower age groups (Cabelli, 1983; Fattal *et al.*, 1987; UNEP/WHO, 1991; Pike, 1994). As illustrated the main focus of effort concerning the health implications of the recreational use of water focuses on the effects of faecal contamination of bathing waters and the incidence of gastrointestinal diseases and other transmissible diseases to participants in water recreation. The data concerning some of the other hazards is weaker. There are very few epidemiological studies which have considered special interest activities Evans *et al.* (1983) found no evidence of any particular health risk from short-term immersion in Bristol City Docks, UK. However, Philipp *et al.* (1985) studied the health of snorkel swimmers in the same body of water who were immersed for 40 minutes and revealed that statistically significantly more swimmers reported gastrointestinal symptoms compared with the control group, even though the water complied with the European Union (EU) bathing water standards. Medema *et al.* (1995) investigating the risk of gastroenteritis in triathlete swimmers estimated that the exposure of triathlete during a competition was between 15 and 40 minutes and exposure was relatively intense; 75% of all triathlete in his study were compared with biathletes and it was reported that although the health risks for triathlete were not significantly higher than for run-bike-runners (biathletes) symptoms were higher in the week after the event in those athletes that had been exposed to water (feach *et al*., 1983; fierly, 1989; fewtrel *et al*., 1993).

Due population explosion and moderate to rapid urbanization, people rely heavily on water sources of doubtful quality in the absence of better alternatives, or due to economic and technological constraint to adequate treat the available water before use (Anna and Adedipe, 1996; Calamari and Naeve, 1994). The scarcity of clean of water and pollution of fresh water has therefore led to a situation in which one - fifth of the urban dwellers in developing countries and three - quarter of their rural dwelling population do not have access to reasonably safe water supplies (Lloyd and Helmer, 1992). Effluents are composed mainly of either organic, inorganic matter or both and toxic substance depending on it source. Inorganic matter in effluent are formulated using various chemical containing nitrogen, phosphorus and potassium. These element especially phosphorus stimulates the growth of microscopic plant while nitrogen promotes overgrowth of aquatic vegetation which degrades water quality. Potassium promotes productivity of aquatic animals such as fish (Wurts, 2000). Organic matter in effluent are formulated using various chemical containing Carbon, Nitrogen and Phosphorus. Organic matter promotes the growth of zooplankton as well as macro benthic invertebrates (Adigun, 2005). Organic matter also stimulates the growth of decomposers such as bacteria and fungi. Bacteria and fungi are very critical to the breakdown of the toxic component of the effluent. It has been observed that dissolved oxygen in water is required during the decaying of the organic matter, which may lead to depletion of oxygen in the water body and cause harmful substance to accumulate (Watson and Cichra, 2006). Organic matter contains high concentration of Ammonia, which may occur as bubbles attached to the block solid materials known as benthic deposit. Contamination of the environment by effluent is viewed as an international problem because of the effect on the ecosystem in most countries. In Nigeria, the situation is no better by the activities of most industries and populace towards waste disposal and management which usually leads to the increasing level of pollution of the environment. Sewage discharge is a major component of water pollution which is compounded in areas where waste water treatments are inefficient. Such is the case of the Obafemi Awolowo University sewage treatment oxidation ponds, which were constructed as aerobic / anaerobic sewage treatment plant. These allow natural treatment of sewage without added chemicals before it is finally discharged into the receiving stream. This receiving stream serves as a source of water to some communities downstream which is used for a variety of purposes like irrigation, drinking and other domestic uses without prior treatment. The present study on the physiochemical parameters is significant in that some of these parameters may prove lethal to aquatic flora, fauna and ultimately humans who are usually at the top of the food chain. The receiving stream serves as a convenient means of cleaning the highly loaded sewage and carries waste away from its discharge point. The need to know the quality of the water from the receiving stream has informed this study. The study will also provide information on the performance efficiency of the sewage lagoon.

2. THEORETICAL BACK GROUND

The transport of klebsiella pneumonae influenced by porosity and void ration in shallow aquifers has been developed, this model where developed considering the condition of the study area, the soil structural deposition in the study area has a lots of challenges, the study location are polluted by a certain microbes called klebsiella pneumonae, the microbial species are identified to have polluted ground water in the study location, the cause of these type of pollution transport are the soil structural deposition of the soil, the deposition of these soil is the high degree micropore of the soil, and high rate of the soil porosity in study location, the study location is deltaic in nature, most settlers has been complaining of ground water pollution from these type of microbial species, this ugly siege has cause a lots of death from these source of water pollution, base on this ugly siege it become imperative that study to solve stop this high rate of death trap should be carried out. To stop this pollution source mathematical model was develop, the model was developed by thorough examination of all the cause of these sources of pollution source in the study location, the source were considered to variables, whereby a system where developed, Mathematical symbols were dented to all this variables, her an equation where developed. The equation was derived to solve the transport the type of microbial species in the study area. The equations were expressed considering lots of condition including the geomorphology and geochemistry influenced in the soil. As deltaic environment the rate of fast migration of different type of pollution source are prevalence, there fore there was need to examine the best derived approach to apply in developing the model that will monitor the rate of klebsiella pneumonae transport in soil and water environment.

3. THEORETICAL MODEL

$$Q\frac{\partial^2 C}{\partial x^2} = U\frac{\partial C}{\partial x} - \alpha k \quad (1)$$

Applying Laplace transformation into equation (1), we have

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$$\frac{\partial^2 C}{\partial t^2} = S^2 C_{(x)} - SC_{(x)} - C_{(o)} \tag{2}$$

$$\frac{\partial C}{\partial x} = S^1 C_{(x)} - SC_{(x)} \tag{3}$$

$$C = C_o \tag{4}$$

Substituting equations (2), (3) and (4) into equation (1) yield

$$Q\left[S^2 C_{(x)} - SC_{(x)} - C_{(o)}\right] - U\left[SC_{(x)} - C_{(x)}\right]\alpha k C_{(o)} \tag{5}$$

$$QS^2 C_{(x)} - QSC^1_{(x)} - C_{(o)} - USC_{(x)} + UC_{(o)} - \alpha k C_{(o)} \tag{6}$$

Considering the following boundary condition at

$$t = 0,\ C^1{}_{(o)} = P_o = C_{(o)} = 0 \tag{7}$$

We have

$$C_{(x)}\left(QS^2 - QS - US\right) = 0 \tag{8}$$

$$C_{(x)} \neq 0 \tag{9}$$

Considering the boundary condition at

$$t > 0,\ C^1{}_{(o)} = C_{(o)} = C_{(o)} \tag{10}$$

$$S^2 C_{(x)} - US_{(x)} - \alpha k C_{(x)} = QSC_o + QC_o + UC_o \tag{11}$$

$$\left[QS^2 - Us - \alpha k\right] C_{(x)} = \left[QS + Q + U\right] C_o \tag{12}$$

$$C_{(x)} = \frac{QS + Q + U}{\left[QS^2 - Us - \alpha k\right]} C_o \tag{13}$$

Subject to these relations, the variable that control the system where expressed in terms of there relationship, this condition where stressed on the parameters, the expressed parameters where integrated together, as it is related in equation (13) above.

Applying quadratic expression, we have

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \tag{14}$$

$$\frac{-U \pm \sqrt{U^2 + 4Qakc}}{2Q} \tag{15}$$

$$C_{(x)} = A\exp^{\frac{\left[-U + \sqrt{-U^2 + 4Qakc}\right]^x}{2Q}} - \exp^{\frac{\left[-U + \sqrt{-U^2 + 4Qakc}\right]^x}{2Q}} \tag{16}$$

Subjecting equation (16) to the following boundary condition and initial values condition

$$x = 0,\ C_{(o)} = 0 \tag{17}$$

We have $B \quad -1 and\ A = 1$ (18)

So that our particular solution, will be in this form

$$C_{(x)} = \exp\left[-U + \left(U^2 - 4Qakc\right)^{1/2}\right]x - \exp\left[-U + \left(U^2 + 4Qakc\right)^{1/2}\right] \tag{19}$$

But $e^x + e^{-x} = 2Sin x$

Therefore, the expression of (19) can be of this form

$$C_{(x)} = 2Sin\left[U^2 + \left[U^2 + 4Qakc\right]^{1/2}\right]x \tag{20}$$

But if $x = \frac{x}{v}$

Therefore, the model can be expressed as:

$$C_t = 2Sin\left[U + \left(U^2 + 4Qakc\right)^{1/2}\right]^{\frac{v}{t}} \tag{21}$$

Again, if $\frac{v}{t} = x,$ we have

$$C_{(x)} = 2Sin\left[U + \left(U^2 + 4Qakc\right)^{1/2}\right]x \tag{22}$$

ARPN Journal of Earth Sciences

Considering (21) and (22) yield

$$\left(C_{x,t}\right) = 2Sin\left[U + \left(U^2 + 4Qakc\right)^{1/2}\right] + 2Sin\left[U + \left(U^2 + 4Qakc\right)^{1/2}\right]x \tag{23}$$

The transport of klebsiella pneumonae in shallow aquifers has been a serious threat to human life, the study area is predominant with a lots influence from natural origin, the geologic history of the study area where found to have a lots of variables of the influence of these type of microbial species in shallow aquifers, in other solve the problem of transport of klebsiella pneumonae contamination, the behaviour of the microbial species where characterized, this condition developed a conceptual frame work to develop a model that monitor and predict the transport of these microbial species in shallow aquifers ,the model where couple as a system where mathematical tools where applied denoting mathematical symbol, the derived equation generated a model that will monitor and predict the behaviour of the microbes in the study location.

4. CONCLUSIONS

Many studies have concluded that total coliform is not an appropriate indicator in tropical environments. Instead, *E.coli* is a better indicator of recent fecal contamination and *E.coli* is proposed as the indicator organism of choice for routine water monitoring in developing countries. Klebsiella pneumonae is one of the microbes in fecal coliform family. This type of pollution is a serious threat to human life, the transport from the fecal coliform family has resulted high concentration of the microbes, the soil strategraphic are one of the major influence of the rate of high concentration of klebsiella pneumonae in aquiferious zone, this implies that for a quality water free from klebsiella pneumonae in the study area, these developed model is imperative because the model if applied drastically reduce water related disease from klebsiella pneumonae sources in the study area.

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