Estimate the Effect of Rainwaters in Contaminated Soil by Using Simulink Technique

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Abstract. The aim of this paper is to design a Simulink model which can estimate the effect of rainwaters in the contaminated soil by heavy metal. The paper suggests design of Simulink model to estimate concentration of heavy metals in soil depending on the given data. Then compared the results with laboratory inspecting to estimate the accuracy of suggested technique. Where the sample data selected from different zone in Baghdad before and after the rain to determine its effect. The practical results show the efficiency of suggested technique.

1. Introduction
Mathematical Models are simplified representations of some real world entity can be in equations or computer code are intended to mimic essential features while leaving out inessentials, that is, models describe our beliefs about how the world functions. Mathematical modeling aims to describe the different aspects of the real world, their interaction, and their dynamics through mathematics [1]. Simulink, an add-on product to MATLAB, provides an interactive, graphical environment for modeling, simulating. It enables rapid construction of virtual prototypes to explore style ideas at any level of detail with stripped effort. For modeling, Simulink provides a graphical programmer (GUI) for building models as block diagrams. It includes a comprehensive library of pre-defined blocks to be custumized construct graphical models of systems exploitation drag-and-drop mouse operations. The user is in a position to supply an interactive degree “up-and-running” model that will otherwise need hours to create within the laboratory surroundings. It supports linear and nonlinear systems, sculptural in continuous-time, sampled time, or hybrid of the 2. Since students learn expeditiously with frequent feedback, the interactive nature of Simulink encourages you to do things out, you'll be able to modification parameters “on the fly” and immediately see what happens, for “what if” exploration. Lastly, and not the smallest amount, Simulink is integrated with MATLAB and knowledge are often simply shared between the programs.

2. Building a Simulink Model
Building a Simulink model of a problem hold by choosing the suitable blocks and connecting them depending on a means that represents the models. The Simulink model contains six distinct blocks, namely, sine wave, scope, gain, mux, clock, and to workspace. The wave could be a supply block from that a curving input signal originates. The signal is transferred through a line within the direction indicated by the arrow to the gain block. The gain block modifies its input (scales it by 5) and outputs a replacement signal through a line. The output of the gain block and also the output of the sine wave are combined within the electronic device (mux) to create a symptom vector. The signal vector is transferred through a line to the scope block custumized show a symptom very like a cathode-ray...
oscilloscope. Then the model must be creation, where creating is an operating model with Simulink, involves four basic steps as follow: Select desired blocks, Configure block parameters, Connect block inputs outputs, and Configure simulation parameters.

3. Suggested Simulink Design
The suggested model descriptions of the contamination of soils by heavy metals which are distributed throughout the soil system remain in the soil solution as iron, organic and inorganic complexes. Some of these heavy metals are mobile for uptake by plants. This mobility and availability depends on several factors including soil texture and PH [13]. Also, in the industrial regions, where some types of factories are active, several chemical and petrochemical processes would be also active. As a result, industrial water becomes contaminated with various substances which are harmful; these are sources of environmental contamination, which added in the description of the model equation. Then, the model equation, can be written as the relation between the change of concentration \( C \) of heavy metals proportionally with the change of time \( t \) (day-1) and the change of concentration of heavy metals proportionally with the change of space \( x \) (cm) multiplicand with the average pore-water velocity \( V \) (cm/hr). Then adding the fluid velocity in the reactor multiplicand with Dispersion parameter \( D \) (hr). So, the model ‘equation (1)’ can be written as:

\[
\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial^2 x} - V \frac{\partial C}{\partial x}
\]

Which is a second order linear PDE.

Where;
\( C_0 \): Initial concentration (mg/L).

The amount of each element retained by each soil (mg/kg) was calculated from the initial concentration in solution (mg/L) and the final concentration \( C \) in solution (mg/L): ‘Equation (1)’, which can be represented as a mathematical model for spread of contamination through soil which can be used to determine the rate of contamination. we design Simulink model illustrated in ‘figure 1’.

![Figure 1. Design Simulink model for suggested problem.](image-url)
4. Application of Suggested Design
The study area is a different zone in Baghdad city where the samples testing are selected from: residential, commercial and industrial land. Soil samples were collected different times before and after the rain for each zone, it's carefully collected with a stainless steel spatula. They were air-dried in the laboratory, homogenized and sieved through a 2-mm polyethylene sieve to remove large debris, stones and pebbles. Then these samples were stored in clean self-sealing plastic bags for further analysis. Concentration of metals such Pb, Zn, and Cd, are determinant by using XRF device and its mean are given in (table 1). This data are used as initial vale (initial concentrations \(C_0\) of heavy metals) which feeding suggested Simulink model.
Then the results of Simulink design (1) which represent the concentrations of these heavy metals are obtained. The results of laboratory and Simulink before rain given in Table 2, but after the rain are given in (table 3) and each the results are illustrated in ‘figure 2’ and ‘figure 4’.

Table 1. Concentrations \((C_0)\) of heavy metals for different zone in Baghdad city.

| Samples     | Pb  | Zn  | Cd |
|-------------|-----|-----|----|
| State (1) before rain | 70  | 190 | 3  |
| State (1) after rain  | 28  | 85.5| 2  |
| State (2) before rain | 192 | 370 | 2  |
| State (2) after rain  | 65  | 63.2| 1.5|
| State (3) before rain | 340 | 140 | 10 |
| State (3) after rain  | 72  | 98.2| 8  |
| State (4) before rain | 125 | 120 | 3  |
| State (4) after rain  | 81  | 78  | 2  |
| State (5) before rain | 150 | 120 | 5  |
| State (5) after rain  | 51.1| 59.1| 2.6|
| State (6) before rain | 54  | 170 | 2  |
| State (6) after rain  | 39.5| 89.5| 1.7|
| State (7) before rain | 410 | 100 | 5  |
| State (7) after rain  | 80.3| 71.5| 2.4|
| State (8) before rain | 300 | 165 | 2  |
| State (8) after rain  | 101.2| 90.5| 1.1|
| State (9) before rain | 90  | 50  | 2  |
| State (9) after rain  | 50  | 47  | 1.5|
Figure 2. Concentrations of Cd before and after rain in Baghdad city.

Figure 3. Concentrations of Pb before and after rain in Baghdad city.

Figure 4. Concentrations of Zn before and after rain in Baghdad city.

Table 2. Concentration of Pb, Zn, and Cd before Rain.

| No | Laboratory results Pb | Simulink results Pb | Laboratory results Zn | Simulink results Zn | laboratory results Cd ppm | Simulink results Cd |
|----|-----------------------|---------------------|-----------------------|---------------------|----------------------------|---------------------|
| 1  | 70                    | 69                  | 190                   | 195                 | 3                          | 2                   |
| 2  | 192                   | 190                 | 370                   | 372                 | 2                          | 1                   |
| 3  | 340                   | 345                 | 140                   | 138                 | 10                         | 10.5                |
| 4  | 125                   | 123                 | 120                   | 120                 | 3                          | 2.4                 |
| 5  | 150                   | 151                 | 120                   | 120                 | 5                          | 5.3                 |
5. Conclusions
The analysis of the result shows that there is a very good level of agreement between the experimental and simulated results obtained. This can also be confirmed by the numerical analysis of the result by using error / defect weights, Richardson extrapolation and higher order formula.
In conclusion, the suggested design can be considered to be a good representation of the estimating the concentrations of heavy metals in the soil.

The practical results show the effect of the rain for decreasing the rate of contamination in soil. The results of the analysis were showed that concentrations of zinc in the soil did not exceed the permissible limits, indicating the presence of contamination of this element in the soil of Baghdad city. Also, observed by measuring the concentration of Cd it had exceeded the permissible limits, which indicates the existence of this element in the soil of the city of Baghdad, and the reason for the increase in the concentration of this element is due to several reasons including the impact of industrial activities, but by less than in previous years due to suspension of many of these actors to work due to war conditions experienced by the country as well as the impact of adsorption by clay minerals and the presence of organic matter in the soil that play an important role in increasing concentrations of these elements as well as the weathering and irrigation and drainage.

References
[1] Bokil V A 2009 Introduction to Mathematical Modeling Spring
[2] Ajmalkhan M U and Showalter A M 1999 Effect of salinity on growth, ion contact, and osmotic relation. Stipf. Journal of Plant Nutration 22 1 pp 191-204
[3] Kabata A and Pendias H 2016 Trace Elements in Soils and Plants 3rd Edition, CRC press, Washington D C p 550
[4] Tawfiq L N M and Al-Khafaji R M 2011 Mathematical Modeling and Soil Pollution (Lap Lambert Academic Publishing)
[5] Tawfiq L N M, Jasim K A and Abdulmeed,E O 2015 Mathematical Model for Estimation the Concentration of Heavy Metals in Soil for Any Depth and Time and its Application in Iraq, International Journal of Advanced Scientific and Technical Research, 4 pp 718-726
[6] Luma N M Tawfiq and Farah F Ghazi 2015 Using Artificial Neural Network Technique for the Estimation of Cd Concentration in Contaminated Soils International Journal of Innovations in Scientific Engineering (IJISE) 1 1 pp 1-7

| No | Laboratory results Pb | Simulink results Pb | Laboratory results Zn | Simulink results Zn | Laboratory results Cd | Simulink results Cd |
|----|------------------------|---------------------|----------------------|---------------------|----------------------|---------------------|
| 1  | 28                     | 30                  | 85.5                 | 80.9                | 2                    | 1.6                 |
| 2  | 65                     | 70                  | 63.2                 | 60                  | 1.5                  | 0.8                 |
| 3  | 72                     | 72                  | 98.2                 | 99.3                | 8                    | 8.6                 |
| 4  | 81                     | 85                  | 78                   | 78                  | 2                    | 1.8                 |
| 5  | 51.1                   | 50                  | 59.1                 | 58                  | 2.6                  | 2.8                 |
| 6  | 39.5                   | 38                  | 89.5                 | 90.1                | 1.7                  | 1.6                 |
| 7  | 80.3                   | 80.5                | 71.5                 | 70.1                | 2.4                  | 2.6                 |
| 8  | 101.2                  | 103.4               | 90.5                 | 92                  | 1.1                  | 0.9                 |
| 9  | 50                     | 51.2                | 47                   | 49                  | 1.5                  | 1.1                 |
[7] Luma N M Tawfiq and Farah F Ghazi 2016 Mathematical model for estimation the concentration of heavy metals in soil *MJ Journal on Applied Mathematics* 1 1 pp 16-19

[8] Hamad M Salih, Luma. N M Tawfiq and Zainor R Yahya 2016 Estimate The Concentration of Heavy Metals in Soil by Using Trigonometric Cubic B-Spline Method and its Application in Baghdad, Iraq *Global Journal of Engineering Science and Researches* 3 9 pp 13-20

[9] Tawfiq L N M and Jasim K A Abdulhmeed E O 2016 Numerical Model for Estimation the Concentration of Heavy Metals in Soil and its Application in Iraq *Global Journal of Engineering Science and Researches* 3 3 pp 75-81

[10] Janette Worm and Tim v Hattum 2006 *Rainwater harvesting for domestic use*, Agromisa Foundation and CTA Wageningen, First edition