

IMPLEMENTATION OF COMPUTER APPLICATION SOFTWARE FOR SOIL pH IN THE DETERMINATION OF SOIL NUTRIENT STATUS

Francis Omotayo Adekayode, Doctor

Department of Crop, Soil and Pest Management,
Federal University of Technology, Akure, Nigeria

Abstract

The nutrient status of soils based on the soil pH was determined using the C Sharp (C#) computer program to develop an application software that revealed the relationship between the soil pH and the available essential elements in the soil. The databases were created using Microsoft Access as backend and Microsoft Visual Studio as the frontend. The database table listing parameters of Upper and Lower pH limits, Category of soil pH, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Iron, Manganese, Zinc, Boron, Molybdenum, Copper and Cobalt was created in Microsoft Access and saved with .accdb file format. The Design and User Interfaces were created in Microsoft Visual Studio. When the pH was input in the space provided in the User Interface and the Load Information button clicked, the pH category and availability status of each of the essential elements were generated and displayed. The four options for the nutrient availability status were abundant, moderate, slightly and sparingly. Click once method of application publishing was used for program publishing and installation of the software on another computer.

Keywords: Computer program, C#, pH, Nutrient status

Introduction

The assessment of soil nutrient status by different methods had been reported in previous researches (Baruah et al., 2013; Zhao et al., 2013). The desire to meet the food requirement of the ever-increasing human population had been viewed achievable with the cultivation of fertile soil and this would require a good knowledge of the fertility status of soils for judicious fertilizer application (Adekayode and Ogunkoya, 2010).

The previous research conducted had confirmed that intensive agriculture without adequate and balanced use of chemical fertilizer and organic manure had resulted in severe soil fertility deterioration of agricultural soils and the attendant loss of productivity (Havlin et al., 2009). Soil sampling for nutrient inventories had been found essential for fertilizer recommendation and the common sampling designs that had ensured high degree of accuracy were the random grid and bench mark methods (Pennock et al., 2006). Soil chemical analyses that provided inventories for macro and micro elements were reported in previous report (Karlen et al., 2008).

The influence of soil pH in determining nutrient availability and crop performance had been reported in previous investigations (Fernandez and Hoeft, 2012; Mc Cauley et al., 2009). The availability of nitrogen was observed maximum between the pH 6 and 8 because this was the most favorable range for soil microbes that mineralized the nitrogen in the organic matter while phosphorus maximum availability was in the range of 6.5 to 7.5. The previous report indicated a good overall availability of nutrients to be observed near pH 6.5 as pH above 8.5 caused high amount of Ca^{2+} , Mg^{2+} and Na^{2+} which resulted in plasmolysis of cell sap resulting into wilting while pH lower than 4 resulted in high concentrations of Fe^{2+} , Mn^{2+} , Zn^{2+} and Al^{3+} which were to be required in small quantities by the plants and such high concentrations of micro elements were toxic to plant root (Havlin et al., 2009).

The investigation on the effects of soil acidification on growth indices and elements uptake by cucumber showed that maximum uptake of calcium and magnesium was obtained at pH 7.5 while maximum uptake of nitrogen, phosphorus and potassium was at pH 6.5 (Ghehsareh and Samadi, 2012). The research conducted to evaluate the effect of soil pH on grain sorghum production revealed soil acidity to reduce grain sorghum yield by 10 % at soil pH 5.2 (Butchee et al., 2012). The positive correlation between soil pH and the availability of essential elements in soil was explained in the investigation conducted on the mapping of soil pH using Digital Mapping Approach (Gardi and Yigini, 2012)

The application of computer-based study of soil pH and soil nutrient status had been reported in previous investigations (Lauber et al., 2009; Adekayode and Akomolafe, 2011; Staugaitis and Sumskis, 2011). The use of computer model with soil physical and chemical data to calculate liming doses for conditioning acid soil in Osijek-Baranja County in Croatia was performed using ALRxp calculator (Durdevic et al., 2011). The technique to obtain soil characteristics rapidly through the development of electrical and electro-magnetic sensors to measure the mechanical, physical and chemical soil properties were explained in Adamchuk (2004) while the use of geospatial technology in a precision soil fertility investigation of a farmland

for arable crop production was explained in (Adekayode et al., 2009). In the research, the GPS receiver was used to determine the geographic coordinates and the elevation data to generate slope, aspect and other parameters relevant to the landscape.

The previous research had mainly reported the result of routine soil analysis to indicate soil pH values and soil nutrient status whereas there is the need for a computer based automated technique that could generate soil nutrient status in relation to pH for an on the spot nutrient status to be obtained by farmers and field scientist. The objective of this investigation was to develop software that revealed the relationship between the soil’s prevailing pH and soil nutrient status.

Materials and Methods

The flow chart for the methodology adopted in sequence is shown in Figure 1.

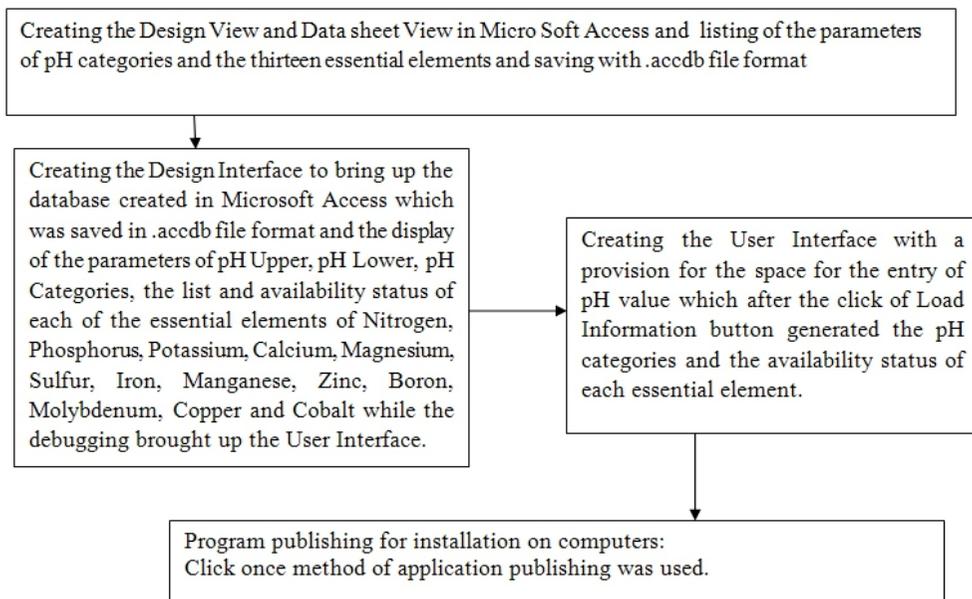


Figure 1: The Flow Chart of the sequence of invention of Soil pH-Soil Nutrient Availability Software

Database Creation in Microsoft Access

The system was made up of two components of backend and frontend. The backend was designed using Microsoft Access while Visual Studio was used for the frontend. The Design View and the Datasheet View were created in Microsoft Access with the parameters of Upper pH, Lower pH, pH Category, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium,

Sulfur, Iron, Manganese, Zinc, Boron, Molybdenum, Copper and Cobalt listed in the design view and saved with .accdb format.

The procedure of the design and user interfaces in Microsoft Visual Studio

The Microsoft Visual Studio 2008 was launched and a new project created with Windows Forms Application Templates and Visual C# Windows Project Type. The Design interface was created after activating the Toolbox for the application of the Label, Text and Button controls which were clicked and dragged from the ToolBox to the interface for the display of the respective boxes. The Properties Tools on the right side of the visual studio screen were activated in order to select the text tool to type Enter pH and Load Information in the Label and Button boxes respectively. The Groupbox control in ToolBox was clicked and dragged to design the space for the placement of the listed essential elements (Figure 2) while the Combobox control was used to create the space box for the expression of the availability status of each of the essential elements. The database created in Microsoft Access which was saved in .accdb file format was brought up in the design interface to display the pH Upper, pH Lower, pH Categories the list and availability status of each of the essential elements of Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Iron, Manganese, Zinc, Boron, Molybdenum, Copper and Cobalt while the debugging brought up the User Interface for the user to enter the soil pH while the click on Load Information button displayed the soil reaction category and the availability status of each of the essential nutrients.

Program publishing for installation on computers

Click once method of application publishing was used. The publishing was initiated by clicking on the design Form 1.cs and activating the Solution Explorer Tools for the application of Security Setting and Publish Tools while the .NET Framework 3.0 was selected in the Downloading. The information on both the Publisher Name and Product Name respectively were supplied while the option to automatically start set up when CD is inserted was selected in order to effect installation of software on a computer.

System Testing

Various users with or without previous knowledge of computer operation were asked to use the software and evaluate its performance. The result presented by the software met the stated objectives.

Result

The stages of the framework of the design and user interfaces are shown in Figures 2 and 3 respectively. The design interface had the Label, Text and Button boxes which were filled with the respective command information of Enter pH and Load Information in the Label and Button boxes respectively. The GroupBox control was used to create the box space for the listed essential elements as shown in Figure 2. The Text Box space was left blank for the user to fill in the pH values.

The first stage in the framework design of the user interface was the listing on the design Form of the essential elements of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, zinc, boron, molybdenum, copper and cobalt in the GroupBox box space. The second stage in the framework design of the user interface was the creation of box spaces with the use of the ComboBox control to indicate the availability status of the essential elements (Figure 3). The click on the Add Button, brought up the code page for the coding of parameters of pH Upper, pH Lower, pH Categories, the list and availability status of each of the essential elements of Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Iron, Manganese, Zinc, Boron, Molybdenum, Copper and Cobalt while the debugging brought up the user interface. The third stage was the creation of the user interface to provide blank box space for the user to input the pH values while the Load information box was to be clicked to initiate command operation and generate the soil reaction category and the availability status of each essential element (Figure 4). The Reset button was to cancel the operation for a reentry of another pH value. The computer generated user interface showing the output with pH values 8.4 for moderately alkaline soil, 6.3 for slightly acidic soil and 4.4 for extremely acidic unproductive soil are shown in Figures 5, 6 and 7 respectively.

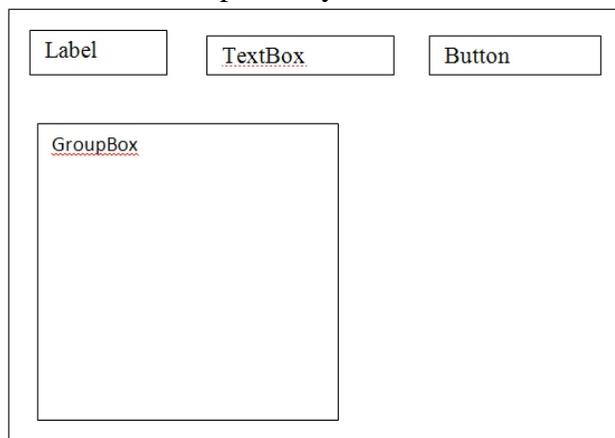


Figure 2: The sketch design of the Design Interface for the application of Label, Textbox, Button and GroupBox controls

S/N	<input type="text"/>	
pH Upper	<input type="text"/>	
pH Lower	<input type="text"/>	
Category	<input type="text"/>	
Nitrogen	<input type="text"/>	Availability Status
Phosphorus	<input type="text"/>	Availability Status
Potassium	<input type="text"/>	Availability Status
Calcium	<input type="text"/>	Availability Status
Magnesium	<input type="text"/>	Availability Status
Sulfur	<input type="text"/>	Availability Status
Iron	<input type="text"/>	Availability Status
Manganese	<input type="text"/>	Availability Status
Boron	<input type="text"/>	Availability Status
Zinc	<input type="text"/>	Availability Status
Molybdenum	<input type="text"/>	Availability Status
Copper	<input type="text"/>	Availability Status
Cobalt	<input type="text"/>	Availability Status
<input type="button" value="Add"/>		<input type="button" value="Cancel"/>

Figure 3: The Design Interface for display of the essential elements and the availability status

<input type="button" value="Enter Soil pH"/>	<input type="text"/>	<input type="button" value="Load Information"/>	<input type="button" value="Reset"/>
pH Upper	<input type="text"/>		
pH Lower	<input type="text"/>		
Category	<input type="text"/>		
Nitrogen		Availability Status	
Phosphorus		Availability Status	
Potassium		Availability Status	
Calcium		Availability Status	
Magnesium		Availability Status	
Sulfur		Availability Status	
Iron		Availability Status	
Manganese		Availability Status	
Boron		Availability Status	
Molybdenum		Availability Status	
Zinc		Availability Status	
Copper		Availability Status	
Cobalt		Availability Status	

Figure 4: The sketch of User Interface for entry of pH value for the display of pH category and availability status of each essential element

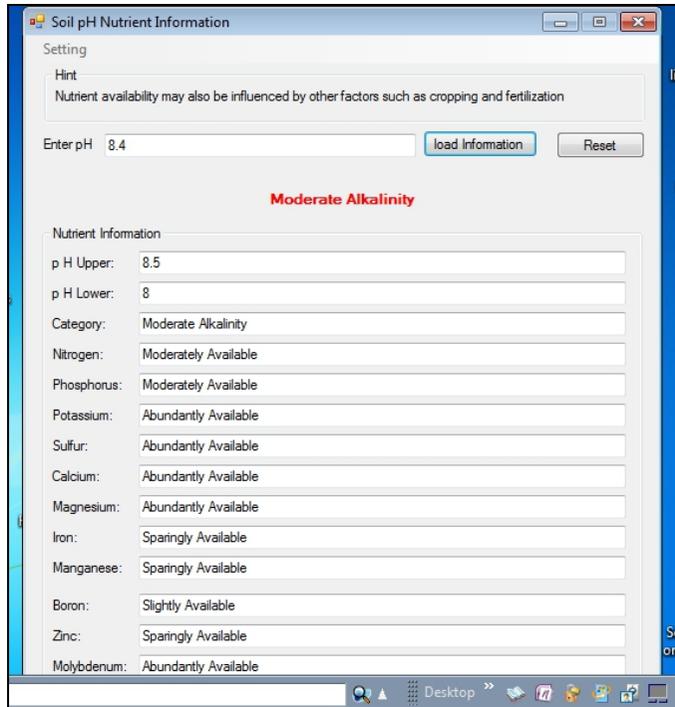


Figure 5: The computer generated output of pH 8.4 of moderately alkaline soil and the availability status of the essential elements

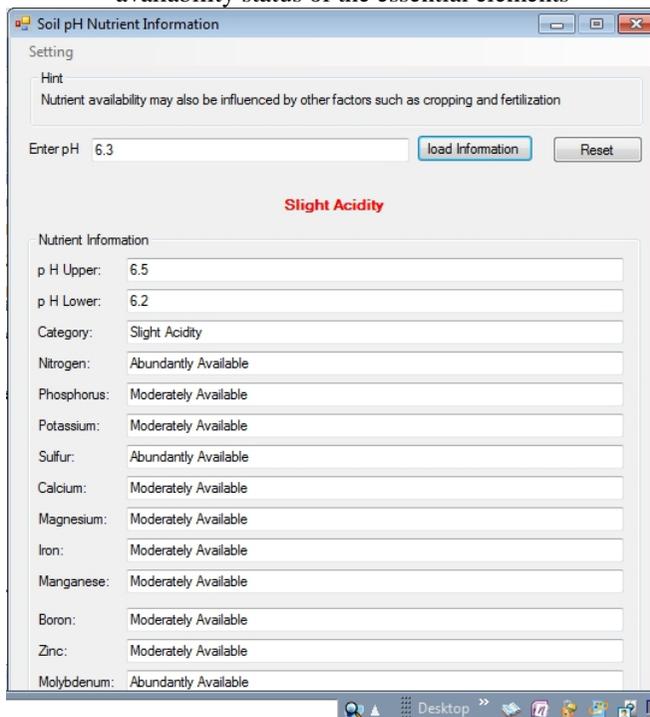


Figure 6: The computer generated output of pH 6.3 of slightly acidic soil and the availability status of the essential elements

Figure 5: The computer generated output of pH 4.4 of extremely acidic unproductive soil

Discussion

The Design View and the Datasheet View created in Microsoft Access with the listing of parameters of pH Upper, pH Lower, pH Categories, the list and availability status of each of the essential elements of Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Iron, Manganese, Zinc, Boron, Molybdenum, Copper and Cobalt, followed the procedures adopted in creating database in previous investigation (Sharma, 2013). The .accdb file format with which the file was saved followed the explanation on the replacement of .mdb file format with .accdb due to the enhanced functionality introduced in the version from Microsoft Access 2007 (Chapple, 2013) The .accdb file format created a connection from Microsoft Access to Microsoft Visual Studio (Massi, 2009).

The Window Forms Application which was created by selecting window application as the template and visual C# as the project type in Microsoft Visual and the eventual display of design and user interfaces followed the procedures illustrated in Microsoft SQL Server (Microsoft SQL Server, 2012). The procedures of creating windows application forms with the use of ToolBox to display label, text, button boxes, GroupBox and ComboBox as controls followed standard procedures (Hicks, 2012). The functions of the ToolBox controls as explained in standard practices,

indicated textbox to provide a way for the user to enter text on the interface. The GroupBox, functioned to categorize related parameters while ComboBox functioned to display availability status of each essential element (Chand, 2010).

The command options such as text, size, in the properties window on the right side of visual studio screen were used to configure, name and manipulate label, text and button boxes. The Form 1 interface which had the label, text and button boxes displayed on it, had the label and button changed to enter pH and load information respectively with the use of the text command in the properties window. The New Form interface created with the listing of the essential elements and their availability status and the Add and Cancel buttons were made through the application of Solution Explorer on the right side of the visual studio screen. The methods adopted followed the procedures in Microsoft SQL Server (Microsoft SQL Server, 2012).

The dragging of controls to the Form interface triggered visual studio to generate the code that corresponded to the control. This was responsible for the double click on the Add button on Form Design interface in Figure 3 to display code message with first few lines that read:

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
```

```
namespace Nutrient_Availability
{
    public partial class frmNew : Form
    {
        public frmNew()
        {
            InitializeComponent();
        }

        private void frmNew_Load(object sender, EventArgs e)
        {
            nutrient_listBindingSource.AddNew();
        }

        private void btnAdd_Click(object sender, EventArgs e)
        {
            nitrogenTextBox.Text = cmbNit.Text;
            phosphorusTextBox.Text = cmbPhos.Text;
            potassiumTextBox.Text = cmbPotash.Text;
        }
    }
}
```

```

sodiumTextBox.Text = cmbSodium.Text;
sulphurTextBox.Text = cmbSulphur.Text;
calciumTextBox.Text = cmbCalcium.Text;
magnesiumTextBox.Text = cmbMagnesium.Text;
ironTextBox.Text = cmbIron.Text;
manganeseTextBox.Text = cmbManganese.Text;
boronTextBox.Text = cmbBoron.Text;
zincTextBox.Text = cmbZinc.Text;
molybdenumTextBox.Text = cmbMolybdeum.Text;
copperTextBox.Text = cmbCopper.Text;
cobaltTextBox.Text = cmbColbat.Text;

double PH = double.Parse(pH_UpperTextBox.Text);

if (PH > 9.0)
{
    categoryTextBox.Text = "Very Strong Alkalinity";
}
else if (PH > 8.6)

{
    categoryTextBox.Text = "Strong Alkalinity";
}
else if (PH > 8.0)
and on and on to pH < 4.5

```

This enabled the category of the soil pH to be stated. The various categories were very strong alkalinity, strong alkalinity, moderate alkalinity, mild alkalinity, neutral, slight acidity, medium acidity, strong acidity, very strong acidity, extreme acidity with their respective pH range values. were abundantly available, moderately available, slightly available and sparingly available. The situation where the soil pH was either extremely alkaline above pH 9.0 or extremely acidic below pH 4.5 programmed the computer to generate the statement that the soil was unproductive and would need ameliorative measures in form of addition of lime for highly acidic soil or the addition of sulfur based compounds for extremely alkaline soils. The computer generated user interface illustrations of such strong alkaline (pH 8.0 to 8.5) or slightly acidic soils (pH 6.2 to 6.5) and extremely acidic soils (pH less than 4.5) and the availability status of each of the essential elements were in Figures 5 and 6 while the extremely acidic soils (pH 4.4) was shown in Figure 7 . The methodology followed the standard procedures in Liberty (2002).

The user interface basically ensured communication between the frontend and backend. It presented information to the user in an understandable format as well as to the machine in the machine readable language. It enabled the user to enter the soil pH in the space provided in the

interface, and when the Load button was clicked, the soil reaction (pH category The debugging brought up an interface which when double clicked brought up a code page that enabled the availability status of each essential element to be coded. The four options of the availability status) and the status of the essential elements already stored in the database appeared in the spaces created while the click on the Reset button cleared all the soil reaction information for a reentry of a new pH value.

The ClickOnce method used in the publishing provided full support for publishing and updating applications. The publish wizard publishing method in ClickOnce provided the advantages of step-by-step configuration setup and also the pre-requisite file (setup.exe) for the application to be automatically created (MSDN_MCP, 2007). The .NET Framework selected in the publishing would prevent conflict with existing software on a computer.

The System Testing was done to ensure that the developed application worked according to the specification and functioned property. The functionality was attested to as shown in the computer generated output in Figures 5 and 6 and 7 for pH 8.0 to 8.5, 6.2 to 6.5 and pH less than 4.5 respectively.

Conclusion

The investigation produced an application software that revealed the relationship between the soil prevailing pH and soil nutrient status. When the pH was input in the space provided in the User Interface and the Load Information button clicked, the pH category and availability status of each of the essential elements consisting of Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulfur, Iron, Manganese, Zinc, Boron, Molybdenum, Copper and Cobalt was generated. The click on the Reset button cancelled the displayed information for a reentry of new pH value. The software worked according to the specification and the function property.

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