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Study of the properties of soil in Kirkuk, IRAQ

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ABSTRACT

The properties of soil in Kirkuk city (IRAQ) are studied using gamma and neutron radiation. Ten locations are selected for the process of making field measurements on soils at 40−50 cm depth levels then the samples were collected to be studied in the laboratory also. In the field, we measured the density and moisture contents of soils. The laboratory measurement has been performed to obtain mass attenuation coefficients, using gamma spectrometer contains shielded NaI (Tl) detector at the energies of 59.5, 356.5, 662, 1173 and 1332 keV. The obtained results were presented and discussed. The study has practical importance to know the nature of the soil in the oil and agricultural city Kirkuk.

1. Introduction

The word “soil” has a variety of different meanings depending upon its relevance to the society. Farmers consider it as the part of the earth's surface containing decayed and organic material in sufficient quantity to grow plants and crops. Geologists take it as the residual (left over) material from underlying parent rock that supports root growth. To the engineer, soils include all earth materials overlying the rock crust and contain particles of minerals, gasses, and liquids (IAEA, 2004).

Soils are complex mixtures of minerals, organic compounds and contain pore spaces filled with water. Soil has chemical properties as on its compositions like C, K, S, P, Ca, Mg, Na, etc. The terms *sand*, *silt*, and *clay* refer to relative sizes of the soil particles. Sand, being the larger size of particles, feels gritty. Silt, being moderate in size, has a smooth or floury texture. Clay, being the smaller size of particles, feels sticky (Tan, 2010).

Physical effects of a gamma-ray beam passing through matter as a basis for soil density, moisture, porosity and field capacity determination were discussed in several studies. Gamma-ray transmission method applied for study the properties of soil (Appoloni & Pottker, 2004; Arouca, Barrozo, & Damasceno, 2005; Baytas & Akbal, 2002; De Groot, van der Graaf, de Meijer, & Maučec, 2009; Demir, Ün, Özgül, & Sahin, 2008; Elias, 2004; Maučec and Denijs, 2009; Medhat, 2012; Naime, Vaz, & Macedo, 2001; Okunade, Adebe, Jonah, & Oladipo, 2008; Oliveira et al., 1998, 2010; Pires, Bacchi, & Reichardt, 2005; Pires, Rosa, Pereira, Arthur, & Bacchi, 2009; Vaz, Naime, & Macedo, 1999). Other researchers such as (Akbal, 1999; Akbal & Baytas, 2000; Alam et al., 2001; Appoloni & Rios, 1994; Bhandal & Singh, 1993; Chaudhari & Raje, 2012; David, 2013; Kitto, 1990; Kumar, Venkataratnam, & Reddy, 1996; Mudahar, Mod, & Singh, 1991; Raje & Chaudhari, 2010; Vaz, 2003) are calculated the mass attenuation coefficients for different soil samples.

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The measurement of moisture contents is based on the thermalization or slowing down of neutron radiation. It is predominately a function of the hydrogen contents of material and to a lesser degree, by other low atomic number elements such as carbon an oxygen (IAEA, 2001, 2008; Jackson, 2004; Visvalingam & Tandy, 1972).

Here we studied the properties of soil in Kirkuk city (IRAQ) using gamma and neutron radiation. Mass attenuation coefficient, dry and wet densities, and moisture are determined for ten locations. At each locations, first, field measurements on soils at 40–50 cm depth levels has been achieved to measure the density and moisture contents of soils using moisture-density gauge. Then, soil samples of appropriate volume are collected at each location spot to be studied in the laboratory. The laboratory measurement has been performed using gamma spectrometer contains shielded NaI (Tl) detector at the energies of 59.5, 356.5, 662, 1173 and 1332 keV. The obtained results were presented and discussed.

2. Theory

2.1. Gamma radiation

In the transmission of gamma rays between a source and detector, a proportion of these rays will be absorbed and scattered in accordance with the density of the material between the source and detector. As the density of this material increases, the number of gamma rays absorbed and scattered also increases and the number reaching the detector decreases. The exponential absorption that characterizes the passage of monochromatic electromagnetic radiation through a homogenous material is given by the Beer–Lambert Law (Davisson, 1965) as:

$$I = I_0 e^{-\mu x} \quad (1)$$

where I_0 is the initial radiation intensity, x(cm) is the sample thickness. The linear attenuation coefficient (μ) of the material is an intrinsic property of each material. The mass attenuation coefficient (μ_m) of the material is given by:

$$\mu_m = \mu/\rho \quad (2)$$

where ρ is density. Equation (1) may then be expressed using the mass attenuation coefficient and the density of the material, and by taking the natural logarithm of both sides,

$$\ln(I) = \ln(I_0) - \mu_m x_m \quad (3)$$

which is also in the form of an equation for a straight line, $y = a + bx$, where $y = ln(I)$, $ln(I_0) = a$, $b = -\mu_m$ and x_m (g cm^{-2}) is the sample thickness.

2.2. Neutron radiation

When fast neutrons with energy of a million electron volts or more, are injected into the soil from a suitable radioactive source, they are slowed by repeated collision with nuclei of atoms and eventually become thermalized. The average energy loss is much greater in neutron collisions with atoms of low atomic weight in ordinary soils in appreciable amounts, hydrogen slows fast neutrons more effectively than any other common elements present in the soil. However, if a neutron strikes hydrogen nucleus, its energy is halved, on average, because the mass of the hydrogen nucleus is the same as that of the neutron. On average, 19 collisions with hydrogen are required to thermalize a neutron. Carbon, nitrogen and oxygen are also relatively efficient as neutron thermalizers (about 120, 140 and 150 collisions, respectively). Hydrogen in the soil is present almost entirely in the form of water and hence the density of the resultant cloud of slow neurons (100 eV or less) is a function of the soil moisture contents (IAEA, 2008; Visvalingam & Tandy, 1972).

A relationship can then be established between the detected slow neutron radiation and the moisture content of the material. This relationship is commonly expressed in the following form:

$$MCR = E + F \times M \quad (4)$$

where MCR is moisture count ratio, M is moisture content, F and E are calibration constants. Two moisture standards are

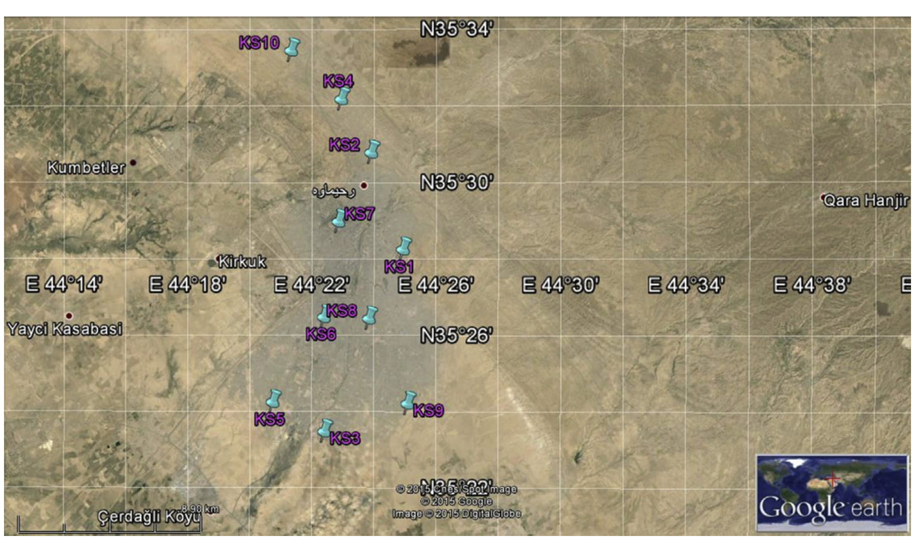

Fig. 1 – Map of the investigated area shows the location of the selected samples for the present study.