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# Evaluation of the underground soil thermal storage properties in Libya

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**Abstract**

Experimental investigation was conducted of temperature distribution through the underground soil of Tripoli (Capital of Libya). The aim of the experiment is to monitor the temperature variation of the underground soil under a depth of 4 m and around the year, in order to know the thermal capacity ability of the soil to be used as a seasonal thermal storage. The measurements covered two types of systems: the first one is dry soil and the second is dry soil covered by a glass sheet. The measurements indicate that, at a depth of 4 m, the average temperatures for the dry and dry-glass covered systems are 21, 46 °C, with maximum temperatures of 21.5 and 47 °C during December and January, and the minimum temperatures occurred in May and June, are reached values of 19, 44 °C, respectively. The temperatures for the two systems were almost constant through the year and fluctuating with a monthly period of $2\pi/12$. Results show that, the underground thermal capacity can be used as a source of heating and cooling of buildings leading to reduce the energy consumption in this application. Furthermore, for industrial and domestic heating processes, one can utilize the dry-glass covered system to cover a significant part of the heating load. Anyhow, the experimental study may not applicable everywhere, so an analytical presentation for the system will be necessary to save money and efforts. The first step to put the analytical model in reality is to get the thermal properties of the underground soil, and this is the aim of the present study.

The paper described the followed procedure during theoretical-heat transfer approach. The thermal properties were presented as a function of the ground depth, furthermore, the paper presented the measured temperatures of the two systems for Tripoli underground soil.


*Keywords:* Underground temperature; Soil thermal properties; Thermal storage

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## 1. Introduction

The temperature of underground soil is affected mainly by the soil thermal properties, such as, thermal conductivity ($k$), density ($\rho$) and specific heat ($C_p$). Also, the meteorological conditions have pronounced effect, these are: solar radiation intensity, wind speed, rain, humidity and the air temperature. Bansal et al. [1], estimated the underground soil temperature at a depth of 4 m during the year, in New Delhi city—India. The maximum temperature was found to be about 53 °C for dry black surface soil covered by a glass sheet, and the minimum temperature is about 17.3 °C for wetted soil with shaded surface. However, the temperature distribution was accompanied by the oscillation of frequency of 2π/12. The thermal properties in Bansal's study were considered to be constant. The thermal storage properties of the soil are of great importance, especially, when one thinks of make use it in heating and cooling of buildings by locating certain type of heat exchanger through the underground soil layer. The principle of the system is of interest if the temperature of the underground soil layer reached to applicable temperatures for heating and cooling of buildings. In order to decide the suitability of the soil for such application, the year round temperatures of the underground soil layers must be estimated experimentally or analytically.

The aim of the present study is to measure the temperatures of the underground soil at defferent depths, theoretical principles of heat transfer phenomena is also explained.

## 2. Theoretical approach

### 2.1. Temperature of the underground soil

Heat transfer through soil layer is considered to be one-dimensional unsteady conduction, performed by the heat conduction equation as:

$$\frac{\partial}{\partial x}\left[k(x)\frac{\partial T(x,t)}{\partial x}\right] = \rho(x)C_p(x)\frac{\partial T(x,t)}{\partial t} \tag{1}$$

where, $\partial T(x,t)/\partial x$ is the soil temperature change with the depth $x$. $\rho(x)$, $C_p(x)$, $k(x)$ are presented the thermal properties of the soil, which are, density, specific heat capacity and thermal conductivity, respectively. $\partial T(x,t)/\partial t$ is the soil temperature change with the time.

### 2.2. Thermal properties of the soil

Thermal properties of soil are thermal conductivity, density and specific heat capacity. Soil composes of many elements, such as, sand, air and water. Thermal properties of soil may be determined by identifying the volumetric percent for each element in the mixture, as:

$$(\rho C_p) = f_s(\rho C_p)_s + f_a(\rho C_p)_a + f_w(\rho C_p)_w \tag{2}$$