AN ALTERNATIVE APPROACH TO MEASURE SUNLIGHT INTENSITY FOR IMPROVED WEATHER INFORMATION GATHERING AND WATER SUPPLY ACROSS AFRICA

by

ALUKO Babafemi David

SALAU Taofeek Ishola

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SUMMARY

Water scarcity and inadequacy threatens the existence and sustainability of Africa. The continent that has been dubbed the continent of the future has to tackle the problem headlong.

Data and information needed to help in the mission to provide water for all the needs of plants and animals must be obtained and every effort must be made to make this happen.

This group therefore is committed to offering its resources and expertise in an attempt to provide the data for stakeholders by participating in this project.

As adverse weather conditions persist, effective water management is at the heart of the sustainability of agriculture and indeed life, on the continent and beyond.

While conventional weather stations measure hydrological variables, they are often costly, inaccessible or not having sufficient robustness.

By putting the above issues in perspective, the group proposes to measure the prevailing solar intensity in an area which, despite its importance has not been well considered as a weather or hydrological parameter. Therefore, cost-effective and robust strategy involving the Hall Effect principle as well as change in mass of the liquid medium used is being presented. Basic knowledge of science and mathematics would also be made use of.

OBJECTIVES

By this project, the following will be achieved:

(i) design and implement a cost-effective weather station; and

(ii) design and implement a robust weather station measuring a weather (hydrological) variable, as desired.

Solar intensity is said to be the amount of solar power (i.e. energy from the sun per unit time) per unit area reaching a location where it is being measured.

The sun is the origin of solar energy. The solar energy is indeed the source of the energy of the world. Solar energy is used by plants for photosynthesis, and growth and development and consequently stored as chemical energy. Animals and man eat plants and obtain energy thereof. Because of its importance, the group proposes to measure its intensity in locations of interest. The methodology of approach to measure the intensity of sunlight at a location is presented in the following sections.

METHODOLOGY

A. Theory

Evaporation is the process in which molecules of liquids with sufficient kinetic energy break loose from the surface of the liquid to escape into the gaseous phase. Evaporation is said to occur at all temperatures but it is hastened or enhanced with increasing temperature. Therefore, with increasing solar intensity, evaporation is further greatly enhanced since there would be more heat to drive the process.

Denatured alcohol, otherwise known as methylated spirit comprises basically **ethanol** in up to more than **99%** of the content, with water and denaturant making up the remaining, according to Glendale Packaging Property Ltd (2008). The vapour density of the chemical is said to be **1.59** (relative to air), implying it has a very low relative molecular mass. Liquids with very low molecular mass have high evaporation rates. The chemical bonds amongst the molecules of the organic ethanol are **covalent**, and are easy to break, especially when heat is applied. The boiling point is **78^{o}C** while the density or specific gravity is between **0.79** and **0.89** (**0.810 @ 20^{o}C**). It has **100%** volatile component.

For the design, methylated spirit, usually clear, colourless, is put in measured quantity (mass and volume) into a glass or metallic bottle or container. A short rubber pipe or hose is made to fit into the head of the open container and the other end of the pipe is made to fit into another container placed in an environment of dry ice to serve as coolant to aid the condensation of the vaporised spirit. Condensation is the opposite process of evaporation, where cooled gas molecules become liquids. Condensation is required in order that the spirit may be reused. The container bearing the denatured alcohol must be placed under the sun for impact from rays of sunlight.

A Hall sensor is placed beneath the container placed under the sun bearing the methylated spirit. The sensor is made to interact with the field of a magnet placed in an enclosure beneath it. As the spirit evaporates, the change (reduction) in mass of the spirit causes a change in the voltage induced in the Hall sensor. A calibration is done to relate the change in mass of the spirit with the amount of voltage induced. The induced voltage is fed into a microprocessor.

Figure 1: Methylated Spirit

Figure 2: Hall sensor

Figure 3: Campbell-Stokes SR

With the cross-sectional area and volume of the container determined, specific gravity of the spirit known, and the calibration done, it becomes easy to track the changes in mass as evaporation proceeds.

The Campbell-Stokes sunshine recorder gives an indication of the sunshine intensity (**W/m^2**) internationally. Therefore, a calibration has to be done to match the evaporation rate of methylated spirit, given as **2.59** (relative to n-butyl acetate) in order to accurately determine the intensity of sunshine at any given point in time.

B. Design

In carrying out the design of the weather station, the stages identified are as shown in the flow chart in Figure 4 below and expatiated on, subsequently.

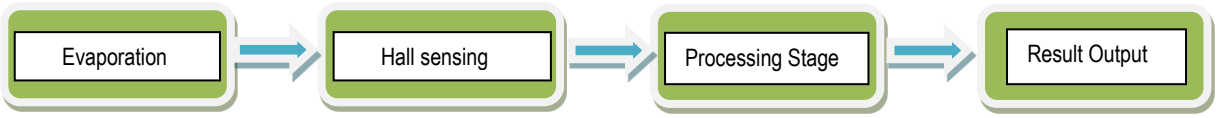

Figure 4: The Design Stages

Input:

As the sun shines, the rate of evaporation of methylated spirit is enhanced. Therefore, there is a reduction in the mass/volume of the spirit in the container being impacted by the sunlight rays. This reduction correlates to changes in the voltage induced in the Hall sensor through its interaction with the field of the magnet beneath it.

Processing

The induced voltage is fed into a microprocessor. The microprocessor samples readings at very close time intervals enough to capture the voltages as induced in the Hall sensor. With the calibration done between the mass differences and the voltages induced, and other parameters such as the specific gravity of the spirit known and cross-sectional area and volume of the container and spirit known, what is left is to calibrate the results according to the internationally accepted standards from the Campbell-Stokes sunshine recorder.

Output

The sunlight intensity, in W/m^2, which is the final result as processed by the microprocessor, is then displayed on a liquid crystal display board and can be easily read off.

CIRCUITRY

The following are needed in designing and implementing the relevant circuits making up the project:

i. The Arduino Kit

ii. Hall sensor

iii. Connecting wires

iv. Coils from loudspeakers

v. Methylated spirit

vi. Cooling chamber/Dry Ice and Condensation Pipe/Hose

vii. Two glass or metallic containers

A source of power is required to energise the Arduino.

CONCLUSION

This proposal has presented information about the design and implementation of a cost-effective and robust weather station that measures the intensity of sunlight at points in time. A lot of information will be derived from the active implementation and use of the sensor. Common materials are required for its design.

With information obtained from here, it would be a lot easier to monitor and distribute water much more effectively across the African continent.

REFERENCE

Glendale Packaging Property Ltd (2008). "Material Safety Data Sheet".

< http://bit.ly/1pwSVIA >. Retrieved 23rd June, 2014.