AN INNOVATIVE APPROACH TO MEASURE RAINFALL FOR IMPROVED WEATHER INFORMATION GATHERING AND WATER SUPPLY ACROSS AFRICA

by

OKE Niyi Funsho

SOTOMIWA Abdulquadri Abiodun

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SUMMARY

The African continent desperately needs to tackle the problem of water supply plaguing it on a daily basis.

For this to be achieved, all hands must be on deck to ensure that every available resource is deployed in the provision and availability of the required hydrological data and information required, as the first step in solving the problem.

This therefore justifies the keenness of the group in participating in the project since it is a major attempt to mitigate the effects of this challenge.

In adverse weather conditions, effective water management is crucial for the sustainability of agriculture and indeed for living organisms.

Existing conventional weather stations measure hydrological variables but they are often expensive, inaccessible or lacking in robustness.

With the aforementioned in perspective, the group decided to measure rainfall which is an important weather or hydrological parameter by employing cost-effective and robust strategies involving piezoelectricity, with the Hall Effect principle as an equally viable alternative. 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.

Rain is liquid water in the form of drops or droplets which have condensed from the water vapour that is in the atmosphere. The precipitation of the condensed water vapour results in rain which then falls under gravity. The group proposes to measure the amount of rain that falls to the earth when it is precipitated in the atmosphere.

Rain is important for plants and animals as it is an essential means by which water enters into the water cycle, to be made available in the soil for growth of plants and animals. Water is used in virtually all processes of nature and those organized by man.

The methodology of approach to measure the amount of rain when it is precipitated is presented in the following sections.

METHODOLOGY

A. Theory

One of the processes involved in the water cycle is the evapotranspiration of water molecules from plants, earth surface and water bodies into the atmosphere. Another important process is the condensation of these vaporised water molecules which ultimately results into precipitation. One of the important results of the precipitation action is rain, which adds water to the earth once again. The cycle involves other processes and continues infinitely.

Rain falls to the earth in form of drops. The drops are spheres (or spheroids, more specifically) in shape and often bear quite some impact in form of force or pressure when they strike umbrellas and humans. According to Elert (2001) and Horstmeyer (2008), the maximum diameter of rain drop is **5mm**, and according to Gill (2009), Dr Ewan O'Connor, a University of Reading (England) scientist, said such sizes are possible in the tropics while Dr Emmanuel Villermaux and colleagues from Aix-Marseille University, France determined the maximum diameter of rain drop as **6mm**.

The World Meteorological Organisation (WMO) classifies Low-Level Clouds from which rain falls as having altitudes below **6500ft (1981.2m)**. By applying a basic equation of motion in Physics, and neglecting air resistance that often causes drag, the average time for a rain drop to fall to the earth surface is **20.1s** (with $\mathbf{g = 9.8 m/s^2}$).

When a rain drop strikes a piezoelement[+], a voltage is induced. The pressure with which the drop strikes the piezoelement can be determined by combining the parameters above with the area on the piezoelement that is struck.

The induced voltage is fed into a microprocessor. The microprocessor is timed to take record of induced voltages caused by rain drops as they strike the piezoelement. The microprocessor is then programmed to take a count of the number of times a voltage is induced by the raindrops. This count is then multiplied by the length of a rain drop, which is taken as **5mm**, since the diameter of a sphere is also its length. The result of this multiplication is the length of the rainfall recorded, in **mm**. This result is then output to a liquid crystal display (LCD).

Figure 1: Raindrops

Figure 2: Hall sensor

Figure 3: Piezoelement

[+]The Hall sensor can also be used by placing it beneath a light lever, but in an enclosure where it interacts with the field of a magnet placed in there. As raindrops strike the lever, voltage is induced which is then fed into the microprocessor and counted.

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.

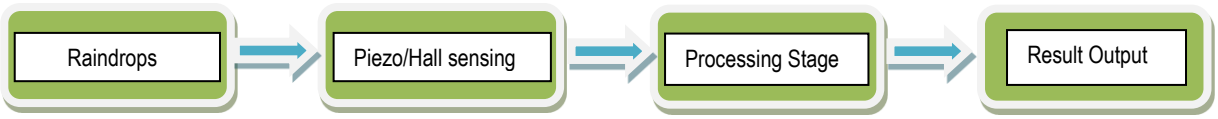

Figure 4: The Design Stages

Input:

When rain falls, its drops strike the piezoelement (or the lever to which the Hall sensor is attached) to induce electric signal in form of voltage. The height travelled by raindrops gives them potential energy and subsequently the kinetic energy for which they strike the sensor used to induce voltages.

Processing

The induced voltage is fed into a microprocessor. The microprocessor samples readings at very close time intervals enough to capture the times when the drops of rain strike the sensor. The microprocessor is also programmed to count the number of times voltage signals are recorded during the period of functioning of the sensor or during rainfall.

The length of the rainfall will then be obtained as the multiplication of the number of counts and the length of the drop of rain, taken as **5mm**. The 5mm diameter figure is said to be alright for Tropical region, part of which is Africa.

Rainfall Amount (mm) = Count of times of voltage inducement by raindrops X 5mm

Output

The amount of rainfall, in mm, which is the 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. Piezoelement

iii. Connecting wires

iv. Hall sensor

v. Coils from loudspeakers

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 amount of rain that falls when it is precipitated. 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.

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