SONIC RAIN GAUGE
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INTRODUCTION
For rain to happen, the weather conditions inside the clouds and surrounding has to cause the droplets to grow. Some droplets will grow by colliding and combining with each other. Some droplets will grow by acquiring more and more water vapor from the air. Some will do both. As soon as any droplets have achieved a critical mass that is sufficiently heavy, it will fall out of the cloud and this is followed by slower growing droplets. Hence at this stage, water droplets that leaves the cloud are of the same critical mass.

The journey of the water droplet between the cloud and the ground, subjects the droplet to air resistance and surface tension. Therefore these big droplets further breaks up into smaller droplets (Extracted from the website of Madsci Network based in Washington University Medical School). Droplets that are of the critical mass continues falling, those that are smaller than the critical mass gets pushed back upwards until they combine with other droplets to achieve sufficient mass. Therefore water droplets that reaches the ground are all of the same mass and volume. With this, the variable of the rainfall would be due to primarily the frequency of impact on a fixed-known area on the ground.

The measurement of rainfall quantity to date has been reliant on the usage of conventional rain gauges.

The total amount of rainfall over a given period is expressed as the depth of water, which would cover a horizontal area if there were no runoff, infiltration and evaporation. This depth is generally expressed in millimeters. Accuracy of rainfall measurement is mainly affected by wind, by the height of the gauge and exposure. Wind and exposure errors can be very large, even more than 50 percent. The catch of rainfall is a function of the height of the gauge; the more open the location the greater will be the difference in catch with height. (*The information in this paragraph was obtained from FAO irrigation and Drainage Paper 27, Agrometeorological Field Stations, Chapter 6).

Accuracy of rain gauges
The accuracy of rain gauges, however, is affected by several conditions:

- Operators’ error in reading off from the equipment can affect the accuracy of the rainfall.
- Rain gauges do not give an accurate reading for small quantity of precipitation especially during the dryer months.
- The presence of obstacles near the gauge can affect the catch.
- The height and orifice of the rain gauge affects the accuracy and consistency of readings.
• The presence of wind eddies around the opening.
• Evaporation of catch reduces the actual quantity collected.
• The absence of the gauge in place at the time of precipitation results in the loss of catch and accuracy.

The usage of conventional rain gauges to measure rainfall is inconvenient as:

• The gauges have to be read periodically and emptied after each reading.
• The deployment location of the equipment is selective as the site must be level and the surrounding ground has to be uniform. The ground should preferably be grassed or loose earth. No object such as another instrument, building or trees should be closer than four times their height. Very exposed sites, such as on the top of a hill, should also be avoided.
• The rain gauge is unable to provide an impromptu estimation of the rainfall.

**Objective**

Our objective is to study the relationship between the rainfall frequency and the rainfall volume so as to provide an alternative mean for the measurement of rainfall quantity. The device should preferably be able to reduce the errors in accuracy that exists in a conventional rain gauge. The device should also enhance convenience and be operable in environments that are traditionally out of bounds to conventional rain gauges.

**MATERIALS AND METHOD**

In order to study the variability of the rainfall field at small scales, an accurate and convenient but yet affordable method is an acoustic one. The concept of our sonic rain gauge consists of an impact platform on which hydrometeors (rain, sleet, and even snow) fall. The impact makes a sound, which is then captured by a microphone attached beneath the platform. An amplifier is connected to the microphone to amplify the signal for further processing on an oscilloscope, which then digitizes the signal for the microphone.

![Diagram](Diagram extracted from McGill University J.S. Marshall Radar Observatory)

The project was however carried out using available resources due to several constraints in an attempt to study the general relationship between the frequency of impact and volume of rainfall. Thus an experiment studying the frequency of impact of water droplets is being put against an experiment using conventional method of volume of catch acting as a control. The experiments were also conducted in a controlled environment for the feasibility of studies. The following equipment were used:

• Showerhead of 27 number of water outlets
• Catchment container
• Impact Surface
• Calibrated cylinder
• Oscilloscope
• Microphone
• Amplifier
• Effective water outlet controlling disk
• Stopwatch

Impact Surface
Amplifier
Oscilloscope
Outlet control disk

**Procedures:**

1. The showerhead, connected to a water source, is placed in a fixed position and angle throughout the experiment. The angle selected is such that the showerhead is facing skywards and that, at the point of impact, the water exist as droplets instead of streams of water to simulate rainfall.
2. The microphone is being connected to the amplifier, which in turn is connected to the oscilloscope.
3. The microphone is slotted into a gap created underneath the drum, with the gap sealed to waterproof it.
4. With the tap turned on, water droplets fall upon the drum’s surface, which acts as a resonating plate. The frequency of the resonance is being picked up by the microphone and displayed on the oscilloscope.
5. The response on the scope is being paused and the frequency recorded. 6 readings are taken and the average calculated.
6. The control is being carried out by replacing the drum with the large container. Water droplets is allowed to fall and collected in the catchment container. The process is being carried out for 20secs before measuring the quantity of water collected using the calibrated cylinder.
7. The process is being repeated for 8 other sets with the number of water outlets decreasing by 3 each time.
8. The results are recorded and tabulated in a table. A graph of the Volume of water collected was plotted against the Average frequency of impact.

**RESULTS AND DISCUSSION**

**Table of results**

<table>
<thead>
<tr>
<th>S/no.</th>
<th>No. of water outlets</th>
<th>Frequency (Hz)</th>
<th>Average Frequency (Hz)</th>
<th>Vol. of water (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading 1</td>
<td>Reading 2</td>
<td>Reading 3</td>
<td>Reading 4</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>392.3</td>
<td>291</td>
<td>283.1</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>232.1</td>
<td>311.32</td>
<td>451.2</td>
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<tr>
<td>3</td>
<td>9</td>
<td>241</td>
<td>307</td>
<td>414</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>511.3</td>
<td>593.1</td>
<td>379.6</td>
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<tr>
<td>5</td>
<td>15</td>
<td>759.9</td>
<td>389.6</td>
<td>561.2</td>
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<tr>
<td>6</td>
<td>18</td>
<td>579.1</td>
<td>851.3</td>
<td>731.5</td>
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<td>7</td>
<td>21</td>
<td>410</td>
<td>756.4</td>
<td>568.2</td>
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<td>8</td>
<td>24</td>
<td>632.1</td>
<td>943.1</td>
<td>644.8</td>
</tr>
</tbody>
</table>
**Discussion**

Based on the results obtained and graph plotted, we can infer that there is a linear relationship between the frequency of impact of water droplets and the volume of water collected. We can thus apply this relationship into the study of frequency of rain droplets with rainfall quantity.

**CONCLUSION**

The experiment was conducted with the objective of studying the relationship between the frequency and the volume of rainfall, so as to produce a device that is mobile and able to reduce the errors and inconvenience of existing conventional rain gauges at an affordable cost.

The project was carried out using available equipment under simulated and controlled environment. With the theoretical relationship confirmed, the study of actual rainfall is now possible with customized equipment tailored to weather through the environment as well as to enhance accuracy and control.

The team would look into the possibility of miniaturizing the sonic rain gauge into a compact and mobile equipment in view of producing the sonic rain gauge.

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