Vol. 15(4), pp. 138-150, October-December, 2020
DOI: 10.5897/IJPS2020.4866
Article Number: 9ED7B8164956
ISSN 1992-1950

http://www.academicjournals.org/IJPS

International Journal of Physical Sciences

Full Length Research Paper

River water lever sensor as river flood warning system

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Received 24 January, 2020; Accepted 3 June, 2020

Senate Report recorded last 2013 show that tropical storms and floods are the principal disasters with 102 and 72 occurrences, respectively. Distinctly, flood is still one of the biggest problems of the country. Statistics shows that 31.9% of the natural disasters, which occur in the Philippines in the years 1990-2014, are attributed to flood related episodes with a mortality rate of 5.9%. The researchers seek to approach non-structural measures to mitigate flooding problems of the country, specifically creating flood warning systems and to conduct several experiments testing the effectivity and efficiency of the flood warning system. This paper also aims to confront the century long problem of flooding and address the lack of real time flood warning system, thus reducing the loss of lives and damage to property; and to determine the effectiveness of the design of the river warning system in giving real time river water level updates. Results show that it works better if in contact with river waters than tap water. The device is audible in all distances at average ambient sound level of 50 to 60 decibels. Hence, the device is efficient in giving off sound alarms when deployed in different river systems.

Key words: River water level sensor, river flood warning system, river flood alarm system.

INTRODUCTION

Background of the study

Natural disasters are known connoisseurs in destruction and annihilation. Devastation of natural disasters is evident during and after it occurs. Ruined properties and infrastructures, defaced economic stability, impaired agricultural yield and loss of lives are some of its inimical after effects. One of these cataclysmal natural occurrences is flooding, which is the rising and overflowing of a body of water especially onto normally dry land. According to the Senate Report last 2013, records show that floods are the principal disaster with 72 occurrences. Floods are divided into 2 main categories: Based on location or place of occurrence, and based on duration of occurrence. River floods are categorized as floods based on location or place of occurrence. River flooding occurs when large amount of rain falls in river system with tributaries that drain large areas containing many independent river basins that inundates the adjacent low lying areas. These floods may last a few hours or many days depending on the intensity, amount, and the distribution of the rainfall (PAG-ASA, 2016). Vulnerability of the Philippines to river flooding is pronounced because of its 421 principal river basins

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scattered all over the archipelago (JICA, 2008). The Department of Public Works and Highways (DPWH) and Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) have been working hard to mitigate flood problems in the country. The history of flood mitigation is dated back during the early part of 20th century when storm drains were incorporated into the design of main roads (Liongson, 2000). Ceaseless improvements of the drainage system become the course of action for flood mitigation. New large-scale flood control technologies namely large-scale weirs, large-scale flood gates and high capacity pumping stations can also be incorporated. In like manner, PAGASA, the Philippine weather bureau, is mandated to provide protection against natural calamities and utilize scientific knowledge as an effective instrument to ensure the safety, wellbeing and economic security of all the people and for the promotion of progress. The weather agency is the principal source of information about storm details and possibilities of flooding. However, PAGASA's technologies are limited only on weather forecasting, flood monitoring and hazard maps. During intense precipitation, PAGASA can only issue warnings on possibility of flooding. In the study of Gilbuena et al. (2013a, b), flood structures in Metro Manila are seen ineffective in preventing unprecedented flooding caused by devastating tropical storms. Furthermore, damage to property and loss of lives may have been avoided or lessen if there have been sufficient and timely flood warnings. Thus, there is an immediate need for a real time flood warning system in the Philippine's major flood prone areas. In line with World Bank's guidebook on the most effective way to manage flood risk, the researchers seek to approach non-structural measures to mitigate flooding problems of the country, specifically creating flood warning systems. The researchers will conduct several experiments testing the effectively and efficiency of the flood warning system.

Patent JPH11304570 discloses a method that provides a water level sensor for river requiring no power supply. A material swelling upon absorbing water is stranded with an optical fiber to produce a stranded material which is then laid, in the vertical direction, in the ground at the riverbank or riverbed, or in the river. Distribution of strain is measured along the optical fiber by means of an optical fiber strain distribution measuring unit and a vertical position where strain distribution changes is detected as the water level. Patent CN208704846 discloses a flood prevention position detecting device, which comprises a water level measuring column fixed in a river area, a float, a waterproof cover, an angle sensor, a vertical rod and a baffle; and a lower fixed end of the water level measuring column forms a cone fixing portion for measuring the water level. The column is fixed in the river area, and the waterproof cover is fixedly mounted on the upper end of the water level measuring column; the float sleeve is lifted up and down with the water level on the water level measuring column, the distance measuring sensor and the wireless communication module are installed in the waterproof cover, and the probe of the distance measuring sensor is used for measuring downward. The height of the float is used to detect the height of the water level; a connection portion is arranged on the top side of the water level measuring column, and symmetric shafts are arranged on both sides of the vertical rod, the vertical rod is installed at the end of the connecting portion through the rotating shaft, and the angle sensor is installed at the rotating shaft for measuring. The deflection angle of the vertical rod, the lower end of the vertical rod is connected to the baffle, and the baffle is placed in the water; the data measured by the angle sensor and the distance measuring sensor are transmitted back to the monitoring centre through the wireless communication module.

The aim of this paper is to create a design for real time river flood warning system that is easy to produce and precisely effective. This is to be incorporated in river basins and systems and can be used in other flood sources. The design employs basic electricity concept that gives communities the capacity to make their own flood warning system. Furthermore, the researchers sought to answer the following specific problems:

1. Is there a significant difference in the sound pressure level before and during the device was in contact with different river waters?

a. Tap Water (Control);
b. Different River Waters (Experimental):
c. Butuanon River Water (BR);
d. Cubacub River Water (CuR); and
e. Cansaga River Water (CaR)?

Is there a significant difference in the increased sound pressure level before and during the device was in contact with different river waters:

a. Tap water;
b. Different river water:
c. Butuanon river water (BR);
d. Cubacub river water (CuR); and
e. Cansaga river water (CaR)?

2. Is there a significant difference in the sound pressure level while the device was in contact with different river waters at constant background noise?

a. Tap Water;
b. Different river waters:
c. BR water;
d. CuR, and
e. CaR water?

3. What is the audible sound level pressure of the device

in contact with Tap water at certain distances:

a. 5-meter away from the device;
b. 10-meter away from the device;
c. 20-meter away from the device

Significance of the study

The study is anchored to investigate the design of the river water level warning system to be installed in rivers, drainages and other flood sources. This study is a learning paradigm and will help local governments to devise their own flood warning system which employs the basic concept of electronics. The system will greatly help flood prone barangays giving real time updates on river flood level. Community-wide real time river water level updates will be automatically disseminated with sound alarms without the need of any 24/7 monitoring in the river waters. People living near a river will have sufficient time to prepare for evacuation because the design is conceptualized to bust increasing sound alerts of possible river overflow. This will also assist in the local government's rescue unit operations.

Development of new devices employing basic concepts of science opens an array of opportunities for students, inventors and individual enthusiasts in conceptualizing new technologies without the necessary deep understanding of complex science concepts. The simple science concept employed in this device hopes to attract communities, in general, in engaging in basic science concepts to develop various technologies at a very low cost, easy to manufacture and assemble. This device connects to the community people with no profound science background and aims to not only help them in times of calamity but also to encourage them not to fear science and make science as a tool to help one another.

Scope and limitations

Many families prefer to live near bodies of water, especially near a river. Rivers provide wide array of resources and opportunities. Rivers provide sources of food, water, transportation and protection. However, this harmless looking watercourse can become a raging torrent of large-scale destruction. Unprecedented cataclysmic flooding may result into loss of lives and damage to properties and infrastructures. This unprecedented flooding in our rivers is a serious problem faced and feared by communities living or located near a river system. The following are the limitations of the study:

a. The researchers conducted the experiment only to find out the effectively of the design and have not yet performed in a real river system.
b. The nature of the experimentation. The experiment was conducted in an improvised miniature community that was made by the researchers, and used a prototype of the design apropos to the magnitude of the improvised miniature community. The prototype of the design of the warning system uses batteries and small-sized buzzers.
c. The marketability of the device. The device was made as a primary tool intended for experimentation purposes alone.
d. The device's sound pressure level was not measured during heavy precipitation which may affect the device's loudness.
e. The device cannot be used as an alarm for storm surges and strong water currents; the device design is based on the idea of water level alarm. The device does not predict the precipitation amount of rainwater.
f. The study does not encompass the effects on the device in case of hours of usage.

Conceptual background

Electrical conductivity, in its succinct definition, is a measure of how electric current can flow through a given material; it is the capacity to transmit electricity. It is best-known fact that water with ions conducts electricity far better than some of the metals.

Water conductivity is a measure of water's capability to pass electrical flow. Water, itself, does not conduct electricity. The ability of water to conduct electricity is directly related to the concentration of ions in the water. The more ions that are present, the higher the conductivity of water. Likewise, the fewer the ions that are present in the water, the lesser conductive it is. Distilled or deionized water can act as an insulator due to its very low conductivity value. Sea water, on the other hand, has a very high conductivity (USGS, 2018). The conductive power of water will be put into use in our river flood warning system. However, the conductivity of water depends on its quality. The researchers seek to find the relationship between quality of water and sound pressure level.

The device employs the idea of spreading updates through sound bursts or alarms. It is critical for the device to burst sound alarms audible enough for all the residents residing near a river whether they are near or far away from the source. The sound pressure level of the device is important so that it must be both audible and safe for the residents. It is also necessary to take into account the background noise that may be heard during heavy precipitation and other factors that can add up into the total background noise. Thus, the sound pressure level is critical in delivering the designed purpose of the device.

The sound pressure level produced in each group was measured in three different levels: The yellow alert, orange alert, and red alert, each alert representing different levels of increasing danger. The yellow alert represents water level already at 2-meters below the river bank surface which is signalled by alarm level 1 that means that flooding is possible. The orange alert represents water level at 1-meter below the river bank surface which is signalled by alarm level 2 that means flooding is threatening. The red alert represents water level already reached the river bank surface which is signalled by alarm level 3 that means severe flooding is expected.

In the Philippines where flooding is rampant and news about loss of lives and damage to properties relating to this calamity are always broadcasted, there is therefore an urgent need for an effective, efficient and cheap river flood warning system that is capable of delivering to the community real time updates on river water level. It is important for communities based near a river to eliminate fears of casualties due to devastating floods by having 24/7 automatic flood warning system. This fact opens up the scope for researchers to create a device that acts as a river flood warning system that utilizes the basic concept of electronics and electrical conductivity.

METHODOLOGY

Research design

The study made use of the experimental hypothesis-testing research, which is a type of research method that enables researchers to test hypothesis by reaching valid conclusions about relationships of the control and experimental group. In this study, the researchers sought to determine the effects of varying water quality in the different river systems to the sound pressure level produced by the device during contact. The control group was exposed to tap water as a standard measure of sound pressure level. The experimental group was exposed to selected river waters from different river systems in the province. The sound pressure level produced in each group was measured in three different levels: The yellow level, orange level, and red level with each level representing different levels of increasing danger. It is critical that the device must burst sound alerts that are audible enough for residents living near and far away from the river. The researchers seek to measure the sound pressure level from the following distances away from the river: 5-m, 10-m and 20-m distance. The researchers aim to know whether the device works in different river waters and its capability to burst sound alerts in increasing distances.

The study was initiated by creating the design prototype of the device. Due to time constraints, the device will be tested through an improvised miniature community created by the researchers. River water samples were collected from different river systems in Cebu namely: Cansaga River Water (CaR), Butuanun River (BR) and Cubacub River (CuR). Tap water was also tested as control. The device prototype was attached in the miniature community for testing. Actual river water samples were flooded through the miniature community at a controllable rate. Decibel rating of the device in contact with the river water samples was tested. Sound pressure level of the device at different warning levels, 1, 2 and 3, in 5, 10 and 20 m distance was gathered (Figure 1). The collected data were analyzed through paired T-test, ANOVA and Pearson correlation. Statistically treated data were interpreted. The River Water Level Sensor as River Flood Warning System was developed. Conclusions and recommendations were derived from the expermentation and gathered data of the study.

Research environment

The experimentation was conducted in an open field near Cansaga Bay Bridge, Consolacion, Cebu (Figure 2). The selection of the environment of experimentation was according to the device's intended purpose. It is to take into account the noise level of the area of deployment. The open field location was selected to avoid obstacles that may affect the sound pressure level of the device. The device was kept away from harm and physical damage. The area parameters were maintained to be free from unnecessary hindrances that may affect the results of the experiment. The device is designed for experimentation purposes only. Findings will be disseminated to the residents and LGU's located near a river.

Research procedures

Preparation of instruments and materials

In the development of the River Flood Level Warning system prototype, the following materials were used: Decibel meter (to measure the sound pressure level of the device); three enclosed piezo electronic buzzers 12VDC knock sensor alarm; 10-meter long wire; 13.5 inches 25-mm acrylic pipe and a 36 volts power supply (batteries) (Table 1).

The alarms were attached together in a triangular position and were mounted to a 20-mm pvc pipe which serves as the alarm's foundation. The power supply was prepared by connecting the batteries in series with each other (that is, to equate its resulting voltage to 36 volts so that the buzzers will receive equal distribution of voltage) (Figure 3). Six pairs of 2-mm holes were created in the 13.5 inches acrylic pipe. An uninsulated wire was inserted in each pair of the holes, which served as three levels of open switch. The first level of the open switch was connected to the buzzer and to the power source through a solid wire so as with the second and third levels (making three open circuits).

A buzzer is a device that emits sound when it is connected to a power supply. There were three buzzers in this prototype: Buzzers 1.a, 1.b, and 1.c. Buzzer 1.a emits sound informing normal water level (yellow level), buzzer 1.b emits sound when water level is critical (orange level) and buzzer 1.c emits sound when water is in overflow level (red level). The buzzers will emit sound only when water (river water) touches the unwrapped wires inside the sensor body.

The conductive power of the water closes the circuit depending on the level it is connected. Conductivity is the measure of the ease at which an electric charge can pass through a material.

RESULTS AND DISCUSSION

Table 2 showed that the mean sound pressure level in the area at the first level of alarm before the device is in contact with tap water is 54.7 dBA, and the mean sound pressure level of the area during contact with tap water is 66.7 dBA; the mean difference during and before the contact of the device with tap water is 12.0 dBA.

The mean sound pressure level of the area before and during contact of the device with BR water is 55.3 and 70.9 dBA, respectively. The mean difference during and

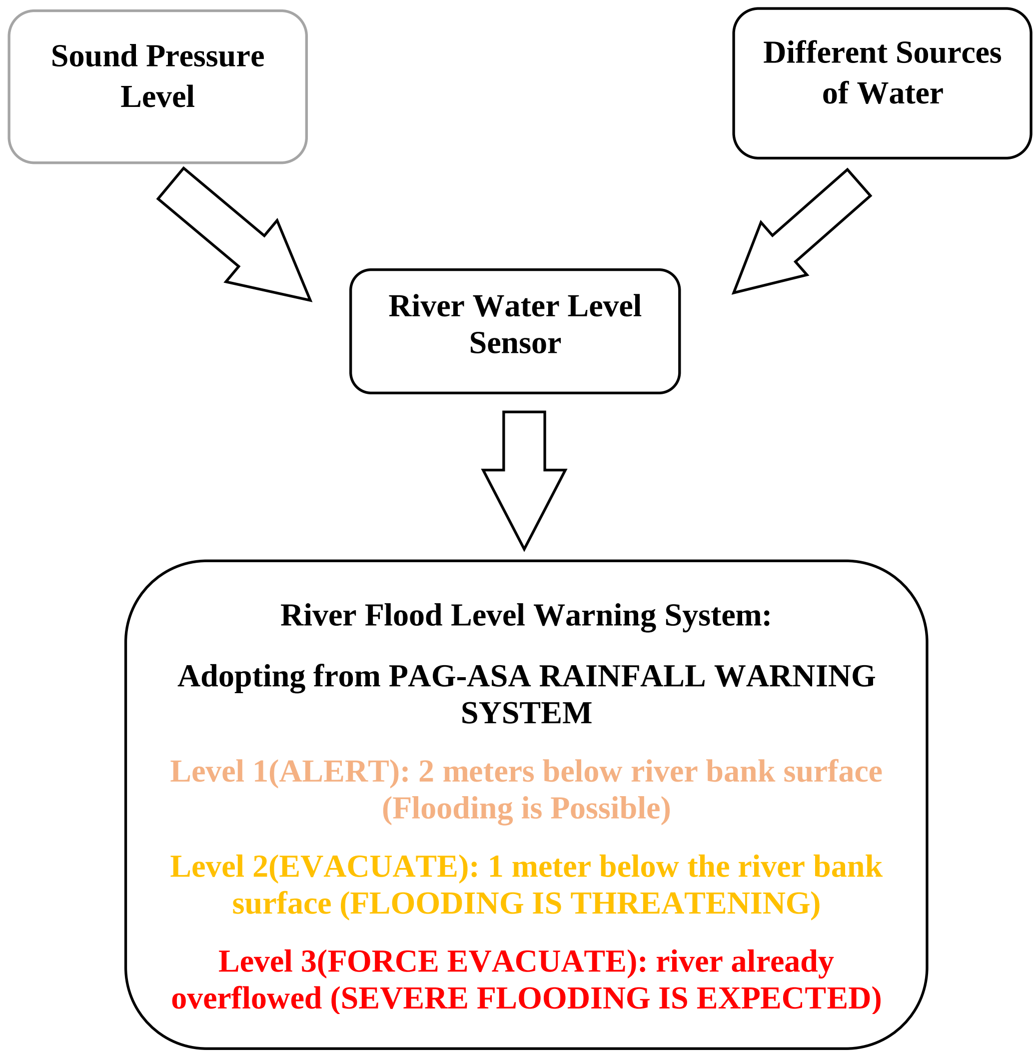


Figure 1. Conceptual framework.

Figure 2. Research environment.

before contact of the device with BR water is 15.6 dBA.

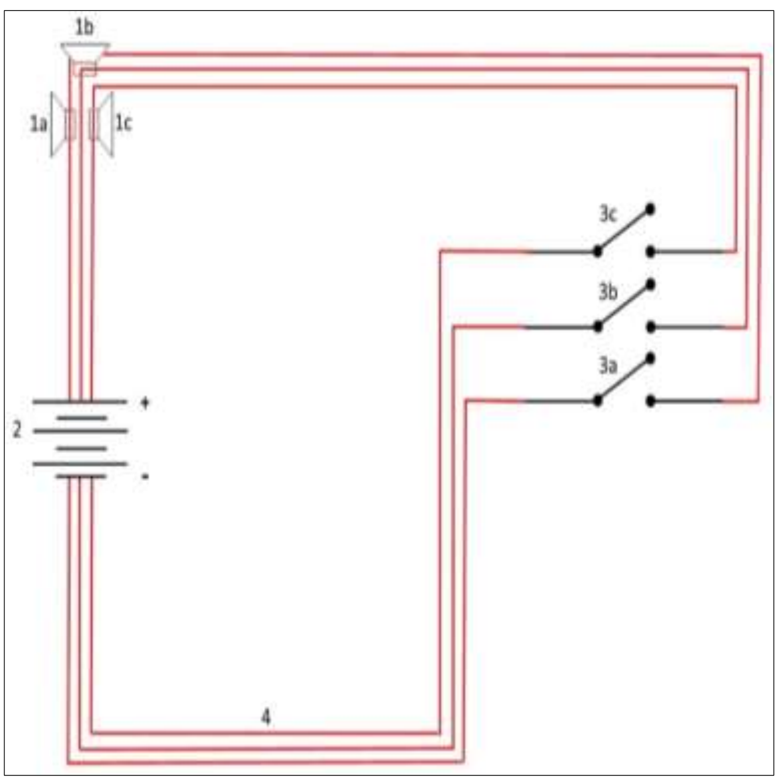
The mean sound pressure level of the area before and during contact of the device with CuR water is 54.2 and 74.5 dBA, respectively. The mean difference during and before contact of the device with CaR water is 20.3 dBA.

The mean sound pressure level of the area before and during contact of the device with CaR water is 56.9 and 70.7 dBA, respectively. The mean difference during and before contact of the device with CaR water is 13.8 dBA. The P-value of the tap water, BR water, CuR water and CaR water are 0.002, 0.000, 0.000 and 0.000, respectively, which are lesser than the accepted value of 0.05. Thus, the null hypothesis is rejected. This statistically means that there is significant increase in the sound pressure level before and during the device is in contact with different river waters.

Table 3 showed that the mean sound pressure level of

Table 1. Instruments and Materials Used in the Prototype.

Materials	Picture	Description
Decibel meter		Used to assess the sound levels by measuring sound pressure produced by the alarm system
12-36 volts piezo buzzer		Used as the source of sound for the alarm



1.a) 1st level buzzer

1.b) 2nd level buzzer

1.c) 3rd level buzzer

2. 36 Volts power source

3.a) 1st level open switch

3.b) 2nd level open switch

3.c) 3rd level open switch

4. Wires

Figure 3. Schematic diagram of the device.

Table 2. Sound pressure level of the device introduced to different river waters (At Alarm Level 1).

Water source	Mean sound pressure level (dBA)	Difference	P- value	Interpretation
Tap water (Control)				
During	66.7	12.0	0.002	Significant
Before	54.7			
Butuanon river water (br)				
During	70.9	15.6	0.000	Significant
Before	55.3			
Cubacub river water (CuR)				
During	74.5	20.3	0.0	Significant
Before	54.2			
Cansaga river water (CaR)				
During	70.7	13.8	0.0	Significant
Before	56.9			

Table 3. Sound pressure level of the device introduced to different river waters (At Alarm Level 2).

Water source	Mean sound pressure level (dBA)	Difference	P- value	Interpretation
Tap water (control)				
During	73.4	18.2	0.0	Significant
Before	55.2			
Butuanon river water (br)				
During	74.5	19.3	0.0	Significant
Before	55.2			
Cubacub river water (CuR)				
During	77.5	22.2	0.0	Significant
Before	55.3			
Cansaga river water (CaR)				
During	74.5	18.8	0.0	Significant
Before	55.7			

the area at the second level of alarm before the device is in contact with tap water is 55.2 dBA, and the mean sound pressure level of the area during contact with tap water is 73.4 dBA. The mean difference before and during contact of the device with tap water is 18.2 dBA. It shows a significant increase in mean sound pressure level difference compared to alert level 1.

The mean sound pressure level of the area before and during contact of the device with BR water is 55.2 and 74.5 dBA, respectively. The mean difference before and during contact of the device with BR water is 19.3 dBA.

The mean sound pressure level of the area before and during contact of the device with CuR water is 55.3 and 77.5 dBA, respectively. The mean difference before and during contact of the device with CuR water is 22.2 dBA.

The mean sound pressure level of the area before and during contact of the device with CaR water is 55.7 and 74.5 dBA, respectively.. The mean difference before and during contact of the device with CaR water is 18.8 dBA. The P-value of the tap water, BR water, CuR water and CaR water at alarm level 2 are all 0.0, which are lesser than the accepted value of 0.05. Thus, the null hypothesis is rejected. This statistically means that there is significant increase in the sound pressure level in alarm level 2 before and during the device is in contact with different river waters.

Table 4. Sound pressure level of the device introduced to different river waters (At Alarm Level 3).

Water source	Mean sound pressure level (dBA)	Difference	P- value	Interpretation
Tap water (Control)				
During	78.0	18.9	0.0	Significant
Before	59.1			
Butuanon river water (br)				
During	78.3	21.9	0.0	Significant
Before	56.4			
Cubacub river water (CuR)				
During	80.8	25.5	0.0	Significant
Before	55.3			
Cansaga river water (CaR)				
During	78.3	21.9	0.0	Significant
Before	56.4			

It is found that the mean sound pressure level difference at alarm level 2 of the device in contact with tap water still shows the smallest increase in sound pressure level. Therefore, the device is most ineffective in tap water. In addition, the mean sound pressure level difference at alarm level 2 of the device in contact with the different river water registers greater increase in sound pressure level compared to tap water, in which CuR shows greatest increase in mean sound pressure level difference at alarm level 2.

Table 4 shows that the mean sound pressure level of the area at the third level of alarm before the device is in contact with tap water are 59.1 dBA, and the mean sound pressure level of the area during contact with tap water is 78.0 dBA. The mean difference before and during contact of the device with tap water is 18.9 dBA. It shows a significant increase in mean sound pressure level difference compared to alerts level 1 and 2.

The mean sound pressure level of the area before and during contact of the device with BR water is 56.4 and 78.3 dBA, respectively. The mean difference before and during contact of the device with BR water is 21.9 dBA.

The mean sound pressure level of the area before and during contact of the device with CuR water is 55.3 and 80.8 dBA, respectively. The mean difference before and during contact of the device with CuR water is 25.5 dBA.

The mean sound pressure level of the area before and during contact of the device with CaR water is 56.4 and 78.3 dBA, respectively. The mean difference before and during contact of the device with CaR water is 21.9 dBA. The P-value of the tap water, BR water, CuR water and CaR water at alarm level 3 are all 0.0, which are lesser than the accepted value of 0.05. Thus, the null hypothesis is rejected. This means that there is significant increase in the sound pressure level in alarm level 3 before and during the device is in contact with different river waters.

It is found that the mean sound pressure level difference at alarm level 3 of the device in contact with tap water still shows the smallest increase in sound pressure level. Thus, the device is most ineffective in tap water. Moreover, the mean sound pressure level difference at alarm level 3 of the device in contact with the different river water registers greater increase in sound pressure level compared to tap water, in which CuR water shows greatest increase in mean sound pressure level difference at alarm level 3.

Of the three different levels of alarm, river waters show significant increase in the mean sound pressure level difference compared to tap water. It is found that the mean sound pressure level difference of the device in contact with tap water shows the smallest increase in sound pressure level in the three different levels of alarm. Therefore, the device is most ineffective in tap water. In addition, the mean sound pressure level difference of the device in contact with the different river water registers greater increase in sound pressure level compared to tap water in the three different levels of alarm, in which CuR shows greatest increase in mean sound pressure level in all levels of alarm. Therefore, the device worked far better in the different river waters compared to the tap water, thus making the device effective and efficient. This result is due to the different ions present in the water (conductivity), the conductivity of water is directly related to the current flowing in the device which is directly related to the pressure level of the sound produced by the buzzers.

Results of Patil and Pati (2010) showed that high

Table 5. Increased sound pressure level of the device introduced to different river waters (At Alarm Level 1).

Water source	Mean	P- value	Interpretation
Tap water	12.0	0.002	Significant
BR water	15.6		
CuR water	20.3		
CaR water	13.8		

Table 6. Increased sound pressure level of the device introduced to different river waters (At Alarm Level 2).

Water source	Mean	P- Value	Interpretation
Tap water	18.2	0.047	Significant
BR water	19.3		
CuR water	22.2		
CaR water	18.8		

electrical conductivity indicates high amount of dissolved inorganic substances in ionized form. Furthermore, according to Kumar (2003) in his book, “Comprehensive Physics XII”, said that conductivity of material is its ability to conduct electric current; the higher the conductivity, the better the ease with which current flows through the material. In conclusion, water of high conductivity signifies strong current flow which then intensifies the sound pressure produced by the device.

Table 5 shows the mean increased sound pressure level of the device at alarm level 1 in contact with tap water is 12.0, the mean increased sound pressure level of the device in contact with BR water is 15.6, the mean increased sound pressure level of the device in contact with CuR water is 20.3, and the mean increased sound pressure level of the device introduced to CaR water is 13.8. The P-value of the mean increased sound pressure level of the device introduced to different river waters is 0.002 which is lesser than the accepted value of 0.05. Thus, the null hypothesis is rejected. This implies that there is a significant difference in the increased sound pressure level of the device in contact with tap water, BR water, CuR water and CaR water. The mean sound pressure level of the device in contact with tap water shows the smallest increase in sound pressure level compared to three river waters in contact with the device. It is also found that the CuR water in contact with the device shows the greatest increase in sound pressure level and is followed by BR water and CaR, respectively.

Table 6 shows the mean increased sound pressure level of the device at alarm level 2 in contact with tap water is 18.2, the mean increased sound pressure level of the device at alarm level 2 in contact with BR water is 19.3, the mean increased of sound pressure level of the device at alarm level 2 introduced to CuR water is 22.2, and the mean increased sound pressure level of the device in contact with CaR water is 18.8. The P-value of the mean increased sound pressure level of the device introduced to different river waters is 0.047 which is lesser than the accepted value of 0.05. Thus, the null hypothesis is rejected. This implies that there is a significant difference in the increased sound pressure level of the device at alarm level 2 in contact with tap water, BR water, CuR water and CaR water. The mean sound pressure level of the device at alarm level 2 in contact with tap water shows the smallest increase in sound pressure level compared to three river waters in contact with the device. The CuR water still registered the greatest increase in sound pressure level and is followed by CaR water and BR water, respectively.

Table 7 shows the mean increased of sound pressure level of the device at alarm level 3 in contact with tap water is 18.9, the mean increased sound pressure level of the device at alarm level 3 in contact with BR water is 21.9, the mean increased sound pressure level of the device at alarm level 3 introduced to CuR water is 25.5, and the mean increased sound pressure level of the device in contact with CaR water is 21.9. The P-value of the mean increased sound pressure level of the device introduced to different river waters is 0.005 which is lesser than the accepted value of 0.05. Thus, the null hypothesis is rejected. This implies that there is a significant difference in the increased sound pressure level of the device at alarm level 3 in contact with tap water, BR water, CuR water and CaR water. The mean sound pressure level of the device at alarm level 3 in contact with tap water showed the smallest increase in sound pressure level compared to three river waters in contact with the device. The CuR water still registered the greatest increase in sound pressure level and is followed

Table 7. Increased sound pressure level of the device introduced to different river waters (At Alarm Level 3).

Water source	Mean	P- Value	Interpretation
Tap water	18.9	0.005	Significant
BR water	21.9		
CuR water	25.5		
CaR water	21.9		

Table 8. Comparison of sound pressure level of the device in contact with different river waters at constant background noise of 60 dBA (At Alarm Level 1).

Water source	Mean	P- value	Interpretation
Tap water	69.1	0.012	Significant
BR water	70.2		
CuR water	73.4		
CaR water	72.9		

Table 9. Comparison of sound pressure level of the device in contact with different river waters at constant background noise of 60 dBA (At Alarm Level 2).

Water source	Mean	P- value	Interpretation
Tap water	73.5	0.012	Significant
BR water	73.8		
CuR water	76.9		
CaR water	75.1		

by CaR water and BR water who logged the same mean increase in sound pressure level. The statistical results show that tap water indicated the smallest increase in sound pressure level in all levels of alarms compared to the three rivers. This signifies that the device works better in river waters compared to tap water.

Table 8 shows the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 69.1, the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 70.2, the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 73.4, and the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 72.9. The P-value of the mean sound pressure of the device in contact with different river waters at constant background noise of 60 dBA at alarm level 1 is 0.012 which is lesser than the accepted value of 0.05; thus, rejecting the null hypothesis. This implies that there is a significant difference in the sound pressure level of the device at alarm level 1 in contact with different river waters at constant background noise of 60 dBA. The mean sound pressure level of the device in contact with tap water at constant background noise of 60 dBA at alarm level 1 shows the smallest average sound pressure level amongst the four water sources. The device displays the loudest average sound at an alarm level 1 at 60 dBA background noise when in contact with CuR water and is followed by CaR water and BR water, respectively.

Table 9 shows the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 73.5, the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 73.8, the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 76.9, and the mean sound pressure level of the device in contact with tap water at alarm level 1 at constant background noise of 60 dBA is 75.1. The P-value of the mean sound pressure of the device in contact with different river waters at constant background noise of 60 dBA at alarm level 1 is 0.012 which is lesser than the accepted value of 0.05; thus,

Table 10. Comparison of sound pressure level of the device in contact with different river waters at constant background noise of 60 dBA (At Alarm Level 3).

Water source	Mean	P- value	Interpretation
Tap water	77.7	0.172	Not significant
BR water	78.3		
CuR water	80.4		
CaR water	79.0		

rejecting the null hypothesis. This implies that there is a significant difference in the sound pressure level of the device at alarm level 1 in contact with different river waters at constant background noise of 60 dBA. The mean sound pressure level of the device in contact with tap water at constant background noise of 60 dBA at alarm level 2 still shows the smallest average sound pressure level amongst the four water sources. The device displays the loudest average sound at an alarm level 2 at 60 dBA background noise when in contact with CuR water and is followed by CaR water and BR water, respectively.

Table 10 shows the mean sound pressure level of the device in contact with tap water at alarm level 3 at constant background noise of 60 dBA is 77.7, the mean sound pressure level of the device in contact with tap water at alarm level 3 at constant background noise of 60 dBA is 78.3, the mean sound pressure level of the device in contact with tap water at alarm level 3 at constant background noise of 60 dBA is 80.4, and the mean sound pressure level of the device in contact with tap water at alarm level 3 at constant background noise of 60 dBA is 79.0. The P-value of the mean sound pressure of the device in contact with different river waters at constant background noise of 60 dBA at alarm level 1 is 0.172 which is greater than the accepted value of 0.05; thus, accepting the null hypothesis. This implies that there is no significant difference in the sound pressure level of the device at alarm level 3 in contact with different river waters at constant background noise of 60 dBA. The mean sound pressure level of the device in contact with tap water at constant background noise of 60 dBA at alarm level 3 still shows the smallest average sound pressure level amongst the four water sources. The device displays the loudest average sound at an alarm level 3 at 60 dBA background noise when in contact with CuR water and is followed by CaR water and BR water, respectively.

At constant background noise of 60 dBA, the device produces the smallest average sound pressure level when in contact with tap water at all levels of alarm. The device is loudest when in contact with CuR water in all levels of alarm and is followed by CaR water and BR water, respectively. The results show a constant order of average sound pressure level in all levels of alarm at 60 dBA background noise. The order of average sound levels from smallest to largest at all levels of alarm is tap water, BR water, CaR water and the loudest is the CuR water.

Tables 8 to 10 show the comparison of the average sound pressure level of the device at different river waters at 60 dBA in all levels of alarm. The sound pressure level of the device is measured from a constant distance of 10-meters using five samples of three different river waters and tap water.

Table 11 shows the relationship of the distance of the listener and sound pressure level of the device at constant background noise of 60 dBA at all levels of alarm. A Pearson correlation coefficient is computed to assess the relationship between the sound pressure level produced by the device and the distance of the listener. There is a significant negative correlation between the two variables at alarm level 1, $r = -0.763$, $n = 15$, $p = 0.001$. In alarm level 2, there is still a significant negative correlation between the two variables, $r = -.781$, $n = 15$, $p = 0.001$. In alarm level 3, there is still a significant negative correlation between the two variables, $r = -0.849$, $n = 15$, $p = 0.000$. The results show that at alarm level 3 there is a stronger relationship between distance of listener and the sound pressure level amongst the three. Overall, there is a strong, negative correlation between sound pressure level of the device and distance of the listener. Increasing distances are correlated with decreasing sound pressure level.

Table 12 shows the comparison of means of the sound pressure level of the device at different distances in all levels of alarm. In all levels of alarm, 5-meter distance shows the loudest average sound heard followed by 10- and 20-meter distance. The mean sound pressure of the device at alarm level 1 at a distance of 5 m is 78.1 dBA, at a distance of 10 m is 69.1 dBA and at a distance of 20 m is 67.6 dBA. The difference between the average sound pressure level of 20-meter distance and 10-meter distance is 1.5 dBA and the difference between the average sound pressure level of 10- and 5-meter is 9 dBA.

The mean sound pressure of the device at alarm level 2 at a distance of 5 m is 82.3 dBA, at a distance of 10 m is 73.5 dBA and at a distance of 20 m is 72.3 dBA. The difference between the average sound pressure level of

Table 11. Distance and sound pressure level relationship of the device (At Alarm Levels 1, 2 and 3).

Alarm level	Mean	Pearson correlation	P- Value	Interpretation
At Alarm Level 1				
Distance	11.7	-0.763	0.001	Significant
Sound pressure level	71.6	-0.763		
At Alarm Level 2				
Distance	11.7	-0.781	0.001	Significant
Sound pressure level	75.9	-0.781		
At Alarm Level 3				
Distance	11.7	-0.849	0.000	Significant
Sound pressure level	79.6	-0.849		

Table 12. Comparison of the sound pressure level produced by the device at different distances in all levels of alarm.

Alarm level	Mean	Maximum	Minimum
At Alarm Level 1			
5-meters	78.1	81.5	75.0
10-meters	69.1	70	67.5
20-meters	67.6	70	65.0
At Alarm Level 2			
5-meters	82.3	84	79.5
10-meters	73.5	74.5	72.5
20-meters	72.3	73.5	70.0
At Alarm Level 3			
5-meters	85.9	88.5	83.0
10-meters	77.7	79.5	76.0
20-meters	75.2	76.0	74.5

20-meter distance and 10-meter distance is 1.2 dBA and the difference between the average sound pressure level of 10- and 5-meter is 8 dBA.

The mean sound pressure of the device at alarm level 3 at a distance of 5 m is 85.9 dBA, at a distance of 10 m is 77.7 dBA and at a distance of 20 m is 75.2 dBA. The difference between the average sound pressure level of 20-meter distance and 10-meter distance is 2.5 dB and the difference between the average sound pressure level of 10-meter and 5-meter is 8.2 dBA. The decibel lost at all levels of alarm between 10-meter distance and 5-meter distance is too large compared to the accepted value. The sound pressure level of the device measured at different distances is treated under a constant 60 dBA background noise.

According to Kana (2013), alarms used in the public mode must be a minimum of 15 dBA above average ambient sound levels. She also added that up to 6 dBA is the maximum decibel lost every doubled distance from the device.

Summary of findings

From the statistical treatment of the data, the findings are as follows:

1. There is a significant increase in sound pressure level during and before the device is in contact with Cubacub River water at all levels of alarm.
2. There is a significant increase in sound pressure level during and before the device is in contact with Cansaga River water at all levels of alarm.
3. There is a significant increase in sound pressure level during and before the device is in contact with Butuanon River water at all levels of alarm.
4. The tap water shows the smallest increase in sound pressure level.
5. There is a significant difference in the increasing values of sound pressure level of the device introduced to different river waters at all levels of alarm.
6. There is a significant difference in the sound pressure

level of the device introduced to different river waters at 60 dBA background noise at alarms level 1 and 2.
7. There is no significant difference in the mean sound pressure level of the device introduced to different river waters at 60 dBA background noise at alarm level 3.
8. The device is loudest when in contact with Cubacub River. Next is Cansaga River, then Butuanon River.
9. The sound level value of the device between 10-meter distance and 5-meter distance is over the maximum accepted value of 6 dBA.

Conclusion

The river flood level water system device is audible in all distances at average ambient sound level ranging from 50 to 60 decibels, and effective in giving off sound alarms when deployed in different river systems. The device works better if in contact with river waters than tap water. The highest increase in sound pressure level is recorded in the three different river waters. The device is loudest when in contact with the three different river waters.

Recommendations

This study is recommended as a tool for river level updates especially to those people living in flood prone areas. The authors also recommend that the device should have a firm construction specifically on its interior and exterior parts and should be tested during heavy rains in order to have more reliable and better results.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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