

Water Quality In Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon, Philippines

Lizuel Ann A. Arienza, Zaira C. Tirado, Khimtrisha A. Calunsag, Mark Justin G. Penkian, Adonesc Q. Tahanlangit, Jeanalyn A. Celis, Wilfredo I. Balagas, and Ellen A. Azuelo

Abstract: The study was conducted from April to August, 2021 to investigate the water quality in Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon, Philippines. Specifically, it aimed to: (1) determine the physical geography of the spring; (2) examine the water's physico-chemical and microbial parameters; and (3) create precautionary measures in treating, conserving, and preserving the quality of water in Langahan Spring. Three (3) strategic water sampling stations were chosen subject for laboratory testing at Central Mindanao University. Results revealed that pH in stations 1 and 2, HPC in stations 2 and 3 and total coliform, and E. coli of all stations exceeded the maximum allowable level set by the Department of Health (DOH) in the Philippine National Standards for Drinking Water of 2017. Phosphate concentration and TSS in all water samples were also high. Enterobacter sp., Pseudomonas sp., and Shigella sp. were bacteriologically isolated. Thus, the spring's water is not safe to drink as it can be the source of various illnesses. Information dissemination through attending sessions, limited face to face meetings and posting videos and photographs to other social media platforms were done to spread awareness and advocacy to the general public about the research study. A water reservoir with ceramic water filter, intake box, and riprap were then proposed for water treatment as intervention of this study and construction is on-going with the collaboration of LGU – Damulog and Provincial Science and Technology Center – Bukidnon, Department of Science and Technology – 10 on the progress of the study. The researchers recommended to further assess other parameters not included in this study. Recipients are encouraged to maintain, conserve and preserve the good water quality. Regular monitoring of the parameters should also be done as per advised by the DOH.

Index Terms: Water Quality, Damulog, Langahan Spring, Physico-chemical, Microbial

1 INTRODUCTION

WATER is life! It is one of the reasons why Earth is the sole unique planet known to have liquid water which can be considered as the building block of any ecosystem and the most valuable key resource to any organism's survival. As to its vitality, each individual is dependent to water, be it in consumption, domestic-related activities, commercial, and most importantly, in the world of agriculture. In addition, with forty-two (42) liters of water for an average adult body [1], it shows that one can live for weeks without food but not with water [2]. It is essential for bodily functions, especially in

circulation and digestion, regulating the body's temperature, waste products excretion, and for the brains performance for it is mainly composed of seventy-three percent (73%) water [3]. Due to its importance, monitoring water quality is a must. Water quality is usually defined by the physical, chemical and biological characteristic of water [4]. It is the term used by means of the suitability of water with regards to its diverse applications specifically for drinking. Additionally, there's an ascending recognition that natural ecosystems should be considered for water quality management. This is both for their intrinsic value and because of the fact that changes or deterioration of overall water quality can be indicated through the ecosystems, providing a significant role for the chemical, physical conditions of water and other information [5]. In connection to this, good water quality contributes not only to aquatic life but the surrounding ecosystem as well. It is necessary not just for human health but also in the plant kingdom. Geologically, spring is an opening at the ground surface or rock where water flows out from underground. It is the result of an aquifer being filled with water until it overflows [6]. An aquifer is a layer of water-bearing rock below the surface of the earth. They are permeable which allows the water to go and pass through it like a sponge [7]. Langahan Spring is just one of the many springs located within the Barangay Sampagar's parameter. The said barangay is more or less 7.3 kilometers away from Damulog proper and it is one of the 17 barangays of the Municipality of Damulog. It is bounded in the north by Barangay Spring, in the south by Barangay Old Damulog, in the west by Barangay New Compostela, and in the east by Barangay Migcawayan [8]. Furthermore, it is a diverse place with rich natural resources like water spring with numbers of people depending on it. However, the outbreak of COVID-19 has highlighted that safe water provision is highly significant for human health safety amidst the spread of infectious disease [9]. In relation, the Republic Act No. 9275 or The Philippine Clean Water Act of 2004 also aims to protect the different bodies of water in the country from any land-based sources of pollution [10]. With problems concerning water pollution contaminating bodies of

- Lizuel Ann A. Arienza is a senior high school student under the Science, Technology, Engineering and Mathematics (STEM) Strand of the Academic Track of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines. +639639845007, lizuelarjenja@gmail.com
- Zaira C. Tirado is a senior high school student under the Science, Technology, Engineering and Mathematics (STEM) Strand of the Academic Track. She is the President of ODNHS Supreme Student Government, Vice President of the Science Club, Treasurer of the Filipino Club, President of the Girl Scout of the Philippines Damulog Chapter and also a Chief Girl Scout Medal Scheme Awardee of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines, +639169029861, zairactirado@gmail.com
- Khimtrisha A. Calunsag is a senior high school student under the Science, Technology, Engineering and Mathematics (STEM) Strand of the Academic Track. She is the Peace Officer of the Supreme Student Government and President of the Dance Troupe of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines. +639685826845, Khimtrishacalunsag@gmail.com
- Mark Justin G. Penkian is a senior high school student under the Science, Technology, Engineering and Mathematics (STEM) Strand of the Academic Track of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines. +639354511245, markjustinpenkian@gmail.com
- Adonesc Q. Tahanlangit is a senior high school student under the Science, Technology, Engineering and Mathematics (STEM) Strand of the Academic Track of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines. +639630917797, matayba02@gmail.com
- Jeanalyn A. Celis is currently a senior high school teacher handling research and science subjects, an active troop leader of the Girl Scouts of the Philippines, and a science laboratory in-charge of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines. +639190943899, jeanalyn.agor@deped.gov.ph
- Wilfredo I. Balagas is the Secondary School Principal of Old Damulog National High School, Old Damulog, Damulog, Bukidnon, 8721, Philippines. +639177025061, wilfredo.balagas001@deped.gov.ph
- Ellen A. Azuelo is the Science Education Program Supervisor of the Department of Education, Division of Bukidnon, Sumpong, Malaybalay City, Bukidnon, 8700, Philippines. +639171022889, ellen.azuelo@deped.gov.ph

water like stream, river, ocean and spring with toxic and harmful substances, sanitation and safe potable water nowadays became questionable. Hence, a scientific investigation will be put into action. With the absence of research studies done in the selected area, the study was conducted to test the water quality of the spring with regards to its physico-chemical and microbial parameters. Consequently, the result provided information to the quality of water in Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon, Philippines.

2 METHODOLOGY

2.1 ENTRY PROTOCOL

Letters of permit were secured personally from the parents of the researchers, the school principal of Old Damulog National High School, Local Inter-Agency Task Force on Emerging Infectious Diseases (IATF-EID), Barangay Captain of Sampagar, Damulog, Bukidnon, owners of the selected spring, Purok President of Sitio Langahan, Office of the Local Sanitary Inspector and a courtesy call to the Local Government Unit of the Municipality of Damulog. These were done prior to the conduct of the study for the permission in the vicinity of Langhan Spring, Langahan, Sampagar, Damulog Bukidnon. Researchers have followed proper COVID-19 protocol all throughout the duration of the conduct of the study.

2.2 LOCALE OF THE STUDY

The study was conducted from the month of April until August of the current year at Barangay Sampagar, one of the seventeen barangays of the Municipality of Damulog. The barangay is within the grid coordinates of 7° 30' 47" N, 124° 57' 19" E. It is bounded on the North part by Barangay Spring of the Municipality of Kibawe, Barangay Old Damulog on the Southern part, Barangay Migcawayan on the Eastern part, and on the west part by the Barangay New Compostela of Damulog, Bukidnon [8]. Purok 5 of Barangay Sampagar, also known as Sitio Langahan have a 3-kilometer distance from the barangay hall and is abundant with water sources and springs. Unlike the other known springs in the sitio, Langahan Spring is quite far away and it is approximately 200 meters hiking distance from the barangay road. It is classified as a Level 1 water supply [11] and permanently caters approximately twenty two (22) dependent households notwithstanding the other individuals and by passers who use it sometimes. In addition, this spring is where cold, clear and rich water came from. Big Bamboo trees are also found beside it and the water from this spring sufficiently supports the community for domestic and agricultural uses.

2.3 DATA COLLECTION

An ocular survey of the spring was done for the determination of the three (3) strategic sampling stations that were chosen for the study. The three stations were selected for the determination of physico-chemical and microbial analysis for the spring's water quality. Specifically, Station 1 was the spring water source protected in a concrete hole with wooden box cover. Station 2 was the pipe connecting Station 1 and 3. Station 3 is the water tub where the water coming out from the pipe was stored. The measurement of the springs' altitude and grid coordinates were obtained with the help of an android application installed in the smartphone which is the GeoCam.

Also, the determination of the weather pattern of the area for days was from the website, timeanddate.com. Three (3) sterilized water bottles were allotted for each of the three sampling stations. Researchers observed precautionary measures while collecting samples so as to avoid contamination. Using a marker, the bottles were labeled with the stations to where they were collected. Consequently, the bottles were placed in a cooler filled with ice for preservation. Within six (6) hours, six (6) bottles were submitted directly to the experts at Soil and Plant Analysis Laboratory (SPAL) in College of Agriculture for the analysis of chemical parameters and three (3) bottles for the microbial parameters testing to the Microbiology Research Laboratory in the College of Veterinary Medicine, Central Mindanao University, Musuan, Maramag, Bukidnon.

3 RESULTS AND DISCUSSION

The comprehensive discussion, interpretation, and implication of the findings of the study where the order of the presentation follows the sequence of the problem identified in the study: the physical geography of the spring, its physico-chemical and microbial parameters.

3.1 Physical Geography of the Spring

Table 1a and Table 1b show the Physical Parameter and Geography of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon.

Table 1a. Physical Parameter and Geography Relative to Temperature, Altitude and Grid Coordinates of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

| Station | Temperature (°C) | | Altitude (meters AMSL) | Grid Coordinates (Longitude, Latitude) |
|---------|------------------|-------|------------------------|--|
| | Air | Water | | |
| 1 | 21 | 26 | 351.739 | 7°30'28"N, 124°58'11"E |
| 2 | 26 | 26 | 328.574 | 7°30'28"N, 124°58'9"E |
| 3 | 28 | 26 | 328.574 | 7°30'28"N, 124°58'9"E |

AMSL: Above Mean Sea Level

Table 1a above shows the physical parameter and geography relative to temperature, altitude and grid coordinates of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. Station 1 is more elevated compared to the other stations which have the same altitude. All of the stations have the same position north of the equator. As determined, station 1 again was farther from east of the prime meridian compared to the remaining stations. Minimal differences for elevation and position were there. It is noted that Stations 2 and 3 were at the same exact location, so the similarities in the results were justifiable. Furthermore, the above table depicts that the air temperature of the distinct stations during the sampling varied from 21°C to 28°C of which Station 3 is the highest, while the water temperature were all the same. These temperatures could be attributed to the altitude and grid coordinates and

weather pattern of the study area before and during the sample collection (Table 1b). These values could differ monthly, daily or even hourly. There was no maximum water temperature set by the Department of Health (DOH) in the Philippine National Standards for Drinking Water of 2017 (PNSDW) as it is not considered to be the primary or secondary parameters for drinking water [12].

Table 1b. Physical Geography Relative to Weather Pattern of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

| Time | Stations 1, 2 & 3 | | | | |
|----------|-------------------|-------------------------|------------------------------|--------------|------------------------|
| | May 7, 2021 | May 8, 2021 | May 9, 2021 | May 10, 2021 | May 11, 2021 |
| 12:00 AM | Passing clouds | Light rain and overcast | Overcast | Overcast | Passing clouds |
| 6:00 AM | | | | Overcast | |
| 6:00 AM | Partly sunny | Partly sunny | Partly sunny | | Partly sunny |
| 12:00 PM | | | | Overcast | |
| 12:00 PM | Thunder showers | Partly sunny | Partly sunny | | Partly sunny |
| 6:00 PM | | | | Overcast | |
| 6:00 PM | Overcast | Light rain and overcast | Thunder showers and overcast | | Sprinkles and overcast |
| 12:00 AM | | | | | |

Source: timeanddate.com

Table 1b revealed the physical geography relative to weather pattern of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. The weather pattern for days differs from partly sunny, overcast, light rain, sprinkles and thunder showers. Henceforth, the weather pattern generally was not that good. Also, the pattern could be linked to the rainy seasons of the Bukidnon Province where monthly fall were generally somewhat in excess of 200.00 millimeter (200mm) from March to October [13]. There could be a possibility that the thunder showers for hours which happened days before the date of sampling could have affected the water quality of water in Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon in relation to its microbial parameters. Microbial contamination could increase due to storm events, heavy rainfall, and runoff [14].

3.2 Chemical Parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

Table 2a and Table 2b below show the chemical parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon.

Table 2a. Chemical Parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

| Station | pH | Nitrate (ppm) | Phosphate (ppm) | Potassium (ppm) | Sodium (ppm) | Sulfate (ppm) |
|---------|------|---------------|-----------------|-----------------|--------------|---------------|
| 1 | 6.14 | 0.029 | 0.507 | 0.800 | BD | 0.017 |
| 2 | 6.32 | 0.025 | 3.404 | 1.0 | BD | 0.000 |
| 3 | 6.55 | 0.019 | 0.195 | 1.1 | BD | 0.029 |

BD: Below Detection

Table 2a depicted the chemical parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. As for the pH, only the last station passes standard Maximum Allowable Level (MAL) pH of 6.5-8.5 [12]. This means station 1 and 2 have acidic water. Nitrate content of the water samples was below the DOH standard which is 50.00 mg/L or 500 ppm [12]. In addition, Station two's phosphate content was higher in comparison with other stations. It might be because of the growth of algae which then affect the dissolved oxygen in water [15]. Despite all of this, the chemical's concentration in the spring water could not be rated as above or below the standard since there was no MAL set in the PNSDW [12]. Furthermore, potassium concentration of water samples showed narrow variations which ranged from 0.800-1.1 in parts per million and station 3 was the highest. Similarly, the latest standard for drinking water given by the DOH does not have the maximum level of potassium [12]. Continually, no sodium was detected from all samples of water and it was less than the method detection limit (MDL). With regards to the results, sodium should not be a problem at all. Lastly, all the stations have lower sulfate concentration compared to the permissible MAL, 50.0 mg/L, in PNSDW [12]. Hence, illnesses in relation to the concentration of sulfate in Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon is unlikely to occur.

Table 2b. Chemical Parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

| Station | TDS (mg/mL) | TSS (mg/mL) | Carbonate (ppm) | Bicarbonate (ppm) | Chlorine |
|---------|-------------|-------------|-----------------|-------------------|----------|
| 1 | 0.070 | 0.270 | BD | BD | BD |
| 2 | 0.100 | 0.250 | BD | BD | BD |
| 3 | 0.130 | 0.440 | BD | BD | BD |

BD: Below Detection

Table 2b portrays the chemical parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. Based on the table, the TDS values found from each of the station's water sample were below the standard maximum allowable level (MAL) set by the DOH which is 600 mg/L [12]. Water in the water tub or in the third station have the highest level of which, if converted to mg/L turned to be 130 mg/L. Nevertheless, this could mean that TDS is not alarming in the site. The presence of TDS might have originated from natural sources in the selected site. In addition, Station 2 has the

lowest TSS of 0.250 mg/mL compared to 440 mg/mL in Station 3 which is the highest. In similar with other parameters, standard maximum allowable level (MAL) for TSS was not included in PNSDW [12]. On the other hand, the remaining chemicals, namely, Carbonate, Bicarbonate, and Chlorine were all below detection (BD). Hence, all station's water were considered soft [16]. As for the below detection of chlorine, this could have happened due to the absence of the chlorination process for spring water treatment in the study site.

3.3 Microbial Parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

Table 3a and 3b show the microbial parameters and bacterial isolates of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon, respectively.

Table 3a. Microbial Parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

| Station | Total Coliform (MPN/100 mL) | Thermotolerant Coliform/E. coli (MPN/100 mL) | HPC (CFU/mL) |
|---------|-----------------------------|--|--------------|
| 1 | <8.0 | >8.0 | 349 |
| 2 | <8.0 | >8.0 | 580 |
| 3 | <8.0 | >8.0 | 594 |

MPN: Most Probable Number; CFU: Colony Forming Units

Table 3a displays the Microbial Parameters of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. It reveals that all water samples from the three stations tested positive both for the Total Coliform and E. coli and were all above the authorized standard from the DOH which is <1.1 MPN/100 mL [12]. The said standard would be the result or value when the no. of tubes giving positive reaction out of five (5) is none or zero (0) in Multiple Tube Fermentation Technique. In relation, the result >8.0 shows that out of the five (5) test tubes, all gave a positive reaction. Total coliform detection could be attributed to the environment where the spring is located at while the E. coli might be traced from the feces of the animals surrounding the spring site which could contaminate the water through run-offs. Moreover, Heterotrophic Plate Count (HPC) varied from 349 CFU/mL to 594 CFU/mL of which Station 1 is the lowest among the three as compared to Station 3 as the highest. Hence, the first station was the sole site which passes the allowed MAL for HPC in the 2017 PNSDW of the DOH which is less than 500 colony forming units per milliliter (<500 CFU/ml) [12]. Although incidence of illnesses correlating to high HPC measurements has not been found, still it should be remedied for they do indicate favorable conditions for the growth of bacteria [17].

Table 3b. Bacterial Isolates of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon

| Station | Bacterial Isolates |
|---------|---|
| 1 | Enterobacter sp.; Pseudomonas sp. |
| 2 | Enterobacter sp. |
| 3 | Enterobacter sp.; Pseudomonas sp., Shigella sp. |

Table 3b shows the Bacterial Isolates of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. Three (3) species of bacteria were found in the study site, namely, Enterobacter sp; Pseudomonas sp., and Shigella sp. Enterobacter sp. were

found in all stations. Pseudomonas sp. can be found both in Stations 1 and 3. Shigella sp. is unique in Station 3. The last station is depicted to have the highest count of bacteria with all the three (3) bacteria species isolated found in its water samples. Based on Table 3a and 3b, the water in Langahan Spring is not safe to drink as it can be the source of various illnesses because of the presence of microbes and bacteria.

3.4 Treatment, Conservation and Preservation of Langahan Spring

Numbers of parameter have failed to meet the standards for drinking water of Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon. Specifically, microbes were found present in the water supply that the residents consumed. The researchers believed that one of the purposes of every research study was not just solely about gathering information but most preeminently, to inform and to take actions for the overall significance of the study.

Reservoir Construction with Ceramic Water Filter

Following the results of the laboratory tests from Central Mindanao University, the researchers shared the information and raised the concern for possible interventions and treatment of the spring especially with the state of its microbial parameters. Last June 2, 2021, a Sangguniang Bayan session headed by the municipal vice mayor and on June 3, 2021, a Barangay session in Barangay Sampagar spearheaded by the barangay captain were attended by the researchers, presented their research study and further explain the water analysis result. They also highlighted the need of building a reservoir as per advised by the analyst from the Microbial Research Laboratory and agreed by the local sanitation inspector of the Municipal Health Unit, since the level of total coliform, E. coli and HPC of the water samples exceeded the MAL of the DOH. The sessions ended well where help and support financially was promised for the reservoir construction given that the health of the residents in the selected area were at stake and the project would not only benefit to one person but the twenty two (22) dependent households and by passers in the study site as well. Subsequently, a consent from all the involved stakeholders as well as the Municipal Health Officer and COVID-19 Incident Commander Designate, was obtained for the permission to carry out the perceived ground breaking ceremony and information drive. Although the boiling of water and letting it simmer for 10 minutes was one of the actions advised by the analyst in the Microbiology Research Laboratory to kill the microbes present, putting up a reservoir was more likely and one of the most appropriate actions to take to resolve the problem. The concept of the reservoir with ceramic water filter is that it would hold the water coming from the station 1 or the spring source to treat the water before its distribution to the recipients for their safety. Last June 6, 2021 at Langahan, Sampagar, Damulog Bukidnon, a ground breaking ceremony and benediction for the planned reservoir was successfully done. The ceremony was attended by the Municipal Vice Mayor and the head of the Sangguniang Bayan, the barangay officials of Sampagar, the Sangguniang Kabataan chairman of Barangay Sampagar, SK Federation president, the local sanitation inspector, school principal of Old Damulog National High School, the Barangay Health Worker, Purok President, and most importantly, the residents consuming the spring water. The researchers collaborated with

the Provincial Science and Technology Center – Bukidnon, Department of Science and Technology – 10 on the Ceramic Water Filter (CWF) after a webinar discussion with the Provincial Science and Technology Director – Bukidnon last June 16, 2021.

4 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The study revealed that generally, the weather pattern days before and during the date of sampling was not that pleasant. Geographically, Station 1 is more elevated and farther from east of the prime meridian compared to the two stations. It was found that the pH in Station 3, levels of nitrate, potassium, sulfate and TDS in all 3 stations, and HPC in station 1 were within the maximum allowable level set by the DOH in the PNSDW of 2017. The air and water temperature of the distinct stations cannot be categorized as below or above the standard since it was not included in the PNSDW of 2017, same as for the phosphate and TSS, regardless of their high values. Parameters such as sodium, carbonate, bicarbonate and chlorine were below detection. Nonetheless, water samples collected showed that the pH in Stations 1 and 2, Total Coliform and E. coli of all stations and HPC of stations 2 and 3 have exceeded the allowed levels. Three bacteria were also isolated. Based on the existing results, the water in Langahan Spring, Langahan, Sampagar, Damulog, Bukidnon is not safe to drink as it can be the source of various illnesses. As intervention of this problem, the water treatment through a reservoir with ceramic water filter, intake box, and riprap were proposed and construction is on-going with the help of LGU – Damulog and Provincial Science and Technology Center – Bukidnon, Department of Science and Technology – 10. Information dissemination through attending sessions, limited face-to-face meetings and posting photos and videos online were done for general public awareness.

4.2 RECOMMENDATION

The researchers recommended to further assess other parameters not included in this study. Recipients are encouraged to maintain, conserve and preserve the good water quality by monthly clean up-drive surrounding the Labahan Spring and water reservoir to be led by the purok president together with the residents/ constituents/ beneficiaries of Langahan, local officials and the researchers. Regular monitoring of the parameters may also be done as per advised by the DOH. A Local Executive Order may be crafted by the local officials as a guide for the maintenance, conservation and preservation of Langahan Spring.

5 ACKNOWLEDGMENT

The researchers would like to extend their profound gratitude to the following:

To the Almighty God, for the wisdom, strength and the courage to arrive at the realization of the study above all circumstances, mainly the threat of COVID-19 pandemic; To Central Mindanao University, especially Mr. John Rey Labajo, Mr. Rainear A. Mendez, Ms. Airish Jane B. Risma and Dr. Maria Lourdes Callejo, for their unwavering services in analyzing the water samples; To Ms. Maricel M. Gonzales, Ms. Jessiel G. Valmores, and Mr. Raul Ebuña for giving related

research studies as references; To LGU Damulog Officials and staff spearheaded by Municipal Mayor and the IATF Chairman, Hon. Melino L. Buro with COVID-19 Incident Commander Designate Cres Kristian C. Silva, MD., and Sanitation Inspector Mr. Geroncio S. Coritico, Sangguniang Bayan with Municipal Vice Mayor Alberto G. Salmasan Sr., SK Federation President Hon. Yubert Rez P. Vios, Engr. Jose G. Orzal and Engr. Ariane E. Primacio for the construction of the intake box; To Barangay Sampagar Council headed by Barangay Captain Hon. Trencio L. Pequiro, Hon. Leeric Jan M. Pequiro, Hon. Zaldy O. Deloso, SK Chairman Hon. Aljon R. Subsuban and to Mrs. Lina T. Tagapulot that raised funds for the construction of the reservoir and initiated the ground breaking ceremony; To Barangay Old Damulog Council with Barangay Captain Neil C. Talatala and SK Chairman Hon. Luke D. Malate; To the Provincial Science and Technology Center – Bukidnon, Department of Science and Technology – 10 thru PSTD – Bukidnon Ma'am Ritchie Mae L. Guno; To the Department of Education, Division of Bukidnon spearheaded by SDS Randolph B. Tortola, PhD., CESO IV; To Purok 5 President Mrs. Pedrita Pancito, land owners Mrs. Catalina Preglo, Mr. Pedro Pequiro and Mrs. Lucia Simbajon; To Barangay Health Worker, Mrs. Mary Jane Sarate along with all the supportive Langahan residents; To Mr. Remus M. Penkian and Mr. Joseph Ryan P. Arendain for the convenient and safe travel to CMU during the delivery of the water samples and for taking the water analysis results; To Central Mindanao Newswatch that published the research study in the newspaper; To their teachers, classmates, friends especially Mr. Jeric C. Lofranco, Ms. Mikee Lou C. Tirado, Mr. Mark Raimond C. Leuterio, Ms. Kim Debra M. Caminade, and beloved and treasured families, Mr. Reuel C. Arienza and Mrs. Ana Liza A. Arienza, Mr. Ronald M. Tirado and Mrs. Jacqueline C. Tirado, Mr. Reynaldo B. Calunsag and Mrs. Marites A. Calunsag, Mr. Remus M. Penkian and Mrs. Beatriz G. Penkian, and to Mr. Diosdado C. Tahanlangit and Mrs. Estrella Q. Tahanlangit, Engr. Vicente G. Celis, Jr., Mr. Alejandro D. Agor and Mrs. Vilma C. Agor, for their all-out support, prayers, sacrifices and critical advices in preparing the researchers for their future, academically. To all unmentioned individuals who had given significant contribution for the researchers in taking each step towards their academic excellence and in fulfilling their mission as an instrument of God's greater honor and glory.

6 REFERENCES

- [1]. Otsuka. (n.d.). The Human Body and Water. Retrieved at <https://www.otsuka.co.jp/en/nutraceutical/about/rehydration/water/body-fluid/>
- [2]. Spector, D. (2018). Here's How Many Days a Person can Survive without Water. Retrieved at <https://www.businessinsider.com/how-many-days-can-you-survive-without-water-2014-5>
- [3]. United States Geological Survey. (n.d.). The Water in You: Water and the Human Body. Retrieved at https://www.usgs.gov/special-topic/water-science-school/science/water-you-water-and-human-body?qt-science_center_objects=0#qt-science_center_objects
- [4]. Florida Keys National Marine Sanctuary. (n.d.). What is Water Quality? Retrieved at <https://floridakeys.noaa.gov/ocean/waterquality.html>

- [5]. Meybeck M., Kuusisto E., Mäkelä, A., and Mälkki, E. (1996). Chapter 2-Water Quality. In J. Bartram and R. Ballance (Eds.), *Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes*. United Nations Environment Programme and the World Health Organization.
- [6]. United States Geological Survey. (n.d.). Springs and the Water Cycle. Retrieved at https://www.usgs.gov/special-topic/water-science-school/science/springs-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects
- [7]. Texas Aquatic Science. (n.d.). Aquifers and Springs. Retrieved at <https://texasaquaticscience.org/aquifers-and-springs-aquatic-science/>
- [8]. Barangay Development Council. (2015). Barangay Development Five Years Comprehensive Plan
- [9]. World Health Organization. (2020). Water, Sanitation, Hygiene, and Waste Management for SARS-CoV-2, the Virus that Causes COVID-19. Retrieved at <https://www.who.int/publications/i/item/WHO-2019-nCoV-IPC-WASH-2020.4>
- [10]. Environmental Management Bureau. (n.d.). RA 9275 – The Philippine Clean Water Act. <https://r12.emb.gov.ph/ra-9275-the-philippine-clean-water-act/>
- [11]. Department of Health. (2008). Operations Manual| Nationwide Drinking Water Quality Assessment.
- [12]. Department of Health. (2017). Administrative Order No. 2017-0010 II Philippine National Standards for Drinking Water of 2017. Retrieved at <https://www.fda.gov.ph/administrative-order-no-2017-0010-philippine-national-standards-for-drinking-water-of-2017/>
- [13]. Province of Bukidnon. (2012). Climate. Retrieved at <https://bukidnon.gov.ph/2012/12/13/climate/>
- [14]. Bastaraut, A., Perthame, E., Rakotondramanga, J-M., Mahazosotra, J., Ravaonindrina, N., and Jambou, R. (2020). The Impact of Rainfall on Drinking Water Quality in Antananarivo, Madagascar. *PLoS ONE*, 15(6): e0218698. Retrieved at <https://doi.org/10.1371/journal.pone.0218698>
- [15]. Water Technology. (2012). Phosphates. Retrieved at <https://www.watertechonline.com/home/article/15540707/phosphates>
- [16]. Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development. (1991). *Standard Method of Analysis of Soil, Plant, Tissue, Water and Fertilizer*.
- [17]. LeChevallier, M.W. (2003). Conditions Favouring Coliform and HPC Bacterial Growth in Drinkingwater and on Water Contact Surfaces. In J. Bartram, J. Cotruvo, M. Exner, C. Fricker, A. Glasmacher (Eds.), *Heterotrophic Plate Counts and Drinking-water Safety*. IWA Publishing.