Can Tho University Journal of Science
website: ctujs.ctu.edu.vn

DOI: 10.22144/ctu.jen.2022.025

# Quality profile and suitability of Quirino State University - farm pond irrigation system

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**Article info.**

*Received 24 Aug 2022*
*Revised 11 Oct 2022*
*Accepted 14 Oct 2022*

**Keywords**

*Farm pond, irrigation, hardness, pH, salinity, suitability, water quality*

**ABSTRACT**

*The quality of available water must be tested to check its suitability prior to use. The physicochemical analysis of the Quirino State University -farm pond irrigation system was undertaken to assess its quality for irrigation needs. The quality analysis was made through the estimation of its temperature, pH, salinity, total dissolved solids and electrical conductivity, alkalinity, chloride, hardness, iron, and sulfate as irrigation water criteria. The analytical data were processed and compared with standard permissible limits for irrigation waters. Regarding the suitability of the farm pond irrigation system for irrigational purposes with the measured quality criteria, the results showed that the farm pond waters were within the safe limits except for a few parameters that did not meet the required irrigation standard limit criteria and require further attention. The quality profile results may be used as a basis for future management and strategic interventions.*

## 1. INTRODUCTION

Water is regarded as one of the most essential and vital substances on earth as all the living things need it for their sustenance (Munta et al., 2021). It is important necessary to monitor water quality to understand the changes that have occurred to it over time (Carvalho et al., 2020). Water quality is defined as an information of the biological, chemical and physical elements of water and their interactions to decide suitability for use (Taner et al., n.d.). Water quality is influenced by natural processes such as rainfall, soil erosion, etc., and by anthropogenic activities such as agricultural, urban and industrial activities (Wu et al., 2018). Furthermore, factors such as poorly disposed chemical waste, agrochemical waste, poorly maintained septic systems, increased population and urbanization have contributed to the problem of quantity and quality of water supply globally (Munta, et al., 2021). Water quality plays a crucial role in the socio-economic development of all countries especially in rural areas, where it is used for irrigation and human consumption (Abbasi & Abbasi, 2012).

Irrigation comprises of water that is applied by an irrigation system during the growing crop season and also includes water applied during field preparation, pre-irrigation, weed control, harvesting, and for leaching salts from the root zone (Dieter et al., 2018). Irrigated agriculture depends on water availability and good quality, which in turn, is associated with water physical, chemical and microbiological features (Souza & Queiroz, 2020). Poor quality irrigation water can be responsible for slow growth, poor aesthetic quality of the crop and, in some cases, can result in the gradual death of the plants (Nwajagu, 2021). In addition, poor irrigation water quality damages crops and soil structure directly with impacts depending on the soil, crop, and environmental conditions (Bauder et al., 2014), and other irrigation water contaminants that may affect its suitability for agricultural use which include heavy metals and microbial contaminants (CDCP, 2016). Full benefit of crop production technologies such as high yielding varieties, fertilizer use, multiple cropping, crop culture and plant protection measures can be derived only when an adequate supply of water is assured and good quality irrigation water is essential to maintain the soil-crop productivity at a high level (Geron et al., 2018). Irrigation water suitability analysis is not very common in developing countries, including its significant impact on crops (Singh et al., 2021). Yet, knowledge of irrigation water quality is critical to understanding management for long-term productivity (Bauder et al., 2021).

Water quality problems are often complex and a combination of problems may affect crop production more severely than a single problem in isolation. The more complex the problem, the more difficult it is to formulate an economical management program in response. If problems do occur in combination, they are more easily understood and solved if each factor is considered individually (Ayers & Westcot, 1994). A diagnostic assessment of the quality of water for irrigation purposes needs to be carried out to identify the bottlenecks for irrigation water intervention and selecting a strategic improvement option. Irrigation water quality should be evaluated as one of the factors that may affect the agricultural sector (Rango, 2013). Water quality can be assessed on the basis of several physicochemical parameters of water that can be easily understood by both experts and the general public.

The aim of this paper is to propose a quality profile for the Quirino State University (QSU) -farm pond irrigation system, located in the province of Quirino, Philippines, that expresses the results of several parameters in order to assess if the water is suitable for irrigation needs. To explore the main purpose of the study the following specific objectives guided the study namely:

1. Collection of water samples from different water stations of the farm pond irrigation system;

2. Analysis of the physical and chemical parameters of the irrigation system; and

3. Evaluation of the water quality for its suitability as irrigation water.

Figure 1 highlights the assessment steps conducted. Water sampling and physicochemical analysis were conducted as part of the assessment of the water system. The data were used to construct a profile for its quality as irrigation water. A decision on its suitability was confirmed guided by standard water criteria for irrigation water. Overall, the results may be utilized as basis for future research endeavors and other management issues of the said farm pond irrigation system of the university.

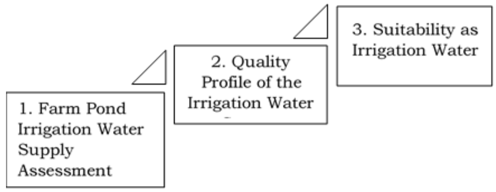


**Figure 1. The conceptual framework of the study**

## 2. MATERIALS AND METHOD

### 2.1. Study area

In order to determine the water quality profile needed, four (4) stations were chosen for sample collection from the QSU-farm pond water system. Results of on-site investigations like pH, Electrical Conductivity, and temperature were recorded at the sampling stations whereas the parameters: salinity, Total Dissolved Solids, alkalinity, chloride, hardness, iron, and sulfate were recorded in the laboratory.


**Figure 2. The map of the study area showing the different sampling stations**

Four quadrats of estimated equal distances of approximately 100 meters between each sampling stations were the collection sites of the study.

### 2.2. Sample Collection

Discrete grab sampling was applied at each station. A discrete grab sampling is characterized by taking a sample at a specified sampling station, depth and time (Simpson et al., 2013). It is suitable for analyzing unstable parameters that have to be measured right away or on site, e.g., temperature, pH, electrical conductivity, salinity, etc. Direct sampling was also undertaken using the sample container which has wide-mouthed plastic container. The samples intended for the on-lab analyses were brought to the Food and Nutrition Research laboratory of Quirino State University, Quirino province, Philippines for testing.

### 2.3. Physio--Chemical Analysis

#### *2.3.1. On-site measurements*

Meters and probes were used like, thermometer, pH, and electrical conductivity meters to determine the pH, temperature, EC, and total dissolved solids of the water samples. These instruments were calibrated to obtain accurate and precise data.


**Figure 3. The probes (a) and other on-site measurements (b) used in the analyses**

#### *2.3.2. Laboratory Test Measurements*

Chloride Test: MATERIALS: 5 ml water sample; small plastic vessel; Diphenyl carbazone indicator; nitric acid solution; titration syringe; mercuric nitrate solution

The plastic vessel was filled with 5 water sample up to the 5 ml mark. 2 drops of Diphenyl carbazone indicator were added and was mixed carefully with until the solution become a reddish-violet color. nitric acid solution was added until the solution turned yellow. The titration syringe was filled completely with mercuric nitrate solution and added dropwise until the solution in the plastic vessel changes from yellow to violet. The milliliters of titration solution from the syringe scale were read and the reading was multiplied by 1000 to obtain mg/L (ppm) chloride.

Sulfite Test: MATERIALS: small plastic vessel; 5 ml water sample; sulfamic acid solution; EDTA reagent; sulfuric acid solution; starch indicator; titration syringe; reagent titrant solution

The plastic vessel was filled with 5 ml water sample. 4 drops each of sulfamic acid solution and EDTA reagent was added to the water sample. 2 drops of sulfuric acid solution and 1 drop of starch indicator was added to the solution. The titration syringe was filled with reagent titrant solution and slowly added until the solution in the plastic vessel changes from colorless to blue. The milliliters of titration solution will be read from the syringe scale and the volume obtained was multiplied by 200 to obtain mg/L (ppm) sodium sulfite.

Alkalinity test: Determination of phenolphthalein alkalinity. MATERIALS: plastic vessel; 5 ml water sample; phenolphthalein indicator; titration syringe; HI 3811-0 solution

The plastic vessel was filled with 5 ml of the water sample. 1 drop of phenolphtolein indicator was mixed carefully. (note: if the solution remains colorless, record the phenolphthalein alkalinity as zero and proceed with the procedure for the determination of Total Alkalinity (see below). Titration solution was added (note: if the solution is pink or red) until the solution in the plastic vessel turned colorless. The milliliters reading of titration solution was multiplied by 300 to obtain mg/L (ppm) $CaCO_3$.

Determination of total alkalinity: MATERIALS: plastic vessel; 5 ml water sample; bromophenol blue indicator; titration syringe; titration solution

The plastic vessel was filled with 5 ml of the water sample. 1 drop of bromophenol blue indicator as mixed and if the solution turned yellow acidity test must be carried out and if the solution turned green or blue, HI 3811-0 solution was added until the solution in the plastic vessel turned yellow. The milliliters of titration solution will be read from the syringe scale multiplied by 300 to obtain mg/L.

Hardness Test: MATERIALS: small plastic beaker; 5 ml water sample; hardness buffer; calmagite indicator; EDTA solution; titration syringe

The plastic beaker was filled with 5 ml of the water sample. 5 drops of hardness buffer was mixed and 1 drop of calmagite indicator was again added until the solution becomes a red-violet color. The titration syringe was filled with EDTA solution and slowly added to the solution dropwise until the solution becomes purple, then mixed for 15 seconds after each additional drop until the solution turned blue. The milliliters of titration solution were read and the reading from the syringe scale was multiplied by 300 to obtain mg/L (ppm) $CaCO_3$.

Iron test: MATERIALS: small plastic beaker; 10 ml water sample; reagent HI 3834-0; color comparator cube

The plastic vessel was filled with 10 ml water sample. 1 packet of reagent HI 3834-0. was mixed until the solids dissolve. The solution was transferred into the color comparator cube. It was set for 4 minutes and the color was matched in the cube. The result was recorded as mg/L (ppm) iron.

### 2.3.3. *Statistical Analysis*

The study made use of both descriptive and inferential statistics. Descriptive statistics were the mean scores obtained from the different replicate measurements conducted. Inferential statistics used were T-tests. These statistics were employed if significant differences existed between the measured parameter and the standards.

## 3. RESULTS AND DISCUSSION

### 3.1. Information about the irrigation water system.

**Table 1. Sample data information in one of the on-site discrete grab samplings conducted in the irrigation system.**

| | |
|---|---|
| Time of Sampling: | *8:00 am to 11:30 am and 1 to 5pm* |
| No. of Stations: | *4* |
| Location: | *Quirino State University, Andres Bonifacio, Diffun, Quirino, Philippines* |
| Name of Water Body | *QSU- farm pond irrigation water system* |
| Depth of Water: | *1-3 meters* |
| Air Temperature: | *25-28 $^{0}$C* |
| Depth of Sampling from Surface: | *12 inches* |
| Weather Condition: | *Sunny and Rainy* |
| Odor of Water Sample: | *Odorless to acrid* |
| Visual Color of Water: | *Light Green* |
| Observation of Surroundings: | *Trees and grasses on the sides of the lagoon* |
| Sample Matrix: | *Discrete grab water sampling* |
| Preservative: | *None* |
| Test Parameters: | *Temperature, pH, Electrical Conductivity, Iron Test, Total Hardness, Chlorine, Alkalinity, Sulfite Test* |
| Description of the different stations: | |
| Station 1 | *Shaded with trees, muddy bottom* |
| Station 2 | *Gateway of the lagoon as irrigation, sandy and muddy bottom, own stream portion* |
| Station 3 | *Middle part of the lagoon, parts were half-covered with shade of trees, muddy bottom* |
| Station 4 | *Upstream portion, main source of water supply, muddy bottom, grassy surroundings* |

### 3.2. Results and discussions

#### 3.2.1. *Temperature of the QSU farm pond irrigation system*

Table 2 shows the temperature of the farm pond irrigation water system. During the on-site testing, the temperature of the water system ranged from 29.8°C to 30.6°C. When compared with the standard acceptable limit (SAL) for irrigation water for irrigation waters (WQI, 2014), the temperature of the farm pond waters ($\mu$=30.3) was significantly higher (p-value=0.000, SD=0.356) than the SAL. The results imply that the temperature of the farm pond water system should undergo intervention before it can be used for irrigation purposes. The temperature can be controlled by the use of small shaded cooling basins before its application to fields as irrigation (Raney et al., 1957). It can also be done by applying irrigation at night time or on cool, cloudy days.

**Table 2. Water temperature of the different stations**

| PARAMETER | STATIONS (N=30/Station) | | | | | SAL | SD | p-value |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | | |
| Temperature (°C) | 30.5 | 30.3 | 30.6 | 29.8 | 30.3 | 20-27(˚C) | 0.356 | 0.000 |

*Legend: SAL* Standard Acceptable Limit; SD** Standard Deviation*

*3.2.2 pH level classification of the farm pond irrigation system*

The acidity (or alkalinity) of a water supply can affect plant growth, irrigation equipment, and pesticide efficiency (Brunton, 2011). During the on-site study, the water pH values were found from ranges 7.67 to 8.37 as shown table 3. The normal pH range for irrigation water is from 6.5 to 8.5 (Roa, 2017). Results of comparison using *one-samples T-test* showed that the water pH of the farm pond irrigation system exhibited no significant difference with the SAL for irrigation waters (p-value=0.603). Therefore, the farm pond irrigation water system is within the acceptable range of the water quality criteria for irrigation use. Water with abnormally low pH (acidic) is uncommon. However, when this happens, acidic water can cause corrosion of irrigation equipment. On the other hand, as irrigation water pH increases above 8.4 (alkaline), the potential for sodium hazards increases. High pH above 8.4 are often caused by high bicarbonate ($HCO^{3-}$) and carbonate ($CO_3^{2-}$) concentrations, known as alkalinity (Krishnamurthy, 2016). Acidic water can also have a detrimental effect on plant growth, particularly causing nutritional problems, while strongly acidic water (below pH 4) can contribute to soil acidification while a pH less than 6 indicates corrosiveness, which can lead to damage to metal pipes, tanks and fittings. Water lower than pH 6.0 or higher than pH 8.5, when used in spray mixes, can lessen the effectiveness of some pesticides (Brunton, 2011).

**Table 3. pH of the farm pond irrigation  system**

| PARAMETER | STATIONS (N=30/Station) | | | | | SAL* | SD** | p-value |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | | |
| pH | 8.37 | 8.42 | 8.65 | 7.67 | 8.28 | 6.5 to 8.5 | 0.423 | 0.603 |

*Legend: SAL* Standard Acceptable Limit; SD** Standard Deviation*

pH of water must be kept between pH 5.5 and pH 7.0 because water in this pH range can maintain the nutrient balance, prevent scale formation in irrigation equipment and provide effective chemical disinfection. Water pH can be adjusted by adding an acid or an alkaline substance to the water supply. The appropriate acid or alkaline may be injected into the pipeline for automated systems or mixed in a tank for manual systems or larger volumes of water. The use of an acid (such as sulfuric acid) will lower the pH, while an alkaline (for example, lime) will increase the pH.

*3.2.2. Alkalinity classification of the QSU-farm pond water system*

Table 4 shows the alkalinity classification of the tested farm pond irrigation water. Generally, results showed that the water system (μ=150 mg/L) reached the maximum ideal range for total alkalinity, however, station 4 which is the main source of the lagoon water system is regarded as problematic and has the potential to cause various nutrient problems when used as irrigation water. In addition, water with high alkalinity can cause other problems like clogging of the nozzles of pesticide sprayers and drip tube irrigation systems with detrimental effects. The activity of some pesticides, floral preservatives, and growth regulators is markedly reduced by high alkalinity. When some pesticides are mixed with water, they must acidify the solution to be completely effective. Additional acidifier may be needed to neutralize all of the alkalinity (CAFE, 2021). Acid injection is suggested to be used in treating high alkalinity (PSE, 2021).

**Table 4. Alkalinity Classification of the farm pond irrigation water system**

| PARAMETER | STATIONS (N=30/Station) | | | | | IRTA* | Effect |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | |
| Alkalinity (mg/L) | 90 | 141 | 150 | 219 | 150 | 30 to 100 mg/L but levels up to 150 mg/L | Suitable for many plants |

*Legend: SAL* Standard Acceptable Limit; SD** Standard Deviation*

*3.2.3. Salinity Hazard (TDS/EC) Classification*

The Table above shows the salinity hazard classification of the QSU-farm pond irrigation water system. Results showed that the TDS (μ=226.8) is within the salinity range classification (160-480 ppm) which is described as good. In terms of EC (μ=0.00468 ds/m), the farm pond water system exhibited excellent hazard classification (below 0.25ds/m). These results imply that the water system will not cause detrimental effects to plants and that no soil buildup is expected, however sensitive plants may show stress when irrigated with the water system and that moderate leaching will prevent salt accumulation in the soil (Hopkins et al., 2007). Therefore, in regards to the permissible limit as irrigation water, the water system in this study was classified as excellent to good. The low salinity values make the water irrigation suitable for plants with the exception of sensitive plants.

**Table 5. Salinity Classification of the different stations**

| PARAMETER | STATIONS (N=30/Station) | | | | | SRC*** | Salinity Hazard Classification |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | |
| TDS* (ppm) | 246 | 197 | 194 | 270 | 226.8 | 160-480 | Good |
| EC** (ds/m) | 0.000456 | 0.000394 | 0.000396 | 0.000541 | 0.004468 ds/m | Below 0.25 ds/m | Excellent |

*Legend: TDS* Total Dissolved Solids; EC** Electrical Conductivity; SRC*** Salinity Range Class*

*3.2.4. Chloride level classification of the pond water system*

Table 6 shows the result of the chloride range classification of the farm pond irrigation water system. Results from the chlorine test showed that the water system (μ=37.5) is classified as low hazard, as what was indicated by the chlorine range classification (below 70). It implies that the water system is generally safe for all plants (Bauder, 2014).

Most plants can tolerate chloride up to 100 mg/L although as little as 30 mg/L can be problematic for a few sensitive plants. Damage caused by high-chloride irrigation water can be minimized by planting less sensitive crops, avoiding foliar contact by using furrow, flood, or drip irrigation, and applying irrigation at night time or on cool, cloudy days (Roa, 2017).

Drop nozzles and drag hoses are also recommended when applying any saline irrigation water through a sprinkler system to avoid direct contact with leaf surfaces (Bauder et al., 2014).

**Table 6. Chloride test results and classification**

| PARAMETER | STATIONS (N=30/Station) | | | | | CRC* | Effect on Crops |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | |
| Chloride Test (mg/L) | 30 | 30 | 20 | 70 | 37.5 | Below 70 | Generally safe for all plants. |

*Legend: CRC* Chlorine Range Class*

*3.2.5. Iron concentration of the QSU-farm pond water system*

Table 7 shows the result of the conducted iron test on the irrigation water system. Results showed that the iron concentration (overall mean=1.0) is below the recommended maximum concentration for irrigation waters (5.0 ppm). This means that the water system is safe to use in plants but may cause clogging of drip irrigation emitters and may lead to iron rust stains, and discoloration on foliage plants in overhead irrigation applications.

There are several ways to remove these elements. If enough space is available, the least expensive approach is to pump the source water into a pond or tank where the insoluble iron compounds can precipitate and settle out (CAFE, 2021). The recommended treatment to remove iron is oxidation, sedimentation and then filtration with procedures used including aeration and settling chlorination and use of potassium permanganate (Bruntun, 2011).

**Table 7. Iron test result and classification of the farm pond irrigation system**

| PARAMETER | STATIONS | | | | | RMC* | Effect on Crops |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | |
| Iron Test (mg/L) | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 5.0 | Not toxic to plants |

*Legend: RMC* Recommended Maximum Concentration*

*3.2.7 Sulfate range classification of the QSU-farm pond water system*

Sulfur is an essential element for plant growth that is not commonly included in fertilizers. It is measured in irrigation water to give an indication of possible deficiency problems.

Table 8 shows the result of the conducted sulfate test to the irrigation water system. Results showed that the system (overall mean=7.5) is within the desirable quality as irrigation water (<400 ppm). The concentration is less than about 50 ppm, therefore supplemental sulfate may need to be applied for good plant growth (CAFE, 2021).

**Table 8. Sulfate test result and classification of the farm pond irrigation system**

| PARAMETER | STATIONS | | | | | DRC* | Effect |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Overall Mean | | |
| Sulfate Test (mg/L) | 10 | 6 | 6 | 8 | 7.5 | < 400 ppm | Desirable as irrigation water |

*Legend: DRC* Desired Range Concentration*

*3.2.6. Water hardness class range*

Table 9 shows the result of the hardness test conducted in the irrigation water system. Result showed that the classification of the current farm pond water system is considered as hard (Mean=165 mg/L). Equipment clogging and foliar staining problems at levels above 150 mg/L is the expected effect if the water is used for irrigation purposes. Hardness does not affect plants directly, but hardness caused by bicarbonates can affect soils, thus having an indirect impact on plant growth (DPINSW, 2021).

Reducing hardness is called water softening. Ways to soften water include: ion exchange, water-softening agents, desalination processes such as reverse, osmosis, use of lime, pH adjustment, and controlling water temperatures. Removal of hardness by using a water softener is necessary only if the water is causing problems (PSE, 2021).

**Table 9. Water hardness test result and classification of the farm pond irrigation system**

| PARAMETER | STATIONS | | | | | HCR* | Water Description |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Mean | | |
| Hardness Test (mg/L) | 159 | 156 | 144 | 201 | 165 | 150-300 | Hard |

*Legend: HCR* Hardness Class Range*

*3.2.7. Summary showing the overall quality profile of the QSU-farm pond irrigation system*

Table 10 shows the summary of the water quality profile of the QSU-pond irrigation system. Generally, the water system is suitable for irrigation use, except for some potential hazards. Irrigation equipment clogging and staining are the main hazards based from the obtained quality profile of the pond irrigation water of the university.

**Table 10. Quality profile of the QSU-farm pond irrigation system**

| PARAMETER | Measured Profile | DRC/SAL (WIQ, 2014) | Result | Hazard /Effect |
|---|---|---|---|---|
| Temperature (°C) | 30.3 | 20-27 | Significantly higher than the SAL | Needed intervention before application |
| pH | 8.28 | 6.5 to 8.5 | no significant difference with the SAL | Need to maintain its pH |
| Alkalinity (mg/L) | 150 | 30 to 100 mg/L up to 150 mg/L | Good | Suitable for plants |
| TDS* (ppm) | 226.8 | 160-480 | Excellent to Good | Best and suitable for plants in exception to sensitive plants. |
| EC** (μs/m) | 0.004468 ds/m | Below 0.25 ds/m | | |
| Chloride Test (mg/L) | 37.5 | Below 70 | low hazard | Generally safe for all plants. |
| Iron Test (mg/L) | 1.0 | 5.0 | Below the recommended maximum concentration | Not toxic to plants, clogging of drip irrigation emitters, discoloration on foliage plants |
| Sulfate Test (mg/L) | 7.5 | < 400 ppm | Desirable as irrigation water | Supplemental sulfate is recommended |
| Hardness Test (mg/L) | 165 | 150-300 | Hard | Equipment clogging and foliar staining problems |

*Legend: DRC* Desired Range Concentration; SAL* Standard Acceptable Limit*

## 4. CONCLUSION

Based on the results and findings of this study, water quality indicators and the water discharge at the study sites are all safe to use for irrigation. However, water hardness, temperature, and sulfate need further attention in the case that strategic and management issues and concerns on the farm pond water system of the university is raised.

The water system in general may harm, stress, and stain sensitive plants, may cause damage like clogging to irrigation equipment, and may lessen the effectivity of pesticides based from the results of the conducted quality profile of the current study.

It is then highly suggested that intervention should be undertaken to avoid water quality deterioration of the said farm pond irrigation water system.

## ACKNOWLEDGMENT

We wish to express our sincere thanks to the following person/s for the various ways they helped during the course of this research:

To our able and resourceful Program Chair, Arlyn J. Yra, for her advice, suggestions and constructive criticisms;

We also express my profound gratitude to our colleagues and friends at the College of Health Sciences, for their motivation;

To Quirino State University, particularly the Research and Development Office of Diffun, for the encouragement which made this study a successful masterpiece, thank you very much; and

To God the Father of all, we thank Him for the strength that keeps us standing and for the hope that keeps us believing that this study would possible.

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