DESIGN OF DRINKING WATER TREATMENT FACILITY SYSTEM IN CENTRAL PHILIPPINE UNIVERSITY

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ABSTRACT

This project study presents an innovative way of constructing a drinking water treatment facility system within Central Philippine University. It starts with the preparation of a preliminary process flow that can treat raw water supplied by the Metropolitan Iloilo Water District to produce a potable drinking water supply. Laboratory scale experiments performed in the chemical engineering laboratories tested the effectiveness of the prepared process flow and after necessary adjustments, the relevant information necessary for the preparation of the final process flow and equipment design were collected. The final process flow and design of equipment based on the laboratory work results followed. The facility is composed of five major process tanks namely: coagulation, settling, chlorination, filtration, and treated water tanks. The facility can operate 24 hours a day, seven days a week and can treat 1.2 liters of water per minute. The flow of water in the facility is by virtue of gravity. It has a total land area of 456 square feet or 42.4 square meters and is located near the University Gymnasium. The drinking water treatment facility is estimated to cost PHP 154,000.00.

INTRODUCTION

Background of the Study

Water is man's most important resource in life. No matter how rich a person is, without water, he cannot possibly exist because water is both the least expensive and most essential commodity that man has ever used.

This resource has been exploited and along with it, the problem of water contamination arose has become a serious problem. A glass of what seems to be a crystal clear drinking water from an unknown source may contain thousands of particles which may be in the form of salts, silt, inorganic minerals, bacteria, germs, and viruses. Contaminated water can cause arthritis, kidney stones, gallstones, arteriosclerosis, enlarged heart, emphysema, obesity, constipation, glaucoma, diabetes, and diarrhea. This seemingly unbelievable danger is strengthened by a World Health Organization report that 80% of all diseases are caused by contaminated water (water.me.vccs.ed).

Flooding became a frequent phenomenon at Central Philippine University and the surrounding communities, thus, the demand for safe drinking water has tremendously increased. The university does not have an existing water treatment facility system. It was on this premise that the research was conducted. Although the CPU community will primarily benefit from the results of the research, the researchers do not discount the possibility that the surrounding communities might be adopting it into their system as well.

If ever this water treatment facility will be put up inside the CPU Campus, it will generate not only safe drinking water for the students but will also create income for the university.

Objectives of the Study

The purpose of this study is to design a water treatment facility system that will serve the CPU community. Specifically, this study was conducted to:

- Prepare a preliminary process flow that can treat raw water supplied by the Metropolitan Iloilo Water District and to produce a potable drinking water supply.
- Conduct laboratory work in order to:
  - Test the effectiveness of the prepared process flow and do all the necessary adjustments;
  - Establish the process variables given the water parameters like raw water flow rate, the concentration of undesirable substances present in the raw water, etc., and;
  - Collect all the relevant information necessary for the preparation of the final process flow and equipment design.
- Prepare the final process flow and design of equipment based on the laboratory work results, and;
- Prepare a report that will include the technical and financial feasibility of the project.

Significance of the Study

Due to frequent flooding in the vicinity of the university, the demand for safe drinking water tremendously increased. Through this project, CPU students are provided with an ample supply of potable and safe drinking water with good physical quality, free from unpleasant taste or odor, and free from substances which might be detrimental to their health. Through the services of the existing water laboratory of the university (DOH accredited to conduct water quality testing in Region VI), this project also ensured that the water used by the entire CPU community is free not only from bacterial pathogens but also from harmful biological organisms and from deleterious inorganic matter. If ever this water treatment facility will be put up inside CPU Campus, it will generate not only safe drinking water for the students but will lessen the university's expenses in buying purified drinking water for its own consumption from outside sources.

Limitations of the Study

Time limitation. This study starts immediately after it was approved and terminates after 12 months.

Place and subject limitation. This is a research study to determine the most feasible and most economical design of a water treatment facility system for Central Philippine University, Iloilo City.

Content limitation. This study includes a preliminary process flow, the performance of laboratory work to test its effectiveness, the establishment of the process variables (i.e. raw water flow rate, concentrations of unwanted substances present, etc.), and gathers the necessary information for the preparation of the final flow process. Based on the laboratory work results, this study will prepare the design of the equipment needed for the treatment facility.

METHODS

Research Design

Descriptive research was used in this study because laboratory work was done to test the effectiveness of a preliminary process flow needed in the design of the water treatment facility, taking into consideration the factors like availability, quality, and sufficiency of the present water supply. After having proved the effectiveness of the preliminary process flow, the process variables which were necessary for the preparation of the final process flow process and equipment design were established.

Water source. The source of drinking water of CPU comes from the Metropolitan Iloilo Water District. This is the water that is treated in the designed drinking water treatment facility. The water input to the water treatment facility is about 1.2 liters of water per minute.

Preliminary process flow. The preliminary process flow shown in Figure 1 was followed to treat the water to ensure that it is safe for drinking. The raw water first entered the coagulation tank where it underwent coagulation with the use of lime and alum. After coagulation, the water underwent sedimentation or settling process in the settling tank. The water then proceeded into the chlorination tank where chlorine was added.

Upon finishing the chlorination process, the water was filtered in the filtration tank using activated carbon as the filter media. After filtration, the water was stored in the final treated water tank. In the treated water tank, the filtered drinking water was subjected to ultraviolet light. The drinking water was then collected and stored inside portable drinking water containers.

Process Description

Coagulation. In the coagulation tank, alum and lime were added and mixed to the water. For 1.2 liters per minute of water entering the tank, 0.048 gram per minute of alum was added, along with 24 milligrams per minute of lime. The alum and lime tanks added alum and lime to the raw water, respectively. After addition and mixing of lime and alum to water, the particles and impurities present in the water started to agglomerate. The water with agglomerated particles will then leave the coagulation tank and entered the settling tank.

Sedimentation or settling. In the settling tank, the agglomerated particles in the water were allowed to settle down in the bottom of the settling tank. While at the bottom of the settling tank, there were pipes that collected the agglomerated particles. The pipes then transferred the agglomerated particles from the settling tank to the slurry tank. The water free of agglomerated particles will then leave the settling tank and entered the chlorination tank.

Chlorination. In the chlorination tank, chlorine was added and mixed with the water. Approximately, 4.8 milligrams per minute of chlorine were added to the water. The chlorine tank added chlorine to the water. After addition and mixing of chlorine, the water will then leave the chlorination tank and entered the filtration tank.

Carbon filtering. In the filtration tank, the water was made to pass through six layers of filter, wherein activated carbon was used as the filter media. The dimensions of the filter were 0.914 meters (three feet high) and 1.524 meters (five feet) wide. After passing through all filters, the water will then leave the filtration tank to enter the treated water tank.

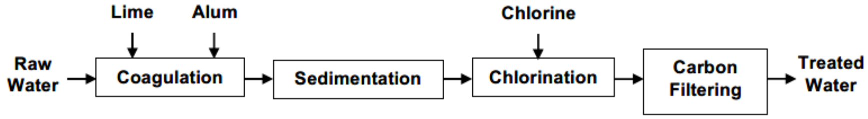

Figure 1. Schematic diagram of preliminary flow process

Water testing. The treated water from the treated water tank was then collected and placed into small sterilized water vials. Water samples for laboratory tests were collected from the treated water tank. The effectiveness of the process flow was tested through a series of laboratory experiments. Necessary adjustments were made to establish the process variables (raw water flow rate, etc.) that were necessary for the preparation of the final flow process and design of the equipment. Samples of water from the treated water tank were taken and tested using various laboratory tests. Parameters such as color, pH, dissolved oxygen, total dissolved solids, conductivity, alkalinity, acidity, calcium and chlorine content, and total hardness were tested to determine the quality of water produced by the water treatment facility.

RESULTS AND DISCUSSION

Water Treatment Facility Design

The water treatment facility was comprised of five main process tanks and three support tanks. The main process tanks were the coagulation, settling, chlorination, filtration and treated water tanks. The supports tanks were the alum, lime and chlorine tanks. The water treatment facility had a total floor area of 17.374 meters by 2.438 meters (57 feet by eight feet) or 42.36 square meters (456 square feet). The facility operated 24 hours a day, seven days a week. Maintenance was done monthly or as needed.

Equipment

The bulk part of the facility was fabricated using stainless steel plate and bars because of its high resistance to corrosion, economical aspect of construct the facility, availability of materials and low maintenance.

Coagulation tank. This was the tank where the coagulation process occurred. Water to be treated in this facility first entered this tank. Alum, a coagulating agent, was added to the water. Alum formed particles called “floc” in the water. The “floc” attracted dirt and other impurities present in the water. The tank comprised of a cylindrical body with a conical tip. The diameter of the tank was about 0.96 meters (3.152 feet). The height of the cylindrical body and the conical tip was about 1.829 meters (six feet) and 0.783 meters (2.57 feet), respectively.

Due to the presence of stresses, the weight of the equipment and its contents, it was supported by columns which were capable of absorbing the stresses due to the load and the operation of the tank. Four columns were designed to be attached to the tank. The height of each column was approximately 1.829 meters (six feet). The alum and lime tanks contained the alum and lime, respectively, which were eventually mixed to the raw water.

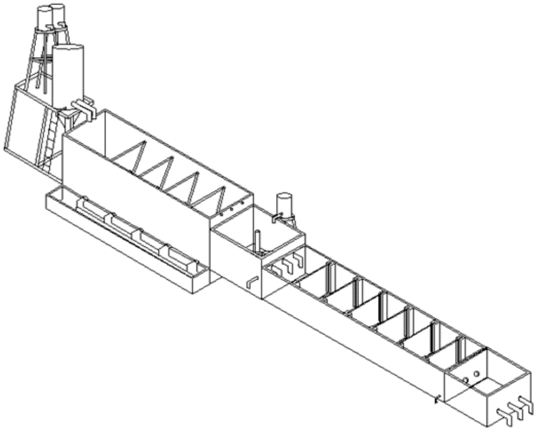

Figure 2. Image of the proposed water treatment facility

In order to thoroughly mix the alum and lime added to the water, two pairs of rotating blades were placed inside the coagulation tank. Each of the blades was 0.381 meters (1.25 feet) in length.

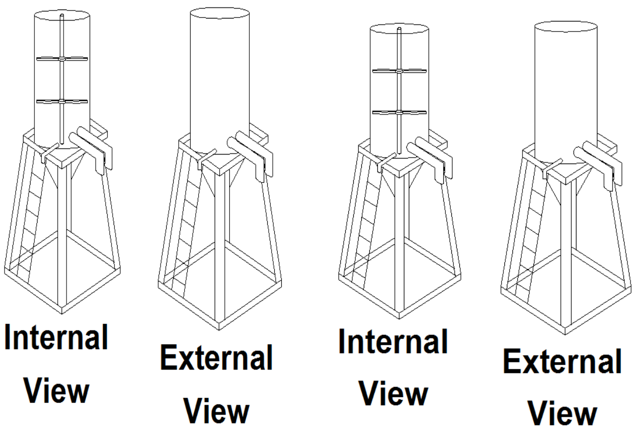

Figure 3. Images showing the internal and external views of the coagulation tank

For every liter of water that would be treated by the facility, 0.04 grams of alum was needed to make impurities in water coagulate, while 20 milligrams of lime was needed to neutralize the effect of alum to the pH of the water. While for 1.2 liters per minute of water entering the water treatment facility, 0.048 grams per minute of alum and 24 milligrams per minute of lime were added to the water. The total volume of the coagulation tank was 1.518 cubic meters (53.503 ft3) which accommodated about 1,515 liters of water at a time. By virtue of gravity, the water from the coagulation tank flowed to the settling tank through a tube located at the bottom side of the tank.

Settling or sedimentation tank. The settling or sedimentation process occurred in the settling or sedimentation tank. The particles that formed during the coagulation process were allowed to settle in the tank. Rectangular in shape, the length of the tank was 5.182 meters (17 feet) while the height and width of the tank were 1.524 meters (five feet). The tank contained five baffles. The first baffle was 1.372 meters (4.5 feet) away from the inlet of the tank and the succeeding baffles had a distance of 0.914 meters (three feet) from the previous baffle. The baffles were 1.524 meters (five feet) long and were inclined 45 degrees with respect to the bottom of the tank. The baffles ensure that the coagulated particles settle at the bottom of this tank. At the bottom end of the baffle, there are pipes with holes that would collect the coagulated particles and transport these particles to the slurry tank.

The slurry tank collected all the coagulated particles that settled at the bottom of the settling tank. The slurry tank was 0.914 meters (three feet) wide, 5.182 meters (17 feet) long and had a height of 0.61 meters (two feet). The sedimentation tank had a total volume of 12.058 cubic meters (425 ft^3) accommodated about 12,034 liters of water at a time. The large volume of the tank allowed water to have enough residence time in the tank to ensure that the agglomerated particles settled at the bottom of the settling tank. By virtue of gravity, the water from the settling tank flowed to the chlorination tank through holes located at the top end of the last baffle.

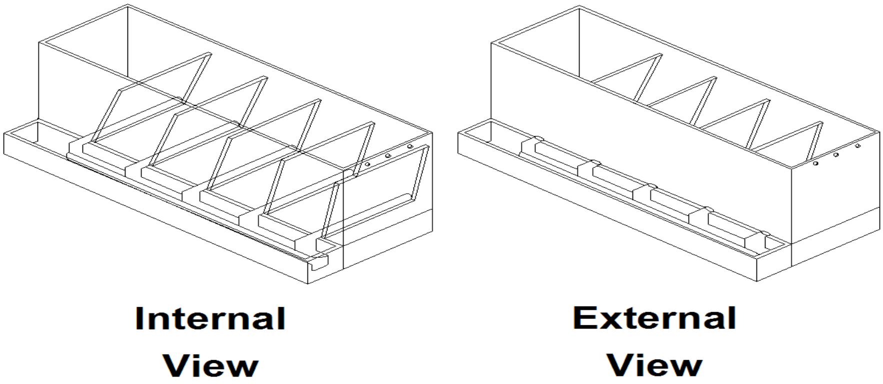

Figure 4. Images showing the external and internal views of the settling tank

Chlorination tank. The disinfection process occurred in the chlorination tank. Chlorine, a disinfecting chemical, was added to the water and destroyed the pathogens present in the water. The tank was rectangular in shape with dimensions 1.829 meters (six feet) long, 1.219 meters (four feet) high and 1.524 meters (five feet) wide. The chlorination tank contained the chlorine that will be added to the water. In order to mix the chlorine to the water thoroughly, a rotating baffle was placed inside the tank. The blade of the rotating baffle was about 0.762 meters (2.5 feet) long.

For every liter of water that would be treated by the facility, four milligrams of chlorine was needed to destroy the pathogens present in the water. The total volume of the chlorination tank was approximately 3.405 cubic meters (120 ft^3) which accommodated 3,398 liters of water at a time. By virtue of gravity, the water from the chlorination tank flowed to the filtration tank through three pipes located at the side of the tank. There were three holes through which water passed to get into the filtration tanks. The holes were one foot in diameter and were 0.152 meters (0.5 foot) away from each other and from the edge of the tank.

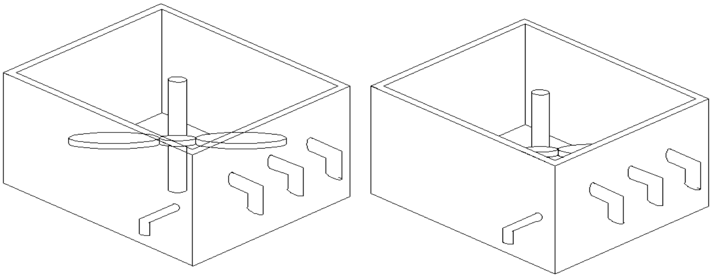

Figure 5. Images showing the internal and external views of the chlorination tank

Filtration tank. Filtration process occurred in the filtration tank. In the tank, water passed through all the six pads of activated carbon. Activated carbon adsorbed the contaminants from water. The rectangular tank is 6.401 meters (21 feet) long, 0.914 meters (three feet) high and 1.524 meters (five feet) wide. The first activated carbon filter or pad was placed 0.914 meters (three feet) from the inlet of the tank and the succeeding pads were 0.914 meters (three feet) away from the previous pad. The total volume of the filtration tank was 8.937 cubic meters (315 ft^3) which accommodated about 8,919 liters of water at a time. The length and large capacity of the filtration tank allowed the water to have more contact time with the activated carbon that permitted full adsorption of all the contaminants and impurities in the water. By virtue of gravity, the water from the filtration tank flowed to the settling tank through three holes located at the bottom side of the tank. The holes were 0.305 meters (one foot) in diameter and were 0.914 meters (0.5 feet) away from each other and from the edge of the tank.

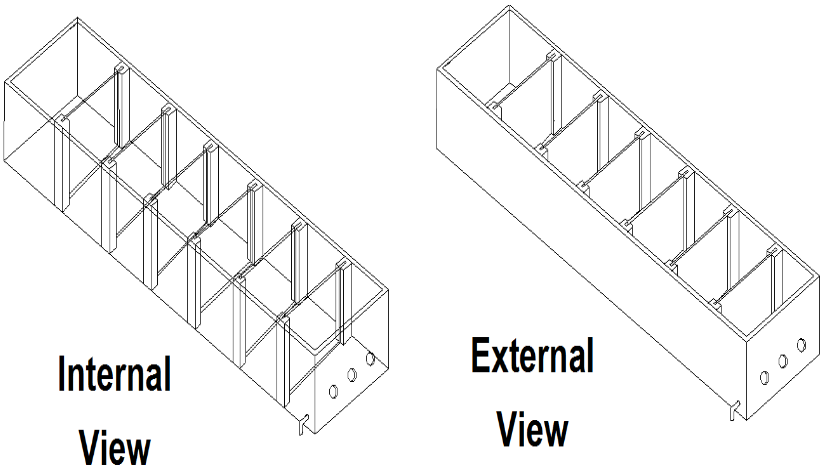

Figure 6. Images showing the internal and external views of the filtration tank

Treated water tank. Finally, this tank was where the treated water resided before they were stored in small containers. The tank is a rectangular in shape, 1.524 meters (five feet) long, 0.914 meters (three feet) high and 1.524 meters (five feet) wide. The total volume of the treated water tank was 2.123 cubic meters (75 ft^3) which accommodated about 2,123 liters of water at a time. By virtue of gravity, water flowed from the treated water tank to the storage containers through delivery tubes. The delivery tubes were approximately 0.0127 meters (0.5 inch) in diameter. The tubes were located at the center side of the tank. The tubes were 0.61 meters (two feet) away from the edges of the tank and were about 0.127 meters (five inches) away from each other.

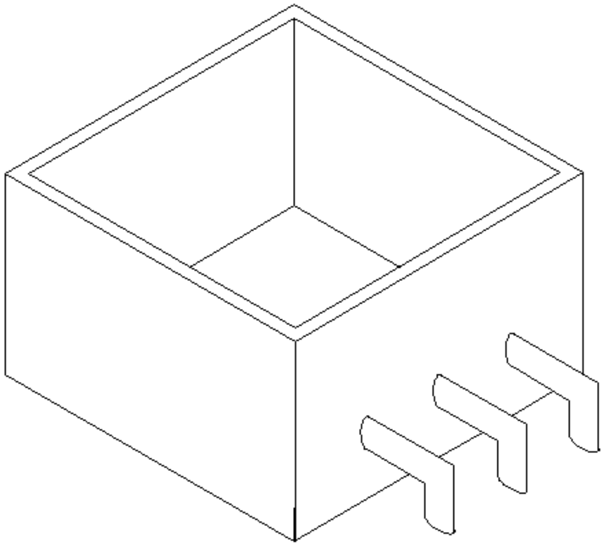

Figure 7.Image of the treated water tank

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of the study showed that the proposed drinking water treatment facility was effective in providing potable and safe drinking water for the community inside Central Philippine University. The laboratory test results revealed that water parameters of the treated water met with the standards for potable drinking water set by the Department of Health. Thus, to ensure that the university will always have a source of potable and safe drinking water, a water treatment facility should be installed inside the university.

In order to meet the demand safe drinking water in the university, a water treatment facility will treat 1.2 liters of water per minute must be constructed. As long as there were enough storage containers for the treated water, the facility will be able to operate for 24 hours a day and seven days a week. The facility has a total land area of 456 square feet or 42.4 square meters and will be located near the university gymnasium. Finally, the facility is estimated to cost ₱154,000.00 but will increase during the actual implementation due to a possible increase of prices of the materials involved in the study.

Recommendations

The favorable results of the study indicated the possibility of installing a drinking water treatment facility within the university. The effectiveness of the designed facility and having met the standard levels of the water parameters set by the Department of Health prompted the proponents of this study to recommend another undertaking that will improve the quality of water being treated by this facility. An aeration process and ultraviolet exposure should be included within the water treatment facility. Aeration is a water treatment process in which water is brought into intimate contact with air. Moreover, the process increases the oxygen level of water, reduces the carbon dioxide level of water, and removes methane, hydrogen sulfide, and other volatile organic compounds, which are responsible for taste and odor, present in the water. With the aeration, the treated water will have a much better quality and taste. Furthermore, an ultraviolet light exposure system in the water treatment facility will ensure the effective elimination of bacteria and pathogens which were not totally removed by chlorination.

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ACKNOWLEDGMENTS

We would like to thank Engr. Salvador E. Magno, for his contributions in the design of the equipment used; Engr. Jeffrey Sayat, for helping us in preparing a rough cost estimate of project; Prof. Hope G. Patricio, for editing this report; Rev. Joniel Howard H. Gico, Vice President for Administration of Central Philippine University for the positive action and support to construct the facility if funds are made available; our loved ones for the inspiration to face the challenges of life which included the completion of this research report, and finally; the Almighty God who is the source of our strength and wisdom, to Him be the glory!