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Development of calcining system for calcium oxide production from oyster shell

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Abstract: The importance of Calcium oxide as having a lot of uses when it comes to food and sanitation is a well-known fact. Thus, this led to the development of a prototype calcining system. Specifically, it aimed to: (1) Quantify the operating performance of the calcining system in terms of calcination time, fuel used, and percentage yield; (2) Evaluate the characteristic of calcium oxide produced by the calcining system in terms of color, odor, turbidity, ecoli and pH; and, (3) To evaluate the acceptability of the device based on its operating performance. The calcining system was fabricated in Sigma Satellite College and quantitatively measured its operating performance in three replications in the Technology Building of the Education Department. At the same time, the calcium oxide treated in water analysis was at the Agri-Aqua laboratory. Its design was quantitatively evaluated using a researcher-made evaluation sheet by 18 experts in engineering, industrial technology, and education. The system's acceptability criteria focused on responding to technical compositions, performance, and safety issues. The qualitative evaluation of the system and sensory evaluation utilized the research-made evaluation sheet. Calcining system had a remarkable operating performance despite its simplicity in design and low cost of materials. It can withstand the heat requirement of 1000°C and produced the desired amount of calcium oxide. The percentage yield of calcium oxide varies according to the amount of fuel. It had 80% if the fuel is at 25 kilograms compared to 60% with 15 kilograms. The more consumption of fuel, the longer the calcination time, and the higher its percentage yield. The treated water analysis had 11 pH level and >25cfu/ Total Bacterial Count with no objectionable color and odor and clear turbidity. The design of the calcining system was rated "Very Acceptable" due to its simplicity, conformity to the principles of calcination, economics, functionality, and creativity.

Keywords: Calcining system, Calcium oxide, Oyster shell

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INTRODUCTION

The development of the calcining system in producing calcium oxide from the oyster shell is an excellent tool for mass production to fully maximize its usability in food preservation, water, soil treatment, and solution in pretreating white anchovies and other fishes.

Based on the study entitled "Dried White Anchovies Pretreated with Calcium Hydroxide Solution from Oyster Shell" (Untayao,2017). The recommendation for innovation in creating equipment to produce calcium oxide from the oyster shell is potential. Calcium oxide proved to be potential in pretreating white anchovies in the washing and soaking methods. It enhances the quality of the product and maintains its high value in the market even during the rainy season.

The Province of Capiz is blessed with rich fishing grounds that make it famous as the Seafood Capital of the Philippines. The province topped the volume of oyster and mussel production nationwide based on the Bureau of Agricultural Statistics (BAS) Fisheries Statistics of the Philippines report for 2007 to 2008. The two-year report has registered oyster and mussel production at 11,831.6 and 13,404.75 metric tons, respectively, despite typhoons and tidal disturbances, which negatively affected the shellfish production in Western Visayas (Lumaque, 2010). These marine shell wastes are a rich source of several bioactive compounds and materials, such as calcium, chitin, pigments, and proteins. This waste material is currently vastly underutilized and contributes to significant environmental problems due to off-odor and concentration of minerals in landfills.

Despite the high consumer demand for utilizing this calcium oxide from oyster shells, there is no available supply in the market due to the non-availability of the system for mass production. In coastal areas, fishermen venture into the oyster culture because of its high market demand and profitability. Thus, the empty oyster shell becomes waste disposal in the area.

The researcher believes that developing a calcining system to produce calcium oxide from the oyster shells could generate mass production enabling it to respond to consumer demand in the market.

Likewise, the researcher would like to utilize the empty Oyster shell containing CaCO3. When burned at a high temperature, it decomposed and converted into CaO in the form of ash (unslaked lime), and when dissolved in water formed Ca(OH)2 solution or limewater ("Thermal decomposition of calcium carbonate- Learn Chemistry," n.d.). Further, it will motivate fishermen to venture more into oyster production and make them responsible for utilizing the empty oyster shell to generate extra income. This will help solve the environmental problem of waste disposal of empty oyster shells. Hence the study was conducted.

Statement of the problem

The main purpose of this study was to innovate a calcining system to produce calcium oxide from oyster shells.

Specifically, it sought to:

1) Quantify the operating performance of the calcining system in terms of calcination time, fuel used, and percentage yield.

2) Evaluate the characteristic of calcium oxide produced by the calcining system in terms of color, odor, and turbidity.

3) Subject for laboratory analysis for the pH and bacterial count of the treated and untreated water samples.

4) Evaluate the system's acceptability based on its operating performance.

LITERATURE REVIEW

Calcination

Rand (1991) defines calcination as the process of heating of inorganic materials to eliminate volatile components. The discharge of volatile matter during calcination minimizes internal reduction that lead to the development of internal stresses and, eventually, cracking or warping.

The calcination process is also influenced by the prevailing atmosphere. At low calcination temperatures, the porous aggregates that comprise the particles are sufficiently strong to resist breakdown during compaction, so that the density before firing is low and, additionally, the high sintering activity of the tiny crystallites leads to an internal shrinkage within the aggregate that can open up interaggregate pores. Improved mixing and lower calcinations temperatures can be obtained by using coprecipitated gels and spray-dried or freeze-dried mixed solutions of salts instead of oxide or oxide–carbonate mixtures.

Ruys (2019) claims that calcination involves heat treating a powder to fuse and enlarge its primary crystallite size. A highly calcined powder will have a low specific surface area; a large crystallite size will require a very high sintering temperature, and will have low drying and firing shrinkage.

Calcination means that the internal tension of the molecular structure of the substance is relaxed, so that it can adapt to the increasing strength in the shaping process and become stronger when finished. More so, the calcination process has an important influence on the color and brightness (Wen et al., (2020).

Calcining system

The calcining system invented by Yujie, Jun, & Lihu (2017) claimed that they were able to produce an outstanding calcined powder. The device mentioned also prevented the moist air from being condensed after the process of precooling thus, the drying treatment efficiency is high. The calcining device features a rack, a calcining furnace, a drying furnace, a drainage assembly, a heating assembly and a spraying device. The exhaust fan can speed up the circulation of air to prevent condensation of condensed water after the upper end of the humid air precooling, thereby improving the drying efficiency.

The powder calcining device of Wen et al., (2020) claimed to has a simple and reasonable structure, convenience to use, as well as produced a high calcining efficiency. This utility model comprises of a calcining cylinder body which has a material guide rotating screw rod arranged to it, and a heating pipeline placed at its bottom; a rotating shaft that is arranged in the center of the material guide rotating screw rod and is connected to a rotating motor; one end of the guide rotating screw rod is connected with a first conical discharger, the first conical discharger is connected with a discharging conveying belt, and a discharging roller is arranged in the discharging conveying belt; a second conical blanking device is arranged at the other end of the material guide rotating screw rod, the second conical blanking device is connected with a discharging conveying belt, and a discharging roller is arranged in the discharging conveying belt; wherein the calcining cylinder is of a horizontal fixed structure, and three exhaust cylinders are arranged at the upper part of the calcining cylinder; the material guiding rotary screw rod is a blade type screw rod, and a screw rod blade of the material guiding rotary screw rod is provided with a material guiding groove.

As mentioned, this device has a horizontal fixed structure that boost a higher performance strength. The upper part of the body paved way for the three exhaust cylinders which are evenly arranged. The exhaust cylinder aids the discharge of gas during the process and the entry of air thus, increases the oxygen content of the calcination gas in the calcination cylinder and increases the amount of the powder being produced. Also, contains screw blades made of titanium, attached to the inner wall of the calcining cylinder. These screw blades are more resistant to oxidation and high temperature and have a longer service life. And when in use, the temperature reaches the preset temperature, through a heat source, at 260-350°C, and the calcination pipeline is at 750-850°C.

Seo et al., (2020) had prepared calcined oyster shell powder and investigated the effect of its incorporation on the properties of cement mortar in order to recycle the oyster shell waste which is generated in a large quantity annually. The oyster shell was calcined at 1000◦C using an electric furnace for 3 h and confirmed that 98% of the shell was composed of pure calcium oxide having an identical crystal structure of lime.

Oyster shell

Calcium carbonate is one of the most used raw materials in various industries, such as construction materials, food supplement, pharmaceutics, animal feed, plastic production, and others. Calcium carbonate can derive from marine wastes, like crustaceans and bivalve's shells. The worldwide demand for new sources of food has increased exponentially, and following that tendency, the mariculture—especially the oyster culture—has been increasingly resorting to farming techniques. In 2016, 438 billion tons of oysters were produced. The majority of the shells were unduly discarded, presenting a public health problem. (Thamyres H. Silva, 2017).

Estuaries have been described as one of the most difficult environments on Earth. It is difficult to know how to treat the combined wastewater in tidal rivers at the estuary, where the situation is very different from ordinary fresh water rivers. Waste oyster shell was used as the active filler in this study in a bio-contact oxidation tank to treat the combined wastewater at the Fengtang Tidal River. With a middle-experimental scale of 360 m3/day, the average removal efficiency of COD, BOD, NH3-N, TP and TSS was 80.05%, 85.02%, 86.59%, 50.58% and 85.32%, respectively, in this bio-contact oxidation process.

The living microbes in the biofilms on the waste oyster shell in this bio-contact oxidation tank, which were mainly composed of zoogloea, protozoa and micro-metazoa species, revealed that waste oyster shell as the filler was suitable material for combined wastewater degradation. This treatment method using waste oyster shell as active filler was then applied in a mangrove demonstration area for water quality improvement near the experiment area, with a treatment volume of 5 × 103 m3/day. Another project was also successfully applied in a constructed wetland, with a wastewater treatment volume of 1 × 103 m3/day. This technology is therefore feasible and can easily be applied on a larger scale. (Hongbing Lou, et.al, 2013)

There is a high content of calcium carbonate in mussel and oyster shells, which can be used in the formulation of medicine, in construction or as filler in polymer materials. This work has as its main objective to obtain calcium carbonate from mussel and oyster shells and used as filler in polypropylene compared their properties with polypropylene and commercial calcium carbonate composites.

The shellfish was milling and heated at 500 ºC for 2 hours. The powder obtained from shellfish were characterized by scanning electron microscopy (SEM), X-ray fluorescence, particle size distribution and abrasiveness and compared with commercial CaCO3 and mixed with polypropylene. The thermal and mechanical properties of polypropylene with CaCO3 obtained from oyster and mussel shells and with commercial CaCO3 were analysed. The results showed that CaCO3¬ can be obtained from oyster and mussel shell and is technically possible to replace the commercial CaCO3 for that obtained from the shells of shellfish in polypropylene composites.

Production of calcium oxide from waste oyster shells

The production of calcium oxide was investigated from waste oyster shells as a value-added application in inhibiting bacteria. Oyster shell powder was prepared in 4 forms: natural oyster shell powder (NOSP) and calcined in a programmable furnace for 2 hours at 700°C (OSP 700), 800°C (OSP 800) and 900°C (OSP 900). All forms were analyzed for physical properties using thermogravimetric analysis, X-ray diffraction and Fourier-transformed infrared spectrometry.

The results indicated that the calcium carbonate of NOSP, OSP 700 and OSP 800 had a rhombohedral structure of calcite. On the other hand, the calcium carbonate structure of OSP 900 changed to calcium oxide (CaO) and calcium hydroxide (Ca(OH) 2). The findings were consistent with the Fourier-transformed infrared spectrometry results as they showed the peak of CO stretching, indicating a calcite structure, whereas the characteristics of the Ca=O group and O-H stretching of the functional group indicated the structures of CaO and Ca(OH) 2. OSP 900 showed qualitative antibacterial activity by its inhibition zone on NA medium.

Quantitatively, OSP 900 had the highest antibacterial activity against Escherichia coli and Staphylococcus aureus at concentrations of 0.5% and 1.0% w/v, respectively, with significant differences for an exposure time of 30 minutes. In addition, OSP 900 gave the best inhibition of E. coli in contaminated vegetables at a concentration of 0.5% w/v. The results of this study revealed the usefulness of OSP 900 for further antibacterial applications in contaminated vegetables.

The waste shell was utilized as a bioresource of calcium oxide (CaO) in catalyzing a transesterification to produce biodiesel (methyl ester). The economic and environment-friendly catalysts were prepared by a calcination method at 700-1,000°C for 4 h. The heterogeneous catalysts were characterized by X-ray diffraction (XRD), X-ray fluorescence (XRF), scanning electron microscopy (SEM), and the Brunauer-Emmett-Teller (BET) method. The effects of reaction variables such as reaction time, reaction temperature, methanol/oil molar ratio, and catalyst loading on the yield of biodiesel were investigated.

Reusability of waste shell catalyst was also examined. The results indicated that the CaO catalysts derived from waste shell showed good reusability and had high potential to be used as biodiesel production catalysts in trans esterification of palm oil with methanol.

METHODOLOGY

Research design

This study used experimental-developmental research. Experimental method because it explored on the different parameters to measure the operating performance, fuel consumption and percentage yield of a calcining system. Likewise, Developmental method of research was employed by fabricating a calcining system to produce calcium oxide.

Locale of the study and respondents

The locale of the study was the Education Department of CapSU-Sigma Satellite College, where the pilot testing and revision of the calcination and cooling system were conducted. To evaluate the system's operating performance, a researcher-made evaluation sheet was developed and subjected to content validity and reliability testing. The reliability of the evaluation sheet was assessed using a tryout with 30 respondents, including household members, engineers, industrial technology professors, and mechanical shop personnel.

Research instruments

The researcher-made evaluation sheet was used for gathering qualitative data in this study. A five-point rating scale was utilized. Every item in the questionnaire was provided with 5 choices.

The system was evaluated by (18) evaluators who were experts in the field of engineering, industrial technology and education. There were (5) electrical engineers, (1) chemical engineer, and (2) mechanical engineer (7) industrial technology, (3) education professors.

They were selected using purposeful sampling method taking into consideration that their judgment was based on their prior information and knowledge regarding the system under study (Fraenkel and Wallen, 2017).

Data analyses procedure

The operating performance was measured experimentally. Likewise, the quantitative data of the calcining and cooling system operating performance was also determined. The calcination time, fuel used and percentage yield was recorded and noted. The time upon calcination was noted and recorded properly. The fuel used was weighed and recorded. The amount of calcium oxide produced after calcination was weighed immediately after the cooling process considering the following parameters such as color, odor, and turbidity; the pH level, and the total bacterial count or heterotrophic plate count was also determined through laboratory analysis. However, the color, odor, and turbidity were evaluated by the researcher based on the standard characteristics using a sensory evaluation technique.

For the developmental data, a research-made instrument and video served as the basis of a panel of experts in evaluating the operating performance of the system. The evaluators made some suggestions and were asked to rate the operating performance of the system in terms of acceptability.

Thus, the calcining system operating performance was determined quantitatively and the quality of the water produced with calcium oxide was through sensory evaluation. The acceptability of its structure was evaluated qualitatively.

FINDINGS AND DISCUSSION

Quantitative determination of the operating performance of the calcining system

Calcination of oyster shells requires 1000°C to produce the desired calcium oxide. After three trials, the time was recorded in order to get the most accurate calcination process to produce desired results. On the first trial, with a total mean of 29 minutes of calcination then for the second trial a total mean of 34 minutes and the last trial lasted for 39 minutes total mean calcination. The results show the calcination time of oyster shells using the calcining system.

The calcination time varies on the fuel used. The bigger the amount of fuel used the higher the calcination time. However, with less fuel, it lowered the calcination and it likewise influences the percentage yield. Calcination reactions usually take place at or above the thermal decomposition temperature. This temperature is usually defined as the temperature at which the standard Gibbs free energy is equal to zero. The decomposition reaction of the limestone is $CaCO3= CaO + CO2$ (g). 1,150 degree Celsius the decomposition was 700 degrees to 1,300 degrees the calcination is at least 800 degree Celsius. Kiln type and fuel are factors for calcination. To compute the calcination time, the Time final refers to the time duration during calcination; Time initial refers to time started the first trials. (Ruys, 2019).

Based on the series of trials in terms of calcination time, there was 106.89% for the first experiment, 76.47% for the second experiment, and 53.84 % for the last experiment. The time initial of 60 minutes was taken based on the previous study on calcination of the oyster shell without the use of any system.

Calcination is a process of heating a substance under controlled temperature and in a controlled environment (B. Kaur,S.N. Bhattacharya,"Handbook of Textile and Industrial Dyeing, 2011). This process is known to improve the chroma, tinctorial strength, pigmentary texture, weather stability, light-fastness and thermal stability of pigment whereas it has adverse effect on the dispersibility of pigments. Calcination is an important step in the production of calcium oxide from oyster shell. Calcination time influence the color of calcium oxide. Higher calcination results in lighter and brighter pigments whereas lower calcination time results in deeper shade.

The experimentation had three trials. For the first round 15 kilograms, then second round we used 20 kilograms and for the last round it took 25 kilograms.

To compute the weight of bamboo before burning, on the first trial we used 15 kilograms of sliced bamboo. A second trial was 20 kilograms and for the last trials we used 25 kilograms. Weight of fuel after burning was zero since bamboo is a grass. It can easily catch the fire.

There was no remaining bamboo after calcination, due to its characteristics as grass. The fire can quickly catch the bamboo and continuous burning immediately takes place. 100% of bamboo placed in the rack was burnt and contributed to the calcination process of oyster shell.

Oyster shell wastes used in this study were sourced from Basiao, Ivisan, Capiz one of the coastal areas in the Province. The manufacturing process of calcium oxide powder through calcination of oyster shell waste is depicted in Figure 1. Surface of oyster shell was brushed and soak in water for washing to remove salt and foreign substances. Washed oyster shell was naturally dried and then burned for a maximum of 40 minutes. Calcined oyster shell was slowly cooled down using cooling system to produce calcium oxide in the form of an ash.

To compute the percent yield, it is first necessary to determine how much of the product should be formed based on stoichiometry. This is called the theoretical yield, the maximum amount of product that could be formed from the given amounts of reactants. The actual yield is the amount of product that is actually formed when the reaction is carried out in the laboratory. The percent yield is the ratio of the actual yield to the theoretical yield, expressed as a percentage. Actual yield is the amount (by weight) of CaO produced after burning the oyster shell. Theoretical Yield based on stoichiometry is the maximum amount of the product that could be formed from a given amount of reactants (Wen.Et.al ,2020).

The experiment performed and the calcium oxide wascollected mass of 4 kilograms as the lowest yield and 8 kilograms as the highest yielding at 40 minutes of calcination.

To calculate the theoretical yield based on stoichiometry, first, list the known quantities and plan the problem, then solve and last think about the result. After determining the theoretical yield, the next step is to calculate the percent yield since the actual yield is given (https://chem.libretexts.org/, retrieved 2023)

Percent yield is very important in the manufacture of products. Much time and money were spent improving the percent yield for chemical production. When complex chemicals are synthesized by many different reactions, one step with a low percent yield can quickly cause a large waste of reactants and unnecessary expense.

Typically, percent yields are understandably less than 100% because of the reasons indicated earlier. However, percent yields greater than 100% are possible if the measured product of the reaction contains impurities that cause its mass to be greater than it actually would be if the product was pure. When a chemist synthesizes a desired chemical, he or she is always careful to purify the products of the reaction.

There were three trials of experimentation. First trial had 33.33 percent, the second trial with 40 percent and during the last trial which had 53.33 percent.

The chemical compositions of commercial CaCO3 and mussel and oyster shells. Mussel and oyster shells present a slightly lower, although not significant, amount of calcium oxide (CaO) than commercial calcium carbonate. There are differences in chemical composition because oysters and mussels are water filterer, Kurunczi and co-workers, for example, detected mercury (Hg) and lead (Pb) in mussel shells, because the water where these mussels grew was contaminated.

It is possible to observe a larger particle size distribution to oyster and mussel shells than commercial CaCO3. This behavior can be associated with a higher hardness of the shells because there is a higher concentration of silica in the shells that increases shell hardness and the milling conditions used was kept constant. Commercial calcium carbonate grinding consists of several stages with different grinding systems until it reaches the average particle size most appropriate to use.

There were samples given or submitted for water analysis namely the control (untreated water) and the experimental (treated water) with calcium oxide produced by the calcining system.

In contrast, the treated water had no objectionable color and odor because one of the characteristics of calcium oxide was formed into calcium hydroxide when it is dissolved in water, thus it increases the alkalinity of water.

Characteristics of calcium oxide produced by the calcining system

The color and the odor of the calcium oxide differed as shown in Table 4 based on the sensory evaluation of consumers. The tap water had an objectionable color and odor. This is due to the presence of high acidity and minerals that might have contributed to its color and odor. The sensory evaluation technique was done to test mainly the presence of organic substances that may cause objectionable color and odor in tap water. A positive result might indicate a water quality problem that requires further investigation. It is not recommended to taste or directly smell the water of unknown sources as it might cause some health problems (Philippine National Standards for Drinking Water, 2007).

Laboratory analysis of ph and bacterial count of the treated and untreated water samples

When the pH was tested, the control water sample was 6.36 which means it is slightly basic. However, the experiment is high in alkaline with a pH value of 11.10. The treated pH value complies with the maximum level of pH which is 5-7 product water that has undergone treatment with calcium oxide. The pH range is based on aesthetic considerations only. The acceptable range may be broader in the absence of a distribution system. pH is important as operational water quality parameter (Philippine National Standards for Drinking Water, 2007).

Moreover, it is important to monitor the pH of drinking water because a low pH, it is likely that there are other harmful contaminants in water (TDS AND PH-Safe Drinking Water Foundation, 2019).

Based on the released result of Agri-Aqua Laboratory for TBC or HPC the control had 500 cfu/mL (colony formation unit) while the experimental had <25 cfu/mL using a four plate method. The standard value is <500 cfu/mL which should be complied with among service reservoirs, water treatment works, consumer’s taps nearest the meter, refilling station, and water vending machines. This implies that the test itself does not specify the organisms that are detected. Only a small proportion of the metabolically active microorganisms present in a water sample may grow and be detected under any given set of HPC test conditions, and the population recovered will differ significantly according to the method used. The actual organisms recovered in HPC testing can also vary widely between locations, between seasons, and between consecutive samples at a single location. Microorganisms recovered through HPC tests generally include those that are part of the natural (typically non-hazardous) microbiota of water; in some instances, they may also include organisms derived from diverse pollutant sources. Besides, some microorganisms will grow as biofilms on surfaces (e.g. pipelines) in contact with water. Although most of these organisms do not cause illness to humans, they can cause a nuisance through the generation of taste and odor or discoloration of drinking- water supplies. Growth following drinking-water treatment is referred to as “regrowth”. It is typically reflected in the measurement of increasing heterotrophic plate counts (HPC) in water samples (Philippine National Standards for Drinking Water, 2007).

In the same way, abrupt increases in HPC levels might sometimes concurrently be associated with fecal contamination; tests for E.coli or other fecal-specific indicators and other information are essential for determining whether a health risk (Bartam et al., 2013).

Evaluation of the acceptability of calcining system based on its operating performance

The findings show that the evaluation of the calcining system design was “Very Acceptable” with an overall mean of 4.54 which was based on its operating performance. The criteria presented in the table were arranged according to the highest mean rating of the 18 evaluators. First, the easy operation and practicality of the different parts of the calcining system need only less technical orientation was “Very Acceptable” with the highest mean score of 4.67.

This implies that the design can be easily made and reproduced even with less technical knowledge, especially among the residents in the coastal areas and areas where the acidity of water is very high and had discoloration. This is very essential that the community folks should know how to innovate and make their own as answers to water discoloration as a form of filtration using calcium oxide. While the appropriateness of the structure to support the different features of the calcining system was also “Very Acceptable” which got a second highest mean rating of 4.67. The calcining system is composed of a rack, door, chimney, and cooling system. Its operating performance was very much dependent on these components in the production of calcium oxide. Thus, the structure is fitted and suitable to support the other parts of the calcining system.

Third, was on the stability of the structure to sustain the weights of the different components as “Very Acceptable” with a mean rating of 4.61. The calcining system can support the weight of the different components of the feature. The materials being used were strong enough to hold the weight of the entire structure as it continues calcination.

Fourth, the suitability of the different features that can withstand the heat was likewise “Very Acceptable” with a mean of 4.56. The materials used are able to perform the entire process of calcination despite of heat requirement of 1000°C to produce desired calcium oxide.

This was followed by the applicability of the materials used in the cooling system to maintain the quality of the powdered oyster shell as calcium oxide. “Very Acceptable” and got a mean score of 4.50. The materials used are able to perform the entire process of calcination despite of heat requirement of 1000°C to produce desired calcium oxide. This shows that the heat insulator with hardiflex to make it tight and intact to effectively powderize the burned oyster shell. Its efficacy can produce the desired result of calcium oxide in the form of ash.

Likewise, a weighted mean score of 4.44 interpreted as “Very Acceptable” was for the characteristics of calcium oxide produced using the calcining system. the capacity of the calcining system to produce a desired amount of calcium oxide the cooling system is able to yield the desired amount.

However, the performance based on the structure of the cooling system to enhance the powdering of burned oyster shells got the second lowest mean of 4.39 with a verbal interpretation of “Very Acceptable”. This further shows that the different components were properly fitted to enhance the powdering such that the cover is so tight to maintain its cooling capacity.

Finally, the integration of the different parts in the structure of the system is safe in terms of operation and got the lowest mean of 4.33. Although it had a verbal interpretation

of “Very Acceptable”, the safety in operating the system needs to be improved because there is a possibility of being burned during the calcination process due to the use of plainsheet as cover. Hardieflex was first used however, it was found to be not suited to withstand the heat requirement, thus it was not feasible to use. Precautionary measures need to observe during performing the calcination by ensuring that everyone in the area will be restricted to touch any of the surface of the structure while the procedure is ongoing.

The evaluation of the calcining system as to its structure was comparable with other studies and conforms to the principles of calcination process.

CONCLUSIONS AND RECOMMENDATION

In the light of the findings established, the researcher found that the respondents had a varied extent of experiences about problem situations that one could encounter as breadwinners in their families. They tended to cluster on the agreement that they sometimes had encountered difficulties in doing their teaching job. All possible situations were agreed to be sometimes experienced by them as they discharged their duties and responsibilities as teachers in the profession. Majority were very satisfactory in performing their teaching jobs. Nobody was fair and poor. The extent problem situations at work were encountered by the respondents significantly could influence their teaching performance.

These findings suggest that the calcining system should be composed of stone bricks for durability, placed in a specific area to lose heat, and safe to operate, especially on the structure's surface. To get the appropriate pH of calcium oxide-treated water, another trial with powder and water amounts is recommended. This prototype calcining system with an innovation to its development is only suitable for small-scale calcium oxide production due to its capacity. Before using the calcining system, a survey should be done in the community or household where it will be installed to adjust the calcium oxide yield needed to treat water for discoloration, washing clothes or dishes, or cooking. Future researchers, students, and environmentalists can process calcined calcium oxide. Calcium oxide can also alleviate pond water discoloration and agricultural soil acidity. To avoid burns, the calcining system should be operated with caution on hot surfaces and others should not touch the building. If odor and color are unpleasant, water chemical analysis and calcium oxide post-treatment may be done. Importantly, this technology should be transferred to places where water acidity has to be addressed owing to color, odor, and turbidity by policymakers or local government units within their capacity to manage and maintain.

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