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# Perceived Problems and Prospects on Acceptability of Industrial Waste Sludge As An Alternative Component for Bricks Making

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**Abstract**

This paper shows the perceived problems that the manufacturers might encounter in producing bricks using industrial waste sludge as an alternative component. These include the mechanical, thermal, and physical problems. The above-mentioned issues are directly and/ or indirectly affect the acceptability of the bricks in the said manufacturing companies. And each owners or prospects have different view on those factors, whether it is acceptable or not in their standard. Those issues will lead to the conservative way of producing bricks using industrial waste sludge as an alternative component that will be used in home construction, as in wall decoration, roofing, and even flooring.

For its approach, the research used descriptive research methods including document analysis as well as statistical analysis of all the data gathered. For the population of the study, the research used random sampling technique in identifying the respondents of the study. These respondents are engineers, managers and experts in the production and selling of commercial bricks.

### *1.1 Introduce the Problem*

Management of waste is one of the colossal problems that the country is facing now. Manufacturing companies in the Philippines produce approximately 659,012 tons of sludge each The Southern Tagalog area alone, industries generated an estimate of one third of the total accumulated industrial wastes in the country. Alarmingly, 30% of that sludge was disposed of at sea and some are used as a landfill. A World Bank funded study discovered that more than half of this waste could possibly be recovered.

Waste management starts at a point where people learn how to conserve the resources available, thus promoting sustainable development. Awareness on how to conserve resources is expected to reduce the volume of waste generated whether at the industrial level or household and commercial levels. It requires extensive education to change the values of the people.

Some government regulations and directives as well as some environmental issues led to the unearthing of ways to manage these sludge wastes. Waste management emphasizes recycling, re-use and composting as methods to minimize and eventually manage the waste problem. In some, the use of appropriate technology will also be significant. Food, yard and agricultural wastes can be processed through composting and eventually distributed and used as organic fertilizers. Sludge waste is an excellent fertilizer so as long as it is subject to additional treatment such as anaerobic digestion. Using sludge as fertilizer is not permitted, unless a number of stringent requirements are met, as stated in Sludge Regulations 1989. The principle behind these regulations is to prevent the accumulation of heavy metals on farmlands and to prevent the bacterial contamination of crops.

A study shows the other alternatives for the disposal of sludge versus putting it in a landfill. After investigating the alternatives, an engineer from Toyota (Kentucky) Company partnered with a local scientist and has found out that it is possible of using Industrial sludge and sludge ash as a component of building and construction materials. In mixing 60 percent sludge and 40 percent cement kiln dust, a material that would otherwise be disposed of to landfill; one can produce an alternative brick that can be used as construction material. The highly alkaline dust kills the microorganisms and binds up the metal components. It also dilutes the potential reactivity of sludge.[9]

On the other hand, in producing such materials, the proponent is faced with the problem of the brick's physical, mechanical and thermal properties as perceived by the brick manufacturers. Strength is the prime thing that satisfies the end. Secondary is the brick's appearance or its color shading.

[9] John Thyen, "*Uses of Sludge As Construction Materials".* (Kentucky Pollution Prevention Research Center), Journal, Vol.20.No.74, 2003, pp.28-31. [on-line] Available: www.sludge.waste.com/pprc/tmm/

 

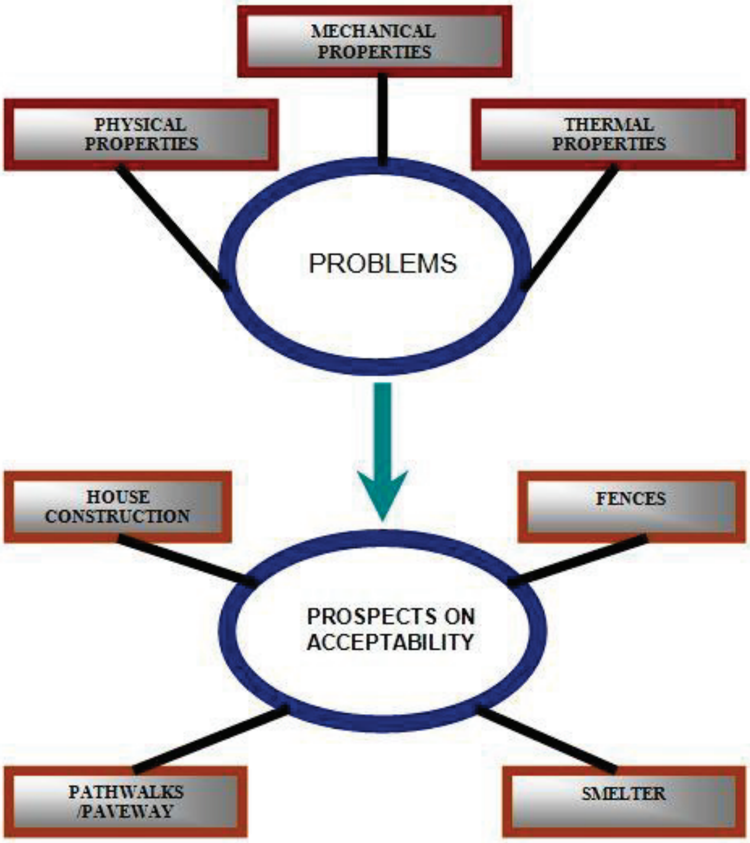


Figure 1
**Conceptual Framework**

This paradigm shows the perceived problems that the manufacturers might encounter in producing bricks using industrial waste sludge as an alternative component. These include the mechanical, thermal, and physical problems. The mechanical properties include the quality of the bricks or its strength is the main concern of manufacturers. It ensures the suitability of the performance of the produced product. The strength of the brick is measured in its ability to resist the stresses caused by compressive, tensile, flexural and shearing forces and its ability to resist the forces of deterioration. The forces of nature that cause deterioration includes expansion caused by wetting and drying, reaction between sludge, water and hydrated cement, the time and manner of kilning, and freezing and thawing of water saturated brick. Strength is also refers to the ability of a material to resist failure in bending. The strength of brick is very much dependent upon the hydration reaction. Water plays a critical role, particularly the amount used. The hydration reaction itself consumes a specific amount of water. Brick is actually mixed with more water than is needed for the hydration reactions. This extra water is added to give brick sufficient workability. Flowing mixed material is desired to achieve proper filling and composition of the forms. The water not consumed in the hydration reaction will remain in the microstructure pore space. These pores make the brick weaker due to the lack of strength-forming calcium silicate hydrate bonds. Some pores will remain no matter how well the brick has been compacted.

Workability, also a mechanical property of bricks, is the ability of the mixture to flow freely around and fill all the voids inside the mold. It is also described as consistency, plasticity or mobility. Consistency is the degree of wetness and slump of the brick mixture while plasticity is the ease with which fresh brick can be molded or deformed without segregation. Mobility is the capacity of the mixture to flow or move. Bricks is said to be workable under the following conditions: the sludge particles must be uniformly distributed and its ability to easily mold into desired fill the space it is to occupy. Workability is often considered to be a measure of the work needed to compact the wet concrete, but it is used to quantify the ease with which concrete can be placed, although this depends on other properties such as cohesiveness.

The manufacturing companies or the prospect industries must be meticulous with the quality of the product produced to ensure the continuing demand of the product. The availability of the supply refers to the direct and indirectly, the number of competitors which is currently limited and since the construction industry is fast-growing, the demand is expected to increase.

Physical properties includes the color shading, which should be in line with the preference of the end-user, especially if the bricks will be used as decoration. The color's consistency, brightness, lightness and its ability to fade easily are the major problem when it comes to color shading. The contemporary color shading that is available in the market is red, orange, and light yellow. Color shading is very important especially for face bricks which are made from clay material used on exposed exterior and interior masonry walls and other architectural applications.

Storing of the end product will also cause some concern. It needs a drudgery place to pile up before the delivery. Areas should be allocated and repaired for the storage of bricks and should have clean, firm, level surface. Where color is an important requirement pack of bricks should be mixed in usage to ensure that any color variations are within acceptable limits. Bricks should be off-loaded onto the hard-standing surface, leaving banding and packaging in place to avoid damage such as chipping, soiling or breakage.

The above-mentioned issues are directly and/ or indirectly affect the acceptability of the bricks in the said manufacturing companies. And each owners or prospects have different view on those factors, whether it is acceptable or not in their standard. Those issues will lead to the conservative way of producing bricks using industrial waste sludge as an alternative component that will be used in home construction, as in wall decoration, roofing, and even flooring. As well as in fences wherein bricks are laid in horizontal and vertical layers using string or nylon chord as a guide. Also in path walks or pave ways wherein bricks are flattened on the ground using mortar is moderately pressed into the space between the bricks; and in smelter or industrial furnace wherein bricks resistance to temperature as high as 178$^{o}$C is required. These smelters are chiefly used in steel making furnace, glass melting furnace and industrial furnace where heat conditions are severe. It has a 178°C maximum service use limit, excellent high temperature strength and good thermal shock resistance. This medium density brick also features insulation thermal conductivity values half those of conventional dense firebrick.

### *1.2 Explore Importance of the Problem*

To the environment, the outcome of this research would be beneficial as it will find possible ways to lessen the industrial wastes sludge that the industries usually dump to seas and to farmlands. Making these wastes into bricks will eradicate the bacteria in contaminating the crops.

To the government, this research would help in minimizing the wastes thrown in farmlands. Technologically speaking, this research wouldl be a breakthrough in the possible uses of industrial waste sludge. This research would also help the construction industry in having an alternative for brick's production at a lesser possible costs.

To the people, this research would also provide awareness to the people in recycling wastes.

To the industries, through this research, people from the industries would unearth a way in innovating and recycling wastes sludge. This would also help the bricks industries in using industrial waste sludge as an alternative material or component.

To other researchers, this study could give the readers additional information on making construction. It could also help enlightening the other researchers on the possible problems and prospects that bricks' manufacturer might encounter in using industrial waste sludge as an alternative component.

To the researcher, this study provides fulfillment because through this research, the proponent helps find methods in recycling industrial wastes and ways on how to encourage the manufacturers of proper waste management.

### *1.3 Describe Relevant Scholarship*

Waste is unwanted or undesired material left over after the completion of a process. Waste can exist in any phase of matter (solid, liquid, or gas). When released in the latter two states, gas especially, the wastes are referred to as emissions. It is usually strongly linked with pollution. Waste produced in the wild is reintegrated through natural recycling processes, such as dry leaves in a forest decomposing into soil (Rivera 2002). Outside of the wild these wastes may become problematic, such as dry leaves in an urban environment. The highest volume of waste, outside of nature, comes from human industrial activity: mining, industrial manufacture, consumer use, and so on (Roa 2001). Almost all manufactured products are destined to become waste at some point in time, with a volume of waste production roughly similar to the volume of resource consumption.

Industrial sludge consists of waste water from domestic, trade and industrial sources as well as rainfall and surface water. It contains wastes as well as other solid material. An Industrial treatment works initially separates solids from the liquid through a process of primary treatment, involving both screening and passing the waste through large settlement tanks where approximately 70% of material sinks to the bottom. This material is known as Industrial sludge. It is a thick odorous liquid containing about 4% solids. The Harper Collins Dictionary of Environmental Science defines sludge as a 'viscous, semisolid mixture of bacteria and virus-laden organic matter, toxic metals, synthetic organic chemicals, and settled solids removed from domestic and industrial waste water at an Industrial treatment plant.

Industrial sludge can be disposed of in its raw form, but it is generally treated prior to disposal or recycling. The disposal of Industrial sludge presents a major problem and generally accounts for half the overall costs of industrial treatment. Sludge treatment is generally carried out using one of the following methods:

Dewatering wherein the water content of the sludge is reduced through centrifugal treatment or filter pressing.

Thickening the solidity of the sludge can be increased by drying it in the sun or using gravity andmechanical dehydration techniques. Other less commonly used methods include ultrasound and freeze-drying.

Digestion Organic matter is broken down by bacteria and micro-organisms to produce methane gas for energy production.

Thermal drying reduces the sludge content to approximately 80% solids.

Lime treatment the addition of lime to lower the acidity for a specified length of time, which produces a material for use as an agricultural liming agent.

Composting the biological treatment of sludge using composting techniques to produce a stabilized material with high dry solids content.[10]

Over 60,000 toxic substances and chemical compounds can be found in Industrial sludge and each year 700 - 1,000 new chemicals are being developed. The heavy metal content in Industrial sludge (copper, nickel, zinc, cadmium, mercury, lead and chromium) present major restrictions to the use of industrial sludge in agriculture. Some towns associated with a particular industry have high levels of metals linked with that industry.

The health and environmental effects of industrial sludge are largely centered on its ability to harbor bacteria, viruses, fungi and intestinal worms. Many of the pathogens contained within Industrial sludge have the ability to cause diseases that can debilitate or even kill humans. These include salmonella, shigella and e-coli and parasites which can cause diarrhea, respiratory diseases, meningitis and paralysis. The pathogens can be transmitted through various media: the air, contaminated groundwater, vermin, and uptake into the roots of crops or direct contact.

One of the reasons that environmental organizations have either supported or not complained about the use of sewage sludge as fertilizer is that the alternatives of incineration or land filling are just as bad, if not worse. And, according to some researchers, if the sludge is composted, it may be relatively benign. In fact, composting sewage sludge is being promoted within the organic movement by *DENR*.

Industrial waste sludge is mutagenic (it causes inheritable genetic changes in organisms), but no one seems sure what this means for human or animal health. Again, regulations don't mention asbestos. Governments issue numeric standards for metals. However, the movements of metals from soils into groundwater, surface water, plants and wildlife – and of the hundreds of other toxins in sludge – are poorly understood. Soil acidity seems to be the key factor in promoting or retarding the movement of toxic metals into groundwater, wildlife and crops. The National Research Council (NRC) of the DENR gives sewage sludge treatment of soils a clean bill of health in the short term, "as long as...acidic soils are agronomical managed." Research clearly shows that, under some conditions (which are not fully understood), toxic metals and organic industrial poisons can be transferred from sludge-treated soils into crops. Lettuce, spinach, cabbage, and carrots have all been shown to accumulate toxic metals and/or toxic chlorinated hydrocarbons when grown on soils treated with sewage sludge. In some instances, toxic organics contaminate the leafy parts of plants by simply volatilizing out of the sludge.

[10] L.O. Vargas, Contents of Industrial Sludge (Manila: Miriam Printing, 2000), pp. 20-31.

There is good reason to believe that livestock grazing on plants treated with sewage sludge will ingest the pollutants – either through the grazed plants, or by eating sewage sludge along with the plants. Small mammals have been shown to accumulate heavy metals after sewage sludge was applied to forest lands. Insects in the soil absorb toxins, which then accumulate in birds. It has been shown that sewage sludge applied to soils can increase the dioxin intake of humans eating beef (or cow's milk) produced from those soils (Lantoa 2000).

Bricks have many properties that make it a popular construction material. The correct proportion of ingredients, placement, and curing are needed in order for these properties to be optimal.

Good-quality brick has many advantages that add to its popularity. First, it is economical when ingredients are readily available. Brick's long life and relatively low maintenance requirements increase its economic benefits. Bricks are not as likely to rot, corrode, or decay as other building materials. Bricks have the ability to be molded or cast into almost any desired shape. Building of the molds and casting can occur on the work-site which reduces costs.

Brick is a non-combustible material which makes it fire-safe and able withstands high temperatures. It is resistant to wind, water, rodents, and insects. Hence, brick is often used for storm shelters. Brick does have some limitations despite its numerous advantages. Brick has a relatively low tensile strength (compared to other building materials), low ductility, low strength-to-weight ratio, and is susceptible to cracking. Brick remains the material of choice for many applications regardless of these limitations.

The safe disposal of hazardous waste has been a challenge for both industry and governments for decades. Under increasing assault by environmental groups for dumping waste into landfills, oceans, rivers and lakes, or burning it in incinerators, corporations and governments seem to have agreed upon a new solution.

They rename the waste as fertilizer or dust suppressant and spread it on farmers' fields and country roads. The code word for this practice is "beneficial use". While it may be an environmentally sound example of recycling, in many cases it's merely relocating pathogens rather than disposing of them (Greer 2003).

Although many different industries are "recycling" their toxic waste in this manner, one of the most controversial substances is sewage sludge, which is widely used as a soil amendment by farmers in both the United States and Canada (Brown 2001).

Sludge is the mud-like material that remains after treatment of the wastes that flow into local sewage treatment plants. If human wastes were the only thing entering the sewage treatment plants, then sewage sludge would be a relatively safe, nutrient-rich fertilizer that could be safely returned to the land. However, sewage treatment plants also inevitably receive industrial and household toxic wastes.

In a November, 1990 edition of the United States *Federal Register*, the Environmental Protection Agency (EPA) had this to say of sewage sludge: "Typically, these constituents may include volatiles, organic solids, nutrients, disease-causing pathogenic organisms (bacteria, viruses, etc.), heavy metals and inorganic ions, and toxic organic chemicals from industrial wastes, household chemicals and pesticides."(Linten 2000).

In fact, there are thousands of substances that can be found in typical sewage sludge, including any of the 100,000 or so chemicals produced and used in industrialized nations, many of which illegally end up in the sewers. Anything that is dumped into a sewer – and that is removed from water by the treatment process – becomes sludge.

This sludge is being legally marketed to farmers who plough it into soil as fertilizer. Although the practice has been around for more than 30 years, there has been a dramatic increase since 1990, according to Agriculture and Agri-Food Canada. This has prompted governments to put in place standards to regulate the levels of toxics in the final product.

Some Canadian provinces have their own regulations, as does the federal government. Agriculture and Agri-Food Canada's Food Production and Inspection Branch have set maximum acceptable metal concentrations for processed sewage and sewage-based products which are sold as fertilizers or supplements.

Ontario's guidelines require that each field on which sludge fertilizer is to be spread must be approved and monitored to ensure the mandated nitrogen to heavy metal ratio is not exceeded. The Ontario Ministry of the Environment and Energy maintains the practice is very safe and will not contaminate groundwater, since the fertilizer only penetrates the soil for four or five inches, just like liquid manure.

In the United States, the Clean Water Act contains specifications for metals concentrations, pathogen reduction and disease-carrying animals such as rodents and vermin. These standards are permissive compared with those of other countries, including Canada.[11]

Nevertheless, there is growing controversy about the safety of sludge-based fertilizer. In the U.S., the National Food Processors' Association says it "does not endorse the use of sewage sludge on crop land". And some of its members also shun the process. Heinz and Del Monte both say none of their products are grown with sludge.

One of the reasons for the concern is confusion about the presence of heavy metals. Maximum allowable levels of metals vary widely around the world. Take cadmium, for instance. Denmark limits this metal to less than one part per million in sludge fertilizer. Germany allows ten parts per million, the state of New York allows 25 and the EPA allows 39 parts per million.

In Canada, the practice is to adopt metal concentration standards as a result of long-term (40 year) effects of heavy metals in soils. The American standards were apparently set using different criteria. After 1992, when a U.S. government ban on ocean dumping of sewage sludge went into effect, the one economical disposal option still available was land application. So with the blessing of the Environmental Protection Agency (EPA), the municipal waste industry hired the public relations firm Powell Tate, which rechristened sludge as "beneficial biosolids". Then, with the sweep of a pen, the EPA reclassified sludge from "hazardous material" to "compost".

This amazing process is documented by authors John Stauber and Sheldon Rampton[12], in their book about the public relations industry, *Toxic Sludge is Good for You*. They write, "Our investigation into the PR campaign for 'beneficial use' of sewage sludge revealed a murky tangle of corporate and government bureaucracies, conflicts of interest, and a cover-up of massive hazards to the environment and human health."

According to Abby Rockefeller, a Boston philanthropist and advocate of waste treatment reform, the move to land application of toxic sludge in the United States was sanctioned by some of the country's most respectable environmental organizations, like the Environmental Defense Fund and the National Resources Defense Council.

Nevertheless, Rockefeller states, "...the menace of toxic and otherwise non-life-compatible substances that can be found in sludge so greatly outweigh the potential nutrient benefit as to make that potential benefit an irrelevance...The sheer number of dangers associated with treating sludge as if it were a fertilizer is so great, so various, and so serious that it would be the life work of thousands of professionals to divide up and respond to the categories of problems that will arise from this practice."

The body of literature on sewage sludge is large, but much of it consists of articles intended to break down public resistance to the use of the product on farmland. There is, however, a core of serious scientific research that has tried to discover what the long-term consequences will be from using sewage sludge as fertilizer. Peter Montague in a recent edition of *Rachel's Environment & Health Weekly*, summarized this literature.

The Composting Council of Canada, an organization of companies, municipalities and individuals involved in large-scale composting operations, provides extensive information to its members on composting organic wastes, including municipal sewage sludge.

Agriculture Canada's Henri Dinel has recently published a paper which describes how composting may reduce the immediate availability of metals found in sludge. He reasons, "Metals are in our environment. Landfilling them is not a solution because they leach out eventually. So my philosophy is that we need to process them properly so they will release slowly enough to make them not toxic."

Some organic certification agencies agree. The Organic Crop Producers and Processors (Ontario) Inc. allows the application of sludge fertilizer "on rotation on green manure crops if free of contamination". According to CEO Larry Lenhard, "free" refers to the maximum allowable limits

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[11] M.L. Newton, Waste Water Treatment in Highly Industrialized Country (New York: McGraw Publishing Inc., 2001), p. 45.

[12] J. Stauber and Rampton, S. Toxic Sludge is Good For You (Vancouver: Knight Publishing Inc., 2000), p. 65.

set by the Ontario Ministry of Environment and "contamination" refers to heavy metals. All other applications of sludge, he says, "should be avoided."

Most organic certifiers forbid its use outright. The Organic Crop Improvement Association (Ont.) prohibits sludge fertilizer as it's "likely to be contaminated with heavy metals."

Despite the Americans' high-powered lobbying efforts and Canadians' more low-key approach, opposition is growing, largely fuelled by problems that are surfacing. In New Hampshire, eight rural municipalities have either banned or sharply restricted sludge fertilizer.

A recent series by the *Seattle Times* newspaper entitled "Fear in the Fields" documented a number of problems.

For instance, in Tifton, Georgia, Lime Plus, a toxic brew of hazardous waste and limestone that had been sold legally to unsuspecting farmers, killed more than 1,000 acres of peanut crops. It is the worst confirmed case in the United States of heavy metals in fertilizer destroying crops aimed for human consumption.

There are other cases: Dairy farmers whose cows died apparently as a result of sludge contaminated with heavy metals and a man who ran a coffee truck near a sludge composting site who died from a variety of ailments apparently caused by inhaling *Aspergillus fumigatus*, a common by-product of sludge composting.

An environmental group in Santa Cruz, California called CURE has also found problems with composting sludge, pointing to a growing body of anecdotal evidence of a relationship between the recent increasing cases of human asthma and exposure to dried bioaerosol products in the sludge.

The evidence has even surfaced at mainstream television network CNN, which reported earlier this year that the United States Fifth Circuit Court of Appeals ruled that "experts have yet to reach a consensus on the safety of land application of sludge."

At present, there are at least 200 brick manufacturing plants in Philippines, directly employing over 10,000 people (50 percent of whom are women) and indirectly employing over 30,000 workers. Most of these plants are situated in rural areas, although due to high growth rates and the booming construction industry, larger plants are being built in suburban areas. Successful farmers own most of the rural plants, while entrepreneurs who have gained experience through working in other brick plants own most of the urban plants. There are very few brick plants owned by corporations or by very wealthy entrepreneurs. Information gathered from informants indicates that there are at least 50 other very small brick plants that are run on a part-time basis by families who live in small villages. These brick industries produce less than 500,000 bricks in total and the income is used to supplement their farm income (Martin 2002).

Many of the bricks are used in rural townships and urban centers. Overall, the brick industry contributes approximately 20.8 million pesos to the rural economy. Our survey results indicate that much of the money made in the brick industry flows to the rural landless and to farmers who own the clay and the wood that is used in the production process. Many of the rural brick owners use clay dug from their own land and wood harvested from their own plantations (although this is much less common in the Northern and Central regions, where there is a real shortage of wood), wood purchased from wood sellers, or rice husks gathered after milling their rice, a commonly practice in rural areas.[13]

In the South, it appears that all industries use wood as their only source of fuel, although in the Northern and Central regions both rice husks and wood are used to fire bricks. A specially designed vertical shaft kiln, known as a clamp, is used when it is fired by wood. There is little standardization in this kiln's construction. The kiln for firing with rice husks is usually made from the bricks that are to be fired, although there are some fixed wall rice-husk-fired clamp kilns in use in Northern Province. From the limited survey, it appears that most of these industries have changed or are in the process of changing from the husks to wood. It is difficult to accurately determine why this is occurring, especially since wood is becoming scarce. The reasons include the present high transport cost of husks; their relative scarcity, as mills are changing over from diesel power to rice-husk-fired steam engines; and difficulty in hiring laborers to work in the highly polluted environment that exists around kilns fired with rice husks.

The clay brick product has long been the traditional building material in Philippines. These

[13] M. Tinorio, "*Wood Shortage Due To Brick Making Industry"* (Masters' Thesis, UPLB School of Engineering, 2001) Vol. 13, No. 2, p. 4.

bricks are fired at a relatively low temperature, leading to low strength and a high moisture absorption capacity. Consumer preference has led to a range of different brick sizes being produced in different areas of Philippines.

Over the past 15 years, cement blocks have taken over approximately 50 percent of the market for wall infill material. Although cement block is more expensive to purchase, bricklayers find it easier and quicker to layering (since it is a larger, more regular shape), and less mortar is required to cement the blocks together. Thus, contractors will purchase cement blocks in preference to clay brick. On the other hand, consumers still prefer clay brick, as they can place nails through it and believe that the walls are cooler and more substantial.

The study indicated that the continued growth of the brick industry in Philippines is essential for the following reasons: to meet the increased housing needs in both rural and urban areas; to use locally available resources in an environmentally sound manner; to provide skilled work for women; to reduce the need for imported building materials; to help promote local rural industries that can provide skilled employment.

Data collected from this study strongly indicate that the industry is under threat. It is predicted that many enterprises will close in the near future. This is due to: the predicted increase in the price of energy; the industry's future inability to hire labor; continued use of thermally inefficient, slow kilns, which in turn ensures the continuation of inefficient material handling practices; continued acceptance of the very small brick module, resulting in poor productivity by brick-layers compared to laying cement blocks; competition from the cement blocks due to their larger module, more efficient manufacturing processes, and capability to respond to market surges for building materials; production of low-quality bricks due to a lack of technical knowledge and inefficient kilns.

However, because the country is facing a cement shortage, more and more people will substitute bricks for cement blocks, and the price of bricks could increase to meet the increasing demand. This will enable the industry to survive due to a higher profit margin (Santos 2002).

The Sludge (Use in Agriculture) Regulations 1989 [14] control the spreading of sludge on agricultural land. These regulations stipulate that no-one, including the farmer or the supplier of sludge, may permit the use of Industrial sludge as a fertilizer on agricultural land unless a number of stringent requirements are met. The Regulations require that Industrial sludge producers, who supply sludge for use in agriculture, test the sludge.

The principle behind these Regulations is to prevent the accumulation of heavy metals on farmland and to prevent the bacterial contamination of crops. A Code of Practice is included within the Regulations relating to: treatment of sludge, utilization practice, and monitoring requirements. Sewage sludge ash is the by-product produced during the combustion of dewatered sewage sludge in an incinerator. Sewage sludge ash is primarily a silty material with some sand-size particles. The specific size range and properties of the sludge ash depend to a great extent on the type of incineration system and the chemical additives introduced in the wastewater treatment process.

Applications that could potentially make use of sewage sludge ash in highway construction include the use of ash as part of a flowable fill for backfilling trenches or as a substitute aggregate material or mineral filler additive in hot mix.

Sludge ash has been used in asphalt paving mixes to replace both fine aggregate and mineral filler size fractions in the mix. A number of test pavements have been successfully placed in UPLB.

Sludge ash can also be vitrified to produce a frit for use as an aggregate substitute material.

Sludge ash has reportedly been used as a fine aggregate substitute in flowable fill applications, although there is no documented use of sludge ash in this application.

John Thyen conducted a research in Toyota Motor Manufacturing (Toyota) in Georgetown, Kentucky. Toyota had an environmental drive to find alternative uses for facility wastes that are disposed of in a landfill. One facility waste is their wastewater treatment sludge that is generated from manufacturing these automobiles. Toyota generates about 180 cubic yards of sludge per month. The sludge was being sent to a landfill for disposal. Disposal costs for the sludge were about $470,000 annually. Engr. Thyen decided to investigate other alternatives for the disposal of its sludge verses putting it in a landfill.

After investigating their alternatives, Engr. Thyen partnered with a local scientist and has

[14] M. Gomez, "*Republic Act 9003 Industrial Waste Management Act: An Assessment* ", (Masters' Thesis, UPLB College of Engineering 2001), pp. 23-25.

found out that it is possible of using Industrial sludge and sludge ash as a component of building and construction materials. If the Government introduces a primary aggregates tax this route will not only benefit the waste management industry but also the construction industry. Sludge and pulverized sludge ash can be used in the production of:

Brick-making materials Up to 40% by weight of dried sludge could be mixed with cement in making bricks.

Filler in concrete Sludge ash could be used as partial cement replacement for concrete mixing.

Lightweight aggregate Palletized or slab sludge ash incinerated at 1060C and 1110C could produce moderate strength concrete.

Lightweight concrete material Incinerated clay-blended sludge is a potential material for the production of lightweight aggregate concrete for structural use.

### *1.4 State Hypotheses and Their Correspondence to Research Design*

The following null hypotheses are presented:

**$Ho_1$**: There is no significant difference in the perceived problems by the respondents when they are grouped according to the profile variables in making bricks using industrial waste sludge as an alternative component.

**$Ho_2$**: There is no correlation between the perceived problems and the perceived prospects in the acceptability of bricks using industrial waste sludge as an alternative component.

## 2. Method

This chapter presents the research design, population sampling, research instruments, data gathering procedures, and statistical treatment of the data which was employed systematically in undertaking this study.

### Method of Research

This study is an action research wherein raw materials such as sludge, specifically 60 % waste sludge from automotive was mixed with 40% cement kiln dust only to test the viability of the product. Furthermore, this study is mainly a descriptive research wherein the problems in physical, mechanical and thermal properties as perceived by the brick manufacturers were discussed. Measurement of acceptability among manufacturer of bricks in terms of color shading, strength and workability were also included in this study.

According to Consuelo G. Sevilla [15], descriptive research is designed to gather all information about the present conditions. This method can describe the nature of a situation, as it exists at the time of the study. It is specifically concerned with the conditions or relationships that exist; practices or attributes that are held; processes that are going on; affects that are being felt or trends that are developing. At times, descriptive research is related to some preceding events that have influenced or affected a present condition or event.

### Respondents of the Study

The proponent considered two representatives per manufacturer of bricks in Metro Manila as well in Cavite area as the respondents. Only the owners and/or managers who have the expertise in evaluating the characteristics of bricks, the color that the customers might prefer, the problems in the storing of such products was considered. The above-mentioned bricks manufacturing companies' owners and/or managers were also those with close contacts with contractors and engineers. Since there are only few existing brick manufacturing companies in the country, the proponent considered all the 30 companies in Metro Manila and 12 companies in Cavite.

The proponent solicited opinions from various individuals who met the following requirements:

1. of legal age;
2. at least 2 years in the business;
3. and who has close contact with the end-users (e.g. architects, engineers, interior designers, contractors, and homeowners) of the product.

### Research Instrument and Techniques

[15] Consuelo g. Sevilla, *Introduction to Research Method*, (Manila:National Bookstore 2000),p69.

The instrument and techniques that was used in the collection of data for this study were:

**1.Questionnaire**. Sets of orderly arranged questions were carefully prepared to answer the specific problems of the study. To measure the level of acceptability as to physical, mechanical and thermal properties, the following degrees are mentioned.

Acceptability was divided into five degrees such as "strongly agree" with weight of 3.51 to 4.50, "agree" with weight of 2.51 to 3.50, "disagree" with weight of 1.51 to 2.50, and "strongly disagree" with a weight of 1.00 to 1.50. The weighted mean was computed, which also disclose the acceptability of the finished product.

**Validation of the Questionnaire**

Five manufacturing companies who were not included as respondents but are also producing bricks were validated the draft questionnaire. Draft questionnaires were distributed to the initial group of respondents who provided the basis for analysis and revisions of questions.

**2. Unstructured Interviews.** The researcher conducted unstructured interviews with some respondents to gather additional information related to the study. Interviews were undertaken simultaneously with the retrieval of questionnaires to augment and enrich the responses reflected in the survey instrument.

**3. Observation.** The researcher conducted direct observations in the activities of the respondents that were related to the brick manufacturing to supplement the findings that were derived from the questionnaire. Visits to other companies with waste water treatment were also made to update the present operating conditions of those companies.

**4. Documentary Analysis.** All documents which the researcher gathered from the brick manufacturing companies were collated and analyzed. Vigorous research was conducted to disclose the history, composition, and all the related studies about the sludge. Gathering of current issues about the condition of the waste management and brick's industry was also considered. Investigation on the current records of various government agencies such as Department of Environmental and Natural Resources, Department of Agriculture, Department of Trade and Industry and others were done to further strengthen the research configuration.

**Research Procedure**

The proponent called the Department of Trade and Industry (DTI) or Philippine Chambers of Commerce and Industry (PCCI) for the listings of possible respondents or brick manufacturing companies in Metro Manila and Cavite area. Then, the researcher called all the companies and explained the nature of the research, etc. A questionnaire was distributed to those brick manufacturing companies to gather information regarding the problems encountered in manufacturing bricks using industrial waste sludge as an alternative component. The proponent explained the contents of the questionnaire and asked the respondents' comments or questions. The questionnaire was collected by the respondent within the week after the distribution. Interviews and observation were carried out simultaneously with the retrieval of questionnaires. The data collected were tallied, collated, and tabulated. All data gathered were subjected to the appropriate statistical treatment.

**Statistical Treatment of Data**

Statistical treatment of data depends upon the nature of the problem, specifically the specific problems and the nature of data gathered. The proponent used the following statistical treatment:

**1. Percentage.** The frequencies of the population of the study were computed in percentage. It was used to determine the profile of the respondents as regards to age, number of years in business, position, highest educational attainment and sales in the previous years.

$$P = (f/n)*100$$

where: $P$ is the percentage
$f$ is the frequency
$n$ is the number of respondents

**2. Weighted Mean.** The researcher computed the mean $\overline{X}$, which is defined as the sum of all values of a given parameter, divide by the number of data in the sample. It was used to compute the average data of the samples taken. The formula is:

$\overline{X} = \Sigma x / n$

where : X is the sample mean

$\overline{x}$ any datum or measurement

n total number of data in the sample

$X_{1....n}$ mean data in company 1....n.

The descriptive interpretation is based on the following:

| | |
|---|---|
| 3.51 - 4.50 | strongly agree |
| 2.51 - 3.50 | agree |
| 1.51 - 2.50 | disagree |
| 1.00 - 1.50 | strongly disagree |

**3. t-test.** For the purpose of testing the null hypothesis and to determine whether or not there is a significant difference in the perceived problems by the respondents when they are grouped according to profile variables.

**4. Analysis of Variance (ANOVA).** For the purpose of testing the null hypothesis and to determine whether or not there is a significant difference of more than two groups to compare, ANOVA was used.

**5. Pearson – r Product Moment Correlation.** Correlation procedures are the common method of describing the relationship between two variables. To determine the relationship between acceptability of bricks with the perceived problems and perceived prospects, use of Pearson-r Product Moment Correlation was employed.

This study considered independent and dependent variables, which consists of the following codes:

| | | |
|---|---|---|
| mechanical | - | $X_1$ |
| physical | - | $X_2$ |
| thermal | - | $X_3$ |

The formula for Pearson-r product Moment Correlation:

$$R = \sqrt{\frac{N\Sigma XY - \Sigma X\Sigma Y}{[N\Sigma x^2 - (\Sigma x)^2][N\Sigma Y^2 - (\Sigma Y)^2]}}$$

where N – no. of respondents

ΣX – sum of the scores in variable X

ΣY – sum of the scores in variable Y

r – coefficient of the correlation between variable X and Y [16]

The following interpretation of the range of r in terms of verbal description was used:

| | | | |
|---|---|---|---|
| 0.00 | - | ±0.19 | denotes little of any correlation |
| 0.20 | - | ±0.39 | denotes low correlation |
| 0.40 | - | ±0.69 | denotes moderate correlation |
| 0.60 | - | ±0.89 | denotes high correlation |
| 0.80 | - | ±1.00 | denotes very high correlation |

(1)

## 3. Results

This chapter presents the result of the surveys, analysis and interpretation of data concerning the correlation between the perceived problems and prospects on acceptability of using industrial waste sludge as an alternative component for bricks making. It presents the answers to the specific questions raised in Chapter 1.

### I. Profile of the Respondents

The profile of the respondents of the study covered age, number of years in business, position and highest educational attainment.

Shown in Table 1 are the findings on the profile of the respondents based on the retrieved data of eighty-one (81) respondents who participated in the study.

#### 1.1 Age

Shown in the table is the frequency and percentage distribution of the respondents' age where 14 respondents representing 17.28 percent are within "30 years old and below" bracket, 28 respondents representing 34.57 percent who are within the range "31 to 35 years old", 24 respondents representing 29.63 percent are

[16] L.P. Stauch, *Introduction to Statistics,* (London:McGraw Publishing Inc. 2003) pp. 341-345.

within the range of "36 to 40 years old", 9 respondents representing 11.11 percent are within range of "41 to 45 years old" and 6 respondents representing 7.41 percent are within "46 years old and above" bracket.

Table 1

**Profile of the Respondents**

| **1.1 Age** | **Frequency** | **Percentage** |
|---|---|---|
| 30 and below | 14 | 17.28 |
| 31-35 years old | 28 | 34.57 |
| 36-40 years old | 24 | 29.63 |
| 41-45 years old | 9 | 11.11 |
| 46 and above | 6 | 7.41 |
| **OVER-ALL** | **81** | **100.00** |
| | | |
| **1.2 Number of Years in Business** | **Frequency** | **Percentage** |
| 0-5 years | 5 | 6.17 |
| 6-10 years | 34 | 41.98 |
| 11-15 years | 36 | 44.44 |
| 16-above | 6 | 7.41 |
| OVER-ALL | **81** | **100.00** |
| | | |
| **1.3 Position** | **Frequency** | **Percentage** |
| Owner | 43 | 53.09 |
| Manager | 38 | 46.91 |
| **OVER-ALL** | **81** | **100.00** |
| | | |
| **1.4 Highest Educational Attainment** | **Frequency** | **Percentage** |
| Undergraduate and Lower | 8 | 9.88 |
| College Graduate and Higher | 73 | 90.12 |
| **OVER-ALL** | **81** | **100.00** |

The result indicates that majority of the respondents are within range of "31 to 35", followed by "36 to 40" bracket. The least number of respondents are within the age range of "30 and below", "41 to 45" and "46 and above" respectively. Putting together the age brackets, the data generally indicates that majority of the respondents are "31 to 35" and "36 to 40" years old.

**Number of Years in Business**

As regards to the number of years in business of the respondents, table 1 shows that 5 respondents or 6.17 percent have "0 to 5 number of years", while 34 respondents representing 41 to 98 percent have been in the business 6 to 10 years. 36 respondents or 44.44 percent of the respondents have been in the business for 11 to 15 years and only 6 respondents representing 7.41 percent were into "16 and above" bracket.

The result shows that majority of the respondents when in comes to the number of years in business are within the bracket of "11 to 15" and "6 to 10" years respectively. Only few have been in the business "16 and above" years and "0 to 5 years". The result also means that majority of the respondents have an enough experience in giving expert opinions.

**Position**

As indicated in Table 1, forty-three (43) respondents representing 53.09 percent of the total respondents are the owners or co-owners while 38 of the respondents or 43.91 percent of the respondents are the managers. The result shows that majority of the respondents are owners while the minority of the respondents are managers because in some cases, the owner also is the manager.

**Highest Educational Attainment**

The highest educational attainments of the total respondents are divided into two categories: "undergraduate and lower" and "college graduate and higher". High school graduate and those who didn't finish their bachelor degree are into the first category and those with a degree or with higher education are grouped into the second category. Eight (8) respondents representing 9.88 percent are into "undergraduate and lower" bracket while 73 respondents or 90.12 percent are into "college graduate and higher".

The result indicates that majority of the respondents are college graduates while the lesser respondents are only high school graduates or didn't finish their bachelor degree.

## II. Problems Perceived to be Encountered by the Respondents

### 2.1 Mechanical Properties

Table 2 shows the mean pertaining to the problems in mechanical properties as perceived by the respondents. The table indicates the respondents' perception that the bricks made of industrial waste sludge are as good as the commercial bricks when it comes to strength and durability. The performance of the said bricks is suitable and of good quality based on the opinions of the respondents because it will not deform and crack easily.

The table also implies that the respondents believe of the ability of the brick to resist forces of deterioration. They presume that the cement mixture dilutes the potential reactivity of sludge.

Most of the respondents also assume that there will be no problems in the workability of the mixture of the bricks, meaning the said mixture can fill all the voids inside the mold. It also signifies that the mixture can flow freely and can be molded and deformed without segregation. Though, it is noticeable that the highest mean is in the workability problem, meaning a few of the respondents' have a slight restriction whether the mixture can really move freely and can fill all the voids.

Overall, the table seems to indicate that based on the expertise of the respondents, the strength and durability of the bricks made of industrial waste sludge is comparable with the existing bricks in the market in terms of the bricks' strength, durability, workability and cohesiveness.

Table 2
Perceived Problems on the Mechanical Properties of Bricks by the Respondents

| Particulars | Mean | Interpretation | Rank |
|---|---|---|---|
| 1.1. Suppleness or Softness of Brick | 1.10 | Strongly Disagree | 1 |
| 1.2. Easily Deformed | 1.11 | Strongly Disagree | 2 |
| 1.3. Deteriorate Easily | 1.17 | Strongly Disagree | 3 |
| 1.4. Crack Easily | 1.31 | Strongly Disagree | 5 |
| 1.5. Inconsistent Mixture of the Brick | 1.20 | Strongly Disagree | 4 |
| 1.6. Inability of Filling Void between Brick | 1.60 | Disagree | 6 |
| 1.7. Unable to Easily Mold into Desired Fill | 1.62 | Disagree | 7 |
| **OVER-ALL** | **1.30** | Strongly Disagree | |

### 2.2 Physical Properties

Table 3 indicates the means as perceived to be encountered by the respondents in terms of the bricks' physical properties.

The table states that the respondents believe that they can produce these bricks in the color that the customers prefer. It also connotes that based on the mean, the bricks will have a moderate color, meaning not too bright and not too light. The colors will not also fade easily as perceived by the respondents.

All in all, the result shows majority of the respondent's believe that there is no problem in bricks' physical properties. It also demonstrates that the respondents' perception on the physical problems is non-existent and it won't be a factor that will hinder in manufacturing such product.

Table 3
Perceived Problems on the Physical Properties of Bricks by the Respondents

| Particulars | Mean | Interpretation | Rank |
|---|---|---|---|
| 2.1. Shading Problem | 1.07 | Strongly Disagree | 1 |
| 2.2. Over brightness of color | 1.07 | Strongly Disagree | 1 |
| 2.3. Over lightness of color | 1.07 | Strongly Disagree | 1 |
| 2.4. Fade Easily | 1.44 | Strongly Disagree | 2 |
| **OVER-ALL** | **1.17** | Strongly Disagree | |

### 2.3 Thermal Properties

Table 4 illustrates the means in thermal property problems as perceived by the respondents. In regards to thermal cracks, the respondents believe that there will not be a problem in thermal crack, meaning they don't think the bricks will break if exposed to extreme heat. But still, it is noticeable that the mean is high compare to thermal warping which means that not all respondents have the strong opinion that there will be no breaking or cracking under extreme heat.

The respondents also presume that there will not be a problem in thermal expansion which means that even if the bricks will be exposed to great heat, it will not expand. But as seen in the mean, thermal expansion has the highest value. It can be assume that some of the respondents think not strongly that there will not be a problem in expansion of the said bricks under severe heat.

All of the respondents also strongly believe that the bricks will not bend or warp under extreme heat as seen in the computed mean.

Table 4

Perceived Problems on the Thermal Properties of Bricks by the Respondents

| Particulars | Mean | Interpretation | Rank |
|---|---|---|---|
| 3.1. Thermal Crack | 1.59 | Disagree | 2 |
| 3.2. Thermal Expansion | 1.62 | Disagree | 3 |
| 3.3. Thermal Warping | 1.38 | Strongly Disagree | 1 |
| **OVER-ALL** | **1.53** | Disagree | |

**Summary of the Problems as Perceived by the Respondents**

The over-all results show that the thermal problems have the highest mean compare to mechanical and physical which may signify that the respondents are more confident that there will be less problem in physical and mechanical. It also means that under extreme heat or temperature, the manufacturers might encounter some problem that the bricks might crack or might expand.

The table also shows that in terms of color shading the respondents do not see any problem if they will produce such material. The strength and durability of the product will no cause a problem also though there might be a slight problem in the bricks' workability.

Table 5

Problems in Mechanical, Physical and Thermal Properties as Perceived by the Respondents

| Problems as Perceived by the Respondents | Mean | Interpretation | Rank |
|---|---|---|---|
| Mechanical Problems | **1.30** | Strongly Disagree | 2 |
| Physical Problems | **1.17** | Strongly Disagree | 1 |
| Thermal Problems | **1.53** | Disagree | 3 |
| **Aggregate Mean** | **1.33** | **Strongly Disagree** | |

**III. Differences in Respondents Perception**

**3.1 Differences in Respondents Perception when Grouped According to Age**

Table 5 connotes the result of the perceived problems when the respondents are grouped according to age. In this table, the analysis of Variance (ANOVA) was adopted considering that three (3) mean aggregate opinions are derived from the mean respondents whose ages are "30 years old and below", "31 to 35", "36 to 40", "41 to 45" and "46 and above".

The computed probability, in regards to the perception of the respondents in the mechanical properties when grouped according to age, is the lowest. It may indicates that compare to the other problems the respondents have slight differences in opinion.

Table 6

Differences in Respondent's Perception When Grouped According to Age

| | Age | Mean | Fc | Sig | Decision |
|---|---|---|---|---|---|
| **Problem 1 Mechanical Problem** | 30 and below<br>31-35 years old<br>36-40 years old<br>41-45 years old<br>46 and above | 1.34 | 2.64 | 0.61 | Accept Ho |
| **Problem 2 Physical Problems** | 30 and below<br>31-35 years old<br>36-40 years old<br>41-45 years old<br>46 and above | 1.16 | 3.05 | 0.94 | Accept Ho |
| **Problem 3 Thermal Problems** | 30 and below<br>31-35 years old<br>36-40 years old<br>41-45 years old<br>46 and above | 1.36 | 2.86 | 0.95 | Accept Ho |

As seen also in the table, the computed probability in regards to the physical and thermal properties is almost the same and the highest. It means that the respondents when grouped according to age have similar opinions regarding the physical and thermal properties.

But all in all, the table only shows that regardless of the respondents' age group, they all have the same opinion on the said mechanical, physical and thermal problems.

3.2 Differences in Respondents Perception when Grouped According to Number of Years in Business

Table 6 implies the result of the perceived problems when the respondents are grouped according to number of years in business. In this section, the analysis of Variance (ANOVA) was used considering that three (3) mean aggregate opinions are derived from the mean respondents whose number of years in business are "0 to 5 years", "6 to 10 years", "11 to 15 years", "16 and above" respectively.

According to table 6, the value of the probability pertaining to the mechanical problems is only 0.07, the lowest among the three. It means that compare to physical and thermal problems, there is a slight difference in the respondents' perception when grouped according to the number of years in business though the null is still accepted. The reason for this is because some of the respondents think that there might be some problem if this bricks will be used as a load bearing material though still majority believes that it is a durable material.

Again, when it comes to the respondents' perception in physical and thermal properties, they all agreed in the same opinions.

Overall, the null hypothesis of no significant difference in the problems pertaining to mechanical, physical and thermal properties is accepted based on the computed probability so the null hypothesis is accepted.

Table 7

Differences in Respondent's Perception When Grouped According to Number of Years in Business

| | No. Yrs. In Business | Mean | Fc | Sig | Decision |
|---|---|---|---|---|---|
| **Problem 1 Mechanical Problem** | 0-5 years<br>6-10 years<br>11-15 years<br>16 - above | 1.23 | 2.95 | 0.07 | Accept Ho |
| **Problem 2 Physical Problems** | 0-5 years<br>6-10 years<br>11-15 years<br>16 - above | 1.22 | 3.49 | 0.61 | Accept Ho |
| **Problem 3 Thermal Problems** | 0-5 years<br>6-10 years<br>11-15 years<br>16 - above | 1.28 | 3.23 | 0.49 | Accept Ho |

**3.3 Differences in Respondents Perception when Grouped According to Position**

Table 7 indicates the result of the perceived problems when the respondents are grouped according to position. It also shows the results of the t-tests that were conducted on the opinions of managers and owners on the problems in mechanical properties; the hypothesis of no significant difference is accepted judging from the calculated value of 2.15, where the probability value of 0.69 is greater than 0.05 level of significance.

In terms of the problems in physical properties as perceived by two groups of respondents, shown in the calculated value that is equal to 2.44 and whose probability value is 0.81 which is higher than the 0.05 level of significance, therefore null hypothesis is accepted.

Table 8
Differences in Respondent's Perception When Grouped According to Position

| | Position | Mean | tc | Sig | Decision |
|---|---|---|---|---|---|
| **Problem 1 Mechanical Problem** | Managers | 1.31 | 2.15 | 0.69 | Accept Ho |
| | Owners | 1.36 | | | |
| **Problem 2 Physical Problems** | Managers | 1.18 | 2.44 | 0.81 | Accept Ho |
| | Owners | 1.15 | | | |
| **Problem 3 Thermal Problems** | Managers | 1.34 | 2.31 | 0.99 | Accept Ho |
| | Owners | 1.34 | | | |

Regarding the perceived problems in thermal properties, the two groups opinions resulted to no significant difference since t-test resulted in calculated value of 2.31 and whose probability is higher than 0.05.

The table also shows that the perception of the respondents when grouped according to position in terms of mechanical problems has a slight difference compared to that of physical and thermal properties.

All in all, regardless whether the respondent is a manager or an owner, they have almost the same opinion on the mechanical, physical, and thermal problems of bricks.

**3.4 Differences in Respondents Perception when Grouped According to Highest Educational Attainment**

Table 8 implies the result of the perceived problems when the respondents are grouped according to educational attainment. It also shows the results of the t-tests that were conducted on the opinions of who are "undergraduate or lower" and " college graduate or much higher" on the problems in mechanical properties. The hypothesis of no significant difference is accepted judging from the calculated value of 2.14, where the probability value of 0.63 is greater than 0.05 level of significance.

In terms of the problems in physical properties as perceived by two groups of respondents, shown in the calculated value that is equal to 2.45 and whose probability value is 0.90 which is higher than the 0.05 level of significance, therefore null hypothesis is accepted.

Table 9
Differences in Respondent's Perception When Grouped According to Educational Attainment

| | Position | Mean | tc | Sig | Decision |
|---|---|---|---|---|---|
| **Problem 1 Mechanical Problem** | Undergraduate and Lower | 1.27 | 2.14 | 0.63 | Accept Ho |
| | College Graduate and Higher | 1.33 | | | |
| **Problem 2 Physical Problems** | Undergraduate and Lower | 1.13 | 2.45 | 0.90 | Accept Ho |
| | College Graduate and Higher | 1.15 | | | |
| **Problem 3 Thermal Problems** | Undergraduate and Lower | 1.23 | 2.31 | 0.55 | Accept Ho |
| | College Graduate and Higher | 1.33 | | | |

Regarding the perceived problems in thermal properties, the two groups opinions resulted to no significant difference since t-test resulted in calculated value of 2.31 and whose 0.55 probability is higher than 0.05. This result further signify that both the respondents who have a college degree and those have lower educational attainment has the same perception regarding the presented problems.

## IV. Prospects

### 4.1 House Construction

Table 9 indicates the prospect's acceptability when bricks are used in house construction. The result indicates the respondents accepted the use of bricks made of industrial waste sludge especially for roofing, walls, flooring and chimneys. But as seen in the table when used as a foundation, the respondents have a slight hesitancy compare to the other applications. It may indicate that the some respondents have a slight restriction in using it as a load bearing material.

Table 10

*Prospects on Acceptability when Used in House Construction*

| Particulars | Mean | Interpretation |
|---|---|---|
| 4.1. Roofing | 4.88 | To a Very Great Extent |
| 4.2. Walls | 4.88 | To a Very Great Extent |
| 4.3. Flooring | 4.88 | To a Very Great Extent |
| 4.4. Chimney/Fireplace | 4.86 | To a Very Great Extent |
| 4.5. Foundation | 4.80 | To a Very Great Extent |
| **OVER-ALL** | **4.86** | To a Very Great Extent |

The over-all mean also resulted that based on the perception of the respondents, the bricks will also be suitable to be use in a part of the house just like the available bricks in the market.

**4.2 Fences**

Table 10 shows the prospect's acceptability when bricks are used as fences. The acceptability of the bricks as perceived by the respondents when used in top level, walls, bottom level and layering of fences are to a very high extent as shown in the calculated means: 4.91 in all four.

All in all, the bricks are perceived to be in high standard and as good as the bricks that are used in path walks and pave ways.

Table 11

Prospects on Acceptability when Industrial Waste Sludge Bricks are Used as Fences

| Particulars | Mean | Interpretation |
|---|---|---|
| 5.1. Top Level | 4.91 | To a Very Great Extent |
| 5.2. Walls | 4.91 | To a Very Great Extent |
| 5.3. Bottom Level | 4.91 | To a Very Great Extent |
| 5.4. Layering | 4.91 | To a Very Great Extent |
| **OVER-ALL** | **4.91** | To a Very Great Extent |

**4.3 Pathwalks**

Table 11 shows the prospect's acceptability when bricks are used as pathway or pave walks. As shown in the said table, there is very little difference in the computed mean pertaining to the acceptability of bricks when used in gutter, side layering, foundation and topmost layer of path walks.

The over-all result which has an average mean of 4.90 shows that the prospects perception on the acceptability of bricks using industrial waste sludge as main component is to very great extent.

The brick's over-all mean acceptability among the owners and managers suggests that in broad sense, it is acceptable to be used as path walks.

Table 12

**Prospects on Acceptability when Industrial Waste Sludge Bricks are used as Pathway or Pave Walks**

| Particulars | Mean | Interpretation |
|---|---|---|
| 6.1. Gutter | 4.91 | To a Very Great Extent |
| 6.2. Side Layering | 4.91 | To a Very Great Extent |
| 6.3. Foundation | 4.85 | To a Very Great Extent |
| 6.4. Topmost Layer | 4.91 | To a Very Great Extent |
| **OVER-ALL** | **4.90** | To a Very Great Extent |

**4.4. Smelter**

Table 12 shows the prospect's acceptability when bricks are used as smelter. The table indicates that the same with the other applications, when this kind of brick is used as smelter, the acceptability is also to a very great extent.

The brick's over-all mean acceptability indicates that based on the expertise of the respondents, it is possible to use this kind of bricks in kiln door, loading deck, roof lining, wall lining, entrance door and in foundation of a smelter as shown in the average mean which is 4.60.

The result also indicates that compare to other applications, when used as a smelter have the lowest computed mean. It may means that some respondents have slight hesitation in using it under extreme heat.

Table 13

Prospects on Acceptability when Industrial Wastes Sludge Bricks are Used as Smelter

| Particulars | Mean | Interpretation |
|---|---|---|
| 7.1. Kiln Door | 4.63 | To a Very Great Extent |
| 7.2. Loading Deck | 4.52 | To a Very Great Extent |
| 7.3. Roof Lining | 4.59 | To a Very Great Extent |
| 7.4. Wall Lining | 4.63 | To a Very Great Extent |
| 7.5. Entrance Door | 4.65 | To a Very Great Extent |
| 7.6. Foundation | 4.57 | To a Very Great Extent |
| **OVER-ALL** | **4.60** | To a Very Great Extent |

The summary of results in regards to the acceptability of the bricks using industrial waste sludge as a main component is seen in Table 14.

The table indicates that the acceptability of the said material is very high because the respondents do not see any problem in mechanical, thermal and physical properties.

It also means that the bricks are comparable to the commercially produced product. The perception of the respondents is that the brick is durable, of high quality, have a color that is in accordance to their preference, and it can stand extreme heat.

The acceptability of the product may also due to the environmental impact of the product. Since it will eliminate the industrial waste sludge in our farmlands and seas, the respondents also highly accepted this product.

Table 14

Summary of Prospects

| Particulars | Mean | Interpretation |
|---|---|---|
| House Construction | 4.86 | To a Very Great Extent |
| Fences | 4.91 | To a Very Great Extent |
| Path walks | 4.90 | To a Very Great Extent |
| Smelter | 4.60 | To a Very Great Extent |
| **Aggregate Mean** | **4.82** | **To a Very Great Extent** |

## V. Relationship Between Perceived Problems and Prospects in Acceptability of Bricks

5.1 Relationship Between Mechanical Problems and Prospects on Acceptability

Table 13 shows the relationship between the perceived problems in mechanical properties and perceived prospects on the acceptability of bricks using industrial waste sludge as an alternative component.

The table indicates that the perceived mechanical problems have no correlation or relationship with the prospects acceptability when used in house construction as shown in the computed r using SPSS. The computed value is -0.01, which means that the two has no correlation. The results were the same with the prospects acceptability when used in fences, path walks and smelter. The computed value were 0.13, -0.03, and –0.15 which all denotes little or no correlation at all.

The mathematical result of measurement suggests that the perceived problems in mechanical, physical and thermal properties have no relationship with the acceptability of the bricks as perceived by the respondents.

Table 15
Relationship Between Mechanical Problems and Prospects on Acceptability of Bricks

| Perceived Mechanical Problems in Relation to Prospects Acceptability When Used in | Computed r | INTERPRETATION |
|---|---|---|
| **House Construction** | -0.01 | No Correlation |
| **Fences** | 0.13 | No Correlation |
| **Path walk** | -0.03 | No Correlation |
| **Smelter** | -0.15 | No Correlation |
| **OVER-ALL** | -0.02 | No Correlation |

**5.2 Relationship Between Physical Problems and Prospects on Acceptability**

It can be seen in Table 14 the relationship between the perceived problems in physical properties and perceived prospects on the acceptability of bricks using industrial waste sludge as an alternative component.

Using SPSS to calculate the pearson–r correlation value, the table shows the computed value of r. The computer r for the perceived problems in physical properties in relation to acceptability of prospects for house construction is –0.18, which denotes no correlation. On the other hand, when used as fences, there is low correlation with a computed r value of –0.28. It also has no correlation when used as path walk and smelter with a computed value of –0.10 and –0.09 respectively.

The overall results indicate that there is no connection or relationship with the perceived problems in physical properties and the acceptability of bricks.

Table 16
Relationship Between Physical Problems and Prospects on Acceptability of Bricks

| Perceived Physical Problems in Relation to Prospects Acceptability When Used in | Computed r | INTERPRETATION |
|---|---|---|
| **House Construction** | -0.18 | No Correlation |
| **Fences** | -0.28 | Low Correlation |
| **Path walk** | -0.10 | No Correlation |
| **Smelter** | -0.09 | No Correlation |
| **OVER-ALL** | -0.16 | No Correlation |

**5.3 Relationship Between Physical Problems and Prospects on Acceptability**

Table 15 shows the relationship between the perceived problems in thermal properties and perceived prospects on the acceptability of bricks using industrial waste sludge as an alternative component. The computed r using SPSS software in getting the relationship of the perceived thermal problems and the acceptability of the bricks when used in house construction, fences and path walk are 0.04, 0.07 and –0.08 which means it has no correlation and for smelter is –0.23 which denotes low correlation

The result indicates that there is no correlation between the perceived thermal problems and the prospects opinion on the acceptability of bricks as seen in the computed value of r, which is –0.05.

Table 17
**Correlation Between Thermal Problems and Prospects on Acceptability of Bricks**

| Perceived Thermal Problems in Relation to Prospects Acceptability When Used in | Computed r | INTERPRETATION |
|---|---|---|
| **House Construction** | 0.04 | No Correlation |
| **Fences** | 0.07 | No Correlation |
| **Path walk** | -0.08 | No Correlation |
| **Smelter** | -0.23 | Low Correlation |
| **OVER-ALL** | -0.05 | No Correlation |

**4. Discussion**

The following findings resulted from the study:

1. The frequency revealed that majority of the respondents are within “31 to 40 years old” age bracket; have “6 to 15 years” in business; mostly are owners; and are college graduates.
2. The mean revealed that in determining differences in the respondents’ perception on the mechanical, physical and thermal properties of bricks, the respondents’ opinion is “strongly disagree” as seen in the computed average mean.
3. The computed probability using ANOVA revealed that there is no significant difference in the perception of the respondents on the mechanical, physical, and thermal problems when grouped according to age so the null hypothesis is accepted.
4. The computed probability using ANOVA revealed that there is no significant difference in the perception of the respondents on the mechanical, physical, and thermal problems when grouped according to number of years in business so the null hypothesis is accepted. The computed value is higher than the level of significance.
5. The computed t revealed that there is no significant difference in the perception of the respondents on the mechanical, physical, and thermal problems when grouped according to position so the null hypothesis is accepted. It also implies that both the managers and owners have the same perception in regards to the problem.
6. The computed t implied that there is no significant difference in the perception of the respondents on the mechanical, physical, and thermal problems when grouped according to highest educational attainment so the null hypothesis is accepted. As seen in the result, the computed value is higher than the level of significance.
7. The calculated mean in getting the prospects acceptability of bricks when used in house construction, fences, path walks and smelter are of high value. It also implies that all the respondents’ agreed that it is comparable with the existing bricks that they are producing.
8. In regards to the relationship or correlation between the mechanical, physical and thermal problems and the prospects on acceptability, the computed-r revealed that there in no association between the two main variables.

*Conclusions*

In the light of the findings revealed in this study, the following conclusions were drawn:

1. Majority of the respondents owned and managed brick manufacturing companies for six to15 years. Most of them also are individuals who are between 30 and 40 years of age and college graduates.
2. The respondents believe that in producing such alternative product, there will be no problem in terms of its mechanical, physical, and thermal properties. Based on their opinions, the brick is durable, of high quality, the mixture is workable, the color shading is satisfactory, and it can endure extreme heat.
3. There is no difference in the perception of the respondents in terms of the problems mentioned even if they are grouped according to age, number of years in business, position and highest educational attainment. Meaning, they all agree that the brick is suitable to introduce in the market commercially.
4. In general, the brick is acceptable as seen in the evaluation of the owners and managers of bricks manufacturing companies when used in house construction, fences, path walks and smelter. It also laid emphasis that this bricks can be an alternative construction material equally as the one existing in the market in terms of quality, strength, durability and workability.
5. Based on the pearson-r result, the perceived problems in making this type of bricks and its acceptability have no association or correlation. Meaning, regardless of the problems that the manufacturer might encounter in producing such product, its acceptability or suitability when used as an alternative construction material will not be affected.
6. Bricks using industrial waste sludge as an alternative component are a feasible material for house construction, fences, path walks and smelter.

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Notes

Note 1. This is an example.

Note 2. This is an example for note 2