

## ENVIRONMENTAL POLLUTION CAUSED BY CERAMIC PRODUCTIONS: A GENERAL PROBLEM IN BISC AND GLAZE FIRING

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### Abstract

*Pollution is generally an inconvenience in the society. It can occur as a result of unpleasant sound, smells, scents or smokes. There are so many other ways that pollutions can occur amongst them are pollutions from the process of ceramics production. This happened when ceramics wares are been made and when they had to pass through series of firing processes. This paper revealed how air pollution takes place in the course of firing ceramics wares. It also revealed that thick black smokes from the kiln are amongst the major sources of environmental pollution in the ceramics production processes. It also concludes that except firing using electric kiln, any other means have a diverse effect on the environment. The paper recommends amongst others that the firing of ceramics wares should be done far away from populated areas and with a higher chimney.*

**Keywords:** Environmental Pollution, Ceramics, Bisc, Glaze, Smell

### Introduction

Ceramics originated from a greek word *keramiskos* or *keramos* meaning burnt clay, earthen or burnt earth. The word ceramic according to Grimshaw (1971) in Arayela (2007), defined ceramics in a general sense as “materials and articles made from naturally occurring earths” Oaikhinan (2000) in (Rakiya 2014), defined ceramics as a special branch of materials engineering which comprises all solid man-made products which are chemically rendered serviceable through high temperature processing. The Webster's international dictionary also defines ceramics as “the art of making earthenware's or products made from earth by the aid of fire.

As it is today, ceramics is important in everybody's daily activities. Arayela.O. (2007) stated that, ceramics is becoming more and more useful to the society. And as such, opined that a way should be fashioned out for a new production technique that will satisfy the ever increasing and ever changing technological appetite. Their unique properties enabled technology by making thousands of consumer products possible. Arayela. Ibid. Today ceramic have grown from traditional molding techniques of coiling, pinching and slab methods to

many other forming techniques using machines like kick wheel, gigger-jolley, electric kick wheel, slip casting and several others for the production of ceramic wares like teapots, plates, computer parts, electrical appliances, hospital equipment, engineering ceramics, medicine etc. apart from the fact that ceramic stands and serve man in various ways , it is also good to know that its production stages, from the processing of the clay down to the firing stage can endangers one's health or life.

### Ceramic Firing

Traditionally ceramic firing is a process of hardening ceramic wares through subjection to high or low temperature firing in a kiln or through other methods of firings. Kilns are an essential part of the manufacture of all ceramics. Ceramics require heat at high temperatures so chemical and physical reactions will occur to permanently alter the unfired body. Clay materials are shaped, dried and then fired in a kiln. Firing is also a process of conversion from clay to pot. It involves heat of at least 600oc (11120of) these conversion or change is called ceramic change. F & J. Hamer (2004). Firing is also describe as “a process whereby the molecular water in the clay is drawn out by heating the piece in the

kiln to a predetermined temperature to change the state of fragile clay to a hardened and desired state.” Chioma (2010) said that, there are two stages of firing namely the biscuit and the glazed/glost firing stage. Firing in ceramics production is very crucial and important because it introduces great strength and durability to the ware and also makes handling of the ware easier. Kilns are an essential part of the manufacture of all ceramics.

#### **Difference Between Bisc and Glazed Fired Ware.**

In ceramic production, the processes of drying of wares are a unique and fundamental process a ceramic product has to go through. From the wet stage of production, ceramic ware advances to the leather hard stage where designs or decorations can be apply onto the body of the ware without getting distorted and proceed down to the bone dry stage. At this stage, the ceramic ware is then subjected to the first stage of firing known as the biscuit or biscuit firing stage.

Normally at these stage, the ware is subjected to certain degree of temperature ranging from 600oc to 900oc (Ajala,A.O & Munai,D.M.2007). After this first stage of firing which usually last for 3-4 hours, the ware becomes strong, looks pinkish in color and one is able to conveniently hold the items (ware) and even put water or store other valuables inside it. Academically biscuit means fired and unglazed ware that is in a condition hard enough for application of glaze.

While glazed wares are those with glaze application and are subjected to another temperature ranging from (1120oc-1150oc) which at most time is higher than that of biscuit firing. It is possible however, to fire the bisque to its highest temperature and apply a glaze that will fuse at a much lower temperature. (Ajala A, 2002 in (Ajala A.O & Ilesanmi, F.A, 2007). Glaze or gloss firing is a term derived from the industry where glaze firing is at a lower temperature than the biscuit firing. The nature of the two distinct bodies gave birth to what ceramists today call biscuit and glaze firing techniques. Below are the two kinds of wares from the two stages of firing



**Plate 1 and 2:** Glazed fired flower vases

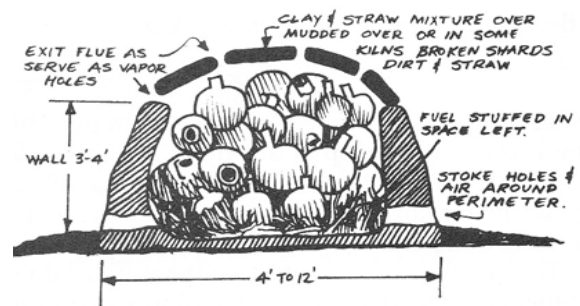


**Plate 3 and 4:** Biscuit or Bisc Fired Wares

### Types of Firing Kilns in Ceramics

There are different types of kilns for firing ceramic wares. They include traditional open firing, kiln firing which is either electrical in nature or uses other source like using liquid fuel (kerosene), diesel, petrol, gas and oil. Solid fuel like wood sawdust and coal are also sources of heat generation. The most affordable of all the mentioned fuel according to (Eweka K.J. 2009), are the waste oil and sawdust type. He further stated that “sawdust and fire wood are however more cumbersome and requires a lot of storage space and produces more of dark smokes during firing. The safety measure is minimal in term of fire hazards to potters. Marvin Bartel, (2012) also noted that, electric firing is among the least efficient and most polluting unless if the power produced is from wind, solar, hydro, etc. There are varieties of firing ceramic kiln which are as follows;

**Pit;** The most simple forms or types of kilns are the pit kilns, which is a pit fire setup where the fuel is placed at the base of pit, followed by the pottery wares then more fuel is placed at the upper layer before firing commences.



**Fig 6—2:** Improved pit kiln with air-supply holes

Improved Pit Kiln with air supply holes around the perimeter. Source; the kiln book. (2016).

**Updraft;** these are another type of kiln, usually cylindrical in shape and consist of two compartments namely the lower and upper compartments. The fuel is placed at the lower compartment while the pottery is placed in the upper compartment. This makes it possible for the heat to effectively rise to the pottery which is fired at a temperature level ranging from 1,000 to 1,200 degrees Celsius. The first constructed kilns contained a firebox in the bottom, and the hot gas from the fire traveled upwards through the ware space and out a flue in the top of the kiln and it's referred to as updraft.

**Downdraft;** The downdraft kiln is a type of kiln, where the products of combustion first traveled up inside the kiln and then forced down and exhausted through the bottom of the kiln. As a result of these, the kiln is more fuel-efficient and improved the temperature homogeneously inside the ware space.

**Periodic Kilns;** A periodic kiln is a heated chamber that contains one opening which gives way for the loading and offloading of ceramic product from the kiln. As soon as the bone-dry products are placed in the kiln, the opening is tightly closed and the firing takes its full-swing to heat up the whole bulk of the kiln. Subsequently, the kiln reaches its ultimate temperature and the firing is put to a halt, the kiln is then allowed to cool for some times before opening it and finally the products are being brought out of the kiln.

**A Shuttle Kiln;** A shuttle kiln is a car-bottom with an opening on one side or on both ends. The Burners are situated at the top and bottom on each side, making it possible for a general, turbulence circular air to flow. This type of kiln is generally a multi-car design and is used for processing white wares, technical ceramics, refractories and electro porcelain in sets. The kiln is built and equipped with a car moving device. These kilns are generally used for restricted-atmosphere and high-temperature applications.

**Continuous Kilns;** A continuous kiln also referred to as tunnel kiln is constructed as a long, usually narrow tunnel with only the central portion being directly heated. The temperature and sometimes the atmosphere changes constantly along its length, with the highest temperature zone occurring somewhere near the middle of the kiln. A stable brook of ware is sent through the kiln, and this ware is heated and cooled. This type of kiln was first invented in the late 19th century during the industrial revolution and is more fuel-efficient because it has a constant and all-round stable temperature.

**Pusher Slab Kiln;** this type of kiln is similar to a tunnel kiln. It is an industrial kiln for glass ceramics and metals it has a fixed floor or hearth. Substantial refractory plates holding the ware are pushed along the surface of this hearth. These kilns were known

before the invention of the roller-hearth. In the present day, pusher slab kiln is principally used for special applications like definite electronic ceramics that cannot be fired in other type of kiln as a result to their small size, slow firing cycles and hostile ingredients.

### **Traditional Kilns**

The invention and creation of kiln is very old. The change of the kiln type from a simple earthen ditch jam-packed with both the pots and fuel before firing. This is a typical example of a pit kiln. Summarily traditional kilns include Anagama kiln in Asian, have being in existence since medieval times, it is the oldest kiln taken to Japan, China and Korea in the 5<sup>th</sup> century. Others are: khmer, Bottle kiln, biscuit kiln, glost kiln, muffle kiln, catenary arch kiln, Noborigama kiln, Sevres kiln, Bourry box kiln, while in Africa (Nigeria), the pit type of kiln was mostly in use.

### **Modern Kilns**

Industrial revolution gave birth to industrialization and mass production of wares and as a result brought about creation and development of more sophisticated modern kilns. These kilns are designed to use electricity and more refined fuels. Like natural gas and propane. Most small/ large scale ceramic/pottery kilns today use natural gas because it's more effective, efficient and easy to control. Modern kilns can also be fitted with computerized gadgets to allow easy controls and adjustments during the firing. Some of these modern kilns includes; Retort kiln, Electric kiln, Feller kiln, Top-hat kiln, beehive, vacuum, solar kiln, Belt kilns, Rotary kilns, etc.

### **Effects of Ceramic Firing on the Environment**

Pottery is one of the oldest known handicrafts. In prehistoric times, water in the pre historic period was carried in woven baskets covered with river clay. If the water was emptied out of the basket, the layer of clay dried up losing the actual moisture body. The shape of the container shrinks and detached from the basket. The detached clay, then formed the shaped of a pot and its removed, dried in the sun on hot sand, to help it maintain and retained the shape and pattern of the basket. The early men and women then realized that they could harden the molded pottery in hot ashes and make durable

vessels to move around with and at the same time store their foodstuffs and valuables. The open firing techniques was born and were used in firing the earliest produced pottery wares with temperature ranging from 600-900 degrees Celsius, the kiln method of firing, is enclosing the pottery wares in a chamber, where much hotter temperature is administered. The temperatures that can be achieved are higher, long lasting and the heat can be controlled effectively.

**Environment:** The Advanced Learners Dictionary defines environment as the conditions, circumstances that is affecting a person's life or the natural conditions like land, air, and water in which people, animals and plants live' while (Ajala & Ilesanmi, 2007). Said, it is man's habitat. International union for the conservation of nature's commission on environmental law and the international council on environmental law 1991 defined environment as the "totality of nature and natural resources including cultural heritage and human infrastructure essential for the socio-economic activities. (Ajala & Ilesanmi, 2007).

**Environmental Pollution;** This simply implies an undesirable or unfavorable environmental situation as a result of certain circumstances like unpleasant noises, for example braving of donkeys, barking of dogs, etc. sounds like honking by vehicles, bell ringing, sirens, drum beating, musical speakers etc., smokes from barbecue, bush burning, garbage burning, smokes from vehicles, bikes, diesel grinding machines, bleaching of palm oil, burnt food, open pottery firing and kiln firing, incinerator or tire burning and also smell from industrial waste, dead animals, spoilt food or drinks, blood in abattoir, defecation and urination around the environment etc. All these are cognate factors for environmental pollution. It may as well be defined as addition of undesirable material into the environment as a result of human activities. Progressive activities such as construction, transportation and manufacturing in Ceramic Industries inclusive, not only destroy the natural resources but also produce enormous number of wastes that leads to pollution of air, water, soil, and oceans; worldwide warming and caustic rains.

### **Ceramic Firing and Environmental Pollution**

The creative ideas concept and construction of firing kiln using gas could be very risky. One should

not make use of gas kiln unless he or she is experienced and have the knowledge of its danger. Firing with gas can cause fire hazards, gas fumes and sometimes explosion. Marvin Barter (2012) says he feels that electric firing is among the least efficient and most polluting unless the power is produced from wind, solar, hydro, etc. He (ibid) also stated that "Generally, less than 35 percent of the power used at the generating plant ends up at the kiln." Mercury from coal plants which is one of the sources of fuel for ceramic firing also contributes to health costs and shortens lives. He further advised that "only adult school personnel responsible for the class should execute kiln firing of ceramic pieces, as there is risk of fire, Smoke and Fog. A fog forms when cold gas reacts with moisture in the air. Other smoke dangerous chemicals include oil based and water-based fog liquid. This chemical can cause skin disease, eye mouth throat or respiratory infections. Good ventilation is very important and essential. Electric kilns in studios that are fired repeatedly in the like air being used by the ceramist or any other individual working in the studio, could be dangerous to his/her health as there is no proper ventilation facility.

Air pollution is a result of industrial and certain domestic activity. It can also be referred to as the presence of any solid, liquid or gaseous substance including noise and radioactive radiation in the atmosphere or an environment in such manner that may be directly and indirectly detrimental to humans or other living organisms, plants, property or interferes with the normal environmental processes. Toxic releases to air, water and also noise emissions arise in the manufacture of bricks and roof tiles. Air pollutant emissions are presented for the firing of bricks and roof tiles. Substantial release to air in the production of bricks and roof tiles ascend during the firing process. Apart from air pollution, during ceramic firing, there is also noise pollution from the (burners) air compressor in the cause of pressuring the kerosene tank. The jaw crusher is another mechanism in ceramic production process that produces noise pollution during the reduction of raw material into smaller bits before milling. Noise is one of the most prevalent pollutants. Noise by definition means sound without value or any unwanted, disturbing and undesirable sound. This noise can cause blood pressure and even deafen the ears.



Fig 1, heavy smoke emission from a ceramic industrial firing.

### Firing Contaminants

Below are some causal agents of toxic fumes during firing. They include; secondary clay, flourspars, chlorides, fluorides, carbonates. Crude feldspars, Cornish Sulfides, stone, gypsum, lepidolite and cryolite all releases fumes in the process of firing. Ball clay contains naturally occurring dioxin which expels the dioxin into the air and at the same time, polluting the environment. Most materials turn to vapor and become floating when heated in the kiln. The poisonous gases include antimony, boron, cadmium, dioxin, lead, selenium, zinc, and precious metals which can easily be inhaled when expelled into the air. Kilns need to be vented and exhausted to the outdoors. The toxic from heavy metal as a result of ceramic firing can form vapors and condense over time on walls, floors, and other facades of the environment where ceramic kiln firing occurs constantly. One can easily get poisoned when he/she rub affected areas with his or her hand and eventually touch his mouth or eyes mistakenly. Serious health problems occur by just living in a house or an environment where there is a firing kiln. Flue gas is usually composed of carbon dioxide and water with excess nitrogen and oxygen remaining from the intake combustion air. It also has some pollutants such as particulate matter, carbon monoxide, nitrogen oxide and sulphur oxide. When

the flue gases are exhausted from stoves, ovens, fireplaces, or other small sources within residential abodes, restaurants, hotels, or other public buildings and small commercial enterprises, the expelled gas are pollutant to the very environment. All the oxides and chemicals that pollutes the environment as a result of smokes creates several sicknesses that endangers human life.

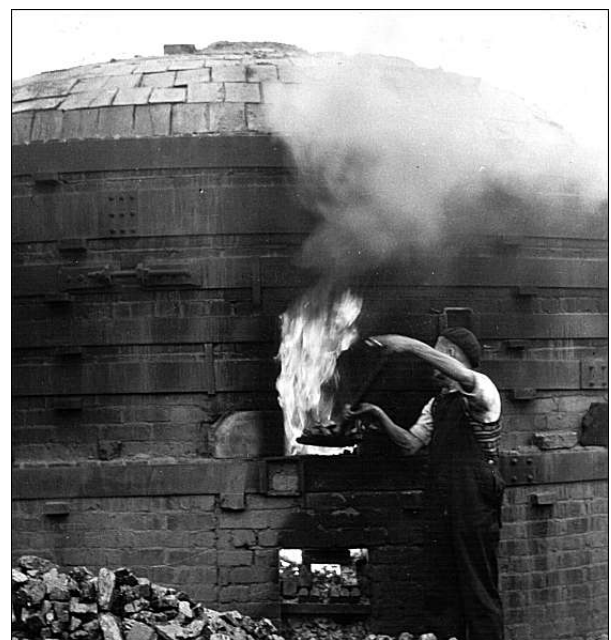


Fig 2, smoke emanate from the chamber



**Fig 3.** Smokes through a chimney high up into the sky



**Fig 4.** A local firing scene with smoke all

### Conclusion

As we all know, one of the major inconveniences we have in the society today is environmental pollution which are created and caused by individuals or group of people in the society. Environmental pollution can surface as a result of dirty black smoke, sound, smells, dust, waste or byproduct from industrial setup, dumping of refuses indiscriminately etc. Ceramics production according to (Kornmann 2007) is one among the source of environmental pollution. Some ceramic materials like Feldspar, Quartz, Oxides, and Clay etc. emit dust particles into the air while some of the machines produce unpleasant noises during



**Fig V.** Fumes emitted from burning tyres contain heavy metals and other harmful pollutant

procession. After the production of ceramics wares it undergoes two stages of firing namely biscuit and glaze/glost firing. During these firing great smokes are released from the firing kiln through the chimney into the sky and as such contaminating the fresh air. These black smokes from the kiln pose as major sources of environmental pollution in the ceramics firing processes and have a diverse effect on the environment causing infections and illnesses on animals and man within and outside the environs states Gardiner, L. (2006).

### Recommendations

Firing kilns should be built with very tall chimneys to ensure release of pollutants at a higher level which enables the pollutants to have enough time to disperse in the atmosphere before it gets to the ground.

Techniques like use of filter, scrubbers, gravity setting chambers should be adopted in arresting pollutant before they are being expelled into the atmosphere.

Kilns such as tunnel kiln, zig-zag kiln, vertical draft kiln, bottle kiln should be encouraged as it reduces pollution and energy wastage.

Utilization of fuel and electric kiln should be considered in ceramic firing as it goes a long way in controlling pollution.

Historically, firing is said to be done outdoors. So, kilns construction should be stationed in uninhabited areas with lots of ventilation or a system of fanning to expel smokes out of the firing arena.

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