LARGE SCALE GRAIN STORAGE STRUCTURES AND THEIR MANAGEMENT IN THE HUMID PART OF NIGERIA

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1. ABSTRACT

Survey of available warehouses and silo structure for storage in humid parts of South Western Nigeria was done to assess the factors and problems associated and affecting grain quality deterioration in these large scale storage structures. A questionnaire was administered for the study to identify the types of large scale storage structures used in South Western Nigeria, and the management problems associated.

Good quality grains were only accepted for storage after thorough examination in most establishments. Manipulation of the storage environment by controlled atmosphere has retard grain quality degradation and possesses good seed viability and consumer friendly. Silo capacity ranges between 5 to 2,500 metric tonnes while ware houses are between 200 to 5,000 metric tonnes. Modern storage structures ages are between 10 to 46 years within this region.

The predominant environmental problems of conventional silos were ambient temperatures fluctuations and high relative humidity.

***Key words:** Silo, Warehouse, Bulk grain storage, Relative humidity and Temperature.*

2. INTRODUCTION

Storage of grain constitutes an essential phase between harvesting, processing and consumption. Stored products are subject to losses that may occasionally be very high. An estimated grain loss in Nigeria was between 20% and 35% of annual production (1). Traditionally, peasant farmers have been known to store their grains over the years in wooden cribs, fire places, roof ceilings, rhumbus, gourds, sacks and by hanging on trees. These mean of storage do not provide adequate protection against rain, insects and rats. Poor hygiene also makes the grains susceptible to mould and pest infestation (2). Traditional methods of storage are unreliable and can store small quantities of grains. The peasant farmers who are the primary producers of grains lack the technology of checking and protecting their grains from mould development and insect infestation (3).

Modern method for bulk storage of grains has been adopted in the Nigeria since 1957 (4). Silos and warehouses of various capacities have been built by government agencies as intervention efforts and for research purposes to prevent food shortages; while private organisations utilize them for storage of bumper harvest and temporary storage in agro-allied industries. Silo can be classified into five types based on their construction materials. These include metal, concrete, wooden, mud and composite silos (4, 5). Convectional silos are available in various sizes and can handle up to 2,500 metric tones of grains. Mechanical ventilation is carried out to remove moisture and reduce grain temperature.

Controlled atmosphere storage system is being introduced as a technique of preserving grains in a modified atmosphere to give a mixture of gases which will inhibit the development and effect of quality degradation agents. The concentration of oxygen gas which supports life is reduced and the environment is enriched with carbon dioxide or nitrogen. "Hermetic" storage in form of underground pit storage is a variant of the controlled atmosphere with the longest continuous history of use in Nigeria.

(6). Warehouses have also been used for the storage of bagged grains stacked on pallet inside a well ventilated building. This system of storage is widely used in research institutes and National Seed Service Centres in Nigeria. The warehouse as a storage structure must be able to protect stored grains from moist conditions, high temperature and pest infestation. It is a large scale storage structure used for granular produce such as beans, rice, cocoa and maize. The modern storage aims to ensure good storage practices that will maintain conditions in the grain bulk and preserve the marketing and processing quality of grains at a high level. The main objective of the study is to asses the size, age, capacity utilization, grain quality, present condition and peculiar problems in management of the silo and warehouse used for large scale storage structures in the South Western Nigeria.

3.0 FACTORS AFFECTING GRAIN STORAGE AND DETERIORATION

There are various natural and artificial factors that limit silo performance. Brummer (7) identified grain respiration, equilibrium relative humidity, moisture condensation, temperature and heat transfer capacity of grains as factors affecting metal silo in the humid tropic. During storage, deterioration of stored grains results from interactions among physical, chemical and biological variable in the grain bulk micro-environment.

3.1 Physical Variables

All living organism remain alive and thrive only within certain limits of temperature. Atmospheric, grain and inter-granular air temperatures are considered to be crucial variables for safe and prolong storage of grains. Grains stored at 25°C have been found to deteriorate twice as fast as those stored at 20°C which is lower than optimum growth temperature range for micro organisms (8). Moisture content is strongly associated with sprouting, mould growth, black spot growth and rot growth (9, 10).

The amount of physically "bound free water" contained by a cereal at harvest time and during storage in most cases determines the keeping quality of the grain. Moisture content of grains below 13% arrests the growth of most micro organism (11). High moisture content increases respiration rate and hasten internal breakdown of stored grains. Heat released within a mass of grain doubles for each additional 1.5% increase in moisture content, while a relative humidity of 25% to 60% considerably slows down breakdown processes (8). Water activity has been generally accepted to be more closely related to the physio-chemical and biological properties of grain than its total moisture content. The affinity for water molecules from the storage environment by dried grains influences the inherent shelf life and qualities of stored grains (10, 13). The water sorption characteristics has been used to study behaviors of agricultural products during storage or storage simulation (12, 13, 14, 15), while sorption isotherm has been used to predict least moisture content which reflects the monolayer moisture of crops and optimum storage stability zones (12, 13, 14, 16). These are necessary since ambient temperature and relative humidity fluctuations greatly influence the moisture content of stored grains.

Physical properties like conduction, convection, radiation, moisture evaporation, condensation and absorption are responsible for transfer of heat and moisture through grain bulk. Large grain bulk tends to maintain greater temperature stability than small size grain bulk, once low temperature is achieved by use of mechanical aeration.

3.3 Biological Variables

The biological variables can be classified as internal and external factors. The internal factors are due to respiration of the grains which results in weight loss of the dry matter, rise in moisture content and temperature as well as rise in carbon dioxide of the inter granular air. Intensity of respiration determines the rate and extent of deterioration of the grain bulk. External biological factors include microorganisms, insects and rodents. They all affects stored products by destroying viability of grains, and high qualitative loses to the endosperm and contamination of stored grains (5, 11).

3.4 Chemical Variable

Oxygen supply is an important chemical variable affecting growth and development of all living organism in the grain bulk ecosystem. Grain can be stored with minimum quality loss if an oxygen deficiency is made in the storage environment (6).

3.4 Climate And Cropping Season In The Humid Tropics

The humid tropical region of Nigeria is a land mass very close to the equator that covers the coastal and rain forest areas in the Southern part of the country. The rainfall is high and ranges from 1200 to 2000 mm annually. The weather is generally humid with 70-90% relative humidity in most of the year (17). Bi-modal pattern of rainfall emerges. Peak months of relative humidity occur in August/September when the drying of early crops commences. Diurnal and yearly variations in temperature affect the deeper regions of large grain bulk slowly. Changes in barometric pressure also affects the volume of inter-granular air, consequently with pressure changes, the grain bulk "breathes" by taking in fresh air and releasing inter-granular air (11). Monthly mean temperature of 20°C or higher in unheated bulks were considered minimum for developments of most stored grain insects (11).

4.0 METHODOLOGY

Visits were made to major silo and warehouse locations in the South Western parts of Nigeria. Places visited include research institutes, educational institutions, strategic grain reserve centres, breweries, flour mills and some agricultural farms. The states covered include Lagos, Oyo, Ogun, Ondo and Osun States. Fifty questionnaires were administered to identify the types, size, age, capacity utilization, present condition and peculiar problems in management of the structures. Investigation was done to access quality of stored grains where possible. Meteorological and grain storage conditions data were collected in some of the locations.

6.0 RESULT AND DISCUSSIONS

Some of the silos and accessories seen on sites visited are shown in Figs. 1 - 8. The silo types identified during the survey includes galvanized steel/aluminum alloy silo (Figs. 1 and 2), wooden silo (Figs. 3 and 4), composite (Fig. 5) and concrete silo (Figs. 6 and 7). Fig. 8 shows silo accessories for grain handling. The size ranges between 5 to 2,500 metric tones and ages between 10 to 46 years. The crops stored include maize, paddy rice, wheat, soybean, sorghum, millet and cowpea. Most research institutes and educational institutions have low capacity silo that ranges between 5 to 200 metric tones, while breweries use aluminum alloy/steel silo mainly for temporary storage of their raw materials. Flour mills and some integrated farms utilize aluminum alloy, galvanized steel and concrete silos up to 1000 metric tones for short duration of storage. The strategic grain reserve in Akure has silos with a storage capacity of up to 2,500 metric tones and ware house of up to 5,000 metric tones capacity. The major problems identified with warehouse during the study include leakages, inadequate ventilation and poor drainage as a result of the adaptation of existing structures, which were not originally designed as warehouse, but eventually converted to warehouses after some modifications were effected by artisans.

A precast concrete silo of 40 cubic metric with an encircling iron strap, as a tensioning device to secure each section layer was found at the National Stored Products Research Institute (NSPRI). It is a low cost silo suitable for the tropics. The general problem of concrete silo is the thermal expansion and contraction, which often leads to crack formation on the walls, that allows moisture entrance, insect infestation and grain deterioration.

Metal silos, steel and aluminum silos are very expensive to acquire and difficult to maintain because of scarcity of spare parts. Metals being good conductors of heats are subject to cycles of low and high temperatures (diurnal) thereby resulting in moisture condensation, heat generation and mould development on the inner walls. Heavy rains in the humid south and morning condensation creates too much dampness that penetrates into the grains through joints of the metal wall. Caking and germination may result due to the above problem causing much grain loss (18). The use or inert atmosphere and control atmosphere in metal silos however seemed to effectively control insect infestations in metal silo; this was noticed in the NSPRI hermetic silo.

The composite silo made of wood frame overlaid with metal sheet, seen during the survey, seemed to exhibit improved performance over the metal silos. It was observed that the wooden silos seen during the survey were affected by the weather conditions and termite infestation and is not suitable for use in the humid tropics. Interactions also occurred between the stored grains and the wood leading to discolorations of grains and increased moisture as observed by Adewumi et al (19).

Generally, crop products stored in silos and warehouses for long period must be subjected to periodic inspection in order to assess the precise condition of the stored products, regions of hot spots, mould development and pest infestation. Appropriate management practices are usually taken to fumigate, ventilate, recondition infested grains, dry, relocate grains into auxiliary silo or immediately dispose of heavily infested grains in the strategic grain complexes, NSPRI, and some private establishments utilizing.

5.0 CONCLUSION AND RECOMMENDATIONS

The inert atmosphere storage system has proved to be a suitable option for insect pest and quality control when storing grains in metal silos. The use of controlled atmosphere silos for storage eliminates the use of toxic pesticides in grain storage with their attendant side effect to the environment, users and consumers of the pesticide treated grains. Therefore, it is strongly recommended that the commonly available metal and aluminum silos used for large scale storage of grain in Nigeria should be modified to incorporate controlled atmosphere for excellent retention of grain qualities during storage. The use of composite silos is also recommended for humid tropical regions.

The Nigerian Agricultural Engineers are especially challenged to develop suitable silos and warehouses for large scale storage of grains to ensure food sufficiency and security and prevent mass wastage of grains at harvest periods.

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Fig. 1: Hermetic silo (Aluminum type)

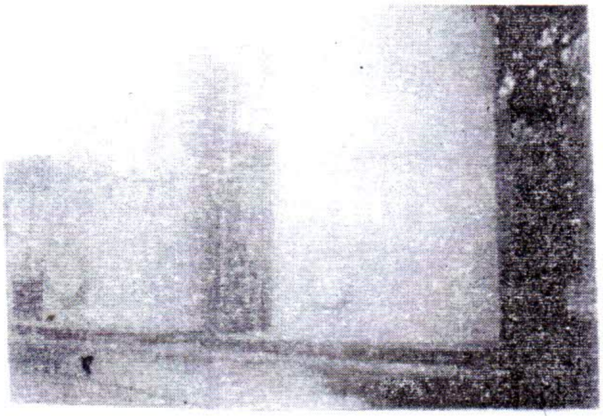

Fig. 2: Hermetic silo (Cast iron type)
(Source: NSPRI, Ibadan)

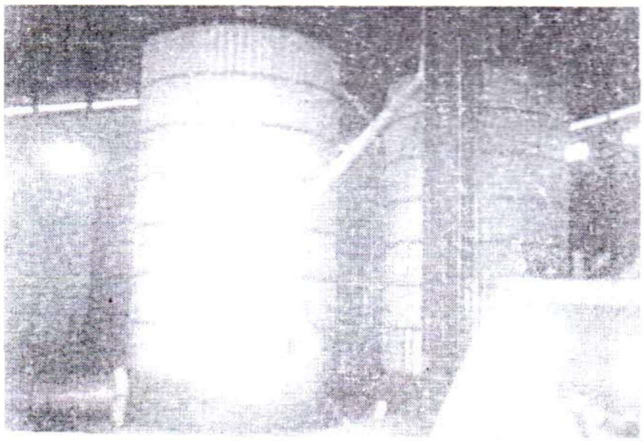

Fig. 3: Ventilated wooden silo
(Source: Old ODSADEP, Ado Ekiti)

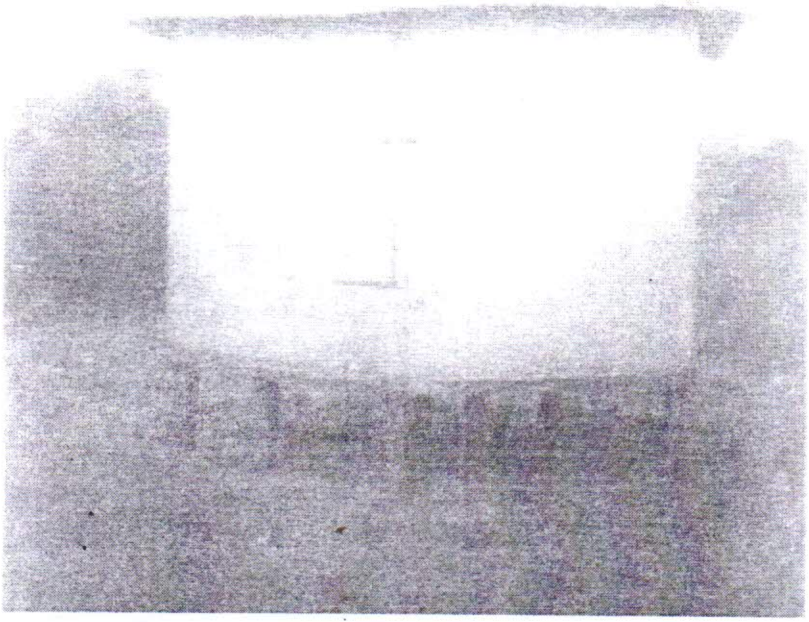

Fig. 4: Wooden silo
(Source: Department of Agricultural Engineering, University of Ibadan, Ibadan)

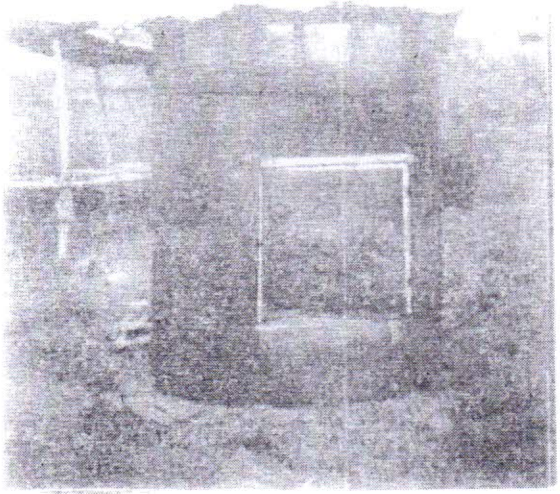

Fig. 5: Small scale composite silo
(Source: Department of Agricultural Engineering, University of Ibadan,

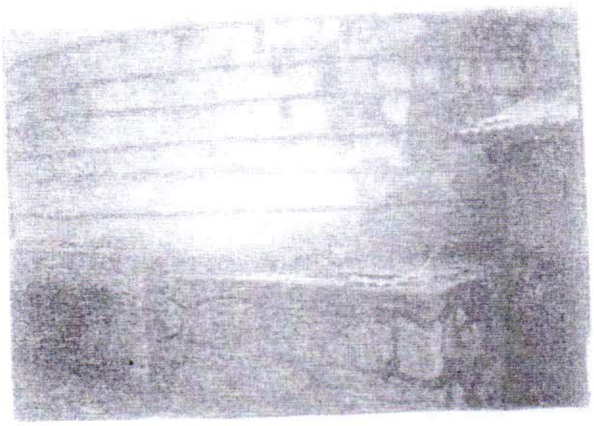

Fig. 6: Concrete silo with wooden floor and metal roof
(Source: Department of Agricultural Engineering, Federal College of Agriculture, Moore Plantation, Ibadan)

Fig. 7: Concrete silo (Small scale)
(Source: Department of Agricultural Engineering, Federal College of Agriculture, Moore Plantation, Ibadan)

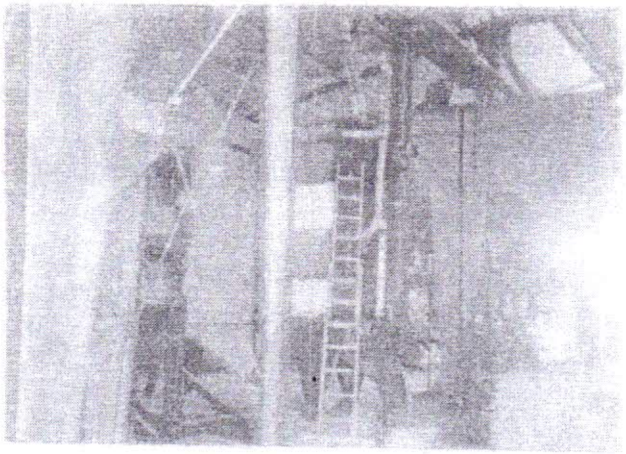

Fig. 8: Material handling accessories for silo (Silo unloaders)
(Source: Old ODSADEP, Ado Ekiti)