## Global Academic Journal of Economics and Business

Available online at https://www.gajrc.com
**DOI:** https://doi.org/10.36348/gajeb.2025.v07i05.001

OPEN ACCESS




ISSN: 2706-9001 (P)
ISSN: 2707-2584 (O)

**Original Research Article**


# Emergence of Bone Waste Recycling Business in Aba Urban, Abia State, South-Eastern Nigeria


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**Article History**
Received: 27.08.2025
Accepted: 17.10.2025
Published: 22.10.2025



**Abstract:** This paper aims to transform animal bone waste into products of economic value that can contribute positively to the growth and development of the Aba urban economy while also restoring environmental orderliness. The study employed an experimental research design in which bone samples were identified, collected, observed, and analyzed using suitable tools and processes. The study revealed that animal bone wastes could be converted into valuable materials, such as hydroxyl apatite (HA), B-charcoal (B-CHAR), and bone meal (BM), which can be used as soil additives e.g., fertilizer, as horn/hoof meal serves as provender for birds, pigs, goats, and sheep. Bones from goats, sheep, and dogs were found to be used in grafting or tissue engineering scaffolds, while bones from pigs, cows, and cattle are suitable for jewelry, hand globules, artworks, and other craftwork productions. Bone-derived materials such as B-char can help produce natural dyes for textile mills, garment manufacturing industries, and pharmaceutical companies. There is, therefore, the need to monitor the performance of animal bone waste processing and recycling to ensure continuous improvements on a sustainable basis and to ensure existing bone waste handling meets global best practices.



**Keywords**: Animal Bone Wastes, Bone Char, Hydroxyapatite, Bone Meal, Bone Processing.




## INTRODUCTION

Domestic solid waste, among other environmental problems, has been an outcome of man's activities in his settlement (James, 2012). This becomes palpable until man begins to seek ways of managing it. However, domestic solid waste management in the early prehistoric, historic, and post-historic eras was not a problem because of the relative dispersal of population and the nomadic nature of primitive man, who migrated from place to place in search of food and protection from the natural environment.

Solid waste management, however, did not attract attention in early human settlements because of the low population density and monotonous consumption patterns existing at that time; the waste materials generated then were putrescible and were not in large quantity (Richard and Rodney, 2013), thereby not requiring elaborate storage and disposal methods. Solid waste accumulates with an increase in population. The immigrants came from different rural areas to seek jobs in the available factories, therefore increasing the demand for shelter and its related facilities. This increase is associated with a corresponding rise in the volume of solid waste being generated. This directs attention to the need to have a mechanism for effective management and reduction of solid waste, with particular reference to bone waste in Aba Urban.

Bone waste is a type of food waste that comes from animal bones that are no longer useful in production, transformation, or consumption. They are considered as non-putrescible wastes, as they are non-decomposable wastes and may last up to 100s of years without losing their physical form. It's a significant environmental challenge due to the large amounts produced in slaughterhouses, markets, and beef processing plants, with little or no recycling value from the public perspective.

A closer look at the experience in Abia State reveals that solid wastes - particularly in the Aba Urban area continue to be generated faster than is currently being disposed of. The reason is not about managerial laxity and weakness but rather an index of professional incompetence and haphazard institutional arrangement for solid waste disposal a factor that could be used to generalize solid-waste management posture throughout the state and beyond.

Therefore, in the framework of sustainable development, two key policy issues require urgent attention. The first is the institutional framework or arrangement for solid waste disposal, while the second concerns the reclamation, recycling, and reuse of solid waste materials (Umunakwe, 2003). This study aims to develop effective methods for bone waste recycling and reuse in Aba Urban. The specific objectives, advanced to realize the stated aim of the study include: ascertaining animal bone waste generation; determining types and costs of animal bone waste collection; identifying the sources of bone wastes; stating the processes of recycling bone-wastes; and examining strategies for a sustainable bone-waste recycling business.

Bone wastes include waste bones from animals (Cow and Goat), birds (Chicken and Turkey), reptiles (Snake and Lizard), and amphibians (Fish and Crab). However, bones used in this study are strictly limited to Animal Bone Wastes (ABW), especially cow, cattle, pig, goat, sheep, and dog bones, often generated from slaughterhouses, households, markets, and restaurants in Aba Urban. The study was constrained to urban areas - Aba North and Aba South (Figure 1) to narrow the research down to more realistic coverage areas that are manageable. Besides, the paucity of funds as the available funds could not cover quite a large and massive area as initially planned.


**Figure 1: Map of Aba Urban, Abia State, Nigeria**
**Source**: Google Map, 2025.

## 2. LITERATURE REVIEW

Adversity is not restricted to the failure to obtain key requirements in life but also the inability to select or manage the immediate environment. Many people who are unable to make a choice or determine their future find themselves living in an environment that they do not like and that does not meet their needs (Agbakabo, 2011; Ademorati, 2015). This loss of the right to choose is the depressing and disgusting aspect that surrounds low-income earners (Ademorati, 2010; Zajic, 2013). What is observed consequently is that low-income earners get used to meager conditions of living: unclean environments, unhealthy habits, and unhygienic lifestyles. The immediate surroundings of the urban low-income earners in Aba Urban are often dirty.

There is a haphazard disposal of bone waste. Heaps of bone waste are left scattered in heaps in front of shambles, markets, and abattoirs, along roadsides, and in drainage channels, which irritate the eyes and inflict pain on the public. They are unsightly, swarming with flies that emit an unpleasant odour, and are sight-seen. To this extent, the dilemma of effective bone waste management continues to pose a nightmare for the state government and the entire people of Aba, the commercial and industrial nerve center of Abia State. The solution to the bone waste generation problem is feasible as everyone craves it. The Federal Government of Nigeria also seems disturbed about solid waste generation and management issues in the country, so it fixed it in the Fourth National Development Plan (Kayode, 2012; Haggard, 2014).

## 3. MATERIAL AND METHODS

The nature of this research suggests the use of experimental and descriptive research methods. This entails field investigation, which involves direct appraisal of bone waste handling and the subjecting of bone samples to real-time experiments, where actions, reactions, and observations should be recorded till the experimental process is concluded. Furthermore, tables and diagrams were used to explain relevant bone waste processes. Consequently, technical assistants were trained in the assessment of bone waste items. Thus, solid waste items available in the study area were succinctly identified, with bone waste generation sources identified. Bone waste items identified were grouped by types, before being exposed to experimental processes. The outcomes from the experiments were presented in the form of tables, figures, percentages, and proportions.

A quantitative approach to data analysis was applied to determine existing bone waste handling over 1 year, although this was corroborated and blended with findings from extant literature. The following equipment was used: an iron pan of 2,000kg capacity, gas burners, molding press, wire cutter, hand tools for carving, and carving and grinding machines. Other methods engaged in the course of the analysis were presented, explained, and applied. Besides, the boiler, digester, crusher, grinder, vibrator, and auxiliary equipment like centrifugal pumps and crane were also, used appropriately.

Data were elicited via direct observation via laboratory experiments following scientific principles and processes to elicit first-hand information to facilitate an informed decision and conclusion. This entails field investigation, which involves direct involvement in bone waste handling from start to finish. Furthermore, tables and figures were used to illustrate the bone-handling process. Therefore, technical assistants were trained to assess solid bone waste items. Thus, sources of bone waste generation were identified. Bone waste items available in the study area were sorted; sorted bone waste items were classified and presented in percentages and proportions to aid data analysis.

## 4. RESULTS AND DISCUSSION

### Bone Waste Generation

Bone waste generation refers to the production of waste bones from various sources. In Aba, bone wastes are generated daily. Table 2 indicates bone waste generation, expressed in tons.

**Table 2: Bone Wastes Generation by Tonnage**

| S/No | Sources | Tons/month | Observation |
|---|---|---|---|
| 1 | Abattoir | 150-450 | High |
| 2 | Beef Processing Factories | 100-150 | Moderate |
| 3 | Restaurants, Hotels and Eatery Centres | 50-150 | Moderate |
| 4 | Animal rendering service places (bone conversion) | 10-30 | Low |
| 5 | Households | 50-150 | Moderate |
| 6 | Markets | 120-350 | High |
| Total Mean | | 77-188 (80-200) | Moderately High |

Table 2 indicates the quantity of bone waste generated in Aba. Around 150-450 tons of bone waste were generated per month from the Abattoir, which is quite significant. Similarly, about 100-150 tons of bone waste were generated from beef processing factories monthly. Furthermore, 50-150 tons of bone waste were generated monthly in restaurants, hotels, and eatery centers, including households. Markets generate between 120 and 350 tons monthly, which was also considered high. However, only 10-20 tons of bone waste were generated by animal rendering service places, which is low, especially when compared with bone waste generation from other sources. This implies that monthly bone waste generation, over the year, generates adequate raw material for bone waste recycling businesses and industries in Aba.

**Table 3: Seasonal Variation in Bone Waste Generation**

| S/No | Season | Monthly Duration | Tons/ Month | Cost/ton/kg ₦(0.00) | Rating | Observation (Activities) |
|---|---|---|---|---|---|---|
| 1 | Peak | December -February | 620-1,420 | 10,000-20,000 | Very High | Festive Periods |
| 2 | Off-Peak | March-April | 280-500 | 2,500-5,000 | Moderate | Non-Festive Period |
| 3 | Normal | May-November | 480-1,280 | 5,000-10,000 | High | Normal Periods (Non-Seasonal) |

**Note**: Table 3 depicts the price of acquiring bone wastes, in Aba Urban, between 2024/2025. Note also that these costs are not constant, but may vary over years, times, and seasons.

The seasonal variation in bone waste generation was examined in Table 3; it indicates peak seasons in Aba urban from December to February. Within this period, 620-1,420 tons of bone waste are generated monthly, especially during festive periods like Christmas, New Year, Easter, and Chieftaincy coronation ceremonies. Non-festive periods occur from March to April; regarded as a moderate off-peak bone waste generation period, as bone wastes range from 280-500 tons/month in the study area. May to November (7 months) is considered a high. However, during the bone waste generation season, as high as 480-1,280 tons of bone waste were generated monthly. This implies that industries and small-scale bone waste recyclers have adequate raw materials and even pay more to secure waste materials for their respective businesses (Tables 3 and 5).

**Table 4: Factors Influencing Bone Waste Generation**

| S/No | Factors | Rating Weight [x(100) %] | Scale (Impact) |
|---|---|---|---|
| 1. | ***Demographic*** | | |
| | Population growth | 0.10 | High |
| | b) Urbanization trends | 0.07 | Moderate |
| | c) Age structure | 0.03 | Low |
| 2. | ***Economic*** | | |
| | Income level | 0.09 | High |
| | Prevalent economic situation | 0.06 | Moderate |
| | Food consumption patterns | 0.05 | Moderate |
| 3. | ***Socio-Cultural*** | | |
| | Cultural and traditional practices | 0.02 | Low |
| | Food preference | 0.10 | High |
| | Lifestyle | 0.08 | High |
| 4. | ***Environmental*** | | |
| | a) Climate and weather conditions | 0.06 | Moderate |
| | b) Waste management infrastructure | 0.05 | Moderate |
| | c) Regulations and policies | 0.09 | High |
| 5. | ***Infrastructure and Technology*** | | |
| | a) Waste collection and transportation | 0.07 | Moderate |
| | b) Waste treatment and disposal | 0.07 | Moderate |
| | c) Agricultural and industrial practices | 0.06 | Moderate |

**Scale**: 0.0-0.04 = Low. 0.05-0.07 = Moderate. 0.08-0.10 = High.

Assessing the factors influencing bone waste generation in Aba urban (Table 4), it was deduced that food preference, population growth, income level, policy regulations, and lifestyle strongly impact bone waste generation. It was also observed that urbanization trends, prevalent economic situations, food consumption patterns, climate and weather conditions, waste management infrastructure, waste collection and transportation, waste treatment and disposal, and agricultural and industrial practices had a moderate impact on bone waste generation in Aba. The other factors assessed, age structure and cultural and traditional practices, had a mild effect on bone waste generation in the study area.

**Bone Waste Classification and Costs**

Bone wastes in Aba urban emanates from different sources. However, the ABW classification (Table 5) considered cattle bones, goat bones, cow bones, sheep bones, and dog bones (Appendix A, B, and C).

**Table 5: Classification and Costs of Animal Bone Wastes**

| Category (Type) | Sources | Observation | Cost of Collection ₦(0.00)/Kilogram as at 2025 |
|---|---|---|---|
| Cattle bones | Slaughterhouses, markets, meat processing factories. | Always available | 5,000.00 |
| Goat bones | Slaughterhouses, markets, households, restaurants, hotels, and eatery centres. | Always available | 3,000.00 |
| Pig bones | Slaughterhouses, markets, restaurants, and hotels. | Available | 2,500.00 |
| Cow bones (Local specie) | Slaughterhouses, markets, meat processing factories, restaurants, and hotels. | Available | 6,000.00 |
| Sheep bones | Slaughterhouses, markets, households, restaurants, hotels, and eatery centres. | Available | 3,000.00 |
| Dog bones | Slaughterhouses, markets, households, hotels and eatery centres. | Scarce, only found in some quarters | 1,500.00 |

**Note:** These prices per kilo per bone are not static but vary over time and seasons (see Table 3).

Animal bone wastes are categorized as follows: cattle bones, goat bones, pig bones, cow bones, sheep bones, and dog bones (Table 5). Horses, donkeys, and other animal species were not seen in the surveyed area. These categories or types of bone waste were gathered from various sources: slaughterhouses, markets, households, restaurants, hotels, meat processing factories, and eatingplaces. It is pertinent to note that, while bones from cattle and goats are always available, pig, cow, and sheep bones, although available, were not as readily available as those of cattle and goat bones. Dog bones were found to be relatively scarce in the area. One reason for this is that dog meat was seen as a pet, quite close and friendly man. Furthermore, some people don'teat dog meat because of its close relation to canines, while some see it as a religious taboo.

Assessing the costs of acquiring animal bone wastes (ABW) in the area, it was discovered that cow and cattle bones are highly priced due to their size, quantity, and quality. For instance, cow bone is slightly higher thancattle bone at₦6,000.00 per kilogram and₦5,000.00 per kilogram (kg). Closely trailed by goat bones (₦3,000.00) per kilogram and sheep bones (₦3,000.00) per kilogram. Pig bones and Dog bones cost₦2,500.00 and ₦1,500.00 per kilogram each to obtain.

**Sources of Bone Waste Collection**

There are six key sources of bone waste in Aba Urban (Table 6), which are:

(a) Abattoir: bones from animals butchered in slaughterhouses, especially lamas, Cows, Goat, and Pigs.
(b) Meat/beef processing centers: Bones were also secured through meat processing, packaging, and sales centers: Crunches, Happy Bites, Food centers, other food service centers, and several other eatery centers. Such meats include Goats, Turkey, and Sheep.
(c) Restaurants and other full-scale food service establishments, particularly bones from food preparation and consumption outfits in Aba. Mostly bone from Sheep, Turkeys, Pigs, and Goats.
(d) Animal rendering plants: waste bones from various animal canning and rendering plants, E.g., Goats, Sheep, and Cows, mainly used for beef (Table 6).
(e) Households: Waste bones from residential areas and houses, majorly comprising bones from goats, cows, cattle, dogs, pigs, sheep, and turkeys.
(f) Markets: includes wastes from various commercial outlets and markets, including shopping malls and shopping centers. Market bone wastes include goat, cattle, cow, pig, sheep, turkey, and dog.

**Table 6: Sources and Percentages of Animal Bone Wastes Collection in Aba Urban**

| S/N | Sources | Cattle Bone Wastes (%) | Goat Bone Wastes (%) | Pig Bone Wastes (%) | Cow Bone Wastes (%) | Sheep Bone Wastes (%) | Dog Bone Wastes (%) |
|---|---|---|---|---|---|---|---|
| 1 | Abattoir (Slaughterhouse) | 50 | 21 | 15 | 10 | 3 | 1 |
| 2 | Meat Processing Factories (Meat Canning) | 44 | 25 | 14 | 11 | 4 | 2 |
| 3 | Restaurants, Hotels, and Eatery Centres (Relaxation and caring service centres) | 27 | 39 | 22 | 9 | 2 | 1 |
| 4 | Animal rendering (bone conversion and sharing centres) | 28 | 30 | 18 | 17 | 7 | N/A |
| 5 | Households (Family Subsistence) | 43 | 28 | 17 | 8 | 1 | 3 |
| 6 | Markets (Trade centres) | 56 | 24 | 13 | 4 | 2 | 1 |
| Total Mean | | 41.33 | 27.83 | 16.50 | 9.83 | 3.17 | 1.33 |

**N/A**: Not Available

Table 6 indicates that 41% of bone waste is sourced from slaughtering cattle for meat. Approximately 28% of bone waste is sourced from Goat killing to meet the proteinoid demand of households. About 16% of bone wastes were pig bones. Cow bone wastes form about 10% of the bone waste stream. Sheep bone wastes and dog bone wastes contributed only 3.17% and 1.33%, respectively.

In a similar trend, it was discovered that the majority of cattle bone wastes collected (50%) emanated from slaughter-house (abattoirs), 44% is from meat processing industries, 27% from restaurants, hotels, and eatery centers, 43% from the household, and 56% of bone wastes generated from markets or trade centers.

Goat bone waste is collected from restaurants, hotels, and eatery centers (39%), households (28%), and markets (24%). Pig bone waste is collected chiefly from restaurants, hotels, and eatery centers (22%), rendering centers (18%), and households (17%). Cow bone waste is mainly collected from rendering centers (17%), meat processing factories (11%), and abattoirs (10%). Meanwhile, sheep bone waste and dog bone waste are obtained mainly from meat processing factories (4%), and households (3%). This implies that bone waste of assorted kinds was readily available for various bone waste appraisals in the area. For the costs of securing bone waste/ton/kg in the study area, see Table 3 and Table 5.

**Bone Waste Processing**

Waste bones are processed at three stages: Bone steaming and digestion, chemical treatment of bones, and processing of waste fat from bones.

**(A-1) Bone Steaming and Digestion**

Bones are steamed and digested to produce the base materials for glue production, fertilizers, poultry feeds, gelatine, and firefighting. Depending on the moisture content, bones are left to decompose naturally in open heaps for three to four weeks, or they are tentatively steam-digested under pressure for about four hours.

After the bones have been digested, they are sun-dried and crushed. The dried material is sieved through sieving screens to produce different gradings of crushed bones (Figure 2 and Figure 3). Therefore, the following equipment or tools were engaged:

a) Boiler (100psi pressure);
b) Digester (0.5-1 tonnage capacity), stationary cylinder or vertical tunnel;
c) Crusher, both manual and electrically operated, with a 3-hp motor;
d) Rotary sieves, of various sizes like 3/32". 1/8", and 3/16";
e) Grinder, with a capacity of grinding 5-10 tin/day;
f) Vibrator screen and Grist Blower (See appendix C);
g) Cranes and centrifugal pumps are used as auxiliary equipment.

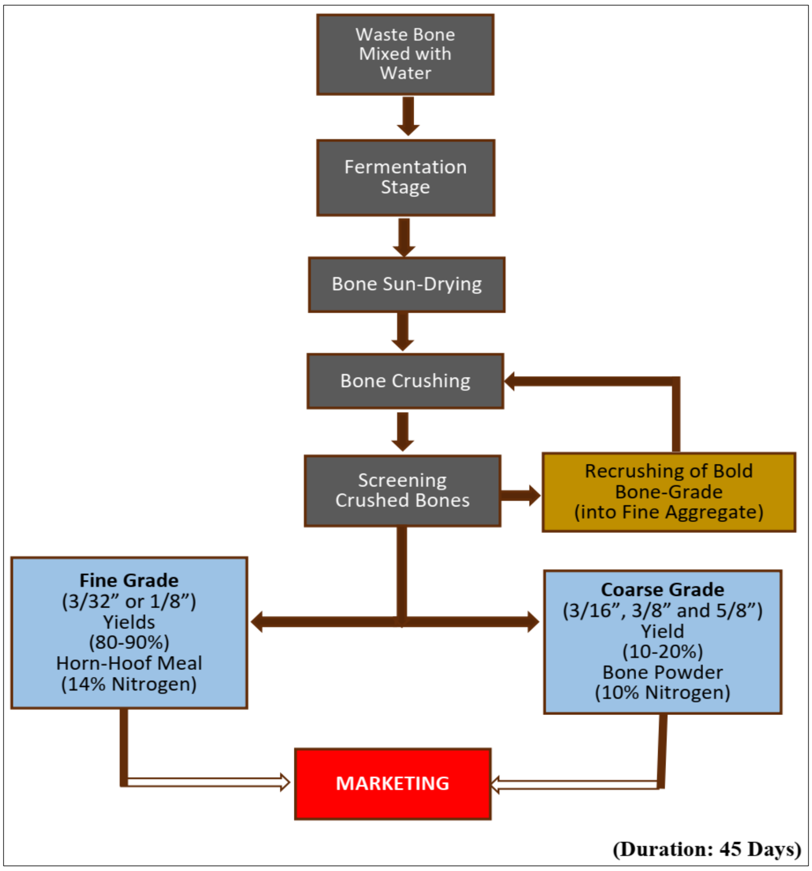



**Figure 2: Bone Processing Flowchart – Alternative (A)**

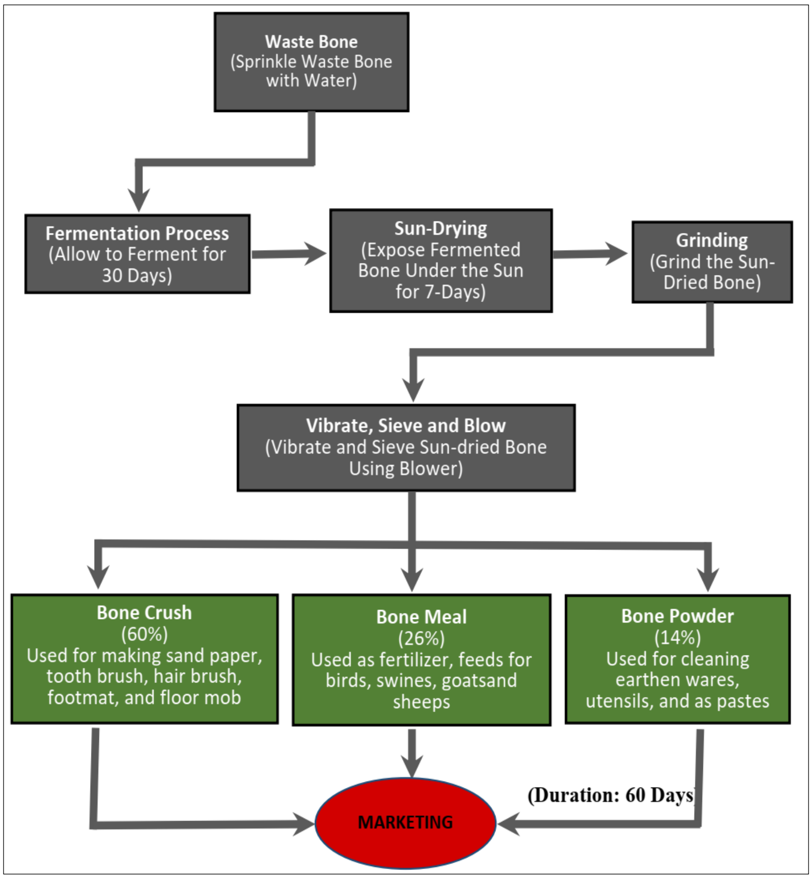



**Figure 3: Bone Processing and Outcomes – Alternative (B)**

As shown in Figures 2 and 3, the inorganic elements in bone powder include P, Ca, Mg, B, Fe, Mn, K, Cu, and Zn, which are associated with catalytic components, the material's surface, and its physicochemical properties. In addition to $Ca_5(PO_4)_3OH$, the bone-derived material for the catalyst also contains metal oxides such as CaO, MgO, $SiO_2$, $Na_2O$, $K_2O$, and MnO. Hence, bone-derived hydroxyapatite material has recently gained attention due to its versatility, low water solubility, high pore connectivity, controlled basicity/acidity, and excellent thermal stability at high temperatures. As an outcome, bone-derived catalysts have demonstrated effectiveness as green catalysts for several reactions such as organic synthesis, oxidation of volatile organic compounds, transesterification for biodiesel production and hydrogen production, organic reduction reaction (ORR), synthesis of bioactive compounds, and degradation of pollutants (Nadrollahzadah *et al*., (2020; Bennett *et al*., 2016).

Bone waste could be recycled and reused in many ways, including bone meal, bone powder, and bone crush (Appendix B).

***Bone Meal:***

A bone meal, in this regard, refers to a material made by dissolving animal bones in Tetra-Oxo Sulphate VI acid – $H_2SO_4$ (sulfuric acid). It can be described as a dried and powder-like substance made from animal bones, especially cows and goats. Bone meal can be used as fertilizer or animal feed. Bone meal is a good source of protein, minerals, energy, and vitamins (Figure 2). It is found to be highly significant in fertilizing soil that has been impoverished by continuous agricultural activities in rural areas and the urban hinterland.

***Bone Powder:***

A loosed and finest grade from bone wastes, often called bone ash. It can be used in many ways. For instance, bone powder can be used as a Brasso for cleaning earthenware, kitchen walls and floor areas, and other domestic equipment (Figure 2). It can also be used as a whitening agent, particularly for cleaning and teeth whitening in mammals, e.g., man. Bone powder has medicinal value, as it has been considered helpful in treating open wounds and helps in blood clothing.

***Bone Crush:***

Also called bone fragments, although seldomly used as bone meal, which is commonly used to mean bone fragments or debris, which is a little bit coarser than the aggregate required in a bone meal. Bone crush can be used as a protein supplement in animal feed. It can also be used in agriculture as a natural fertilizer to boost crop yields. It is a suitable source of calcium and other minerals needed by pharmaceutical companies for drug production. Bone crush is used in paper mills for paper production. It also assists in water treatment.

Bone crush is a valuable source of nutrients, such as calcium and phosphorous. Bone Crush is a sustainable and environmentally friendly alternative to synthetic fertilizers and animal feed supplements. Bone Crush has a high and sustainable economic value as it can generate revenue through its sales and uses in paper-producing industries.

Bone crush varies from fine aggregate to coarse fragments of bones (Appendix B). It is mainly composed of calcium, phosphate, calcium carbonate, and other minerals. Its moisture content is typically low, ranging from 5-10%. The pH level of bone ash is neutral to slightly alkaline, ranging from 7-9.

## CONCLUSION

Having identified, processed, and analyzed animal bone wastes, it is imperative to conclude that animal bone wastes can have significant environmental impacts if not adequately controlled. Impacts such as greenhouse gas emissions, water pollution, land degradation, and soil contamination are likely to occur. There is a need for sustainable animal bone waste practices, such as bone waste management to reduce adverse environmental impacts and stimulate resource recovery.

Animal bone waste can be a valuable resource if properly managed and processed. Moreover, it can revamp the economy through revenue generation, employment creation, and entrepreneurship. Similarly, implementing a sustainable animal bone waste business can lead to cost savings for individuals, companies, and communities.

Community participation and awareness creation are needed to encourage real-time animal bone waste management practices and educate the public on the relevance of sustainable bone handling in the overall management of solid waste. Improper bone waste handling can be disturbing as it poses health challenges to both man and animal. Therefore, there is a need for appropriate bone waste handling and disposal practices in urban areas.

There is a need for a clear code of practice and course of action for animal bone waste handling to ensure regularity and conformity across the board, mostly in communities, commerce, and industries. Besides, effective implementation and monitoring of animal bone waste handling practices in Aba are necessary to making public health and environmental impacts.

**List of Acronyms**

1. HA – Hydroxyapatite
2. B-CHAR - Bone Charcoal
3. BM - Bone Meal
4. ABW - Animal Bone Wastes
5. TETFUND - Tertiary Education Trust Fund
6. $Ca_5(PO_4)_3OH$ – Hydroxyapatite
7. CaO - Calcium Oxide
8. MgO - Magnesium Oxide
9. $SiO_2$ - Silicon Dioxide
10. $Na_2O$ - Sodium Oxide
11. $K_2O$ - Potassium Oxide
12. MnO - Manganese Oxide
13. $H_2SO_4$ - Tetra-Oxo Sulphate VI Acid (Sulfuric Acid)
14. P – Phosphorus
15. Ca – Calcium
16. Mg – Magnesium
17. B – Boron
18. Fe – Iron
19. Mn – Manganese
20. K – Potassium
21. Cu – Copper
22. Zn – Zinc

**APPENDIX (A)**

**Animal Bone Samples Classification**


Cattle Bone


Goat Bone


Pig Bone


Sheep Bone


Dog Bone


Cow Bone

**APPENDIX (B)**
**Crushed Animal Bone Samples**
**Key: (A) Granular aggregate (B) Fine aggregate(C) Powder aggregate**

**1. Cattle Bone**

(A) (B) (C)

**2. Goat Bone**

(A) (B) (C)

**3. Pig Bone**

(A) (B) (C)

**4. Sheep Bone**

(A) (B) (C)

### 5. Dog Bone

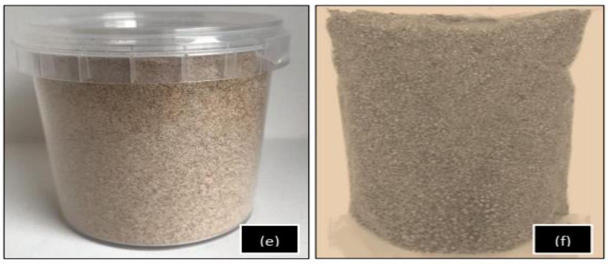
(A) (B) (C)

### 6. Cow Bone

(A) (B) (C)

## APPENDIX (C)
## Packaged End-Products from Animal Bone Waste Recycling


(A) Goat Bone Meal
(B) Sheep Bone Meal
(C) Cow Bone Meal
(D) Cattle Bone Meal




(E) Pig Bone Meal
(F) Dog Bone Meal

**Declarations**

**Ethics Approval and Consent to Participate**: Not applicable.

**Consent for Publication**: Yes.

**Funding**: Yes, we got funding to carry out the project from TETFUND.

**Clinical Trial Number**: Not applicable.

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