Nondegradable Waste Discharges from Soda Lime Silica Glass Manufacturing Process

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Abstract

The components of the solid wastes generated from various units of the soda lime silica glass manufacturing process were investigated. Samples were taken from the wastes generated from cullet and sediments of waste pond of sand treatment plant, also packaging material waste from the cold end (packaging section) classified as domestics. Yield test were carried out on these samples grouped as treatment plants and domestics according to the source to know the amount of both individual and collective components of the sample. The samples contain heterogeneous, materials of different substances. Sand constituents in the domestics sample was 30% and 34% in the sample from cullet treatment. While. Cullet particles was 19% in the domestics and 45% in the sample from its treatment plant. Other materials of dissimilar constituents such as corrugated trays, crown corks, Polythene sheets broke off planks from wooden pallets constitute which are further sorted and discharged as scraps. The solid wastes generated from soda lime silica glass manufacturing process are non-degradable. The sand and cullet particle wastes are used for making concretes for lintels and deckings. Also for earth fill ups in civil construction industries. Other materials that formed past pf the waste of dissimilar constituents to recyclable raw materials were separated and grouped for either recycle or discharge into government-approved dumped site.

Keywords: *Sand, Glass particles, Cullet, Solid waste, non-degradable, Forming, Cold end, Batch*

1.0 Introduction

Wastes in the forms of solids, liquids, and gases are contributing to environmental pollution globally (Lu and Poon, 2017). The effects of non-degradable solid substances contained in the wastes are noticeable in the immediate environment but gases in form of gaseous emission goes into the upper layers of the atmosphere and thus collectively obstruct these layers from their natural structures and existence (Patel *et al.,* 2018). Glass is a product of inorganic substance fused and cooled to rigidity without crystallization (Ismail and AL-Hashmi, 2008; Lu and Poon, 2019; Babajide and and Mosaberpanah. 2023). Each type of glass production generates wastes

peculiar to its manufacturing process. Among various types of glasses such as Borosilicate, Quartz, Crystal, and Soda lime, it is only Soda lime Silica glass that is currently being produced in Nigeria, moulded as bottle containers for now by West Africa Glass Industries in Port-Harcourt, Sun Glass in Kaduna, Glass Force in Aba, and Beta Glass Plc Agbara and Ughelli plants, only the defunct Oluwa glass produced sheet sheets glass. (Olofinnade *et al.,* 2016). Other glass associated Industries imports sheets glass from either China or Brazil for reconditioning or reshaping. They are shaped by molds (moulds) into hollow wares (containers) as produced. Hollow glasses either in bottle or jar forms are used in food, beverages, beer, wine, spirit, pharmaceuticals and soft drinks packaging, which are integral part of the national economy. The type of glass been produced determines the mode of support services required and the raw materials needed for the production process which are functions of the types of bye products and wastes to be generated .(Babajide and Mosaberpanah, 2023).

Wastes that are environmental pollutants from glass factories are from (a) plant treatment of raw materials and water maintained at specified physical conditions for various operational requirements (b) Discharging of raw materials into the Silo and decomposition of the batch in the furnace. (c) Cooling water and Oil from production lines and Power (Electricity and Compressed air) Services sections. (d) Non-conformed products and packaging materials at Cold (sorting and packaging) end (Soliman and Tagnit-Hamou, 2017).

Solid wastes generated from Soda-lime silica glass plants arises from cullet and sand treatment plants as well as production line apart from housekeeping (Topçu and Canbaz, 2004; Olofinnade *et al.,* 2016). The constituent of these waste include bottle cork, straw, paper, wood, nylon or leather and sometimes pieces of metals. These constituent are mainly generated at the cullet washing plant which are parts of impurities from the foreign cullet (broken glass) supplied by the contractors (Byars *et al.,* 2004; Andreola *et al.,* 2008). Packaging end waste was characterized by polyester straps, polyethylene (nylon) cut off, corrugated trays and wooden pallet studs. (Chen *et al.,* 2006). These solid wastes are disposed from the factory by either Federal or State Government Environmental Protection Agency (SGEPA) to an approved dump site.

Solid wastes especially dried ones mostly support combustion, therefore if not checked appropriately or evacuated as generated; it will pose challenges to control in the in the event of a fire outbreak.

The environmental impact of waste glass is one of the major challenges crippling sustainable waste management and mitigation in Nigeria. Reclamation of recycled materials from waste glass remains a tedious task amidst complex technological approaches. The challenge as seen in the global containment measures increase the proportion of waste glass and minimize the existing capacity of landfill space.

Solid wastes are generated from sand treatment plant (Chen *et al.*, 2006), (Byars *et al.,* 2004). There are two types generated from that unit.

Coarse grains with plant roots/other debris are screened out of sieve mesh incorporated into the plant and fine grains with loose irons that move with recycled water into the pond. The sharp grains of over 0.6 or 1.0mm from Sand Treatment plant can be used in civil or text coat paints recipe. The fine sand of less 0.1mm can be used to improve the durability of architectural mortar prepared with glass aggregate matters (Corinaldesi *et al.*, 2005; Lu *et al.,* 2017). The coarse grains of 3mm to 1mm could be retrieved or sorted out for other useful purposes such as

i. Mixing component with soft sand to mould concrete blocks

ii. Mixing component to construct lintel, decking and germane/tile flooring in building industry.

The fine grains below 0.125mm (125micron) could also be used

i. Mixing component in plastering

ii. Paint component in house decoration.

Sand sediments are generated from sand and wastewater treatment operations that settles in their respective ponds as sludge. These and coarse grains with plant roots are deposited in the upland wastes depot (dump). They are evacuated by SGEPA approved contractor to a designated dump site for this purpose.

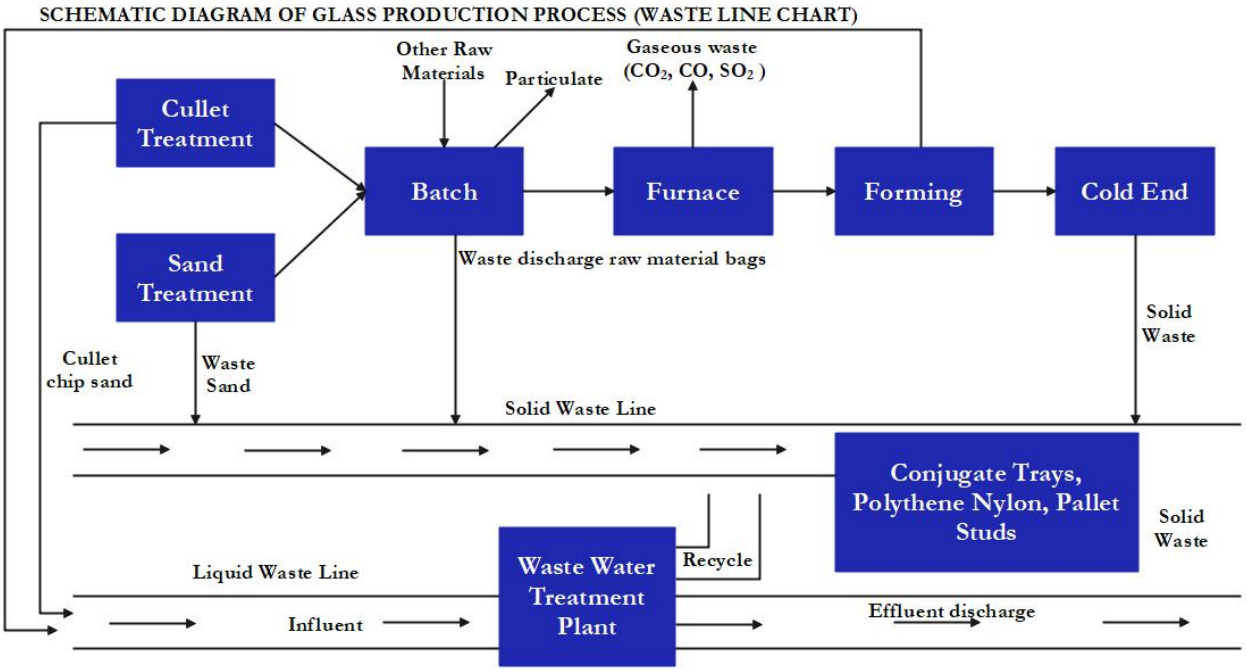

Figure 1: Schematics diagram of Glass production process Waste Line Chart

There is an ideology that glass is infinitely recyclable and can be made into new glass repeatedly without degrading its quality. Even though this may be possible in an ideal world, the realities are far more challenging than this message suggests in Nigeria (Asokan *et al.,* 2009) The public, industry, and even the Government have consistently been misinformed and ill-advised on reality that are practically achievable.

Unlike plastic and other polymeric materials, glass is 100% recyclable. Glass products can be broken down, melted, and mixed with other raw materials to form new glass products. This process is cost-effective as it saves on the energy and material used to make glass from scratch. As a result, less glass waste is deposited in the environment and the process of sourcing for new raw materials becomes unnecessary, hence minimizing carbon emissions but the main challenge facing glass recycling lies in the sorting stage. The single-stream recycling process practice in Nigeria mixes up all forms of waste products such as contaminated glass and broken pieces mixed up with other waste become difficult to sort out, and recyclers end up emptying them in landfills. This is one of the greatest challenges for all glass recycling businesses in Nigeria,

balancing out the environmental issues with the normalization of a profitable waste and recycling strategy. (Corinaldesi *et al.,* 2005)

The method of source-segregated glass collections are the best way of maintaining glass quality, but the costs are often too high to be economically viable, while all the time glass has a low or negative value. It is this vicious cycle that is a factor in holding back the development of glass recycling in Nigeria which has resulted in environmental challenges because of the low rate of recycling of the glass waste generated and the unbiodegradable nature of the waste thereby polluting the environment (Lu *et al*., 2017).

Another factor that makes glass waste a problem in Nigeria is that the high cost of transportation and maintenance which could not be matched to be with cost-effective of the recycling process discourages many industries from taking the initiates to set up many collection point for easy collection of the glass which increase the volume of glass waste in the environment. The price per tonne paid by the Remelt industry is proportionally low compared to say plastic, but the processing costs may often be higher. In most cases, any glass recycler is operating on very slim margins which limits investment in new technologies which could reach new, non-Remelt markets. Landfill of swampy areas and other construction sites from daily waste evacuation being the lowest cost route of disposal, but in most cases it is being sold to communities within for filling swampy areas.

This research is to investigate analytically the nature and size of the waste components and the modalities of categorical collection from the generation point and effective sorting of waste dumped. By this study the major percentage of the waste will be isolated for recycle at they are sold back at scrap to their various sources for recycle. While the minute part if any shall eventually be evacuated to be dumped at government approved site.

2.0 Materials and Methods

2.1 Sampling

Samples were taken from the Central Process waste dump yards. The wastes were heterogeneous in nature containing materials of different substances, where packing end wastes and coarse

grains and organic debris from sand treatment plant were dumped and discharges from cullet treatment plants. Sieve test was carried out on both to determine the content and various sizes of the components of the sample.

2.2 Cullet Yield Test

A sample of 20kg and bag was weighed (cullet + sack (bag) = 20kg using Avery Scale. With the aid of a wheelbarrow, the weighed sample is taken to the cullet washing bay. The sample was then spread on a 2.00mm wire mesh of 65cm x 48cm. The wire mesh with the sample wass placed on the testing stand (Shi. and Zheng 2007), Water was then poured evenly on the sample to wash off impurities. Retained impurities such as crown corks, sticks, straws, and others were picked out. Colour (cullet) contaminants are separated from the non-glass contaminants. The actual cullets and others are packed into separate bags. They were taken to the Auxiliary treatment bay for weighing. The weights were taken and computed thus:

Weight of sample + Bag = Wkg

" of Bag only = X kg

" of Actual Cullet (washed) = Y kg

" of Other Cullets (washed) = Z kg

$$\%\,Cullet\ Yield = \frac{Y}{W - X} \times \frac{100}{1}$$

$$\%\,Glass\ Colour\ Contaminants = \frac{Z}{W - X} \times \frac{100}{1}$$

$$\%\,Impurity\ (non - glass) = \frac{(W - X) - (Y + Z)}{W - X} \times \frac{100}{1}$$

3.0 Results and Discussion

The Physical analysis test was carried out on the sample obtained from the Central Process dump bay are presented below. The wastes were mainly from the Cullet treatment plant of which 6mm sieving screen were installed in the plant to recover cullet particles bigger than size of mesh. And also from the Cold end unit the product sorting and packaging unit housekeeping. Below is the results of test carried out on waste the randomly sampled from the central process dump site.

Table 1.0 Solid Waste Yield Test Results

Waste contents	%Composition
Polythene sheets	3.0
Metal cork	4.0
Plastic corks	7.0
Papers	1.0
Corrugated trays	8.0
Wooden Pallets /Studs	2
Plastics trays	1.0
Plant roots	7.5
Cullet particles	35.0
Leaves	0.5
Sand and Stones	30.0
Straws	1.0

There are three major sources of the wastes deposited on the central process dump point: The Cold end, the Cullet wash plant and the Sand wash plant wastes. Cold end which is the section of quality control process are carried out on finished product (bottles) and the finally accepted

products are finally packaged. The waste generated from this end amounted to 14% comprised of Polythene sheets, papers, corrugated trays and broke off planks and studs from wooden pallets. These wastes ought to have been collected separately at cold end in separate bins. The paper and the corrugated trays could have been disposed for paper recycle. Polythene sheets for nylon producers to serve as recycle material for the regeneration of another polythene sheets through the extruder. Unfortunately this dissimilar constituents such as corrugated trays, corks, polythene sheets, are further junked together before been dumped into central process dump point.

From the cullet wash plant came the plastic trays, straws, metal and plastic corks and cullet particles which amount to 48% of the wastes. The bulk of the wastes came from this end.The wastes from Sand wash plant screen mesh comprised of leaves, and plant roots which amounted to 8%. The sand waste from Sand wash plant contains grains that are bigger than 0.850 mm which are not required in the batch of soda lime silica glass. This grade of sand will cause stones in the final glass product because it will not melt along with the required batch grains of lower of than 0.850mm but greater than 0.212 mm. The sand wash plant contains an outlet through which fine sand particles that houses Fe_2O_3 an impurities are washed out with water and deposited in a pond. This grade of sand below 0.10mm are not suitable for glass batch and thus courses scum in the glass tank. The pond are evacuated when filled up.

Sand and stones of 30% came both from cullet wash and sand wash plants. The sand contains sand and cullet grains contains up to 35% of glass batch grains that are lower than > 0.6mm but greater than < 0.10mm. The cullet grains are further re-sieved and recycled. The sand grains are also further treated to exclude stones greater than 0.850mm as grains of sand greater than this value courses stones in glass tank of an average melting temperature of 1,500 ^oC

Cullet particles and fine sand were more pronounced in the wastes. Reductions in the volume of sand and cullet grains generated as waste at first instance and thereby rework for recycle can be by reduced by replacement of 6mm sieve mesh with 2mm in the cullet treatment plant to retain recyclable grains within acceptable range (Cook, 1978). Acceptance of Raw and packing materials that met up according to plant specified standards and optimum utilization of the materials will reduce the magnitude of the waste generated from each of the units operations.

The domestic wastes mainly generated from raw material processing units and packaging end of the process can be sorted into glass, plastics and metals through which individual materials can be recovered for recycle and other useful process. The sand and cullet particle wastes are in most cases purchased for civil construction site fill ups purposes and the remains ended up on government approved dumped site. The sorted solid wastes are either recovered, recycled, or re-used (3Rs). It is atimes sold or evacuated when found unsuitable to be recycled into the production process (Cook, 1978). The cullet grains can still be further sorted using sensory equipment on the cullet processing lines. It can alternatively be incorporated to reinforce concrete works in the civil industry which has been in practice in some advance countries (Soliman and Tagnit-Hamou, 2017; Patel *et al.,* 2018; Babajide and Mosaberpanah, 2023). Cullet particles are in use as substitute to gravels and the combination of it with sand /stone are been used in sand filling at civil construction site.

4.0 Conclusion

The solid wastes generated from soda lime silica glass manufacturing process are non-degradable. The papers, corrugated trays are sold as scraps to purchased point to make pulp from its cellulose for paper reproduction. Polythene sheets to nylon producers to serve as recycle material for the regeneration of another polythene sheets through the extruder. Sand and cullet particle mixtures wastes are sorted. Cullet particles that are greater than 6mm in size are recycled. The particles are in use as substitute to gravels used for making concretes for lintels and deckings. The combination of it with sand /stone are being used in sand filling at civil construction site. Also in some cases used at sites for fill up of building foundation purposes in civil construction industries. Apart from the cullets and sand sorted out at treatment bays.. The fine sand particles discharged into a pond contains Fe_2O_3 an impurities. Because of their unsuitability for glass batch. The pond are evacuated when filled up and discharged into the government approved dump site. The left over which is insignificant after the sorted and regrouped wastes for recycle, are evacuated and discharged into government-approved dumped site

References

Adekomaya O, Jamiru T, Sadiku R, Huan Z (2017) Negative impact from the application of natural fibers. *J Clean Prod* 143:843–846.

Andreola F., Barbieri L., Karamanova E. , Lancellotti I., and Pelino M. , (2008) "Recycling of CRT panel glass as fluxing agent in the porcelain stoneware tile production," *Ceramics International*, vol. 34, no. 5, pp. 1289–1295, 2008.

Asokan P, Osmani M, Price A.D.F. (2009) Assessing the recycling potential of glass fibre reinforced plastic waste in concrete and cement composites. *J Clean Prod* 17:821–829

Babajide O. S. and Mosaberpanah, M.A. (2023). The Implementation of a Binary Blend of Waste Glass Powder and Coal Bottom Ash as a Partial Cement Replacement toward More Sustainable Mortar Production. *Sustainability* 2023, *15*, 8776.

Blengini G. A., Busto M., Fantoni M. and Fino D (2012) Eco-efficient waste glass recycling: integrated waste management and green product development through LCA. *Waste Manag* 32:1000–1008

Byars E. A., Morales-Hernandez B., and HuiYing, (2004). "Waste glass as concrete aggregate and pozzolan Laboratory and industrial projects," *Concrete*, vol. 38, no. 1, pp. 41–44,

Chen C. H., Huang R., Wu J. K., and Yang C. C., (2006) "Waste E-glass particles used in cementitious mixtures," *Cement and Concrete Research*, vol. 36, No. 3, pp. 449–456, 2006.

Cook, R. F. (1978). The collection and recycling of waste glass (cullet) in glass container manufacture. *Conservation & Recycling,* 2(1), 59-69.

Corinaldesi, V., Gnappi, G., Moriconi, G. and Montenero A (2005), Reuse of ground waste glass as aggregate for mortars. *Waste Management* 25:197–201

Ismail, Z. Z. and Al-Hashmi, E. A. (2008). Recycling of waste glass as a partial replacement for fine aggregate in concrete. Waste management, 29(2), 655-659.

Lu, J. X., & Poon, C. S. (2019). Recycling of waste glass in construction materials. In New trends in eco-efficient and recycled concrete (pp. 153-167). Woodhead Publishing.

Lu, J. X., and Poon, C. S. (2017). Use of waste glass in alkali activated cement mortar. *Construction and Building Materials,* 160, 399-407.

Lu, J. X., Zhan, B. J., Duan, Z. H., and Poon, C. S. (2017). Using glass powder to improve the durability of architectural mortar prepared with glass aggregates. *Materials & design,* 135, 102-111.

Olofinnade, O.M.; Ndambuki, J.M.; Ede A.N., Olukanni, D.O. (2016). Effect of substitution of crushed waste glass as partial replacement for natural fine and coarse aggregate in concrete. *Mater. Sci. Forum* 2016, *866*, 58–62.

Patel, D., Tiwari, R. P., Shrivastava, R. and Yadav, R. K. (2018). Effective utilization of waste glass powder as the substitution of cement in making paste and mortar. *Construction and Building Materials,* 199, 406-415.

Shi, C. and Zheng, K. (2007). A review on the use of waste glasses in the production of cement and concrete. Resources, conservation and recycling, 52(2), 234-247.

Soliman, N. A. and Tagnit-Hamou, A. (2017). Using glass sand as an alternative for quartz sand in UHPC. *Construction and Building Materials*, 145, 243-252.

Topcu, I. B., & Canbaz, M. (2004). Properties of concrete containing waste glass. *Cement and concrete research*, 34(2), 267-274.