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Development of Low-Density Polyethylene-Sand Composite Bricks via Thermal Degradation of used Sachet Water Bags

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***Abstract**: Used water sachets (LDPE)) is the major solid wastes that are being experienced adversely within the environment where treatment and recycling methods are not available. This thereby translates into serious public and environmental concerns. The perceived valueless LDPE like used water sachet bags (UWSB) has been re-engineered by integrating some fine sand particles with the molten form of the waste sachet to achieve bricks of 1017.336m^3 dimension at three different ratios of LDPE: sand (A= 1:6, B=1:3 and C=1:2). The products were characterized by compressibility strength [Higher with sample C (1:2) at day 6 and lower with sample A at day 1; the degree of relationship with the aging (R^2) is 0.9872 for A, B, and C], density [Higher with sample C at day 6 and lower with sample A at day1; the degree of relationship with aging (R^2) is 0.9872, 0.9883 and 0.9872 for A, B, and C respectively], specific gravity[Higher with sample C at day 6 and lower with sample A at day 1; the degree of relationship with aging (R^2) is 0.7533,0.9882 and 0.9873 for A, B and C respectively.], porosity[Higher with sample C at day1 and lower with sample A after 6 days; the degree of relationship with aging (R^2) is 0.7850,0.7923 and 0.7976 for A, B and C respectively.] and water absorptivity [Higher with sample C at day 1 and lower with sample A at day 6; the degree of relationship with aging (R^2) is 0.7955,0.7971 and 0.7966 for A, B and C respectively]. This has proven to be a viable, cheaper and environmentally stabilized process in waste recycling.*

Keywords: Low-density polyethylene; solid wastes; sand particles; environment; pollution**.**

1.0 INTRODUCTION

The issue with ecological pollution and debasement by solid waste particularly with the category of low-density polyethylene (LDPE) has been a focal point both at local and international and assemblies [1]. The case is more awful in upcoming nations like Nigeria, where substantially made of a 69% non-biodegradable waste in solid-state around the environment since it has more combined impacts on the ecosystem than biodegradable natural matter [2]. Reprocessing of low-thickness (density) polyethylene materials and other sorts of solid-state wastes has been proposed and acknowledged in most nations of the world especially in the advanced nations with the economic advantage [3]. This is because reprocessing has a lot of interest over other traditional treatment innovations such as landfills, fertilizing the soil and incineration [4]. Recycling of solid wastes like used water sachets is the transformation into a valuable, cheap and environmentally friendly products. Commercial sachet water particularly which is used in the packaging of treated potable water involves synthetic and biodegradable engineered polyethylene (polythene). Sachet water, commonly called pure water in Nigeria has become an everyday intake for an average Nigerian. The proof is the quantity of discarded sachets littering the roads and the expanded level of outflows and drainages been obstructed.

Sachet water was accustomed to Nigerian markets around 1990 however its guideline by NAFDAC began in 2001[6]. Sachet water got a lot of prominence in Nigeria because it is valuable, moderate and economically practical. It brought 'drinkable' water to the doorsteps of numerous Nigerians. It has likewise empowered Nigerians financially and economically. Despite the advantages with sachet water, the unselective removal of solid wastes in different undesired destinations, like the avenues (streets), drains, engine parks, schools, markets, homes, and settings of social gatherings represents a lot of dangers within the environment. The sachets are made of non-biodegradable engineered polyethylene (polythene) which does not deteriorate after numerous years [7]. As well, exposure to burning results into the generation of destructive greenhouse gases (GHGs) like nitrous oxide, carbon dioxide and carbon monoxide [7]. Sachet water waste removal is a challenge that should be controlled as a result of the suggestions it has on the biophysical conditions like soil, vegetation air, and water.

Brick that is widely used as building material containing 50-60% by weight of silica (sand), 20-30% by weight of Alumina (earth), 2-5% by weight of Lime, 2 to 5% by weight of iron oxide and ≤ 7% by weight of Magnesia[8]. Three major strategies are applied for molding the crude materials into this product. Formulated bricks, which start with natural clay (mud), ideally in a blend in with 25–30% sand to prevent progressive shrinkage. The mud is first ground and blended with water to the ideal consistency, followed by pressing into steel or wooden molds with a pressure press. It is then terminated at 900–1000 °C to accomplish strength [9]. Dry-squeezed blocks which begin with a thicker blend, shaping an increasingly precise, more honed edged bricks [9]. Isolated bricks where the mud (clay) is blended in with 10–15% water or 20–25% water.

The blend is compressed through an opening to make a long link of the material of the ideal width and height. The product is then sized into blocks of the ideal length by a mass of wires [9].

Meanwhile, due to the demand of this construction resource with the advantage of environmental solid wastes, different types of waste have been investigated to be incorporated into the bricks with a considerable imbalance between the accessibility of conservative construction materials alongside their applications currently [10]. Conversely, low-density polyethylene and plastic wastes are abundantly available as their disposal is the biggest challenge while repeated recycling poses a potential danger of being transformed into a toxic material [11].

Only a small proportion of solid wastes are being recycled because of expensive conventional recycling techniques [12].

Hence an increased demand for more scientific and innovative technologies to effectively recycle these materials by exploring the potential and efficient techniques specifically as a binder for paving blocks production which directly minimizes and encourage the reuse of these wastes on the land and of course water bodies to manage and prevent consequent pollution hazards.

2.0 MATERIALS AND METHODS

Materials include gathered sand particles within the neighborhood of 3.35mm British standard test sieve, used sachet water bags, cement, distilled water, aluminum container, and heating mantle.

2.1 Smelting of the LDPE (sachet water bags)

The LDPE materials (wasted sachet water bags) were washed, dried and melted in an aluminum container set above a source of heat. At the point of complete melting of the LDPE which was ascertained at 110^oC [13]

2.2 Blending by the ratio of the LDPE with sand particles

The required quantities by the ratio of the sand-cement mixture were homogeneously blended with the molten LDPE.

The standard composition of cement to the sand ratio (1:6) [14] was modified by blending the molten LDPE as a co binder with cement and sand particles of 3.35mm British standard sieve. Three formulations (A, B and C) were made through the variations of the cement-sand mixture and molten LDPE.

2.3 Molding and curing

Wooden molds of measurement $(194 \times 92 \times 57)\ mm^3$ were utilized in forming out the blocks in the wake of being filled and deliberately secluded. The molds were gathered and covered with neem oil for simple separation a while later. The samples after compaction were permitted to dry over a time of 24 hours. They were kept in a standard restoring tank and permitted to stand for a time of 2, 4, and 6 days

2.4 Determination of the physical properties

Physical tests conducted on the LDPE/sand brick sample include compressive strength based on density [15], density, specific gravity, porosity and water absorption test [16].

3.0 RESULTS AND DISCUSSION

Figure 1. Sachet potable water bags

Figure 2.Used and littered water sachets

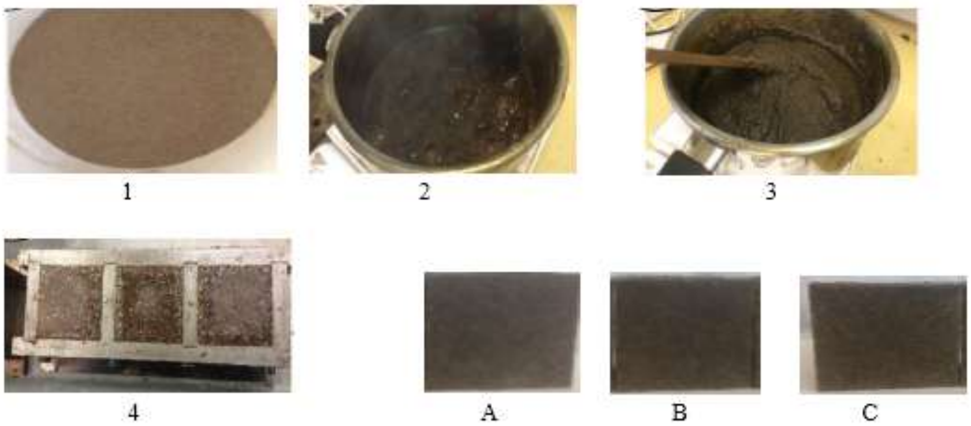


Figure 3. Stages for the preparation of LDPE-Sand composite bricks with A,B and C

Table 1. Selected properties of the varied LDPE-Sand composite bricks with formulations A, B and C

Formulation	Age (days)	Compressibility Strength (N/m^2)	Density (×10^{-3} kg/m^3)	Specific Gravity	Porosity (%)	Water Absorptivity (%)
Standard 1:6(C/S)	28	15-30	1600-1920	2.5-3.0	19.28-53.99	15-20
A 1:6 (LDPE/S)	1	2.25	3.95	0.84	0.35	0.34
	2	3.02	5.30	1.13	0.17	0.17
	4	5.35	9.39	1.10	0.09	0.09
	6	8.43	14.79	3.15	0.06	0.06
B 1:3 (LDPE/S)	1	4.50	7.74	1.68	0.70	0.69
	2	6.04	10.60	2.30	0.35	0.34
	4	10.70	18.77	4.07	0.17	0.17
	6	16.86	29.58	6.42	0.12	0.11
C 1:2 (LDPE/S)	1	6.74	11.82	2.52	1.05	1.03
	2	9.05	15.88	3.39	0.52	0.51
	4	16.03	28.12	6.00	0.26	0.26
	6	25.25	44.30	9.45	0.17	0.17

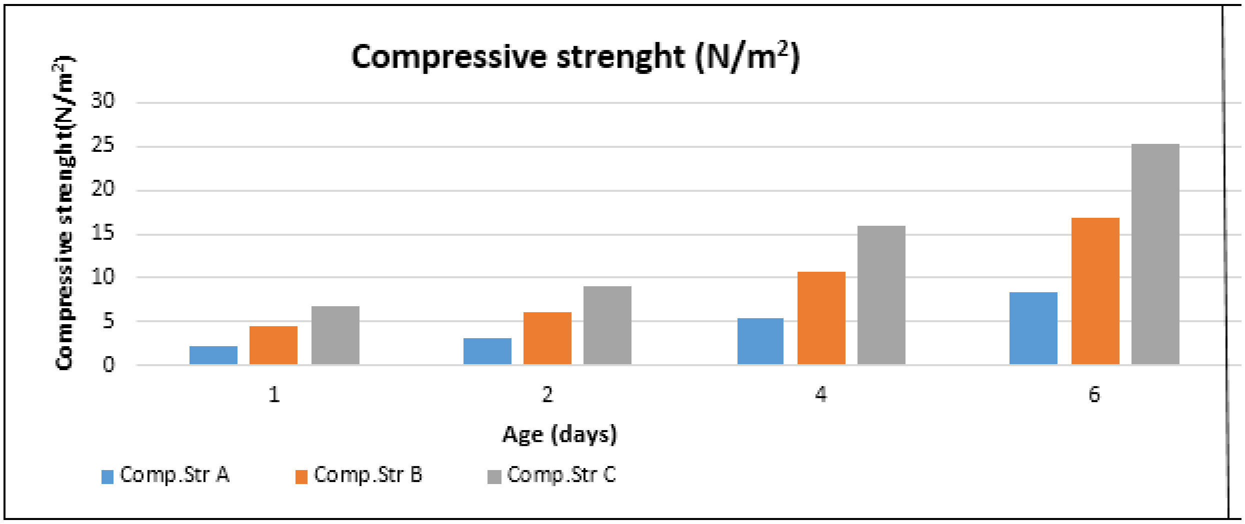
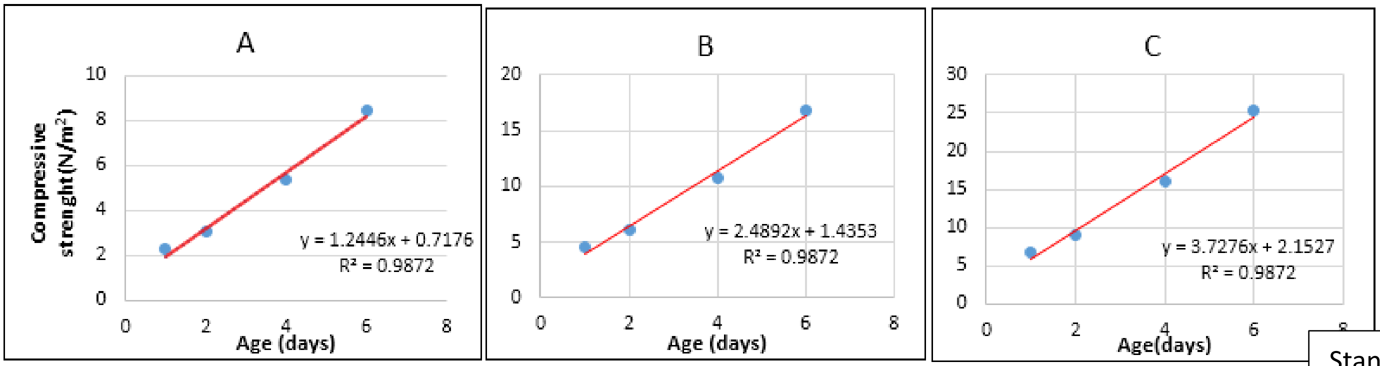


Figure 4. Compressive strengths of formulations A, B and C



Standard

Figure 5. The plots of the compressive strengths of A, B and C against the setting periods in days.

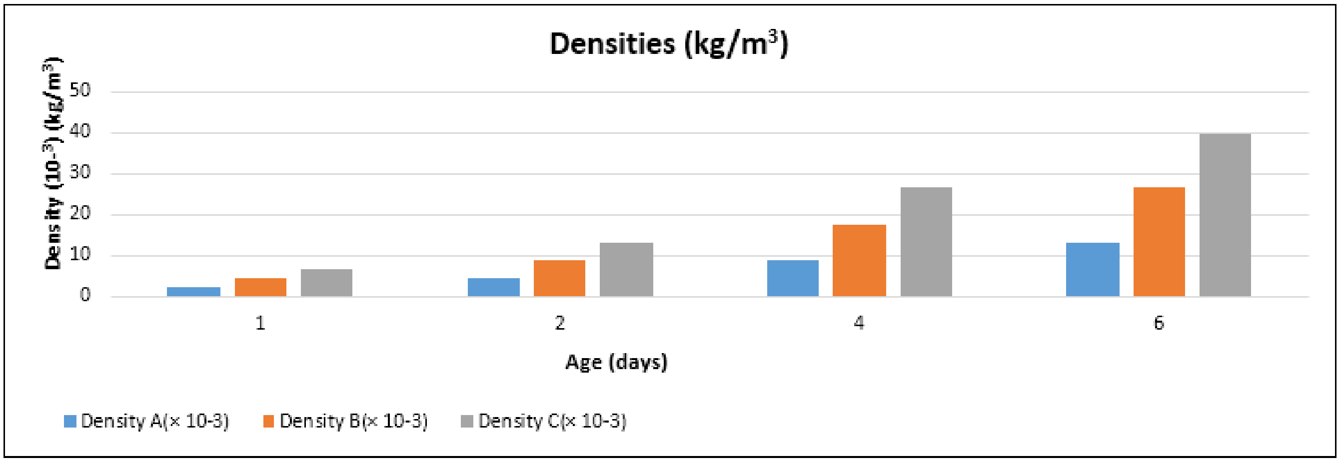


Figure 6. Densities of the formulations A, B and C

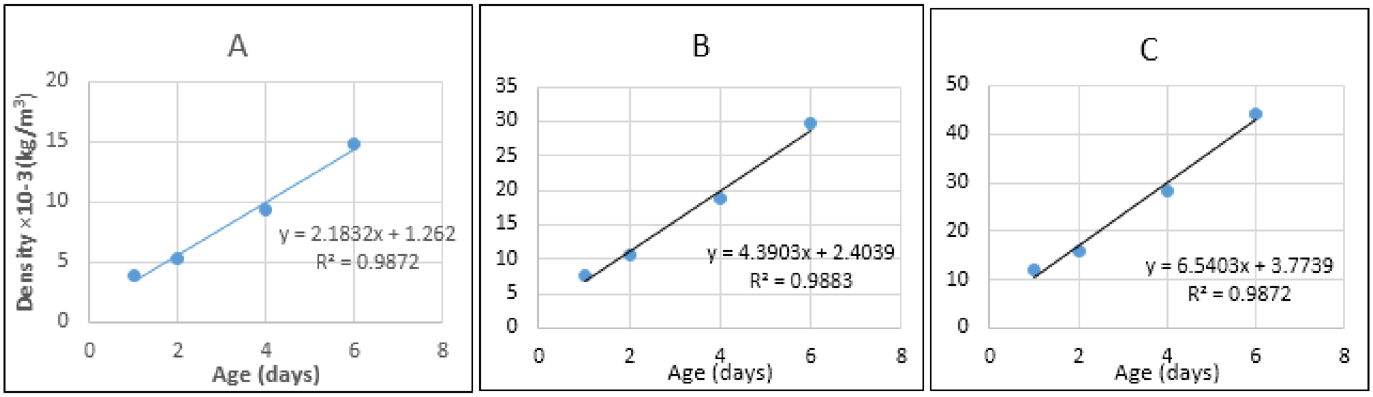


Figure 7. The plots of the densities of A, B and C against the setting periods in days

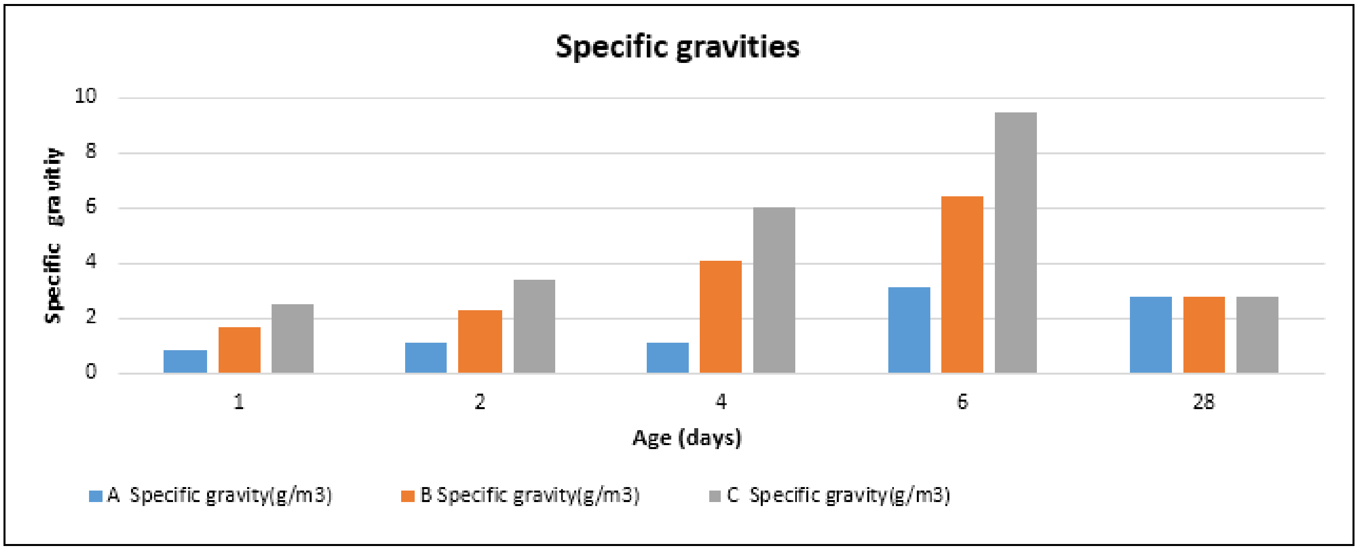


Figure 8. Specific gravities of the formulations A, B and C

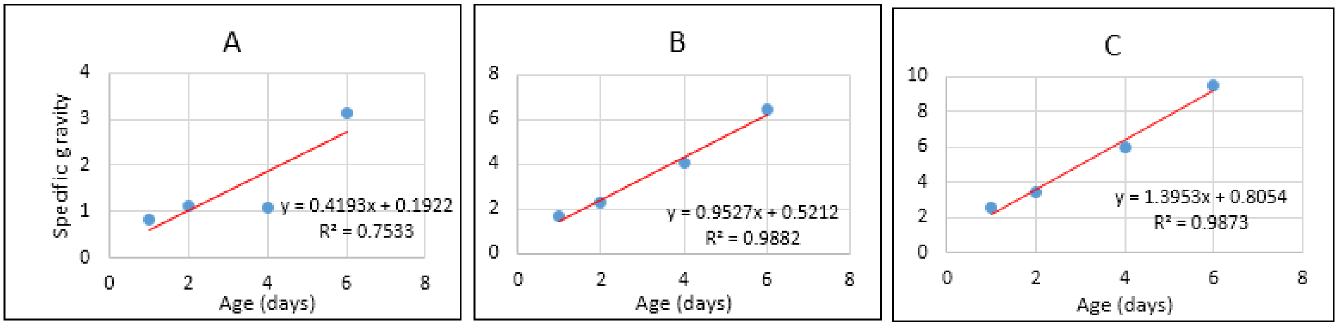


Figure 9.The plots of the specific gravities of A, B and C against the setting periods in days

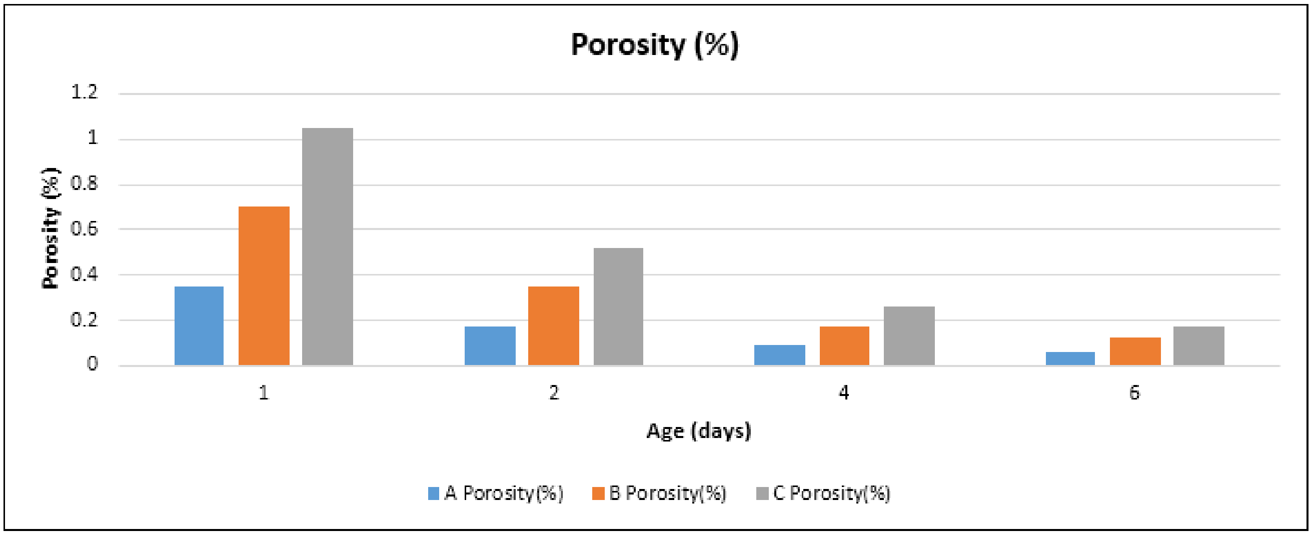


Figure 10. Porosities of the formulations A, B and C

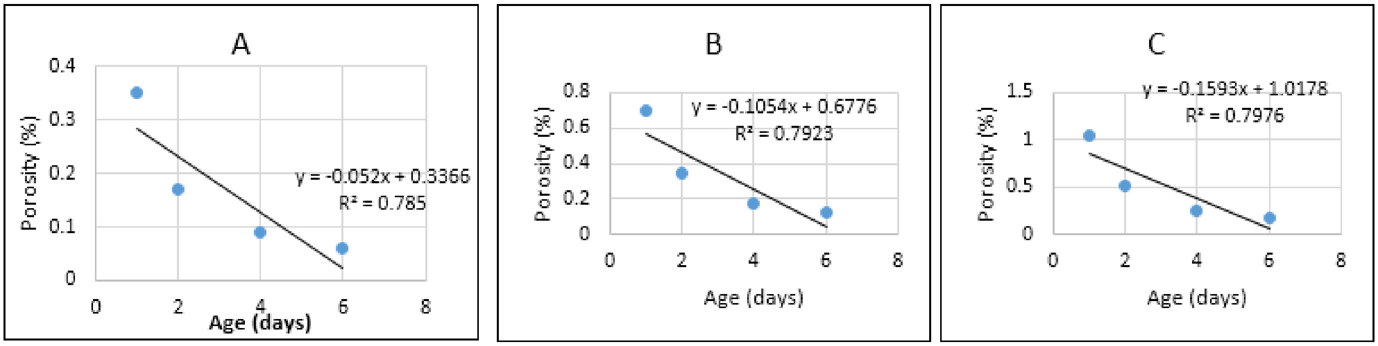


Figure 11.The plots of the porosities of A, B and C against the setting periods in days

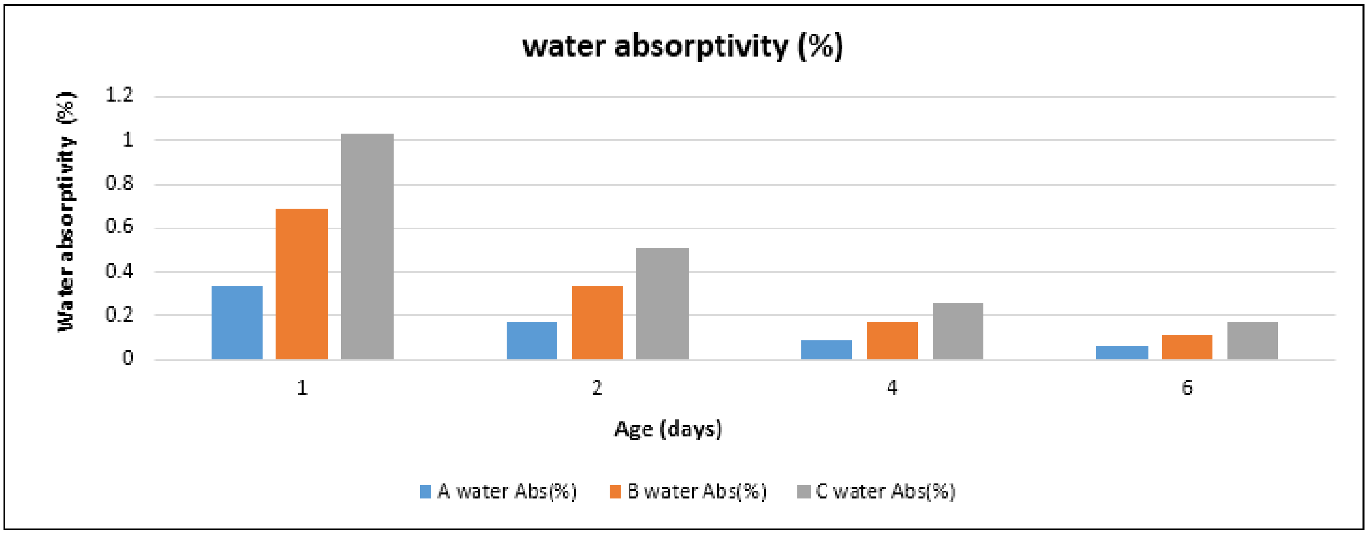


Figure 12. Water absorptivity of the formulations A, B and C

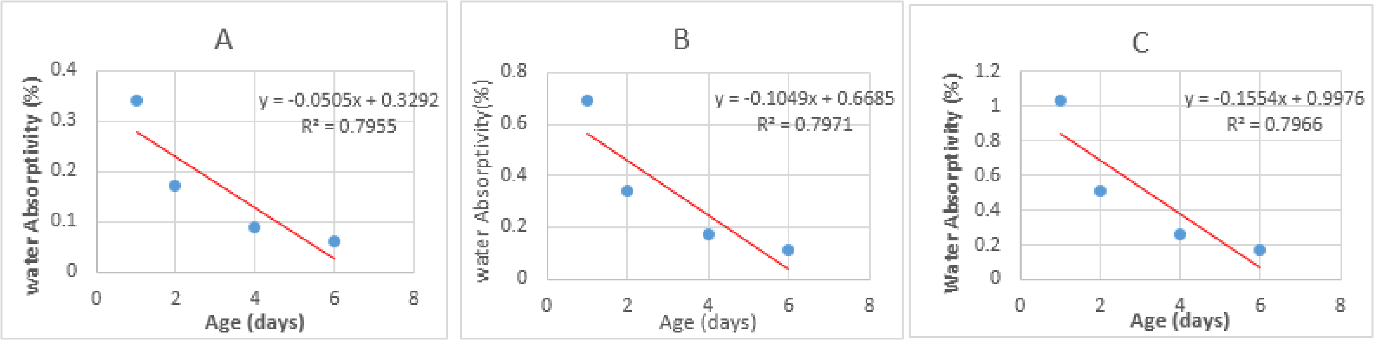


Figure 13. The plots of the water absorptivity of A, B and C against the setting periods in days

Generally, low-density polyethylene that is extensively used in the packaging of treated potable water (Figure 1) is as well a direct source of environmental non-biodegradable pollution which is experiences practically within our immediate environments

(Figure 2).

However, the technique of transforming these agents in the presence and reaction with fine sand particles as shown in figure 3. Picture 1 is the sieved sand particles of 3.35mm British standard sieve. 2 is the reacting mixture of the sand particles and used sachet water bags at 110°C with three different formulations (A= 1:6, B=1:3 and C=1:2).

3 shows the homogenized mixture of the two components under 110°C. 4 is the packed LDPE-sand composites (A, B, C) in a wooden mold.Meanwhile, the properties studied (Table 1) concerning the aging of the brick samples are compressive strength (Figure 4) which declares the force of compression that increases with the aging of the samples. The brick sample C at day 6 retained a value that is more than the standard value. Its relationship with aging was estimated by R^2=0.9872 for A, B, and C. Figure 6 is the densities where at day 6, the highest values were estimated progressively with each sample (Figure 7) and relationship at R^2=0.9872, 0.9883 and 0.9872 for A, B and C respectively (Figure 6).

The specific gravities (Figure 8) was above the standard at day 2

(C= 1:2), day 4(B=1:3 and C=1:2) and day 6(A=1:6, B=1:3 and C=1:2) (Figure 9) and relationship with ageing at R^2=0.7533, 0.9882 and 0.9873 for A, B and C respectively. Porosity with each sample declined from day 1 to day 6, justifying the removal of water molecules over time (Figure 10) and relationship with aging at R^2=0.7850, 0.7923 and 0.7976 for A, B and C respectively

(Figure 11).Water absorptivity also declines in the same pathway with porosity from day 1 to day 6 (Figure 12) and relationship with aging at R^2=0.7955, 0.7971 and 0.7966 for A, B, and C respectively.

4.0 CONCLUSION

Solid wastes such as used water sachets which fall under the category of low-density polyethylene (LDPE) has been applied in the production of sandy composite bricks. The optimum characteristics regarding LDPE- sand ratio were recorded.

Acceptable compressive strength was realized at the ratio blend of 1:2 after day 6, specific gravity at 1:2 after day 6, porosity at 1:2 after day1 and water absorptivity at 1:2 after day 1.

Therefore, LDPE-sand composite brick after six days of production tends to have high compressive strength, density and specific gravity with ratio 1:2 (LDPE to 3.35mm sand particles), while porosity and water absorptivity decline significantly after day 6 with 1:6 of the blend. It is the representation of high compressive strength, durability and good quality of bricks.

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