

A Study on the Effects of Cassava Effluent on Concrete Behavior

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Abstract

Concrete is made by combining cement, water, and aggregate (coarse and fine) materials such as gravel and sand. Water is required to react with the cement in order for the hydration process to commence. Water is thus one of the most significant ingredients in the manufacturing of concrete. The physicochemical properties of cassava effluent and water polluted with cassava effluent were taken to the KAPPA Biotechnology Laboratory in Ibadan, where various elements present in the samples such as cyanide, cadmium, magnesium, calcium, copper, iron, and lead, among others, were analysed and compared to WHO standards. Slump, compaction factor, compressive strength, and split tensile tests were performed on concrete mixed with potable water and cured in potable water (A); concrete mixed with potable and cured in cassava effluent (B); concrete mixed with cassava effluent and cured in cassava effluent (C); concrete mixed with cassava effluent and cured in potable water (D); concrete mixed with polluted water and The findings revealed that cassava effluent and water polluted with cassava effluent have no discernible effect on the workability of concrete made with them when compared to concrete made with potable water; however, concrete made/cured with cassava effluent and water polluted with cassava effluent had lower strength in mixing and curing when compared to those made with potable water. Based on the decrease in the values of the Slump, Compacting factor, Compressive strength, and Split tensile strength of concrete made with either cassava effluent or water polluted with cassava effluent in mixing or curing, it can be concluded that cassava effluent or water

polluted with cassava effluent should be discouraged for mixing or curing of concrete as these will have negative effects on such concrete.

Keywords: *Concrete, polluted water, Cassava effluent, heavy metals, WHO standards*

INTRODUCTION

Concrete is a construction substance made up of basic ingredients that, when combined with water, produce a rock-like solid. Concrete is made up of coarse aggregates, which are generally gravel, fine aggregates, which are usually sand, cement, water, and any other necessary additions. Water is a critical component in the manufacture of concrete. Water is required to start the hydration process of producing concrete by interacting with the cement. There must be enough water available for the reaction to complete, but adding too much water will reduce the strength of the concrete. The water-cement ratio is an essential subject because, in addition to the concrete mix formula, the amount of water used determines the ultimate strength of the concrete (Palmquist, 2003, Ajagbe et al., 2012). More specifically, if too little water is introduced, there will not be enough water available to complete the reaction, causing part of the cement to harden and join with other dry cement, hence shortening the hydration process. On the other hand,

when the cement is being hydrated, it is in a slurry solution, and the likelihood of cement bonding with aggregates decreases if too much water is introduced. As a result, when the hydration process is complete, the cement content will still be in a slurry solution with no strength.

The sort of water that can be used to mix concrete must be drinkable, with no discernible flavour or odour. Water with a total dissolved solids content of less than 2000 ppm can be utilised. Water mixing can cause issues by introducing pollutants that have a negative impact on concrete quality.

Although the major issue is appropriate strength growth, contaminants in the mix water may induce efflorescence. Water should be avoided if it includes a high concentration of dissolved solids or a high concentration of organic compounds (Kuhi, 2002, Adedokun and Oluremi, 2019). The cassava starch/garri processing plants generate massive amounts of wastewater, with an average value of

4,000 to 6,000 litres per tonne of starch/garri generated in the locations surveyed.

This wastewater includes a significant proportion of cyanide, which will have an impact on the quality of life in the areas where the processing plants are usually situated. Because the bulk of cassava-based starch/Garri processing centres are small-scale or in small clusters, a simple and cost-effective treatment method must be devised (Afuye and Mogaji, 2015). Because of its potassium and magnesium concentration, cassava effluent has the potential to be used as a bio-fertilizer.

Its usage as a bio-fertilizer will turn it from a waste product into an organic complement for crop production (Adejumo and Ola, 2016). The experimental investigations of Oluremi et al. (2012) and Adewuyi et al. (2015) show that exposing concrete buildings to assaults from cassava effluent-contaminated soil leads in considerable reconfiguration of the internal microstructure of concrete elements. However, it is strongly recommended that cassava waste-water be properly treated before being discharged into waterways (UNN, 2016). The goal of this research is to evaluate the impacts of cassava effluent on concrete manufacture.

MATERIAL AND METHODOLOGY

Materials

Various materials used in this research include cement (Dangote Ordinary Portland Cement), water (potable water and cassava effluent), cassava (cyanide), coarse aggregate and fine aggregate (river sand).

Cement

This is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. The cement used was Dangote Ordinary Portland Cement of grade 42.5, purchased from a cement depot located at Aroje area, Ogbomoso (Latitude 8.14, Longitude 4.25).

Cassava Effluent

This refers to the waste water generated from the processing of cassava. This wastewater from starch/garri contains very high concentration of cyanide which normally affects the life of people and Civil Engineering Structures in such area (Adamu and Adie, 2014). The cassava effluents used was gotten from a garri processing firm located near Oba River, Ogbomoso, Oyo State, Nigeria.

Aggregates

These are solid particles of low aspect ratio added to a composite material, as distinguished from the matrix and any fibers or reinforcements. The coarse aggregate (granite) used was purchased from local dealers while the fine aggregate was collected from a small river behind LAUTECH bakery, Ogbomoso.

EXPERIMENTAL TESTS

The study was undertaken at the Structural laboratory, Department of Civil Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. The research involved two major steps. Firstly, preliminary investigation of some of the physical and chemical properties (physicochemical test) of the constituents of the concrete was carried out. Secondly, the actual study of evaluating the quality of concrete produced using potable and cassava effluent for mixing and curing was also carried out. The various methods used in this research work are briefly discussed below:

Physico-chemical analysis

Samples of cassava effluent collected from a garri processing factory located close to Oba River likewise water from Oba River itself which has been polluted with cassava

effluent was taken to KAPPA BIOTECHNOLOGY LABORATORIES, Ibadan in order to determine their physical and chemical constituents. .

Preparation of concrete cube

The required mass of sand (51.84kg) was measured and spread very well to accommodate the required mass of cement (25.92kg) which was then poured on the already spread sand. The mixture was then mixed thoroughly by the use of a hand trowel until a homogenous mix was achieved. The required mass of coarse aggregate (103.68kg) was also measured and poured into the already evenly mixed Mixture of cement and sand and the mixing continued until a homogenous mixture of the cement, aggregate and sand was also achieved. This represent concrete mix ratio of 1:2:4. The required volume of Potable water (approximately 13 litres) was then added instantaneously as mixing commences using a hand shovel, mixing continued until a homogeneous fresh concrete was attained.

The fresh concrete was then placed into concrete moulds (150mm by 150mm) already coated with engine oil using standard procedure (BS, 1986), for easy removal of the concrete from the moulds. The surface of the cubes formed was then

finished using a hand trowel to acquire smooth surface. Hand trowel was used to label the cubes for the purpose of identification.

The procedure above was also repeated for concrete made with concentrated cassava effluent used in mixing and also for curing of concrete likewise for concrete made with Oba River (that is, water polluted with cassava effluent). 60 concrete cubes of 150mm by 150mm was made with samples of concrete made with potable water, cured in potable water (A); concrete made with potable water, cured in cassava effluent (B); concrete made with cassava effluent cured in cassava effluent (C); concrete made with cassava effluent cured in potable water (D); concrete made with polluted water cured in potable water (E); concrete made with polluted water cured in polluted water (F). The concrete was labeled A-G respectively and cured in curing tank for 7 days after they were removed from the mould 24 hours after casting. The following analysis and tests were carried out on the fresh concrete and/or on the concretes at their 7 days of casting:

Slump

The concrete slump test measures the consistency of fresh concrete before it sets.

It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions (https://en.m.wikipedia.org/wiki/Concrete_slump_test). The test was carried out using a metal mould in the shape of a conical frustum known as a slump cone or Abrams cone that is opened at both ends and has attached handles. The cone was then placed on a hard non-absorbent surface and filled with fresh concrete in four stages each layer tamped with a tamping rod. At the end of the fourth stage, the concrete was then stricken off, flushed with the top of the mould. The mould was then carefully lifted vertically upwards, so as not to disturb the concrete cone.

The concrete then slump (subsides). The slump of the concrete was measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.

Compacting factor

Compaction factor test is the workability test for concrete conducted in laboratory.

The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete. The compaction factor test is used for concrete which have low workability for which slump test is not suitable.

This test was carried out by placing concrete sample gently in the upper hopper to its brim using the hand scoop and leveling it. The cylinder was then covered. The trapdoor at the bottom of the upper hopper was then opened so that concrete fall into the lower hopper. The concrete sticking on its sides was then pushed gently with the rod.

Opening the trapdoor of the lower hopper and allowing the concrete to fall into the cylinder below. Excess concrete above the top level of cylinder was then cut off using hand towels and leveling it. Cleaning of the outside of the cylinder was done and the cylinder with concrete was weighed to the nearest 10g. This weight is known as the weight of partially compacted concrete (W1).

The cylinder was emptied and then refilled with the same concrete mix in layers

approximately 5cm deep, each layer being heavily rammed to obtain full compaction and leveling the top surface.

The cylinder was weighed with fully compacted concrete, this weight was recorded as (W2). The weight of the empty cylinder was found and recorded as (W).

The compaction factor defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete was calculated.

Compaction Factor Value =

$$(W1 - W)/(W2 - W)$$

The Compaction factor values ranges from 0.7 to 0.95.

Compressive strength

Here, crushing machine was used to test for the strength of concrete cubes formed. The machine was used to determine the crushing load on the specimen cubes at constant rate until a minimum load which corresponds to the ultimate compressive load, and the value was then recorded as the failure load of that cube. The cubes were subjected to compressive strength test at the end of 7 days.

Split tensile test

The tensile strength of concrete is a fundamental and crucial property that influences the degree and size of cracking structures. Furthermore, concrete's weakness in tension is related to its brittle nature, which means it cannot withstand direct stress. As a result, fractures are likely to form when tensile stress surpasses tensile strength. As a result, the load at which the concrete members may crack must be determined. A splitting tensile strength test on concrete is also used to assess the tensile strength of concrete. The process described below was based on the ASTM C496 (Standard Test Specimen), which is similar to other codes such as IS 5816 1999.

After 7, 14, 21, and 28 days of curing, the wet specimen was removed from the water and water was wiped from the surface of the specimen. Following that, diametrical lines were put on the specimen's two ends to confirm that they were on the same axial plane.

The specimen's weight and dimensions were then recorded, and the compression testing equipment was adjusted to the desired range. The specimens' lower and top plates were fitted with plywood strips so that the lines marked on the ends are

vertical and centred over the bottom plate. The specimen was subsequently subjected to constant load without being shocked.

Finally, the breaking loads (P) were noted down and the splitting tensile strengths were calculated as follows

$$T = \frac{2P}{\pi LD}$$

where

T = splitting tensile strength, MPa

P = maximum applied load indicated by the testing machine, N

D = diameter of the specimen, mm

L = length of the specimen, mm

RESULTS AND DISCUSSION

Tables 1–4 give the findings of the chemical analysis of cassava effluent constituents, slump, compaction factor test, compressive strength test, and split tensile test.

Chemical Analysis Test

The following metals were analyzed from the cassava effluent as well as the polluted water from KAPPA

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LABORATORIES, Ibadan, viz-a-viz Cyanide, Magnesium, Calcium, Iron, Cadmium, Zinc, Copper, Lead, Manganese and Nickel as presented in table 1. The result revealed that fermented water

contain heavy metals which make it not suitable for mixing and curing because these heavy metals have adverse effect on the workability and strength of concrete (Babu et al., 2007; Babu, 2009).

Workability

The slump test results (Table 2) demonstrate that all of the concretes have a low degree of workability, however the compaction factor test results (Table 3) show that concrete in categories A, PFC, and FFC, FPC have high workability and FFC, FPC have low workability. Although there is no significant difference in the

slump value of concrete manufactured with potable water and cassava fermented concrete, the difference in their compaction factor value was evident. This suggests that fermented water has a detrimental impact on the concrete sample's workability. Concrete with a low degree of workability (as stated in Table 2) is acceptable for vibrating using power-operated or hand-operated devices on highways. This concrete can also be utilised for mass concrete work in foundations that do not have vibrations and for minimally reinforced sections that do have vibrations.

Table 1: Result of Concentration of Analyzed Metals Present in Cassava Effluent and Cassava Effluent Polluted Water.

Parameter (mg/L)	Cassava Effluent	Polluted Water	WHO Standard
Cyanides	0.27	0.06	0.02
Magnesium	33.33	63.33	25-50
Calcium	83.33	125	40-80
Iron	2.63	0.73	-
Cadmium	0.04	0.01	0.003
Zinc	0.63	0.33	3.0
Copper	0.57	0.27	2.0
Lead	0.12	0.05	0.01
Manganese	0.06	0.02	0.5
Nickel	0.23	0.06	0.02

Table 2: Slump Test Result

Concrete Identification	Slump Value (mm)	Form of Slump	Remark
A	25.5	True Slump	Low Workability
B	25.5	True Slump	Low Workability
C	23.0	True Slump	Low Workability
D	23.0	True Slump	Low Workability
E	24.5	True Slump	Low Workability
F	24.5	True Slump	Low Workability

Table 3: Compaction Factor Test Result

Concrete Identification	Compaction Factor Value	Remark
A	0.95	High
B	0.95	High
C	0.87	Low
D	0.87	Low
E	0.90	Medium
F	0.90	Medium

Table 4: Interpretation of Compaction Factor Test Result as Described in British Road

Note 4

Degree of Workability	Slump (mm)	Compaction Factor		Applications
		Small Apparatus	Large Apparatus	
Very Low	0-25	0.78	0.80	Vibrated concrete in roads or other large sections
Low	25-50	0.85	0.87	Mass concrete foundation without vibration. Simple reinforced sections with vibration
Medium	50-100	0.92	0.935	Normal reinforced work without vibration and heavily reinforced sections with vibration
High	100-180	0.95	0.96	Sections with compacted Reinforcement. Not normally suitable for vibration

Compressive Strength

Table 5 displayed the results of compressive tests performed on each cube at 7, 21, and 28 days of curing, and it can be seen that there is a consistent rise in strength with decreasing cassava effluent content. However, this rise varies. The rate of rise for the control cube is larger than for those in categories C through F.

From the compressive strength test result, it can be observed that there is narrow gap between the results of the control sample A and other samples. For example, the average compressive strength for the control sample is 11.50N/mm² while for C, it is 7.90N/mm² which is the least followed by that of B (8.20N/mm²) and

later by that of D (9.40N/mm²), E (10.50N/mm²) and F (10.80).

However A has the highest compressive strength value of 11.50N/mm² at 7 days, that is, C<B<D<E<F<A in terms of strength. This showed that the quality of water used in mixing has an adverse effect on strength than in curing.

Concrete in the category C is having the least value which implies that fermented water makes concrete weaker thereby reducing its quality. Also the graph in the Figure 1 below illustrates the relationship between the compressive strength of both the control sample and other types of concrete investigated at 7, 21 and 28days of curing.

Table 5: Compressive Strength Test Result for Concrete Cubes Made With Potable Water, Cassava Effluent and Cassava Effluent Polluted Water.

Concrete Identification	Compressive Strength at Various Curing Ages (N/mm ²)		
	7 Days	21 Days	28 Days
A	11.5	17.71	18.81
B	8.2	13.19	14.00
C	7.9	12.15	13.19
D	9.4	15.33	15.95
E	10.5	16.22	16.53
F	10.8	16.52	16.65

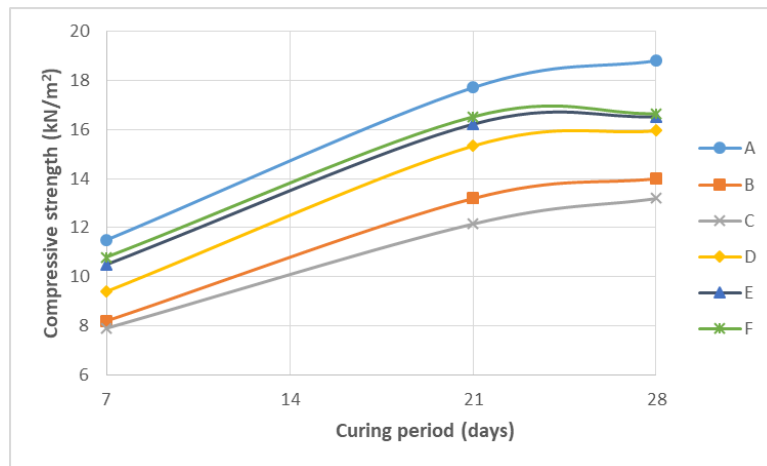


Fig. 1: Graph of Compressive Strength against curing days

Split Tensile Test

Table 6: Split Tensile Test Result for Concrete Cubes Made With Potable Water, Cassava Effluent and Cassava Effluent Polluted Water.

Concrete Identification	Split Tensile Test Result at Various Curing Ages (N/mm ²)		
	14 Days	21 Days	28 Days
A	1.98	2.37	2.43
B	1.15	2.08	2.13
C	1.05	2.00	2.08
D	1.28	2.22	2.24
E	1.37	2.28	2.32
F	1.41	2.30	2.35

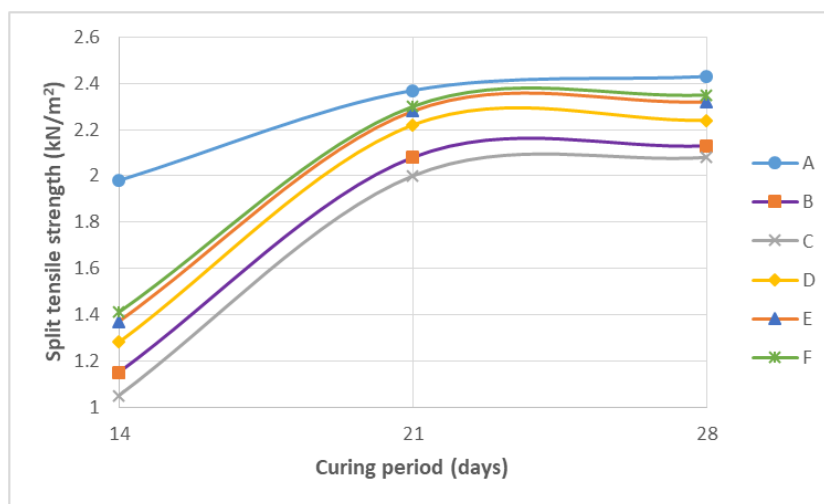


Fig. 2: Graph of Split Tensile against Curing days

Table 6 showed that the result of the split tensile test carried out on each cube at 14, 21 and 28 days of curing and from that result, it can be observed that, there is steady increase in strength with reduction in the concentration of cassava effluent. The rate of increase for the control cube is relatively higher than those in the category C to F. From the tensile test result, it can be observed that there is narrow gap between the results of the control sample A and other samples as shown from the table. Also the graph in the Figure 3.2 below illustrates the relationship between the split tensile strength of both the control sample and other types of concrete investigated at 14, 21 and 28 days of curing.

CONCLUSION

Based on the findings of an examination into the influence of cassava effluent contaminated water on the qualities of concrete, the following conclusion may be taken.

According to the findings, concrete built using potable water and cured in potable water (Category A) has the maximum compressive strength, slump, and compaction factor values. Similarly, the compressive strength, slump, and compaction factor of concrete prepared

with cassava effluent and cured in cassava effluent were significantly reduced (Category C). Finally, the percentage reduction in concrete strength revealed that concrete made with cassava effluent and cured in cassava effluent has the highest percentage reduction, followed by concrete made with cassava effluent and cured in potable water, and concrete made with potable water and cured in cassava effluent has the lowest percentage reduction.

In a nutshell, fermented cassava water is clearly unsuitable for concrete mixing or curing. Because heavy metals such as Cn, Ca, Mg, Mn, Pb, Cd, Zn, Cu, Ni, and Fe are found in cassava effluent, these metals include salt, making cassava effluent unsuitable for concrete manufacture and affecting cement hydration, which can finally lead to concrete degradation (Babu et al., 2007; Babu et al., 2009). It is well known that the quality and quantity of water used in the mixing and curing of concrete has a detrimental influence on its qualities.

RECOMMENDATIONS

Based on the study's findings, the following are recommended: To begin, contractors should be discouraged from obtaining water for use in the construction of Civil Engineering constructions from

streams or rivers that contain cassava effluent, such as the Oba River.

Furthermore, if such water is to be utilised, possibly owing to water shortage, it should be treated with a proper amount of water treatment chemical (e.g. Chloroamine, Zeolite, Biocides, Reverse Osmosis, etc.) or another water treatment method. Furthermore, spreading wet cassava on cement floors, decks, and pavements should not be utilised to eliminate the likely source of heavy metals infiltration.

Similarly, in order to make sufficient quality concrete, the same quality of water should be used for both mixing and curing, and the influence of soaking cassava on the strength of an existing concrete floor should be tested using a Schmidt hammer in the later research. Finally, the influence of cassava effluent on concrete qualities should be studied in a laboratory where the degree of fermentation can be precisely controlled.

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