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Strength Characteristics of Concrete Produced by Replacing Sawdust as Fine Aggregate and Domestic Wastewater as Admixture

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ABSTRACT: This study investigated the strength characterization of concrete produced with sawdust as a partial replacement for fine aggregate and utilizing domestic kitchen wastewater. The materials used are Sawdust, fine aggregates, coarse aggregates, ordinary Portland cement, potable water and kitchen wastewater. The sawdust was used to replace 5-30% of fine aggregates by volume, while kitchen wastewater was compared to potable water for mixing. Tests were conducted on fresh and hardened concrete properties including workability, water absorption, compressive strength, and tensile strength. The experimental results demonstrate that replacing up to 30% of fine aggregate with sawdust is feasible without significantly compromising the workability of concrete, as indicated by consistent slump test results. However, water absorption increased with higher sawdust content and curing time, attributed to the porous nature of sawdust. Concrete made with potable water exhibited slightly higher water absorption compared to that made with kitchen wastewater. Compressive strength tests revealed that strength decreased as the sawdust content increased, with the most significant strength gains occurring within the first 7 to 14 days, and continued development up to 28 days. The 30% sawdust replacement achieved approximately 60% of the control mix strength at 28 days. The optimal sawdust replacement percentage was identified as 5-10%, balancing environmental benefits with structural performance. The study also highlights the necessity of treating kitchen wastewater before use in concrete production, due to its high organic content, acidity, and elevated levels of potentially harmful ions.

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Sustainable development is related to equilibrium in conserving natural resources and solving environmental problems. It is becoming increasingly distinct that combination of sustainable practices and methodologies into concrete production is crucial for the sustainability of the environment (Suhendro, 2014). The construction industry devours more natural resources than any other industry. Concrete is one of the most used materials in the construction industry (Gandomi *et al.*, 2013). The importance of concrete and the water used in its production cannot be overemphasized (Gandomi *et al.*, 2014; Naderpour *et al.*, 2017; Sharbatdar *et al.*, 2020). Concrete is a construction material which consists of a mixture of fine, coarse aggregate, cement which proportionally mixed with certain percentage of water (Ganiron, 2014). Concrete contains about 75 % aggregate, 25 % paste of cement contains 10 % water (Halawa and Al-Sheikh, 2022). The importance of concrete as construction material is increasing on a daily basis.

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Sand as a primary fine aggregate aid the adhesion of the various components in concrete. It provides strength by serving as small fillers in a mixture. Cement binds sand particles together forming one solid sand mix. Saw dust is the waste material generated by wood-based industry. It is formed as a small irregular chips or small trash of wood during chopping of logs of wooden into different sizes. Sawdust is a well-known agriculture and by-product waste material resulting from the wood industry. It is generated as a waste material when timbers are mechanically milled into different sizes and shapes. Many environmental problems are caused by sawdust wastes, wherein the scarcity of space for land fill is a major concern and a severe threat to both developing and developed nations. The excessive sawdust wastes that are accumulated due to the activities of factories, mills, and houses are ever growing annually. It many developing counties like Nigeria, waste saw dust are left unattended to in heaps thereby leading to many environmental hazards. It is estimated that the annual generation of wood waste in the United States of America, Germany, the United Kingdom, and Australia is around 64, 8.8, 4.6, and 4.5 million tonnes per years, respectively, and more than 40% of these amounts are not recycled (Brown and Kearley, 2009; Bratkovich *et al*., 2014; Röder and Thornley, 2018; Ahmed, *et al*., 2018). The dimensions of saw dust depend on the varieties of wood and dimension of the saw teeth. Enormous quantity of saw dust is generated worldwide every year. Dumping of Saw dust on open land is posing threat to the environment. Researchers agree that saw dust can be utilized either as a source of energy or as a raw material for manufacturing of particle and board. Some studies have also utilized sawdust in wastewater treatment (Sepehri and Sarrafzadeh, 2018)

Presently wood savings are used in manufacturing of cement-based products such as cement bonded particle board. The compatibility between wood and cement has attracted the attention of researchers to investigate its use as partial replacement of sand in manufacturing of concrete Siddique *et al*., 2020). Oyedepo *et al*. (2014) used sawdust wastes as a substitute for fine aggregates at different contents from 0% up to 100% and showed that a ratio of more than 25% substitute to natural aggregates can negatively influence the concrete's strength properties and density. Other researchers have also made comparable observations when sawdust was used in concrete at various levels (10%, 20%, 30%, and 40%) as a substitute for sand. It was suggested that an amount of sawdust at up to 10% substitution for sand could produce a better density and mechanical strength of concrete (Adebakin *et al.*, 2012). Boob (2014) also used sawdust as a substitute for fine aggregates (0–15%) in concrete. Mageswari and Vidivelli (2009) showed that sawdust ash as an agent to replace natural sand may be an appropriate choice for fine aggregates in concretes. It can significantly decrease the sawdust waste clearance problem and concurrently allow the conservation of natural fine aggregates. The authors found that concrete including sawdust possessed unique characteristics and presented better outcomes for the thermal and mechanical characteristics of the cement-based composite, making it economical compared to various other materials in the construction sector. Also, surfaces of sawdust concrete hollow bricks have outstanding adhesion which guarantees a successful coating with various paints and varnishes, or other finishing materials.

Used water collected from houses and commercial buildings is called residential or domestic wastewater. Untreated wastewater is a hazard to the environment. Many studies have assessed using wastewater in concrete mixtures on a lab scale. Some researchers have investigated the possibility of using Treated Wastewater (TWW) in concrete production (Pallapu *et al*., 2020). The results concluded that the use of TWW is sustainable in the concrete industry. Using TWW in concrete treatment and cement mortar meets the requirement of standard specifications codes (Saricimen *et al*., 2009). There is a research gap in the environmental and functional aspects of using untreated wastewater in concrete production, filling this gap could lead to a revolutionary movement in the construction industry. Bearing in mind the amount of water required for construction projects, if potable water could be substituted with untreated wastewater, it would not only reduce concrete production costs but would also prevent the wastage of the enormous amount of potable water resources and also prevent the hazards associated with indiscriminate disposal of untreated wastewater into the environment.

In many parts of the world, inadequate water supply and water quality deterioration represent serious contemporary concerns for municipalities, industries, agriculture, and the environment. Factors contributing to these problems include continued population growth in rural and urban areas, contamination of surface water and groundwater, uneven distribution of water resources, and frequent droughts caused by extreme global weather patterns. Increasing water shortages and environmental pollution concerns, provides a realistic background for considering wastewater as a water resource rather than a liability. Hence, the objective of this paper was to assess the strength characteristics of concrete produced by replacing sawdust as fine aggregate and domestic wastewater as admixture.

MATERIALS AND METHODS

a. Cement**:** The Ordinary Portland cement was used according to IS 12269-1970. The preliminary tests like normal consistency (amount of water to be added), specific gravity, initial and final setting time and compressive strength were conducted. Sieve analysis and fineness tests were conducted as well for the determination of moisture content and specific gravity.
b. Fine Aggregate: The River sand of maximum particle size of 4 mm was used. This consists of natural sand from the river bed. The physical properties of the sand was obtained by conducting specific gravity and sieve analysis test.
c. Coarse Aggregate: The physical properties of coarse aggregate which are specific gravity, water absorption and fineness modulus was determined. The granite had a maximum particle size of 12.5 mm.
d. Sawdust Waste: The sawdust used in this research consist of waste from hardwood called Afara and was collected from a sawmill in Akure. The botanical name is *Terminalis Superba* from combretacea family. It is a timber specie with a yellow brown heartwood. The tests conducted include particle size analysis and specific gravity test. Majority of the fine particles of sawdust passed through 4.76 mm BS test sieve.
e. Wastewater
The Kitchen wastewater was obtained from restaurants within FUTA as presented in Plate 3.1.

The sawdust and natural aggregates were thoroughly mixed in order to get rid of debris from the materials. A 1:2:4 concrete mix of cement, fine and coarse aggregates was used in this research. Batching was conducted by volume. The river sand fine aggregate was replaced with 5%, 10%, 15%, 20%, 25% and 30% of sawdust. The cylindrical specimen was cast to investigate the splitting tensile strength of the concrete. The coarse and fine aggregates were first thoroughly mixed with cement. Then the wastewater was carefully added to the mixture. A vibrating tool was used to improve sample compaction. Control samples were cast using potable water. Curing of the samples was performed in ambient condition at room temperature for the first 24 hours and then submerged in normal water in the curing tank until testing.

Plate 1: Kitchen wastewater

Concrete slump test or slump cone test was conducted to determine the workability or consistency of concrete mix prepared at the laboratory according to BS EN 12350-2.

The density (unit weight) of concrete was determined according to specifications of ASTM C 138. Before casting concrete into the moulds, a fresh sample was taken to check the fresh density by filling a container with concrete mix and then compacting and weighing the container. The dry densities was estimated for the cubes soaked in water just before compressive strength test. Water absorption test was used to measure the amount of water absorbed under specified conditions. The water absorption is the percentage increase in weight of dry concrete sample after immersing it in water for some period. This test was carried out according to ASTM C642 – 13. The concrete after curing for 28 days was oven dried at temperature of 105 ºC for 6 h, immediately weighed and subsequently wholly immersed in water for 24 hours and weighed again.

Fresh concrete was placed in molds with the exposed surface of the concrete samples covered with a perforated waterproof sheet for 24 hours, in order to ensure uniform saturation state in the concrete, and then they were demolded and cured in water at 20 ± 20C of room temperature until the test age. A compression machine of 2000 kN capacity was used for the strength determination and loading speed was maintained at 0.2 N/mm^2/s. The compressive strength test was performed after 7, 14, 21 and 28 days of curing for each samples according to ASTM C109 (2010). The test was carried out to determine the strength development.

Split Tensile Strength Tests: The split tensile strength was used for determining performance of concrete under tensile stress and also gives its progressive cracking pattern. The test was conducted in accordance with the provision of BS EN 12390-6.

Water Quality Tests: The kitchen wastewater, as well as the potable water that served as control were sampled and analysed in order to determine the presence of any toxic chemicals and potentially harmful pathogens. The following tests were carried out on the water samples: Temperature, Turbidity, Total Dissolved Solids, Total Suspended Solids, Oil and Grease, BOD, COD, Chloride, Nitrate, Sulphate, Phosphate, Cadmium (Cd), Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), and Zinc (Zn) (Table 1). The results were compared with World Health Organization (WHO) standard for potable water.

Table 1: Water Quality Tests

S/N	Type of Test	Parameters
1	Physical Tests	Temperature, Turbidity, Total Dissolved Solids, Total Suspended Solids
2	Chemical Tests	pH, Electrical Conductivity, Total Suspended Solids, Oil and Grease, BOD, COD, Chloride, Nitrate, Sulphate, Phosphate
3	Heavy Metals	Cadmium (Cd), Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), Zinc (Zn).

Water quality Analysis: The physical and chemical analysis were conducted according to specifications in APHA (2005). The results were compared with World Health Organization (2011) standard for potable water. Samples for both dissolved and suspended solids was treated using both filtration and evaporation. First, the sample was dried to a constant, reproducible weight by drying in a 103° C to 110° C oven for 1 hour and allowed to cool to room temperature in a desiccator. It was then weighed, and heated again for about 30 minutes. The sample was cooled and weighed a second time. The procedure was repeated until successive weights agree to within 0.3 mg. This weight was then be recorded. The pH was measured using a pH meter. A pH meter consists of a potentiometer connected electrically to two electrodes, called indicator and reference electrodes. Electrical Conductivity of the water samples was determined using a sensor consisting of two metal electrodes which protrude into the water.

Mineralogical analysis was carried out using X-ray diffraction (XRD) while elemental composition analysis was done using Scanning electron microscope (SEM).

Data Analysis: The data obtained from the laboratory tests on the wastewater and concrete cubes would be analyzed using Microsoft Excel and SPSS and the results would be presented in tables and graphs.

RESULTS AND DISCUSSIONS

The results of the standard consistency and setting time test (initial and final setting time test) are presented in Table 2. The fineness values for the cement is 2.0%, this value is less than the maximum 10% recommended by BS EN 197-1 2000. According to BS EN 197-1:2000, the minimum initial setting time allowable for a grade 42.5N cement is 60 minutes while the final setting time should not be more than 10 hours. From the results presented in the Table, the cement used met the requirements stated in the various corresponding standards. The cement used had initial and final setting times of 2.48 hours and 3.9 hours. These values are few minutes less than 2.67 hours and 4 hours for initial and final setting respectively reported by Ghalehnovi *et al.,* 2010. Uzoh *et al.,* 2017 reported 1.83 hours and 5.67 hours for initial setting time and final setting time respectively.

Table 2: Properties of the Ordinary Portland cement

Properties	Value
Fineness	2.0
Soundness	30.5%
Consistency Time	10 minutes
Initial Setting Time	148 minutes
Final Setting Time	234minutes

Moisture content of fine aggregate (sand) and coarse aggregates: The moisture content of fine and coarse aggregates was carried out and the results are shown in Table 3. For fine aggregates, an average moisture content of 2.87 % was obtained which is lower than the maximum limit of 3% for fine aggregate moisture content according to ASTM C33-18. This also agrees with the findings of Lippiatt and Meyer (2007) that fine aggregates with particle sizes less than 4.75mm had higher moisture content values compared to those with larger particle sizes. For coarse aggregates, a value of 3.87% was obtained.

Specific Gravity Test of Fine and Coarse aggregates: All the aggregates underwent a specific gravity test to ascertain their weight after being compared to the weight of an equivalent volume of water. From Table

3, the fine aggregate has a specific gravity of 2.79, this value is slightly greater than 2.6, which is reported by Rameshwar and Shrinkant, 2017; and 2.61 by Saha (2015). The value 2.76 shows that the sand is 2.76 times heavier than an equal volume of water. The coarse aggregate has a specific gravity of 2.89. All of the results obtained are within the ranges suggested for particular gravities.

Bulk density: The bulk density test and water absorption test was performed on coarse aggregates and fine aggregates. The results of the two tests are presented in Tables 4.2. The bulk density of the fine aggregates is 1.62 while that of coarse aggregates is 1.71. This value of the coarse aggregate is less than 2.58 g/cm^3 provided by Abdullahi (2016) and 2.60 g/cm^3 by Chong (2019). The water absorption value was 0.55%. This value is less than 0.8% which is usually the limit for the water absorption.

Aggregate Crushing value (ACV) and Impact value (AIV) of coarse aggregate: The average ACV achieved is 27.97%, which indicates that the aggregate is robust enough to withstand crushing from applied loads. According to the standards, the value should not be more than 30% (BS 812-121, 1975). Investigations were also done into the aggregate's shock-load or rapid impact resistance. The observed result of 20.0% demonstrates the aggregate's exceptional toughness and resistance to any impact force (Table 3). For a solid aggregate, the usual AIV is between 10 and 20%.

Table 3: Properties of fine and coarse aggregates

Properties	Fine aggregates	Coarse Aggregates
Moisture Contents	2.70	3.87
Specific Gravity	2.79	2.89
Bulk Density	1.61	1.71
Silt/Clay contents	5%	
AIV		20.03
ACV		27.97

Particle Size Analysis: The particle size distribution curve for the fine aggregate is presented in Fig. 1. The aggregate is finely graded, ranging from fine gravel to fine sand. The uniformity (Cu) and curvature (Cc) factors were numerically determined to evaluate the particle distribution in the aggregate. The following percentage fines are considered: 60%, 30%, and 10%. Cu is the ratio of 60% finer to 10% finer, providing a score of 2.11, whereas Cc is the square of 30% finer to 60% and 10% combined, yielding a value of 1.15, signifying a well graded particle.

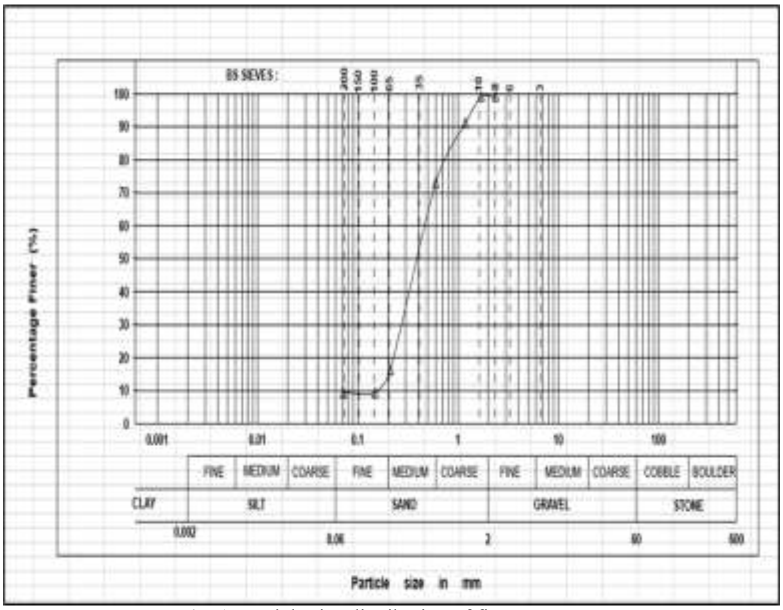

Fig. 1: Particle size distribution of fine aggregates

Physicochemical Property of Portable and Kitchen Waste Water: Table 4 shows the physico-chemical properties of water used in concrete production. Portable H2O, has pH (11.616) which shows its highly alkaline, may accelerate the initial setting time of cement and potentially increase early strength development. The relatively low levels of sulfates, phosphates, and organic matter (as indicated by BOD and COD) suggest that this water may not significantly interfere with cement hydration processes (Zan *et al.,* 2024). Its acidic pH (5.998) could retard cement hydration and potentially reduce concrete strength. The extremely high COD (3,600 mg/L) indicates a significant presence of organic compounds, which can interfere with cement hydration and potentially reduce concrete strength and durability. The elevated levels of sulfates (190 mg/L) and chlorides (591.67 mg/L) increase the risk of sulfate attack and reinforcement corrosion, respectively. Additionally, the high phosphate content (91.55 mg/L) may lead to set retardation and reduced early strength development. Portable H_2O is suitable for concrete production. Kitchen Waste H_2O would require significant treatment before use in concrete mixing. Its high organic content, acidity, and elevated levels of potentially harmful ions make it unsuitable for direct use in concrete production without prior treatment. If used, it could lead to reduced concrete quality, strength, and durability, as well as increased risk of various deterioration mechanisms.

Table 4: Physicochemical Property of Portable and Kitchen Waste Water

Name	Kitchen Waste H_2O
Mg/L chloride	591.67
Unit turbi	11.9 units
Mg/L SO4	190
Mg/L NO4	71.3
Mg/L PO4	91.55
Mg/L BOD	4.94
COD	3,600.00
Oil/Grease, mg/L	1.54
%TDS	0.0179
% TSS	0.0029
(NOS cod) conduct	235 x 10
TRDP	34^0C
PH	5.998

Metal Analysis of Portable and Kitchen Wastewater: Table 5 shows the metal Analysis of both potable water and kitchen wastewater. It is observed that Zinc and iron are present in both sources, with higher levels in kitchen waste water. Manganese is only detected in kitchen wastewater at a very low level (0.02) while Lead is not detected in either source. The kitchen waste water has approximately twice the concentration of zinc and 1.5 times the concentration of iron compared to portable water. These values suggest that both water sources are suitable for concrete production, with portable water being slightly preferable due to lower mineral content.

Table 5: Metal Analysis of kitchen wastewater

Element	Kitchen Wastewater
Pb	0
Ed	0
Er	0
Zn	0.71
Fe	1.24
Mn	0.02

Tests on Sawdust fine aggregates: Particle size distribution of Saw at different percentages: Fig. 2 shows the particle size distribution curves for different percentages of sawdust used as a partial replacement for fine aggregate in a mixture. The percentages of sawdust replacement range from 5% to 30% in 5% variations. It is observed that the curves for all sawdust percentages are very similar, indicating that the particle size distribution remains relatively consistent regardless of the amount of sawdust added. The majority of particles fall within the sand range (0.06 mm to 2 mm), with a small portion extending into the fine gravel range (2 mm to 6 mm). The curves below about 0.3 mm, indicating fewer very fine particles. At the 50% passing, the particle diameter is roughly 1.2 mm for all mixtures. It is also observed that all mixes have very low fines content., and also that the 25% and 30% sawdust mixes have the highest retention of larger particles, with over 90% of particles larger than 3 mm. From the Fig. 2, it is shown that the steepness of the curves increases with sawdust percentage, indicating less uniform distribution in higher sawdust mixes. The 30% sawdust mix shows the most gap-graded characteristic, with a sharp drop between 3 mm and 1.18 mm sizes. The addition of sawdust as a partial replacement for fine aggregate tends to increase the proportion of larger particles in the mix.

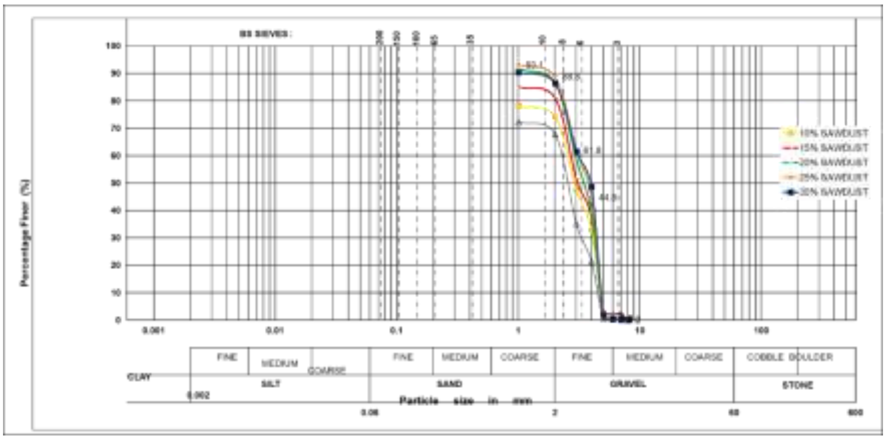

Fig. 2: Particle size distribution of sawdust as partial replacement for fine aggregate at various percentages

Fig. 3 shows SEM-EDS of sawdust. The sawdust is primarily organic as it contains Carbon (85.73% atomic, 81.07% weight) and Nitrogen (11.97% atomic, 13.20% weight). It also contains various minerals in small amounts: Ca, Fe, Al, Na, Si, S, Cl, Mg, K, P. The presence of high carbon and nitrogen content may lead to increased water absorption, potentially affecting the water-cement ratio and workability of concrete, thereby resulting in slower setting times and reduced early strength development.

Fig. 4 shows the XRD analysis test result on sawdust. The composition of sawdust are Urea, syn ($CO(NH_2)_2$): 51% ± 11%; Muscovite ($H_2KAl_3Si_3O_{12}$): 30% ± 11%; Cristobalite (SiO_2): 19% ± 12%; and Graphite (C): 0.82% ± 0.17%. The High urea content (51%) may increase water demand and retard setting time. Muscovite (30%) has the ability to improve workability but may increase water demand and reduce strength.

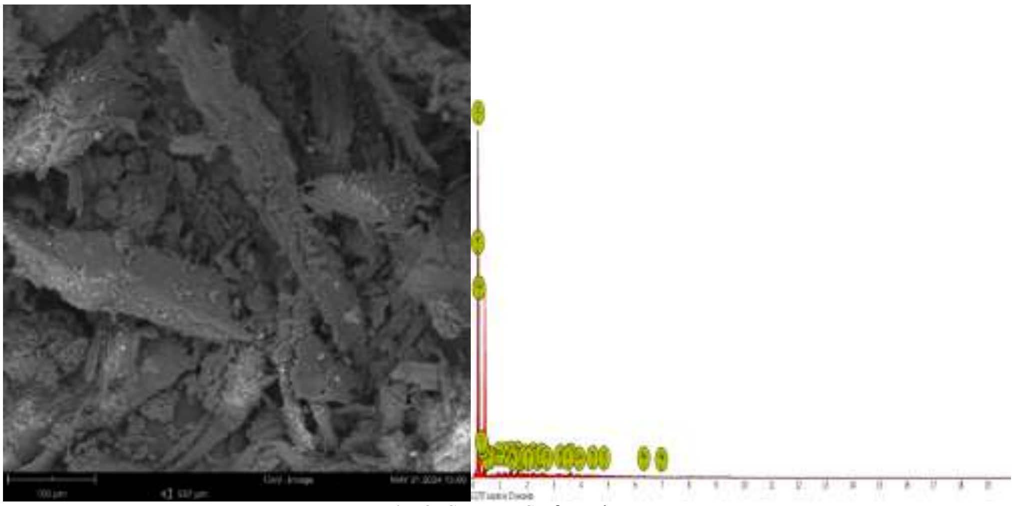

Fig. 3: SEM EDS of sawdust

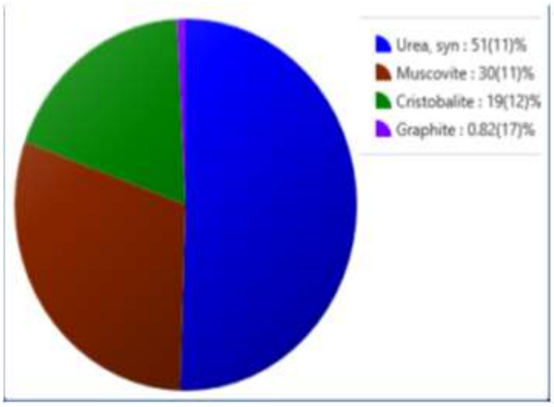

Fig. 4: XRD of sawdust

Figures 5-6 shows the results of the slump tests carried out on Concrete produced with different percentage of sawdust-fine aggregate and potable water and those produced with different percentage of sawdust -fine aggregate and kitchen wastewater. The concrete produced using 5% to 30% sawdust as partial replacement for fine Aggregate (Sand) and kitchen wastewater. The slump got ranges from 60mm – 70mm. The slump got ranges from 60mm – 70mm when using portable water, and later falls within the same range as the kitchen wastewater. When using no sawdust as partial replacement i.e. using river sand as fine aggregate slump of 70mm was achieved. As shown in the Figures, these results suggest that sawdust can be used as a partial replacement for fine aggregate (up to 30%) without significantly compromising the workability of the concrete. These slump test results are promising for the use of sawdust as a partial replacement for fine aggregate in concrete, as well as for the potential use of kitchen wastewater.

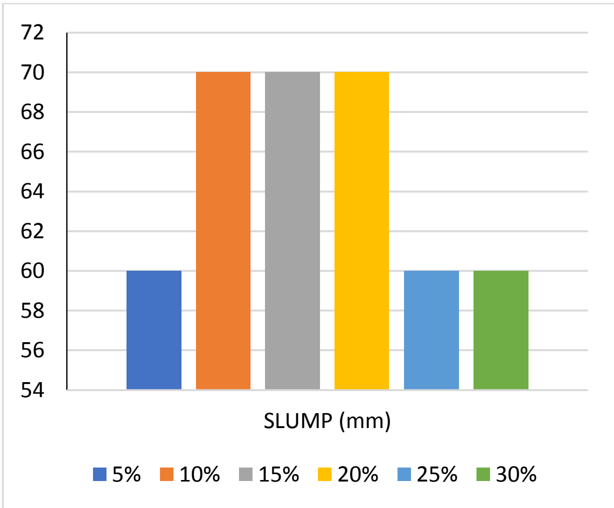

Fig. 5: Concrete produced with different percentage of sawdust-fine aggregate and potable water

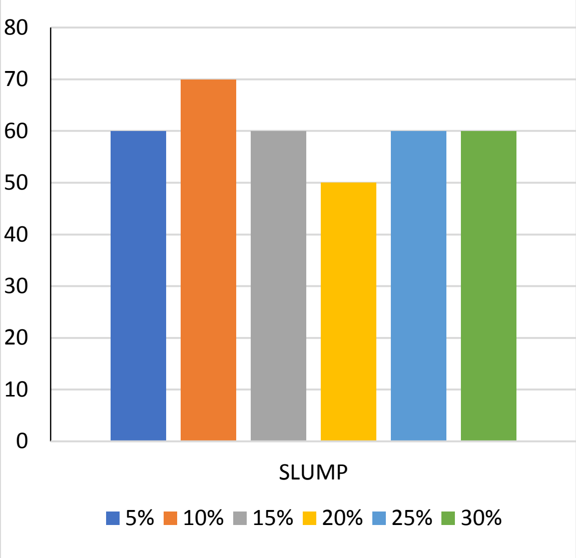

Fig. 6: Concrete produced with different percentage of sawdust - fine aggregate and kitchen wastewater.

Figures 7-10 shows the compressive strength tests results of concrete produced with potable water and kitchen wastewater at different percentages of sawdust-fine aggregates. The compressive strength of the concrete decreases as the percentage of sawdust replacement increases. This is consistent across all curing periods (7, 14, 21, and 28 days). For all mixture compositions, the compressive strength increases with curing time. The most significant strength gain occurs in the first 7 to 14 days, with slower but continued strength development up to 28 days. At 28 days, the 30% sawdust replacement mix achieves only about 60% of the strength of the control mix.

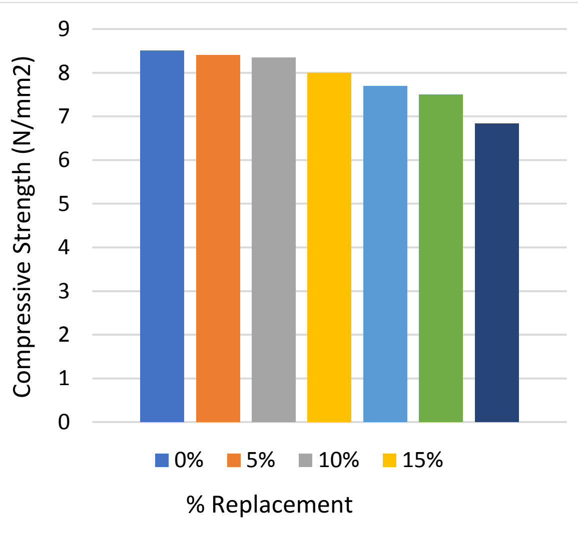

Fig. 7: compressive strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 7 days curing

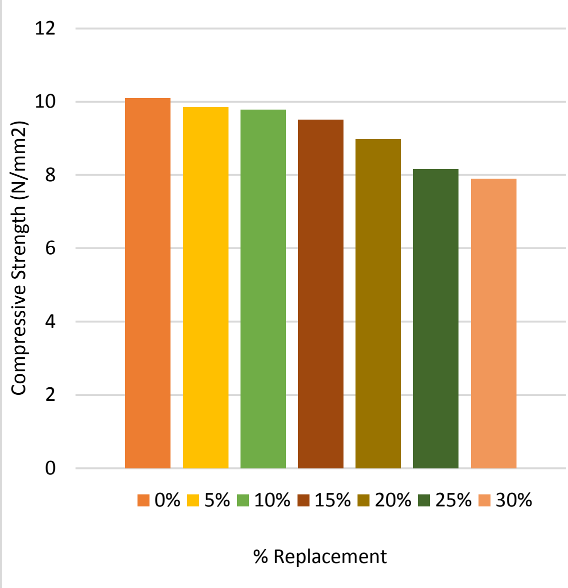

Fig. 8: compressive strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 14days curing

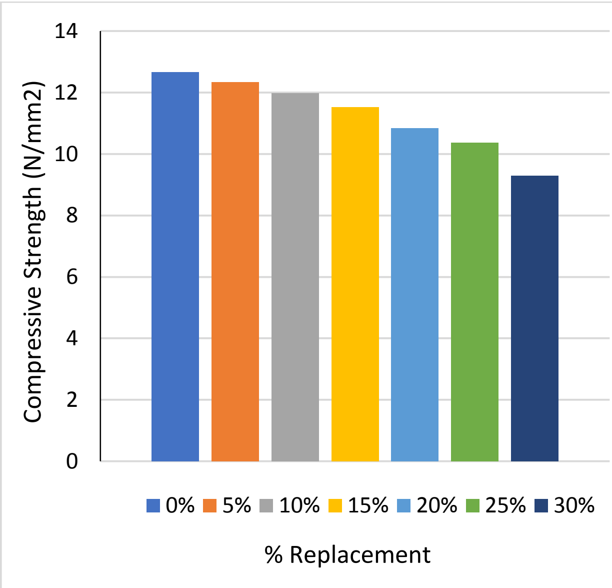

Fig. 9: compressive strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 21days curing

The higher replacement levels (15-30%) may be limited to non-structural uses due to significant strength reduction. The compressive strength data clearly shows that increasing sawdust content reduces concrete strength. However, small amounts of sawdust (5-10%) can be incorporated with a relatively modest impact on strength, potentially offering a balance between environmental benefits and structural performance.

Figures 11-14 shows the tensile strength of concrete samples. Potable water samples show higher tensile strength than kitchen wastewater samples across all curing periods. Both concrete produced from potable water and kitchen wastewater show an increase in strength over time, with the highest values at 21 days (1.77 MPa for potable, 1.72 MPa for kitchen). As the sawdust percentage increases, the tensile strength decreases for both water types.

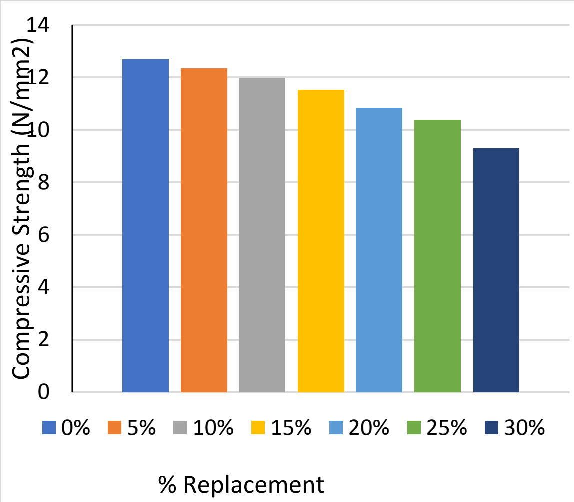

Fig. 10: compressive strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 28days curing

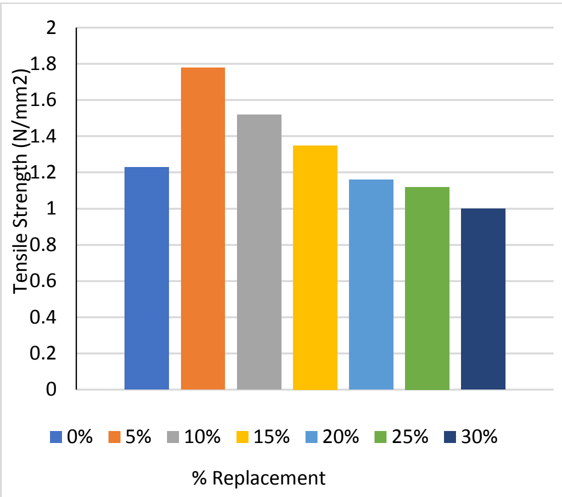

Fig. 11: Tensile strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 7days curing

At 7 days, potable water samples consistently show higher strength than kitchen wastewater samples. At 14 days, there's an unexpected reversal, with kitchen wastewater samples showing higher strength for 5%, 10%, and 15% sawdust content. At 21 and 28 days, potable water samples generally show higher strength again.

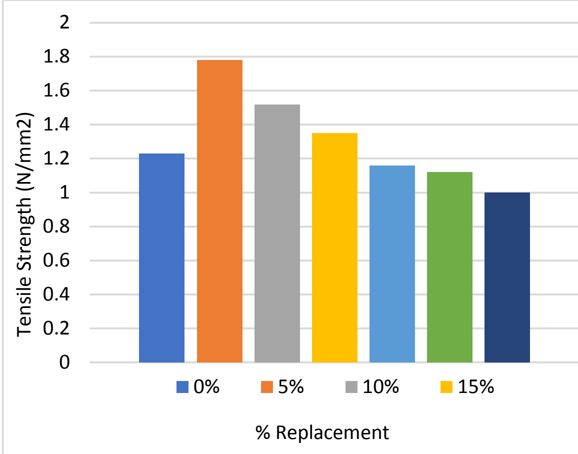

Fig. 12: Tensile strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 14days curing

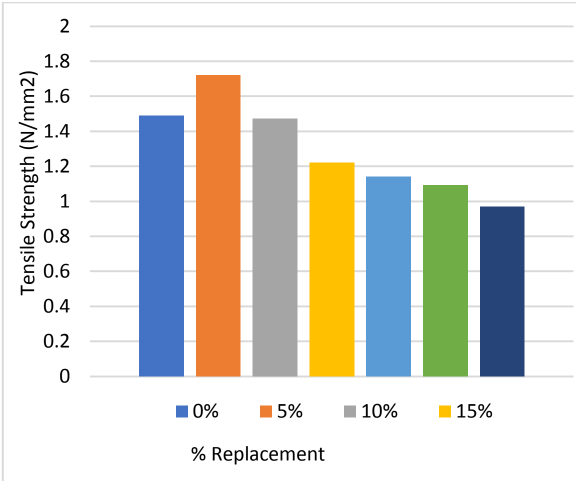

Fig. 13: Tensile strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 21days curing

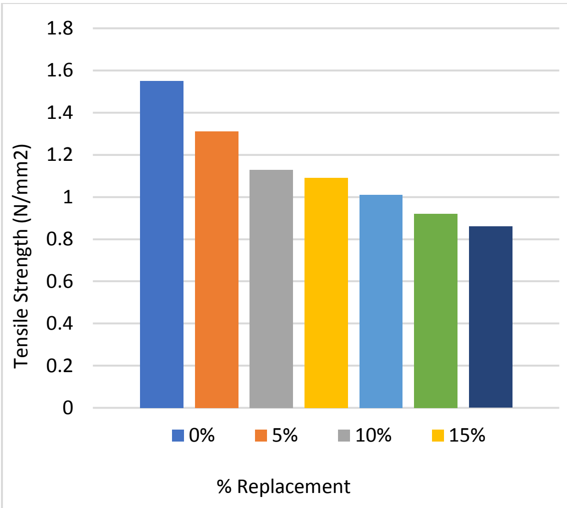

Fig. 14: Tensile strength of concrete produced with kitchen wastewater at different percentage of sawdust-fine aggregates at 28days curing

The optimal Sawdust Percentage is at 5% especially at 28 days (1.77 MPa). For kitchen wastewater, the optimal percentage is also at 5%. It is observed that sawdust generally reduces the tensile strength of concrete, with higher percentages leading to lower strength. The potable water mixes typically outperform kitchen wastewater mixes in terms of tensile strength.

Conclusion: Based on the results of the tests, it can be concluded that the partial replacement of fine aggregates with sawdust, up to 30%, is feasible without significantly compromising the workability of concrete, as evidenced by consistent slump test results. However, water absorption increases with higher sawdust content and curing time due to the porous nature of sawdust, with concrete made using potable water exhibiting slightly higher water absorption than that made with kitchen wastewater. The compressive strength of concrete decreases as the percentage of sawdust replacement increases, with the most significant strength gain occurring within the first 7 to 14 days, and continued development up to 28 days, where 30% sawdust replacement achieves about 60% of the control mix strength. The optimal sawdust replacement percentage appears to be around 5-10%, balancing environmental benefits with structural performance. It is recommended that appropriate treatment measures be implemented when using kitchen wastewater to address its high organic content, acidity, and elevated levels of potentially harmful ions before its use in concrete production. Further investigation into the long-term durability of concrete made with sawdust and kitchen wastewater is also recommended.

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Data Availability Statement: Data are available upon request from the first author

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