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PREPARATION AND EVALUATION OF PHYSIO- CHEMICAL PROPERTIES OF PLASTIC WASTES PAVEMENT BLOCKS

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ABSTRACT

This study investigates the utilization of plastic wastes, such as high-density polyethylene (HDPE), poly propylene (PP), and polyethylene terephthalate (PET) in the production of pavement block. These plastic were mixed in different ratios with cement, sand, and stone dust to produce durable and cost-effective blocks.The plastic wastes was shredded, melted (170^0C-260^0C), and mixed with fillers. The mixture was cast into moulds and tested for water absorption, acid and base resistance properties. Significant improvements were observed: zero water absorption compared to conventional blocks (water absorption 7.8%), the plastic pavement blocks demonstrated superior performance. This research demonstrates the potential of plastic waste in construction, offering a sustainable solution for waste management and environmentally friendly infrastructure development.

Keywords: Plastic waste, Pavement blocks, cement, sand, stone dust

INTRODUCTION

Solid waste management has emerged as a significant challenge in Nigeria, particularly in its municipalities, which rank second highest in solid waste generation, producing nearly 0.40 kg per person per day [1]. The composition of this waste primarily includes organic and inorganic materials, classified into fermentable and non-fermentable categories [2]. In Lagos, the situation is more pronounced, with municipal solid waste (MSW) generation averaging about 0.49 kg per person per day, exceeding the national average of 0.47 kg [3]. Alarmingly, plastics constitute 14% of the total waste generated in the West Zone, where Lagos is located, reflecting an increasing trend compared to other regions [4]. Traditional waste management practices, such as burning and land filling, prevalent across many municipalities, raise significant environmental concerns. These methods release harmful emissions, including greenhouse gases like carbon dioxide, carbon monoxide, and nitrous oxide, which contribute to global warming [5]. Moreover, the aesthetic appeal of municipal areas is undermined by an accumulation of sachet water plastic waste, which presents an opportunity for recycling into construction materials [6]. With the rising use of plastic products for packaging ranging from shopping bags to food wrappers, the generation of plastic waste is poised to escalate in the foreseeable future [3]. Despite the nascent stage of recycled plastic products, innovative engineering applications are emerging globally, including their use in road pavements, furniture, and fishing lines [2], however, the application of recycled plastics in paving units remains underutilized. Given the pressing need for effective plastic waste management, exploring alternative solutions becomes paramount. Certain plastics, such as high-density polyethylene (HDPE), polypropylene (PP), and polyethylene terephthalate (PET), possess

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unique properties that make them viable substitutes for traditional construction materials. Their inherent durability, lightweight nature, and thermal insulation capabilities offer significant advantages, including enhanced water percolation, reduced storm water runoff, and minimized maintenance issues. Incorporating plastic waste into construction not only reduces material costs and supports a circular economy but also promotes sustainability by lowering carbon footprints and increasing design flexibility. This study aims to investigate the feasibility of integrating plastic waste into pavement blocks, focusing on their physio-chemical properties. By highlighting the potential of plastic waste in construction, the research seeks to provide a sustainable solution to waste management and contribute to environmentally friendly infrastructure development.

MATERIALS AND METHOD

Sample Collection

Plastic waste samples were collected from a plastic processing outlet located along Farin Gada Road, Jos. The collected samples were sorted through physical examination and subsequently confirmed using Fourier Transform Infrared (FTIR) analysis to identify the types of plastics present.

Sample Preparation and Processing

Shredding of the Sample

The sorted plastic waste was processed using a locally fabricated shredder, reducing the plastic into smaller pieces to facilitate the melting process.

Design and Fabrication of Mould and Heating Barrel

A custom mould was designed and fabricated from mild steel, utilizing a 3mm sheet for the body and a 5mm plate for the base to withstand the high temperatures involved in the melting process. The moulds were crafted in various shapes and sizes, featuring grips to prevent slippage during operation. The dimensions of the heating barrel used in this process were as follows:

length = 26.5 cm, breadth = 8 cm, height = 6 cm.

Melting of Plastic

following shredding, the plastic was placed into a steel heating barrel, heated with a gas burner to facilitate melting. A digital temperature and humidity sensor (DHT11) was employed to monitor and record the melting temperature of the plastics, which included materials such as soda bottles, chairs, and buckets. The melting temperature ranged from approximately 170°C to 260°C. The melting points of PET, HDPE and PP are 240°C - 260°C, 120°C – 140°C, and 160°C – 170°C respectively.

Production of Pavement Blocks

Pavement blocks were produced by mixing molten plastic with various aggregates in different proportions, After the plastic was shredded into smaller sizes, it was then poured into the heating barrel made of steel iron that has been heated with a gas burner underneath to supply heat for melting. A digital temperature and humidity sensor DHT11 which uses sensors to sense and read the temperature values and humidity was use to measure the melting temperature of the plastic. The melted plastics were a combination of different plastic materials which include soda bottles, chairs, car bombers and buckets. The combined shredded plastic starts melting at about 170^{0}C to about 260^{0}C as measured by the Temperature thermometer.

The proportion of 1.5 kg plastic, 0.5-2.5 kg varying amounts of sand, cement and stone dust were selected for a comprehensive evaluation of the composite material's properties, to identify the optimal mix for best performance, understand how each material composition affects the composite's properties, balance strength, durability, and chemical resistance, and determine the ideal ratio for cost-effectiveness and sustainability ensure industry standard compliance [7] and [8], for easier selection of the most suitable composite composition for specific applications, such as construction (foundations, walls) infrastructures(bridges, road),or industrial settings (Chemical plants, warehouses), considering factors like load-bearing capacity, exposure to hard chemicals, and environmental conditions. The melting ratio variations are shown below:

Table 1: Melting Ratio Variation for Plastic Pavement Blocks

S/N		Molten Plastic (kg)	Stone Dust (kg)	Sand (kg)	Cement (kg)
1	**Control**	-	-	0.3	0.7
2	**Plastic + Stone Dust**	1.5	0.5	-	-
		1.5	1.0	-	-
		1.5	1.5	-	-
		1.5	2.0	-	-
		1.5	2.5	-	-
3	**Plastic + Sand**	1.5	-	0.5	-
		1.5	-	1.0	-
		1.5	-	1.5	-
		1.5	-	2.0	-
		1.5	-	2.5	-
4	**Plastic + Sand + Cement**	1.5	-	0.3	0.2
		1.5	-	0.7	0.3
		1.5	-	1.0	0.5

		1.5	-	1.3	0.7
		1.5	-	1.5	1.0
5	**Plastic + Stone Dust + Cement**	1.5	0.3	-	0.2
		1.5	0.7	-	0.3
		1.5	1.0	-	0.5
		1.5	1.3	-	0.7
		1.5	1.5	-	1.0

Plates 1a & 1b: Melting of the plastic waste

Casting

The melted plastic was then poured into the already prepared mould with oil rub around the mould edges and allowed to take the shape of the mould freely to enable it get to every side of the mould in it molten form and for easy removal from the mould, this is for the pure plastic sample. While for the plastic-sand sample, the melted plastic was mixed manually in the barrel with different proportion of sand before the casting process.

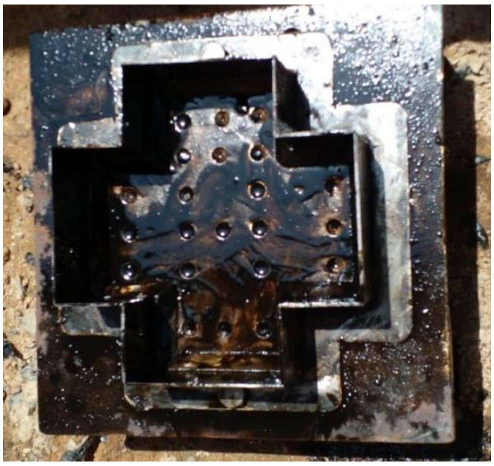

Plate 2a: Greasing of mould

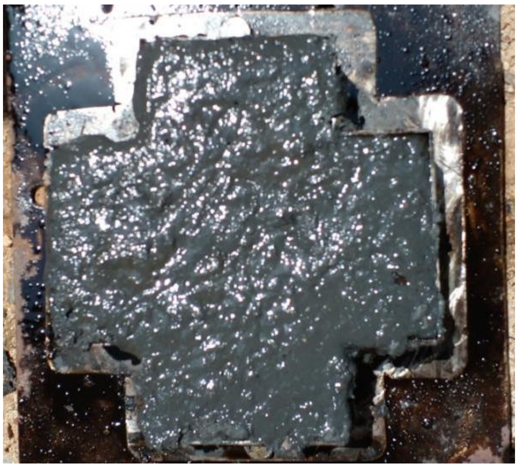

Plate 2b: Casting of the pavement block

Removal of mould

After the melted plastic was poured into the mould and allowed to take the shape of the mould, then allowed to cool under natural cooling process for 45 minutes. The mould was then removed to allowed free access of air for complete cooling. At this stage the plastic or plastic-sand interlocks were fully produced. And was allowed to stay for one month before the mechanical test were done to test the properties of the tile and make comparison between the different samples.

Plates 3a & 3b: Developed plastic pavement block composites

Physio-Chemical Tests

The composite samples were air cured for 28days to assess their long-term strength and durability, following [9] standards. They were prepared into different dimensions according to the various American Society for Testing and Materials (ASTM) Standard before carrying out the test analysis. These tests include water absorption, and chemical resistance tests.

Water absorption

The samples were cut to certain dimensions using ASTM D570 standard and measured using a weighing balance in its dry state, then immersed in separate containers containing water and left for about 30 days. The samples were then removed and weighed to determine the water absorption level daily. It is done to determine the mixture content as a percentage of a dry weight, the water absorption capacity of the tile increase the weight of the tile. Distilled water was used for the purpose of this research. The percentage of water absorption is determined using

$$\%\ \text{water absorption} = \frac{Initial\ weight - final\ weight}{initial\ weight} \times 100$$

Chemical resistance

The chemical resistance of pavement blocks was comprehensively evaluated through 24-hour immersion tests in 5% (w/v) sodium hydroxide (NaOH) and 5% (v/v) hydrochloric acid (HCl) solutions, conducted at room temperature (23°C ± 2°C). Prior to immersion, test specimens (50 mm x 50 mm x 5 mm) were accurately weighed and measured. Following the 24-hour exposure, specimens were removed, rinsed with distilled water, and re-weighed and re-measured to assess changes in weight and dimensions. Additionally, visual inspections were performed to detect any signs of degradation, cracking, or discoloration. The results obtained from this study are presented herein, adhering to the guidelines outlined in ASTM G20 for chemical resistance testing.

RESULTS AND DISCUSSION

Water absorption

The water absorption results of the four samples were presented in Figure 1. The conventional block absorbed 7.8% of its known volume of distilled water, exceeding the ASTM standard for water absorption (less than 5%) [10]. In contrast, the pure plastic block exhibited minimal water absorption at 0.8%. The plastic-cement combination demonstrated exceptional water resistance, with only 0.2% absorption. The plastic sample containing all three fillers (sand, stone dust, and cement) absorbed 1% of the water. These results indicate that the conventional block’s high water absorption is due to its porous nature. The superior water resistance of the plastic-cement sample can be attributed to the hydrophobic properties of cement [11], which enhance interfacial bonding, reduce porosity, and increase block density. In the case of the plastic sample with the three fillers, the water absorption is influenced by the porosity and the interfacial transition zone (ITZ) between the plastic fillers. The distribution of the plastic matrix and fillers minimizes water absorption pathways, resulting in relatively low absorption [12]

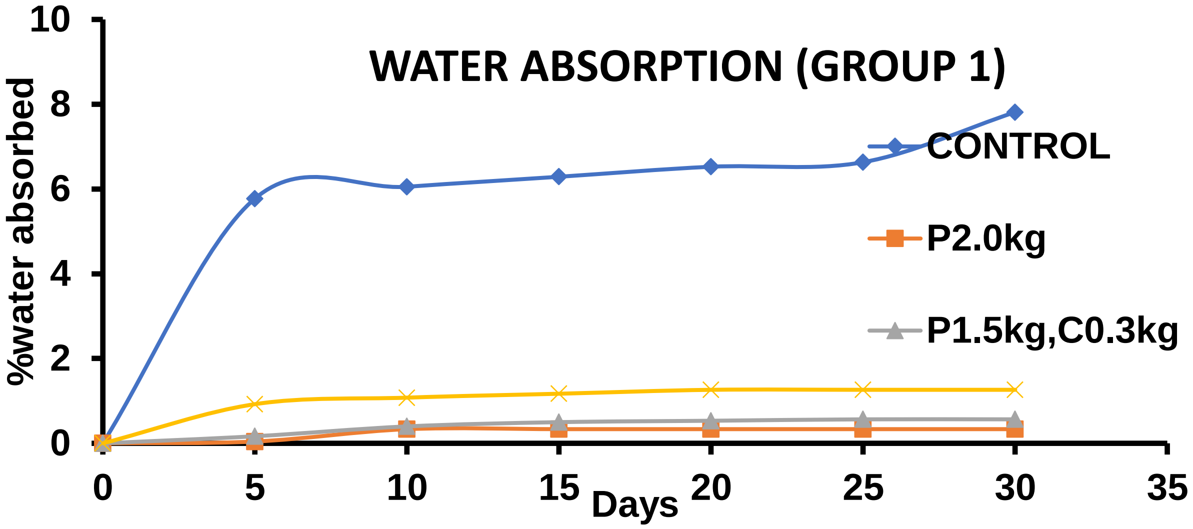

Fig 1: % of water absorbed by group 1

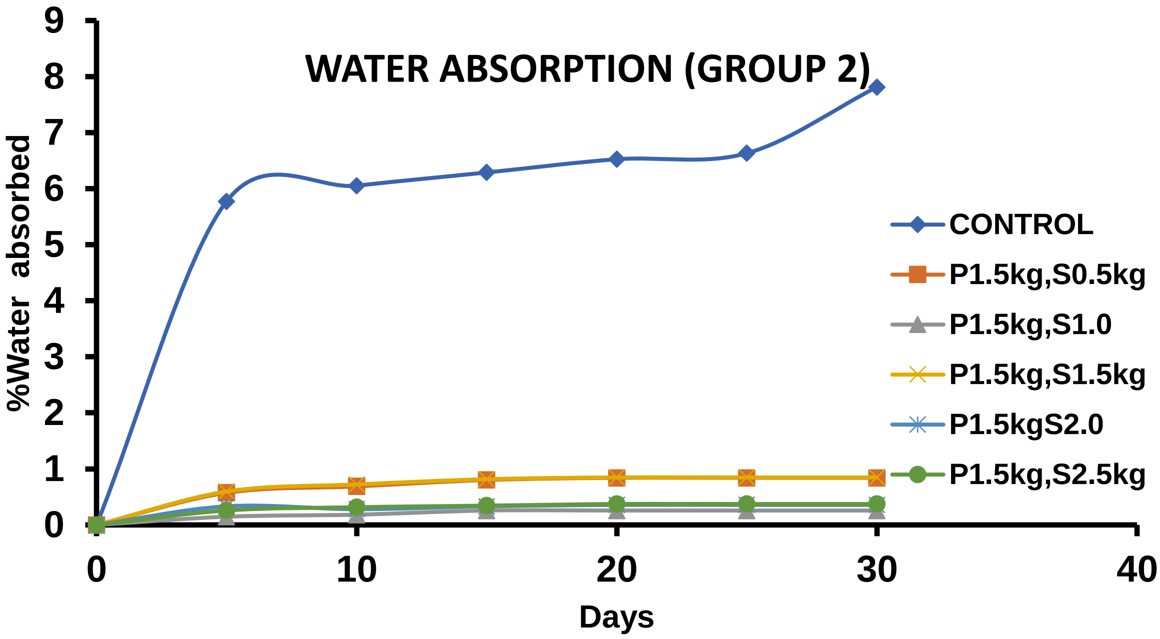

Figure 2: % of water absorbed by group 2

According to the results presented in Figure 2, Group 2's water absorption findings indicated that varying the sand ratios significantly affected water resistance. The 1:1 ratio (1.5 kg of plastic combined with 1.5 kg of sand) resulted in a water absorption of 0.8%. However, increasing the sand ratios to 1:2 (1.5 kg plastic + 2.0 kg sand) and 1:1.67 (1.5 kg plastic + 2.5 kg sand) notably decreased the water absorption to 0.3% [13]. This reduction is attributed to the sand filling voids within the plastic matrix, which enhances mechanical properties [14] and contributes to its hydrophobic nature [15]. When the sand ratio was decreased to 1:0.67 (1.5 kg plastic + 1.0 kg sand), water absorption dropped to 0.2%, likely due to optimal bonding and reduced porosity. However, further decreasing the sand ratio to 1:0.33 (1.5 kg plastic + 0.5 kg sand) resulted in increased absorption to 0.8%, attributed to higher porosity and diminished mechanical properties [16]. These findings highlight the crucial role of sand content in water absorption, with optimal ratios (1:0.67, 1:2, 1:1.67) ensuring effective bonding, minimal voids, and improved mechanical properties, leading to reduced water absorption. The 1:0.67 plastic-sand ratio exhibited the best performance, presenting a promising solution for water-resistant and sustainable pavement construction. Ideal applications for this material include highways, airport runways, and parking lots.

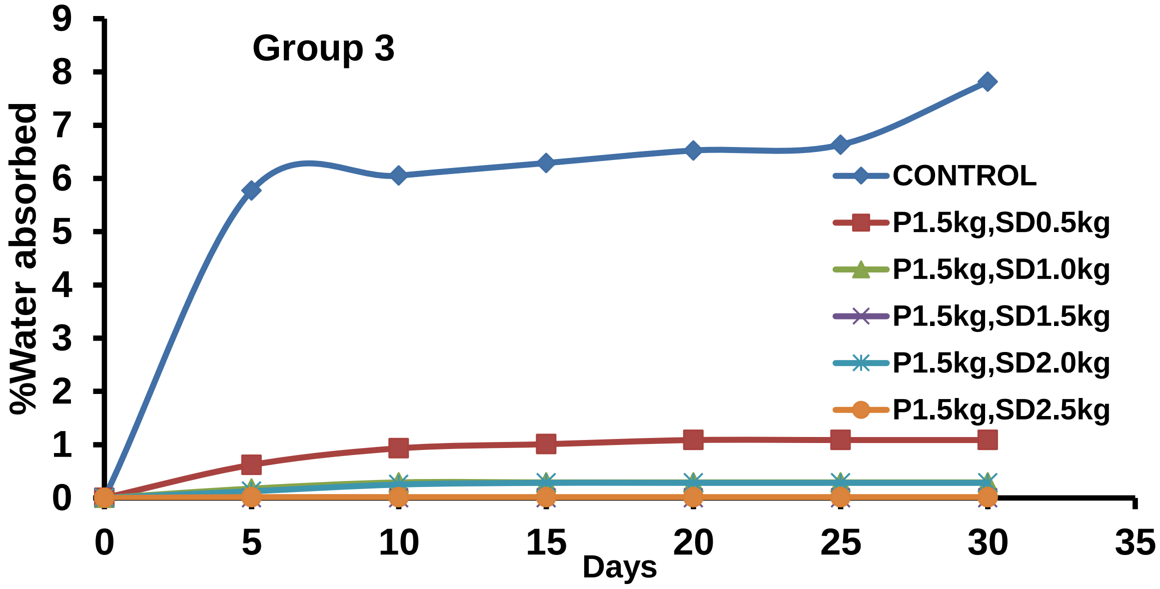

Fig 3: % of water absorbed by group 3

The water absorption results presented in Figure 3 demonstrated significant improvements compared to the control sample (7.8%) [17]. Five plastic-stone dust blocks were tested, each with a constant plastic weight of 1.5 kg and varying ratios of stone dust. The 1:1 ratio (1.5 kg plastic + 1.5 kg stone dust) exhibited the lowest water absorption at 0.002%, indicating optimal bonding and minimal porosity [18]. This reduction is attributed to the stone dust filling voids within the plastic matrix, which decreases porosity and capillary action [19]. The enhanced mechanical properties resulting from increased stone dust content improve interfacial bonding [20], while the hydrophobic nature of stone dust further contributes to the lower water absorption [21]. This sustainable material demonstrates improved durability and offers cost-effective solutions for construction, along with environmental benefits. Conversely, lower stone dust ratios, such as 1:0.33 (1.5 kg plastic + 0.5 kg stone dust), resulted in higher water absorption at 1.0%. When the stone dust ratio exceeded 1:1, water absorption increased, with ratios of 1:1.33 (1.5 kg plastic + 2.0 kg stone dust) and 1:1.67 (1.5 kg plastic + 2.5 kg stone dust) showing absorption rates of 0.28% and 0.01%, respectively. This increase may result from an oversaturation of the plastic matrix with stone dust, leading to agglomeration, potential reductions in interfacial bonding, and increased viscosity.

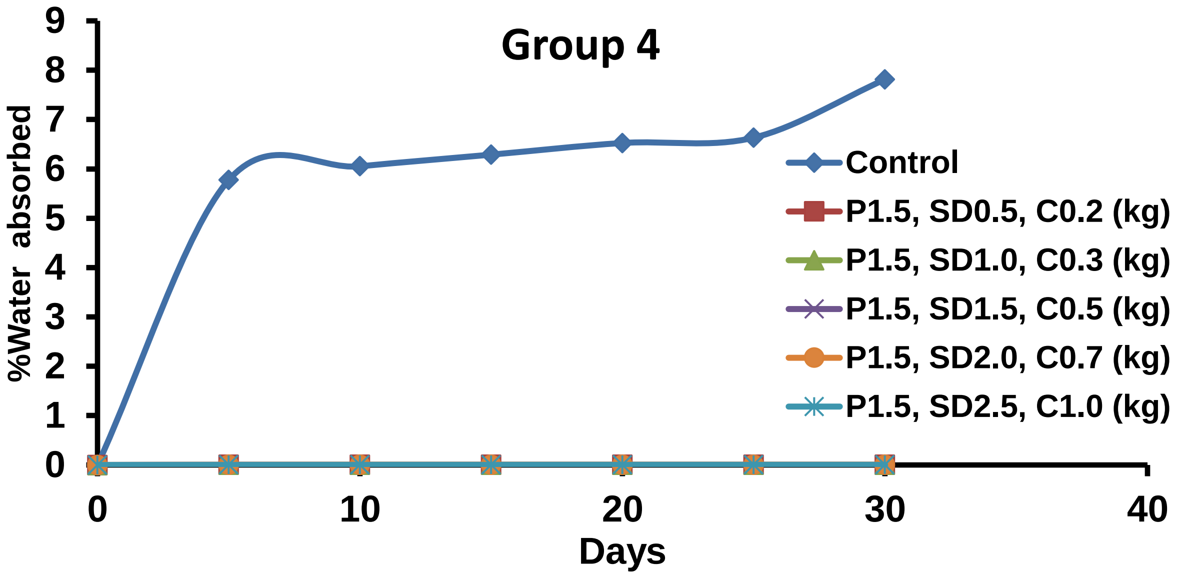

Fig 4: % of water absorbed by group 4

According to Figure 4, Group 4 exhibited notable reductions in water absorption compared to the control sample (7.8%) [22]. The composite samples displayed varying absorption rates: (1.5 kg plastic + 0.5 kg stone dust + 0.2 kg cement) at a ratio of 15:5:2 showed 0.003% absorption; (1.5 kg plastic + 1.0 kg stone dust + 0.3 kg cement) at 15:10:3 had 0.002%; (1.5 kg plastic + 1.5 kg stone dust + 0.5 kg cement) at 15:15:5 also showed 0.002%; (1.5 kg plastic + 2.0 kg stone dust + 0.7 kg cement) at 15:20:7 exhibited 0.001%; and (1.5 kg plastic + 2.5 kg stone dust + 1.0 kg cement) at 15:25:10 demonstrated 0.002%. These reductions are attributed to improved mechanical properties [23], enhanced interfacial bonding [24], and the hydrophobic nature of stone dust, which contributes to decreased water absorption [25], alongside increased cement content that minimizes porosity and capillary action [26]. The optimal water resistance observed in the composite materials can be linked to the synergistic effects of stone dust and cement. The hydrophobic properties of stone dust, resulting from its crystalline silica structure, low-porosity calcium carbonate, chemically inert aluminum oxide, hydrophobic iron oxide, and insoluble magnesium carbonate, contribute to its ability to enhance mechanical strength and interfacial bonding. Meanwhile, the binding properties of cement help reduce porosity and capillary action. As the cement content increased from 0.2 to 1.0 kg, the strength and durability of the composite improved, resulting in minimal water absorption (0.001-0.003%) across the samples (15:5:2 to 15:25:10). This collaboration between stone dust and cement highlights their potential for creating water-resistant materials, making them suitable for flooring applications. The optimal ratios reflect carefully balanced combinations of plastic, stone dust, and cement, supporting previous research on sustainable construction materials [27]. As shown in Figure 5, Group 5 demonstrated outstanding water resistance, with samples exhibiting significantly lower water absorption compared to the control (7.8%) [22]. Five composite samples, each containing 1.5 kg of plastic waste, were prepared with varying cement-sand ratios: 15:3:2, 15:7:3, 15:10:5, 15:13:7, and 15:15:10. These samples consistently showed low water absorption values of 0.002%, 0.001%, 0.001%, 0.001%, and 0.001%, respectively. This remarkable consistency is due to the optimal combination of properties from sand and cement.

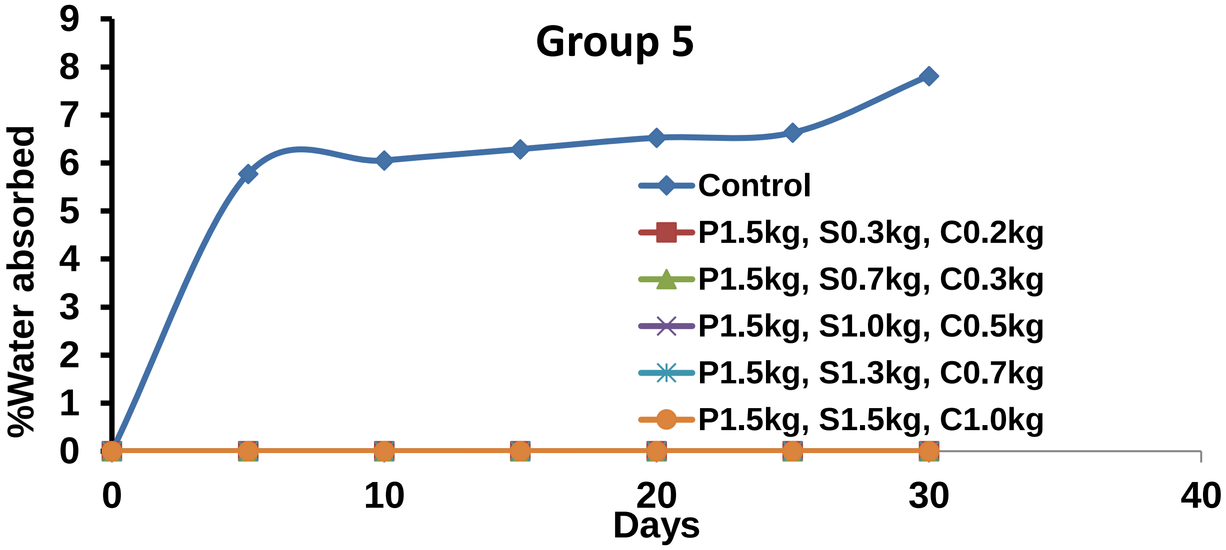

Fig 5: % of water absorbed by group 5

The hydrophobic nature of sand [28], along with its low porosity [29], uniform particle size and distribution [30], chemical inertness [31], and irregular surface texture [32], minimizes water attraction and penetration. Additionally, the hydration process of cement [33], its binding properties [34], low porosity [35], chemical reactivity [29], and filling effect [31] further contribute to reducing water absorption. The synergistic combination of these properties led to a significant reduction in water absorption. The water absorption rates of the five groups of plastic waste composites varied as follows: Group 5 (0.001%) < Group 4 (0.001-0.03%) < Group 3 (0.002-1.0%) < Group 2 (0.2-0.8%) < Group 1 (0.04-7.8%). This study outperforms previous studies, which reported higher water absorption rates despite varying proportions [36, 37]. However, the current study demonstrates a significant reduction of 94-97% in water absorption.

Chemical Resistance

(a) Acid Resistance

From Figure 6, the chemical resistance test results indicate that incorporating plastic waste in pavement blocks enhances their resistance to acidic environments significantly [29]. When subjected to HCl acid for 24 hours, the control sample exhibited the highest acid absorption at 4.39%, whereas samples containing plastic waste showed lower absorption rates. Specifically, sample 2 with 2.0 kg of plastic absorbed 0.26% of the acid, while sample 3 (1.5 kg plastic + 0.3 kg) and sample 4 (1.5 kg plastics + 0.2 kg sand + 0.3 kg cement) absorbed 0.28% and 0.25% of the acid. The drastic reduction in acid absorption is a result of the hydrophilic nature of plastic, which repels acidic substances, and its ability to fill pores within the block, reducing acid penetration [38]. The minimal variation between samples 3 and 4 suggests that sand addition does not significantly impact chemical resistance.

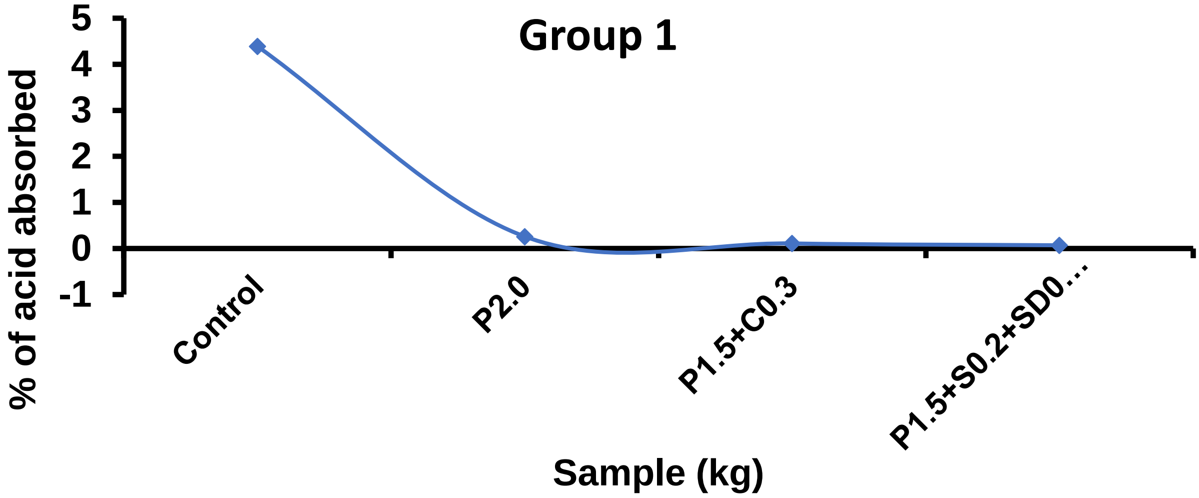

Fig 6: % of acid absorbed by group 1

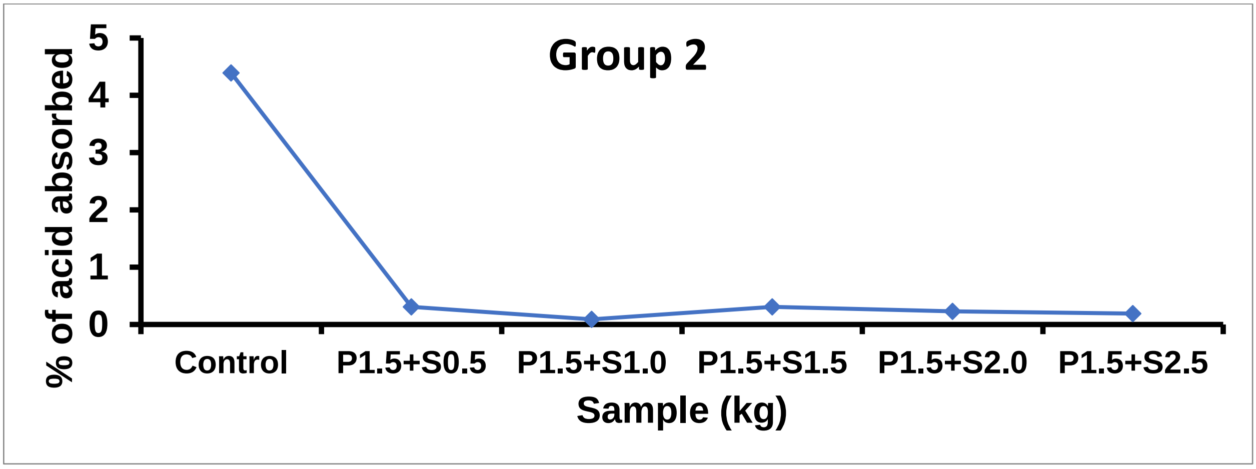

Fig 7: % of acid absorbed by group 2

From Figure 7, the chemical resistance test results demonstrate that incorporating plastic waste and sand in pavement blocks enhances their resistance to acidic environments [39]. When exposed to HCl acid for 24 hours, the control sample exhibited the highest acid absorption at 4.39% of acid, whereas samples containing plastic waste and varying sand proportions showed significantly lower absorption rates. Sample 3, containing 1.5 kg plastic and 1.0 kg sand, exhibited the lowest acid absorption at 0.09%, suggesting an optimal sand-plastic ratio. This improvement can be attributed to the hydrophobic nature of plastic, which repels acidic substances, and sand's ability to fill pores, reducing acid penetration [40]. The data indicates a non-linear relationship between sand content and acid absorption. Samples with higher sand proportions (2.0 kg and 2.5 kg) exhibit lower acid absorption rates compared to those with lower sand proportion (0.5 kg-1.5 kg). To investigate the non-linear relationship between plastic-sand acid absorption, further tests are recommended, including Scanning Electron Microscopy (SEM), Mercury Intrusion Porosimetry (MIP), Contact Angle Measurement, and Mechanical Strength Test to examine microstructure, porosity, hydrophobicity, and mechanical properties. Statistical analyses, such as non-linear regression and ANOVA, can be employed to model and understand the relationships between the variables.

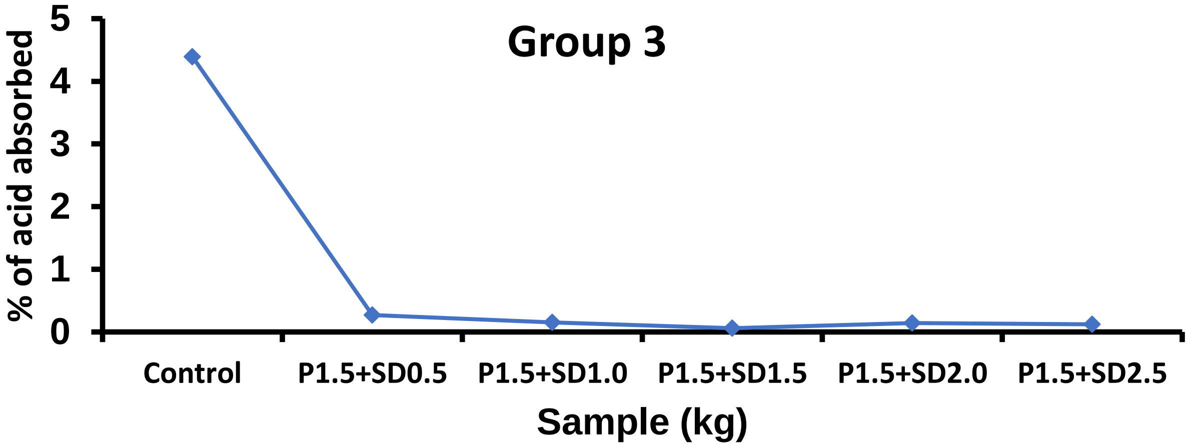

Fig 8: % of acid absorbed by group 3

Figure 8 shows the chemical resistance test results, demonstrating that incorporating plastic waste and stone dust in pavement blocks enhances their resistance to acidic environments [41]. When exposed to HCl acid for 24 hours, the control sample absorbed 4.39% of the known volume of acid, while samples with plastic waste and varying proportions of stone dust showed significantly lower absorption rates. Acid absorption decreases progressively with an increase in the stone dust content, with sample 4 (1.5 kg plastic + 1.5 kg stone dust) exhibiting the lowest absorption at 0.06%. This improvement can be attributed to stone dust's pore-filling ability, reducing acid penetration, and plastic's hydrophobic nature, repelling acidic substances [42]. The consistent decrease in acid absorption with increased stone dust content is a synergistic effect between plastic waste and stone dust.

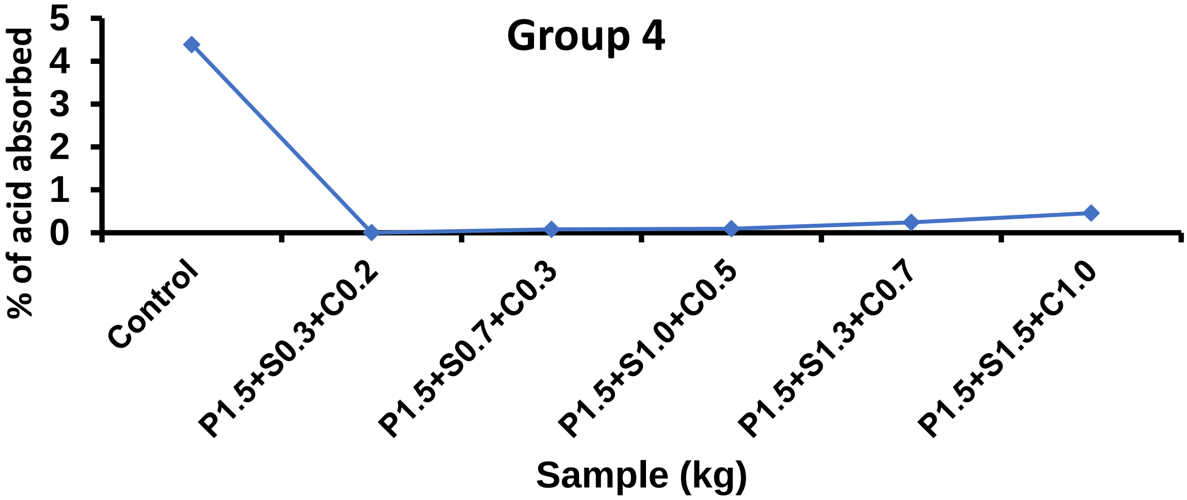

Fig 9: % of acid absorbed by group 4

The chemical resistance test results of Group 4, as shown in Figure 9, demonstrate a significant improvement in acid resistance with optimal proportions of plastic-sand-cement. The control sample showed 4.39% absorption, whereas Sample 2 (1.5 kg plastic + 0.3 kg sand + 0.2 kg cement) exhibited remarkable 0.0% acid absorption, indicating excellent chemical resistance [43]. Increasing sand content to 0.7 kg and 1.0 kg (Samples 3 and 4) slightly increased acid absorption to 0.08% and 0.09%, due to increased porosity. Further increase in sand and cement content (Samples 5 and 6) significantly reduced chemical resistance, with 0.24% and 0.46%, respectively. This decline was attributed to aggregate effects, reduced plastic-sand interaction, and increased cement alkalinity [44]. These results show that optimal chemical resistance is achieved with low sand and cement proportions.

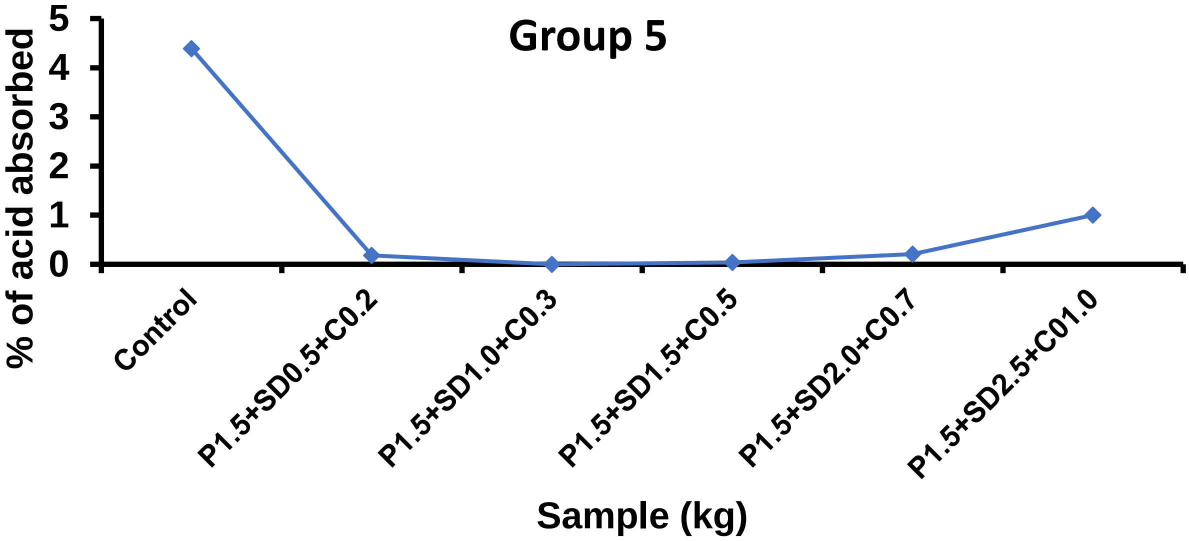

Fig 10: % of acid absorbed by group 5

Figure 10 represents the chemical resistance test of Group 5 samples, demonstrating significant improvements in acid resistance with the optimal proportions of plastic, stone dust, and cement. Sample 2 (1.5 kg plastic + 1.0 kg stone dust + 0.3 kg cement) achieved 0.00% acid absorption, indicating exceptional chemical resistance due to the synergistic effect between plastic's hydrophobicity and stone dust's pore-filling interaction [45]. Increasing stone dust content beyond 1.0 kg slightly reduced chemical resistance, potentially due to aggregate effects or reduced plastic-stone dust interaction. Excessive cement content (Sample 6) compromised chemical resistance with 1.0% acid absorption, due to cement's alkalinity and increased porosity [46]. Optimal acid resistance was achieved with the combination of 1.5 kg plastic, 1.0 kg stone dust, and 0.3 kg cement.

Acid Absorption Comparison of Plastic-Stone dust-Cement Composite Materials

Table 2: Chemical Resistance of Similar Studies

Study	**Plastic (kg)**	**Stone Dust (kg)**	**Cement (kg)**	**Acid Absorption (%)**
Siddique *et al.,* (2017)	1.0	0.8	0.2	1.2
Ali *et al.,* (2018)	1.0	0.6	0.2	1.5
Jha et al., (2019)	1.2	1.2	0.4	0.08
Ravindrarajah et al., (2020)	**1.5**	**1.0**	**0.3**	**0.12**
Kumar et al., (2020)	1.2	1.5	0.6	0.05
Sharma et al., (2020)	1.5	1.2	0.4	0.01
Current study	**1.5**	**1.0**	**0.3**	**0.00**

Table 2 demonstrates our composites material’s superior chemical resistance, surpassing existing studies. This optimized composition has significant implications for harsh environment applications, including coastal infrastructure and chemical plants. Further research will focus on scalability, predictive modeling, and expanded applications.

(b) Base Resistance

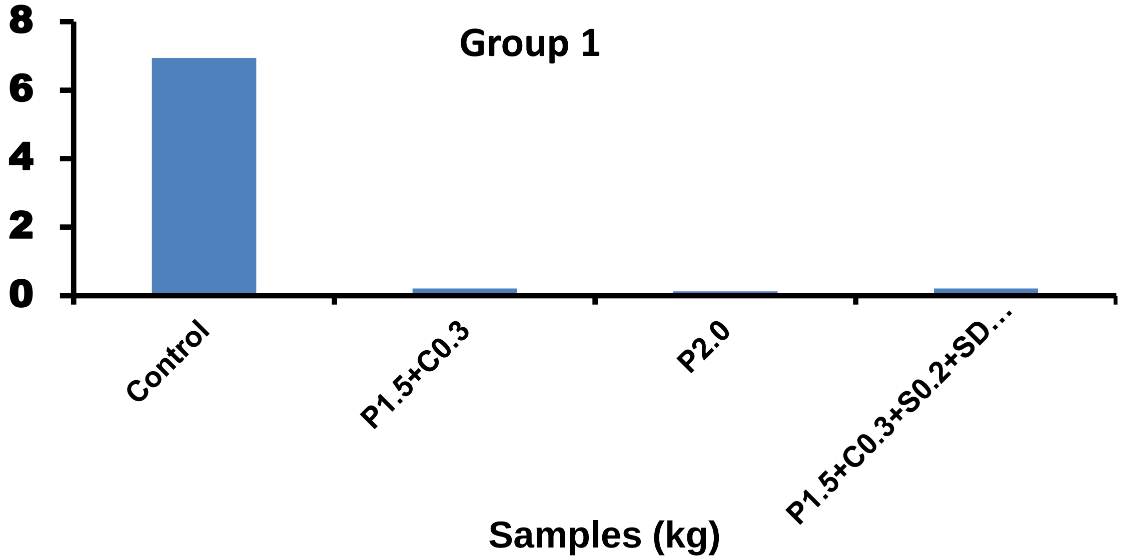

Fig 11: % of base absorbed by group 1

Figure 11 presents the chemical absorption results, showing that composite samples exhibited significantly lower NaOH absorption compared to the control sample (6.94%). Sample 3 (2.0 kg plastic) demonstrated the lowest NaOH absorption (0.13%), indicating improved chemical resistance with increased plastic content [47]. The combination of plastic (1.5 kg) and cement (0.3 kg) showed similar NaOH absorption (0.21%) as the sample with added sand, stone dust, and plastic, which reduced absorption. The addition of sand increased material density, while plastic enhanced impermeability [48]. These results classify materials as having excellent (≤ 0.2%) to good (≤ 0.5%) NaOH resistance, meeting (ASTM C672-17) and (ACI 201.2R-08) standards for applications in construction and chemical processing.

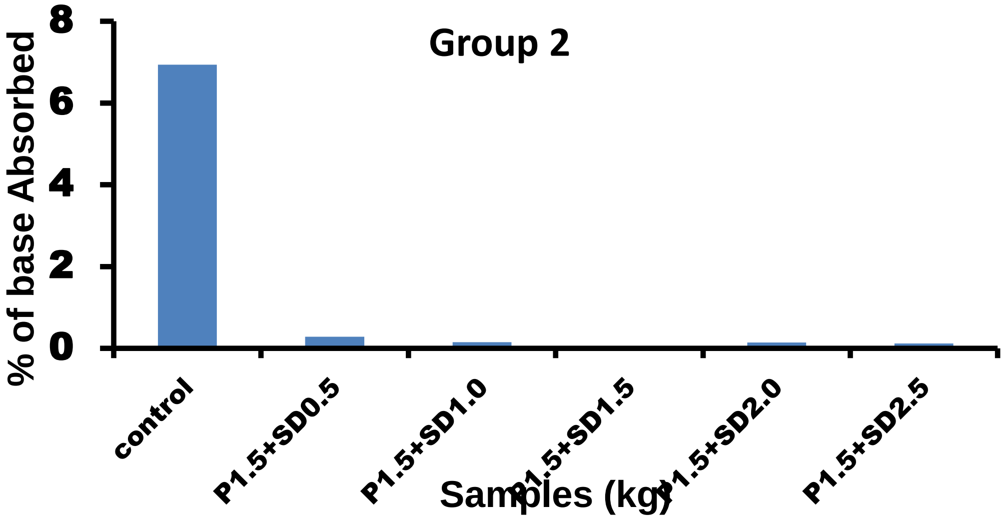

Fig 12: % of base absorbed by group 2

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Figure 12 presents the NaOH absorption test results, showing significant improvements in chemical resistance with increasing stone dust content in plastic-based composites. The control sample absorbed 6.94%, while combinations of 1.5 kg plastic with varying stone dust amounts showed reductions: 0.5 kg (0.28%), 1.0 kg (0.15%), 1.5 kg (0.06%), 2.0 kg (0.14%), and 2.5 kg (0.12%). Increasing stone dust improves chemical resistance by reducing voids and densifying the structure, but excessive stone dust (beyond 1.5 kg) may lead to uneven plastic distribution, slightly increasing absorption [49]. This aligns with [47] and [50] standards, demonstrating that the optimal composition (1.5 kg plastic, 1.5 kg stone dust) achieves excellent NaOH resistance.

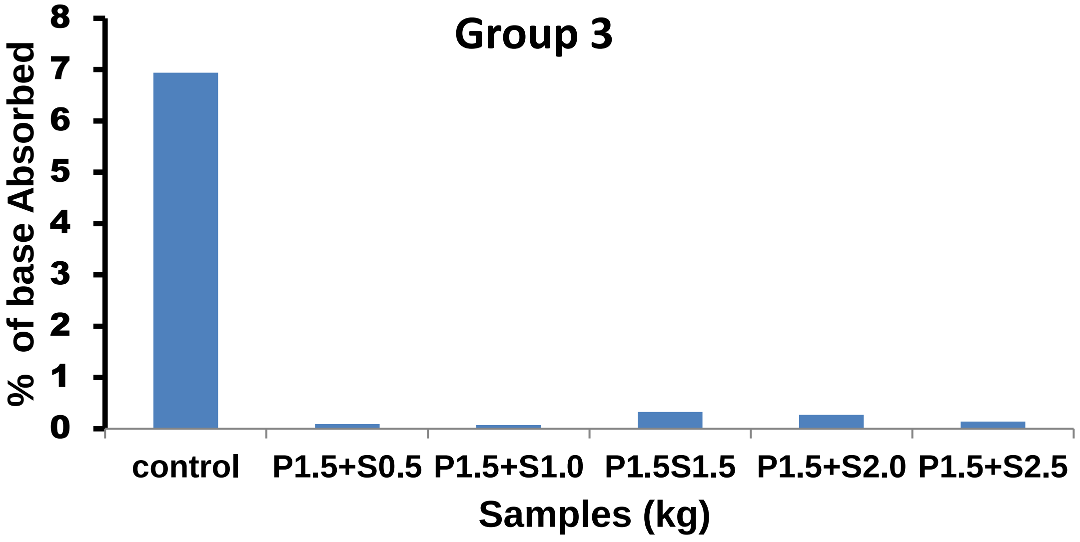

Fig 13: % of base absorbed by group 3

The absorption rates of Group 3, as shown in Figure 13, demonstrate a significant reduction with the addition of sand to a constant 1.5 kg of plastic. The optimal mixture, comprising 1.5 kg of plastic and 1.0 kg of sand, achieved the lowest absorption rate (0.07%), compared to the control (6.94%). This improvement is attributed to enhanced particle packing and reduced porosity [51]. Increasing sand beyond 1.0 kg decreased performance, likely due to increased voids and reduced plastic-sand interaction [52]. The results suggest an optimal sand-plastic ratio for minimizing absorption.

GROUP 4

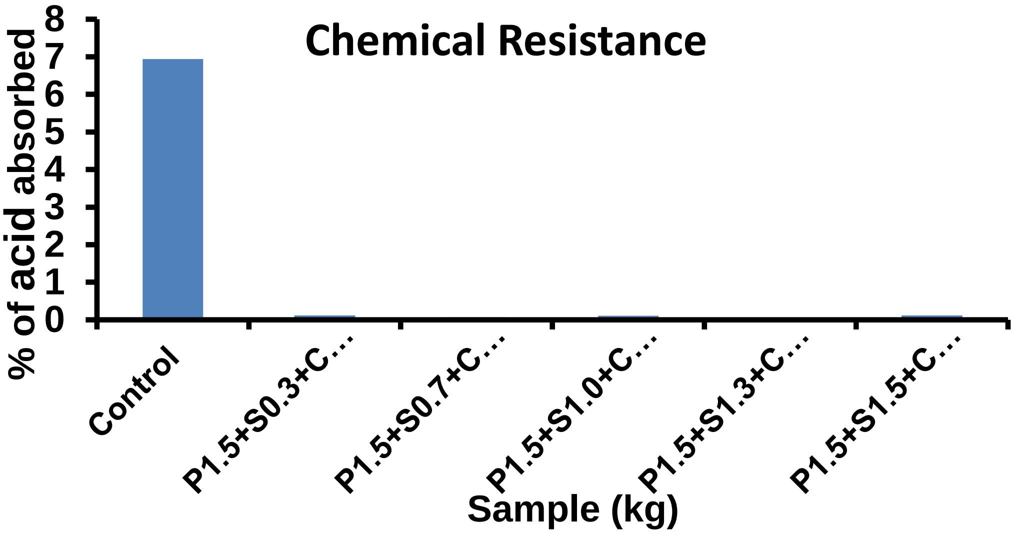

Fig 14: % of base absorbed by group 4

The results indicate a substantial reduction in absorption rates for pavement blocks composed of optimized plastic, sand, and cement proportions, as shown in Figure 14. The control exhibited an absorption rate of 6.94%, whereas the optimal mixture consisting of 1.5 kg plastic, 1.3 kg sand, and 0.7 kg cement achieved a remarkable 0.00% absorption rate. This significant improvement can be attributed to enhanced particle packing and reduced porosity [51], as well as improved interfacial interactions between plastic, sand, and cement [52]. The binding properties of the cement contributed to the reduced absorption [53]. Excessive sand content (1.5 kg plastic, 1.5 kg sand, 1.0 kg cement) resulted in increased absorption (0.12%), underscoring the importance of optimal proportioning.

The pavement block's absorption rates significantly decreased with the optimal proportions of plastic, stone dust, and cement, as shown in Figure 15 for Group 5. The control showed an absorption rate of 6.94%, whereas the optimal mixture consisting of 1.5 kg plastic, 2.0 kg stone dust, and 0.7 kg cement achieved a remarkable 0.07% absorption. This improvement is attributed to improved mechanical interlock and bonding between plastics, stone dust, and cement particles. This finding aligns with studies by [54], who achieved 0.01% absorption using 1.5 kg plastic, 1.8 kg stone dust, and 0.9 kg cement [55], who achieved 0.03% absorption using 1.2 kg plastic, 1.5 kg stone dust, and 0.6 kg cement. [56], who achieved 0.05% absorption using 1.8 kg plastic, 2.5 kg stone dust, and 1.2 kg cement in plastic-based concrete. These comparisons highlight the importance of optimized mix design for minimizing absorption. Increasing stone dust from 1.0 kg to 2.0 kg and cement from 0.3 kg to 0.7 kg yielded optimal results. Excess stone dust (2.5 kg) and cement (1.0 kg) increased absorption to 0.2%.

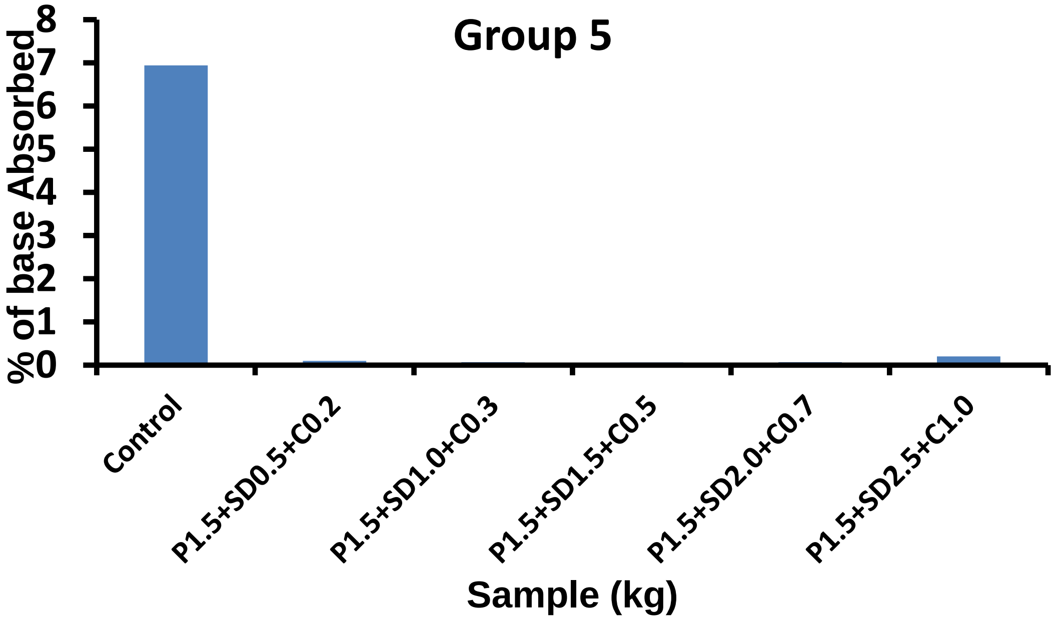

Fig 15: % of base absorbed by group 5

CONCLUSION

This study has efficiently and effectively demonstrated the application of plastic waste into useful constitutional materials as well as reducing the hazards caused by plastic wastes in our environment.

The pavement blocks produced by the virtue of this study has shown far better quality in terms of both mechanical and chemical resistance properties than the conventional pavement blocks while reducing cost of production and creating eco-friendly environment.

Furthermore, this study has demonstrated a very inherent economic importance of plastic wastes that on a norm, are littered in our surroundings disadvantageously.

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