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PHYSICOCHEMICAL CHARACTERISATION OF POLYESTER AND NYLON SYNTHETIC FIBRES AS POTENTIAL PLANT GROWTH SUBSTRATES FOR GREEN ROOF SYSTEMS: A PRELIMINARY STUDY

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ABSTRACT

Green roofs are recognised as effective urban sustainability infrastructure, yet the conventional use of soil-based growing media poses challenges, including high dead loads, progressive structural decomposition, and costly long-term maintenance. This study presents a preliminary physicochemical characterisation of shredded Polyester and Nylon textile waste fabrics as novel, lightweight, synthetic growing substrates for green roof systems, evaluating their suitability against established benchmarks. No plant growth trials were conducted; the scope is limited to laboratory characterisation of key physicochemical properties. Growing medium containers filled with shredded polyester and Nylon fabrics were characterized for bulk density, particle density, total porosity, Water Holding Capacity (WHC), Water Retention Capacity (WRC), pH, and Electrical Conductivity (EC). Mean bulk densities of 0.22 ± 0.015 gcm^{-3} (Nylon) and 0.145 ± 0.019 gcm^{-3} (Polyester) represent reductions of 63-89% relative to conventional green roof soils. Total porosity exceeded 74% for nylon and 84% for polyester, exceeding the FLL minimum of 35%. WHC ranged from 63-66% (Nylon) and 72-78% (Polyester), satisfying the FLL requirement of ≥35% by volume. The water retention curves demonstrated that polyester maintained consistently higher water retention throughout the drying period, retaining approximately 17% of absorbed water, indicating polyester's superior capillary water-holding capacity driven by its fibrous matrix structure. Both substrates exhibited pH values within the optimal horticultural range and EC values indicating minimal salinity stress risk. These preliminary results suggest that recycled synthetic textile waste fibers warrant further investigation as lightweight, chemically inert,

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and structurally stable growing media for green roof systems, pending validation through plant growth trials.

Keywords: *Green roof substrate; Growing media; Nylon; Polyester; Synthetic fibre; Urban greening.*

1. INTRODUCTION

Rapid urbanisation worldwide has led to the systematic displacement of natural vegetated surfaces by impervious built environments, resulting in a range of well-documented ecological and infrastructural consequences. These include exacerbated Urban Heat Island (UHI) effects, diminished stormwater management capacity, habitat fragmentation, elevated energy consumption in buildings, and deterioration of urban air quality (Getter & Rowe, 2006; Vijayaraghavan, 2016). Green roof technology has emerged as one of the most promising strategies for recovering lost green coverage within dense urban environments, simultaneously delivering stormwater attenuation, thermal insulation, biodiversity enhancement, and extended waterproof membrane life (Dunnett et al., 2008).

A green roof system is typically composed of overlapping functional layers: a structural waterproofing membrane, a root barrier, a drainage layer, a filter fabric, the growing substrate, and the vegetation layer, as illustrated in Figure 1. Among these, the growing substrate is widely regarded as the most critical layer, as it provides physical anchorage, water and nutrient retention, and aeration for root respiration (Ampim et al., 2010, Farrell et al., 2013).

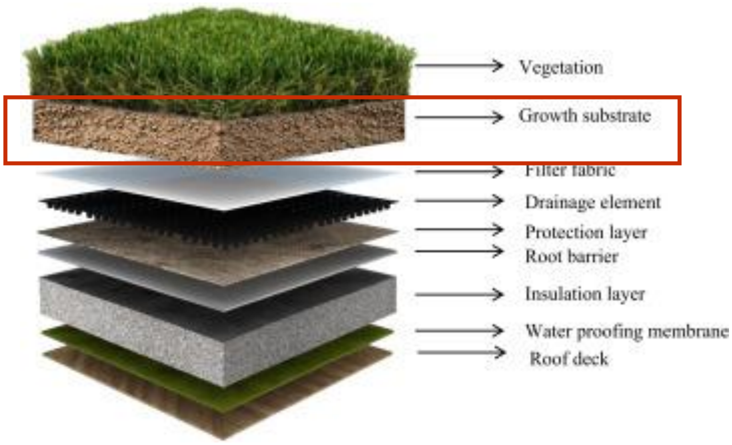

Figure 1: Overlapped functional layers of the green roof (Vijayaraghavan, 2016)

Despite substantial advances in green roof technology, soil remains the most commonly employed substrate material in many developing countries, largely due to its local availability and low cost. However, soil-based substrates impose significant dead loads on the roofing structure, exhibit progressive compaction and structural decomposition over time, and demand ongoing maintenance interventions including amendment, topping-up, and weed management (Getter & Rowe, 2006; Vijayaraghavan, 2016).

The ideal green roof growing substrate must satisfy a demanding and often competing set of physicochemical criteria. International guidelines, most notably the German FLL Guidelines (Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau [FLL], 2018), stipulate that substrates should exhibit a dry bulk density not exceeding 1,200 kg/m³ (1.2 g/cm³), a total porosity and Water Holding Capacity (WHC) between 35 and 65% by volume, a pH in the range of 6.0-8.5, and an Electrical Conductivity (EC) below 3.5 g/L for extensive systems (Graceson et al., 2013). Meeting these criteria while simultaneously minimising structural weight and long-term maintenance costs remains a core challenge in green roof substrate design.

In response to these challenges, researchers have explored a broad range of alternative and recycled growing media, including crushed brick and tile, pumice and volcanic tuff (Tala et al., 2020), expanded clay aggregates (Graceson et al., 2014), coco-peat blends (Vijayaraghavan & Raja, 2014), rice hulls (Farrell et al., 2013), and biochar (Nguyen et al., 2024). The growing global textile industry generates enormous quantities of synthetic fabric waste, with polyester and nylon constituting the two most widely produced synthetic fiber categories. Both are manufactured from petroleum-derived polymers and are characterised by high durability, chemical inertness, low biodegradability, and pronounced resistance to biological decomposition. These properties, while often cited as environmental liabilities, may in fact confer significant advantages in the context of green roof substrate design, where long-term structural stability and resistance to organic matter breakdown are desirable attributes.

The use of synthetic fibrous materials as plant growing substrates is supported by specific experimental evidence. Studies by Pasian and Frantz (2008) demonstrated that polyethylene terephthalate (PET) fibers can serve as effective soilless growing media for floriculture, while Sharma et al. (2022) documented the compatibility of polyester and nylon agrotextiles with plant root systems. These investigations indicate that polyester and nylon fiber matrices can function as effective plant growing media in soilless cultivation and horticultural systems. Recyclable Polyethylene Terephthalate (PET), which is the same polymer used in polyester fibers, has been investigated as a component of synthetic growing media. These studies suggest that PET-based substrates can serve as a viable alternative growing medium for floriculture and other soilless crop production systems (Pasian & Frantz, 2008). Their investigation demonstrated that PET had already been applied as a growing medium substrate. Therefore, physical support, moisture retention, and appropriate aeration for seedling establishment in the same functional requirements demanded of green roof growing substrates. Furthermore, a substantial literature on agrotextiles, synthetic fabric materials applied directly in agricultural and horticultural settings, corroborates that Nylon and Polyester fibers are compatible with plant root systems and are routinely employed in crop protection, filtration, and root-zone management applications without phytotoxic effects (Sharma et al., 2022). These converging lines of evidence from soilless horticulture, agrotextile science, and Green roof engineering establish a firm scientific foundation for the hypothesis that Polyester and Nylon textile fibers are suitable as growing substrate materials, and motivate systematic characterization of their key physicochemical properties for Green roof application.

Despite the promising conceptual basis for textile-derived substrates and the supporting evidence from adjacent fields, no peer-reviewed study to date has systematically characterised shredded polyester and nylon fabrics as standalone green roof growing media and benchmarked their physicochemical properties against established substrate standards. The present study aims to address this gap by evaluating the bulk density, particle density, total porosity, water holding capacity, water retention capacity, pH, and electrical conductivity of shredded Polyester and Nylon textile substrates and comparing these parameters against both the FLL guideline thresholds and empirical values reported for conventional and alternative green roof growing media in the literature.

2. MATERIALS AND METHODS

The research methodology consisted of the following steps, as illustrated in Figure 2. Each step is briefly described in the sections below.

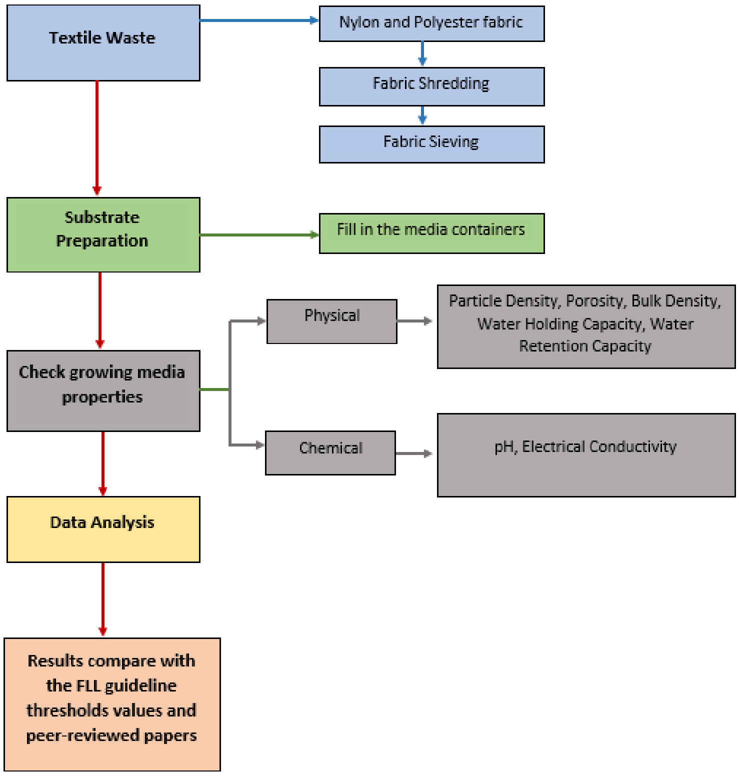

Figure 2: Flow diagram of the methodology

2.1 SUBSTRATE PREPARATION

Polyester and nylon textile waste fabrics were collected and subjected to mechanical shredding to produce fibrous substrate materials (Figure 3a–d).

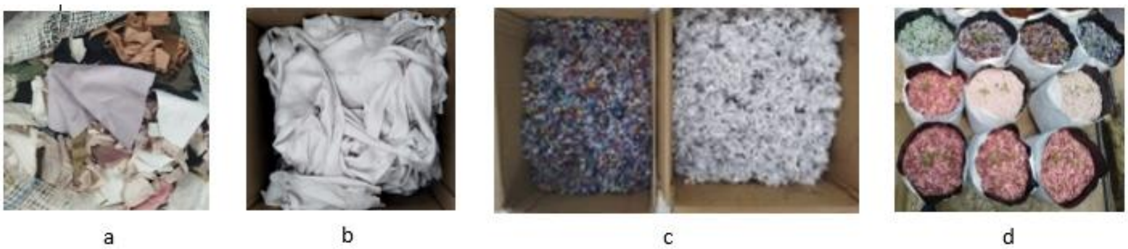

Figure 3: a: Polyester fabric, b: Nylon fabric, c: Shredded polyester and Nylon, d: Growing media filled to the grow bags

Shredded fabrics were packed into standardised grow bags to a uniform depth. Four replicate bags were prepared for each substrate type, designated as T1R1–T1R4 (Nylon) and T2R1–T2R4 (Polyester). All bags were prepared under controlled laboratory conditions (temperature: 25 ± 2°C; relative humidity: 60 ± 5%) to ensure consistent packing density across replicates and to minimise environmental variation in the physicochemical measurements.

2.2 PHYSICAL PROPERTY ASSESSMENT

Bulk density (g/cm³) was determined gravimetrically as the ratio of dry substrate mass to the volume occupied within the media (FLL, 2018). Particle density (g/cm³) was measured using a volumetric method with water as the displacement medium (FLL, 2018). Total porosity (%) was calculated using the standard formula:

Porosity (%) = [1 - (Bulk Density / Particle Density)] × 100. (01)

WHC was determined as the mass of water retained by the substrate after free gravitational drainage, expressed as a percentage of saturated substrate mass (FLL, 2018; Di Gioia et al., 2017). Water Retention Capacity (WRC) was assessed by measuring the percentage of water retained relative to the saturated mass after a defined drainage period (Durpekova et al., 2021).

2.3 CHEMICAL PROPERTY ASSESSMENT

The pH of each substrate was determined using a calibrated pH meter in a 1:2.5 substrate-to-distilled water suspension following standard horticultural protocols. EC was measured in the same suspension using a calibrated EC meter and expressed in μScm^{-1} (FLL, 2018).

2.4 STATISTICAL ANALYSIS

Descriptive statistics (mean and standard deviation) were computed for all measured parameters across the four replicates of each substrate type. Results were compared against FLL guideline thresholds and published empirical data from peer-reviewed studies on conventional and alternative green roof growing media.

3. RESULTS

3.1 PHYSICAL PROPERTIES

The physical properties of Nylon and Polyester substrates across all replicates are presented in Table 1.

Table 1. Physical and chemical properties of nylon and polyester synthetic fiber substrates

Synthetic growing media type	Treatments	Bulk Density (g/cm³)	Particle Density (g/cm³)	Porosity (%)	WHC (%)	pH	EC (µS/cm)
Nylon	T1	0.22 ± 0.015	0.955 ± 0.050	76.87 ± 2.44	64.47 ± 1.44	7.02 ± 0.16	210.3 ± 8.0
polyester	T2	0.145 ± 0.019	1.063 ± 0.125	86.10 ± 2.72	76.14 ± 2.19	7.04 ± 0.19	171 ± 4.56

WHC = Water Holding Capacity; SD = Standard Deviation

Nylon substrate recorded bulk densities 0.22 ± 0.015 gcm^{-3}, while Polyester replicates exhibited consistently lower bulk density mean 0.145 ± 0.019 gcm^{-3}. Particle density of Nylon growing substrate was 0.955 ± 0.05 gcm^{-3} and Polyester substrate was 1.063 ± 0.125 gcm^{-3}. Total porosity values ranged from 74.73 to 80% for nylon (mean 76.9 ±

2.4%) and from 84 to 90.4% for polyester (mean 86.1 ± 2.7%). WHC was high across all replicates, with nylon recording a mean of 64.47 ± 1.44% and polyester a mean of 76.14 ± 2.19%. WRC was notably variable, with nylon replicates ranging from 17 to 30% and polyester replicates from 22 to 45%.

3.2 WATER RETENTION CURVE OVER TIME

The temporal decline in water retention capacity for both substrate types across a six-day drying period is illustrated in Figure 4.

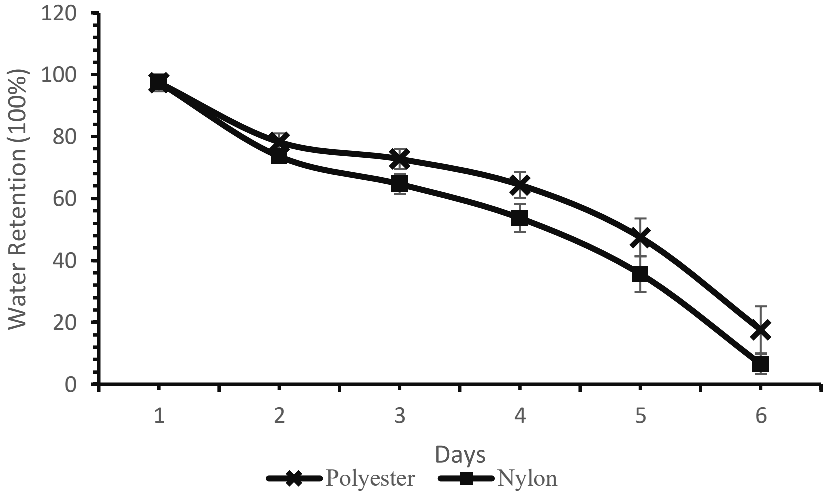

Figure 4: Water retention curve of Nylon and Polyester synthetic fibre substrates. Error bars represent standard deviation across four replicates (T1R1–T1R4 for Nylon; T2R1–T2R4 for polyester).

On Day 1, immediately following saturation and initial drainage, both substrates retained near-complete water content: polyester recorded approximately 98% and nylon approximately 96%. Water retention declined progressively for both materials across the observation period, with Polyester consistently retaining a higher percentage of water than Nylon at each time point.

By Day 2, polyester retained 79% and nylon 75% of initial water content. On Day 3, both substrates converged to 70% retention, with Polyester marginally higher. Divergence between the two substrates became more pronounced from Day 4 onwards: by Day 5, Polyester retained 48% while Nylon had declined to 36%. On Day 6, Polyester retained 17% compared with Nylon's near-zero retention (~3%). The error bars visible on Days 5 and 6 for polyester reflect inter-replicate variability in WRC, which is consistent with the higher standard deviation observed in the measured WRC values (Table 1). Nylon's more rapid and complete drainage to near-zero retention by Day 6 indicates a lower capacity to hold water against prolonged evaporative and gravitational losses, while polyester's sustained retention through Day 6 underscores its superior capillary water-holding performance as a green roof growing substrate.

3.3 CHEMICAL PROPERTIES

Both substrate types demonstrated near-neutral pH values. Nylon substrates exhibited a mean pH of 7.02 ± 0.16, Polyester substrates showed a mean pH of 7.04 ± 0.19. As shown in Table 2, these values fall well within the FLL-recommended pH range of 6.0 - 8.5 for green roof substrates (Eksi & Rowe, 2019).

Table 2. Comparison of physicochemical properties of synthetic fiber substrates with conventional and alternative green roof growing media reported in the literature

Substrate / Study	Bulk Density (g/cm³)	Porosity (%)	WHC (%)	pH	EC (µS/cm)	Reference
FLL Guideline Thresholds (Extensive)	0.60-1.20	≥35	35–65	6.0-8.5	-	(FLL, 2018)
Nylon Fiber (This Study)	0.22 ± 0.02	76.87	64.47	7.02	210.3	This study
Polyester Fiber (This Study)	0.145 ± 0.02	86.10	76.14	7.04	171	This study
Perlite	~0.12-0.24	~80.76	(~15–49)	~6.5-8.1	0-20	(Ampim et al., 2010; Cakar et al., 2023; Tala et al., 2020)
Expanded Clay (LECA)	~0.23-0.42	~78.20	~6-50	6.5-7.5	20	(Tala et al., 2020),
Volcanic Tuff (Coarse)	0.80–1.50	60-80	35-55	7.0-8.0	260-530	(Tala et al., 2020)
Pumice	0.83	~56.22	~30-40	~7.0	300-400	(Tala et al., 2020)
Optimal Mix (Vermiculite + Perlite + Sand + Coco-peat)	0.431	~60-70	39.4	~6.5-7.0	500-100	(Vijayaraghavan, 2016)
Sandy Loam Soil	1.10-1.40	40-55	30-60	6.5–7.6	1100	(Ampim et al., 2010; Cakar et al., 2023; Papadopoulos & Lieth, 2008; Tala et al., 2020)
Crushed Brick + Composted	-	-	10-32.5		-	(Graceson et al., 2013)
Sawdust (60:40 organic: base medium	~0.40-0.60	~60-70	High	~7.06	-	(Kader et al., 2024)
Biochar-amended	0.55-0.75	58-68	38-52	6.4-7.8	70-700	(Cao et al., 2014; Francis et al., 2021; Lacarne et al., 2021)
coir	0.19-0.8	79.2		6.0 - 6.8	861	(Cakar et al., 2023; Kader et al., 2024)

Substrate / Study	Bulk Density (g/cm^3)	Porosity (%)	WHC (%)	pH	EC (µS/cm)	Reference
Cocopeat	1.2-1.9	-	86.77	5.5-6.72	50-770	(Cakar et al., 2023; Tala et al., 2020)
Peat moss	1.2	-	79.28	3.5-5.9	760	(Tala et al., 2020)

Values represent means or reported ranges. WHC values for polyester and nylon exceed many conventional inorganic substrates while bulk densities are substantially lower.

Electrical conductivity values were very low for both substrates. Nylon exhibited the highest variability, with EC values 210.3 ± 8.0 μScm^{-1}. Polyester substrates recorded EC value 171 ± 4.56 μScm^{-1}). All measured EC values are substantially lower than those reported for conventional soil-based substrates in previous studies (Cakar et al., 2023; Kader et al., 2024). The FLL Guideline does not clearly mention the exact EC values.

4. DISCUSSION

4.1 BULK DENSITY AND STRUCTURAL WEIGHT IMPLICATIONS

The bulk densities recorded for both Nylon 0.22 ± 0.015 gcm^{-3} and polyester 0.145 ± 0.02 gcm^{-3} substrates are remarkably low in comparison to all conventional and most alternative green roof growing media reported in the literature. The FLL guidelines recommend a dry bulk density range of 0.60-1.20 gcm^{-3} for green roof substrates (FLL, 2018; Ampim et al., 2010), while typical sandy loam soil-based substrates commonly used in developing countries exhibit bulk densities of 1.10-1.40 gcm^{-3}. Even the lightest recognized inorganic substrates, such as perlite (~0.12 gcm^{-3}) and expanded clay (~0.23 gcm^{-3}) (Cakar et al., 2023; Tala et al., 2020), approach the range recorded for synthetic fiber substrates. The extremely low bulk density of shredded textile substrates translates directly to reduced dead load on roofing structures. This reduction would allow green roof installation on a far wider range of building types, including structures with limited load-bearing capacity that currently preclude conventional extensive green roof deployment. This finding is consistent with the growing recognition in the literature that lightweight substrates are a prerequisite for scaling green roof uptake in densely built urban environments, particularly in tropical and developing-country contexts (Kader et al., 2024; Vijayaraghavan, 2016).

The slightly sub-optimal lower bound of FLL bulk density guidelines 0.60 gcm^{-3} is primarily intended to ensure structural stability and prevent substrate displacement under wind uplift and heavy rainfall. In the case of synthetic fiber substrates, the high inter-fiber entanglement of shredded textiles provides physical matrix stability that may compensate for their ultra-low density. Nevertheless, field validation of substrate stability under operational conditions, including exposure to wind, precipitation, and root penetration, is recommended as a priority for future research (FLL, 2018; Philippi, 2005).

4.2 POROSITY, AND WATER HOLDING CAPACITY

Total porosity values of 76.87 % Nylon and 86.10% Polyester substantially exceed the FLL minimum threshold of 35% v/v and compare favorably with high-porosity inorganic substrates such as perlite (80.76%) and expanded clay (78.20%) reported by Tala and Clkar (Tala et al., 2020), (Cakar et al., 2023). Critically, unlike perlite and expanded clay which exhibit low water holding capacity despite high porosity, the textile substrates in this study achieved high WHC values (Nylon: 64.47%; polyester: 76.14%), well above the FLL minimum of 35%.

The high WHC of textile substrates is attributable to their fibrous matrix structure, which creates a network of capillary pores capable of retaining water against gravitational drainage. This combination of high total porosity and high WHC is particularly desirable for green roof substrates, as it simultaneously satisfies the need for adequate air-filled porosity (to prevent waterlogging and support root respiration) and sufficient water retention (to buffer plant water availability during dry periods and contribute to stormwater attenuation) (Carrillo-Angeles et al., 2018; Vijayaraghavan, 2016).

The superior WHC of Polyester relative to Nylon is consistent with differences in the surface chemistry and moisture behavior of these two polymers. Polyester (PET) exhibits low inherent moisture absorption (~0.4% moisture regain) due to the hydrophobic structure and chemical inertness of ester groups (Tala et al., 2020; Viši, 2022), Nylon (polyamide), while structurally similar in fiber form, has a slightly higher inherent moisture absorption (~4.2%), which may contribute to WHC (Hearle, 2001; Vlasveld et al., 2005).

4.3 MECHANISMS UNDERLYING THE SUPERIOR WATER RETENTION CAPACITY OF POLYESTER

Water retention capacity (WRC), defined here as the percentage of absorbed water retained by the substrate following a defined gravitational drainage period, was notably higher and more variable in Polyester compared with Nylon growing substrate. While both values remain well within practical ranges for green roof substrates, the consistently higher WRC of Polyester warrants mechanistic examination, as it underpins the material's effectiveness as a moisture buffer between rainfall events.

The superior WRC of polyester relative to Nylon can be attributed to a convergence of polymer-level, fiber-structural, and pore-geometric factors. These factors collectively enhance capillary action through the inter-fiber pore network (Ailenei et al., 2021; Das et al., 2007; Hearle, 2001; Morton & Hearle, 2008; Vlasveld et al., 2005; Wang, 2018; Zhang et al. (2022). These properties also have important implications for green roof water management. Substrates with higher WRC retain a greater proportion of absorbed rainfall within the substrate matrix following storm events, slowing runoff generation and contributing to peak flow attenuation (Vijayaraghavan & Raja, 2014). Polyester substrate recorded a mean WRC of 29.5%, compared with a mean of approximately 18% for Nylon. This difference of approximately 11 percentage points is considered practically significant for green roof applications, as it indicates that polyester retains substantially more water within the substrate matrix during inter-storm dry periods, which can directly support plant survival and stormwater attenuation performance. The wider divergence between the two substrates observed from Day 4 onwards (Figure 4) further underscores this distinction under prolonged drying conditions.

4.4 PH SUITABILITY

The pH values recorded for both Nylon (7.02 ± 0.16) and Polyester (7.04 ± 0.19) substrates are well within the FLL-recommended range and the range mentioned in the review paper of 5.5-8.5 (Ampim et al., 2010; Cakar et al., 2023; Papadopoulos & Lieth, 2008; Tala et al., 2020). and align closely with the optimal pH of 7.0 identified by review literature as the most suitable for plant nutrient availability in green roof substrates (Kader et al., 2024; Vijayaraghavan, 2016). A pH near neutrality ensures that a broad spectrum of macro and micronutrients remains plant-available, reducing the need for pH amendment supplements and simplifying substrate management (Kader et al., 2024). The chemically inert nature of synthetic fiber substrates thus presents a pH management advantage over both organic and many inorganic alternative substrates.

4.5 ELECTRICAL CONDUCTIVITY AND SALINITY ASSESSMENT

Both synthetic fiber substrate types exhibited optimum electrical conductivity values. Polyester substrates recorded a mean EC of 171 ± 4.56 μScm^{-1}, while Nylon substrates showed a mean of 210.3 ± 8. μScm^{-1}. Both values are relative to the previous studies (Cakar et al., 2023; Kader et al., 2024). Importantly, the EC of synthetic fiber substrates reflects their chemical inertness; Polyester and Nylon polymers do not release soluble salts, nutrient ions, or ionic compounds into the substrate solution under typical environmental conditions (Vijayaraghavan & Raja, 2014). The exceptionally low EC of both fiber substrates indicates negligible salinity stress risk for plant growth in these media, which is advantageous for a broad range of horticultural species.

4.6 COMPARISON WITH PREVIOUS GREEN ROOF SUBSTRATE STUDIES

Placing the present results in the context of the broader green roof substrate literature (Table 2), it is evident that synthetic textile fiber substrates compare favorably across all key physicochemical parameters relative to both conventional and emerging alternative substrates. Their porosity values are among the highest reported for any green roof substrate material, exceedingly even perlite in the case of polyester. Their WHC values substantially exceed those of perlite and expanded clay, the two most compared lightweight substrates, while remaining within or above the FLL-recommended range. The physicochemical profile of synthetic fiber substrates most closely resembles that of mineral wool and rockwool substrates commonly used in plant cultivation (Papadopoulos & Lieth, 2008), which are also synthetic, fibrous, chemically inert, and characterised by low bulk density, high porosity, and high WHC. Textile waste substrates offer the additional environmental benefit of diverting solid waste from landfill, contributing to circular economy objectives within the construction and urban greening sector.

4.7 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study has several important limitations that should be acknowledged. First, no plant growth trials were conducted; the findings are limited to laboratory physicochemical characterisation, and plant compatibility, root penetration behaviour, and long-term biological performance in the presence of vegetation remain untested. Second, the study was conducted under controlled indoor laboratory conditions, and field-scale performance may differ due to variable rainfall patterns, solar radiation, temperature fluctuations, and urban heat island effects common to real rooftop environments. Third, the long-term durability and structural integrity of shredded synthetic textile substrates under sustained wetting-drying cycles, UV exposure, and microbial activity have not been evaluated. Fourth, potential microplastic leaching from polyester and nylon substrates under weathering conditions represents an environmental concern that was outside the scope of this study but warrants dedicated investigation. Fifth, the study examined only two synthetic fibre types; future research should include a broader range of textile waste types, fibre blends, and shredding configurations to identify optimal substrate formulations. Future studies should prioritise plant growth trials under controlled greenhouse conditions, long-term field performance monitoring on real green roof installations, and LifeCycle Assessment (LCA) to quantify the circular economy and environmental benefits of textile waste reuse in green roof systems.

5. CONCLUSIONS

This preliminary physicochemical characterisation study demonstrates that shredded Polyester and Nylon textile waste fabrics possess key physicochemical properties that are well aligned with established standards for green roof growing substrate materials, though plant growth suitability remains to be confirmed through dedicated plant trials. Both fiber types exhibited exceptionally low bulk densities (Nylon: 0.22± 0.02 gcm^{-3}; Polyester: 0.145± 0.02 gcm^{-3}), total porosities exceeding 76.87% and 86.10% respectively, and water holding capacities well above the FLL minimum threshold of 35%. The optimum pH values (7.02, 7.04) respectively, and electrical conductivity values show chemical suitability of these materials as growing substrates for a broad range of horticultural plant species. In comparison with conventional soil-based substrates and established inorganic alternatives such as volcanic tuff, pumice, and crushed brick, synthetic textile fiber substrates offer substantially lower structural dead loads, adequate or superior water retention, and stable chemical conditions, without the pH instability associated with many organic media or the high cost of premium inorganic substrates such as LECA and perlite. The low-cost advantage of these substrates arises specifically from their origin as textile waste that would otherwise be landfilled, making them a cost-competitive option not only due to the near-zero raw material cost, but also due to the avoided disposal costs of waste management, a dual advantage that distinguishes them from other reusable or alternative materials. The chemical inertness and structural resilience of Polyester and Nylon polymers suggest that these substrates would resist long-term decomposition, addressing one of the key limitations of organic growing media under tropical and subtropical climatic conditions.

The findings of this preliminary physicochemical characterisation study indicate that recycled synthetic textile fiber substrates exhibit physicochemical properties consistent with established green roof substrate standards. However, it is important to note that plant growth suitability and field-scale viability have not yet been demonstrated, as the current study is limited to laboratory characterisation. Validation through plant growth trials and field-scale performance testing is required before practical recommendations can be made. Subject to such validation, textile-based growing substrates may offer possibilities for the expansion of green roof systems in weight-constrained and resource-limited urban environments globally.

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