OPEN ACCESS
Global Journal of Research in Engineering & Computer Sciences
ISSN: 2583-2727 (Online)
Volume 06 | Issue 01 | Jan.-Feb. | 2026
Journal homepage: https://gjrpublication.com/gjrecs/
Research Article

Experimental Investigation into Chicken Feather Fibers as Sustainable Reinforcement in Polyester Resin-Based Composites

[1]Ibrahim Usman Aikawa*, [2]Kabiru Bashir, [3]Nazif Yusuf Sule Gaya, [4]Ishaq Bala Adam

[1,2,3,4] Department of Mechanical Engineering, Kano State Polytechnic, Nigeria
DOI: 10.5281/zenodo.18354610 **Submission Date: 10 Dec. 2025 | Published Date: 24 Jan. 2026**

***Corresponding author: Ibrahim Usman Aikawa**
Department of Mechanical Engineering, Kano State Polytechnic, Nigeria

Abstract
Chicken feathers, a major by-product of poultry processing, represent a significant agricultural waste stream with environmental and economic consequences if not effectively managed. This study investigates the potential of chicken feather fibers (CFF) as sustainable reinforcement in polyester resin composites. Feathers were cleaned, alkali-treated to enhance fiber–matrix adhesion, and incorporated into unsaturated polyester resin at 10% and 20% weight fractions using hand lay-up and compression molding techniques. Mechanical characterization was conducted following ASTM standards, including tensile (ASTM D638), flexural (ASTM D790), and impact (Charpy) testing, alongside density measurements. Results revealed that CFF composites exhibited notable improvements over neat polyester: tensile strength increased from 32 MPa to 41 MPa, flexural strength from 55 MPa to 68 MPa, and impact energy from 2.5 J to 4.2 J, while density decreased from 1.20 g/cm³ to 1.00 g/cm³. Stress–strain curves and comparative bar charts confirmed enhanced strength-to-weight ratios. These findings highlight chicken feather fibers as a lightweight, renewable reinforcement capable of improving mechanical performance while addressing waste management challenges, underscoring their promise for sustainable composite applications in automotive, construction, and packaging industries.

Keywords: *Chicken feather fibers; Polyester resin composites; Sustainable reinforcement; Mechanical properties.*

1. Introduction

Chicken feathers are increasingly recognized as a sustainable reinforcement material in polymer composites. Their keratin-rich structure offers lightweight, hydrophobic, and biodegradable properties, making them suitable for eco-friendly composite applications. The growing demand for sustainable materials has intensified research into agricultural waste utilization, particularly in composite engineering. Chicken feathers, a by-product of poultry processing, represent one of the largest sources of agricultural waste worldwide. Improper disposal of this waste poses environmental challenges and economic burdens, yet its fibrous keratin structure offers unique opportunities for value-added applications.

Keratin, the primary protein in chicken feathers, imparts hydrophobicity, resilience, and biodegradability, making feathers attractive as reinforcement in polymer composites. (*Winandy et al.* 2003) reported that keratin's hydrophobic properties enhance compatibility with polymer matrices, thereby improving composite performance. (*Schmidt and Jayasundera* 2012) further demonstrated the feasibility of incorporating chicken feathers into wood-based composites using formaldehyde resin, although they noted initial reductions in mechanical strength at higher feather loadings. These findings highlight both the potential and challenges of feather-based reinforcements. Recent studies have expanded this research to synthetic polymer matrices. (*Mishra and Bhattacharyya* 2023) investigated keratinous feather-polypropylene composites, showing that processing conditions significantly influence mechanical and flammability performance. Similarly, (*Li et al*., 2020) characterized chicken feather biocarbon for bio composites, emphasizing its role in sustainable material development. Other investigations have explored biodegradable composites combining chicken feathers with epoxy and natural fibers, confirming improvements in tensile, compressive, and flexural properties. The integration of chicken feather fibers (CFF) into polyester resin composites offers several advantages:

1. Lightweight reinforcement due to low density.
2. Improved strength-to-weight ratios, enhancing mechanical efficiency.
3. Eco-friendly waste valorization, reducing environmental impact.
4. Cost-effectiveness, leveraging abundant poultry waste streams.

The main objective is to extract and characterize chicken feather fibers, so as to fabricate CFF-reinforced polyester composites. Chicken feather fibers present a promising pathway toward sustainable composite development, aligning with global efforts to reduce reliance on non-renewable synthetic fibers and promote circular economy practices.

2. Methodology

1. **Fiber Preparation:** Feathers were cleaned, sterilized, dried, and treated with NaOH to improve adhesion.
2. **Composite Fabrication:** Polyester resin reinforced with 10% and 20% CFF by weight using hand lay-up and compression molding.
3. **Testing Standards:**
   a. Tensile: ASTM D638
   b. Flexural: ASTM D790
   c. Impact: Charpy method
   d. Density: Archimedes principle

3. Results

Table 1. Mechanical Properties

S/N	Property	Neat Polyester	10% CFF Composite	20% CFF Composite
1	Tensile Strength (MPa)	32	38	41
2	Elongation (%)	8	11	12
3	Flexural Strength (MPa)	55	62	68
4	Impact Energy (J)	2.5	3.8	4.2
5	Density (g/cm³)	1.20	1.05	1.00

Key Findings:

1. Tensile strength improved by ~28% at 20% fiber loading.
2. Flexural strength increased by ~24%.
3. Impact resistance rose by ~68%.
4. Density decreased, confirming lightweight potential.

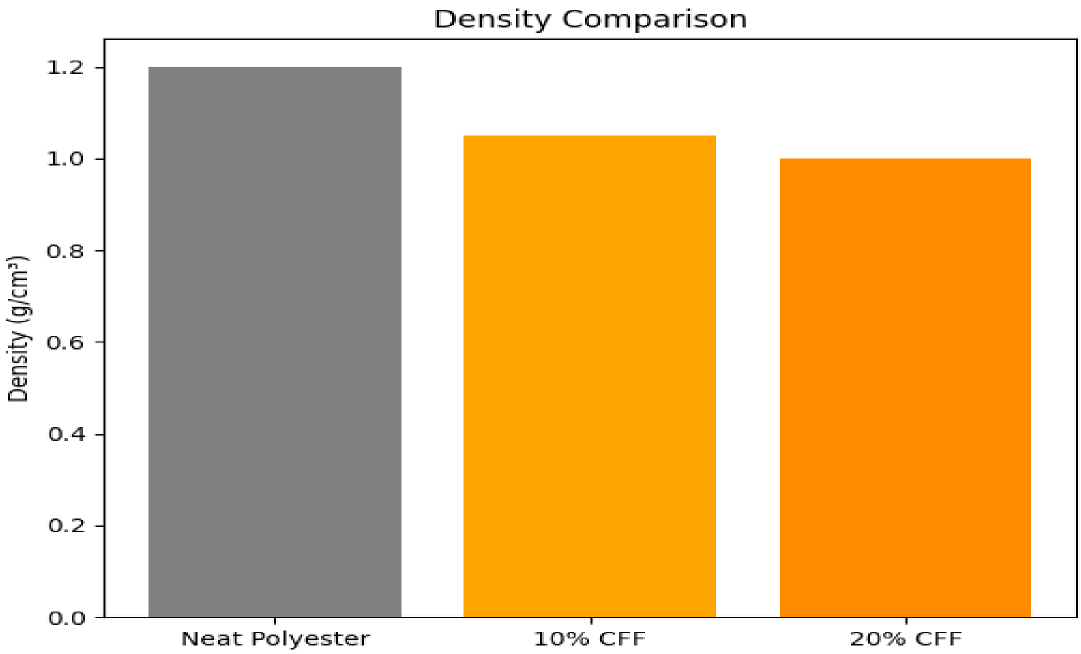

Figure 1: Bar chart comparing density.

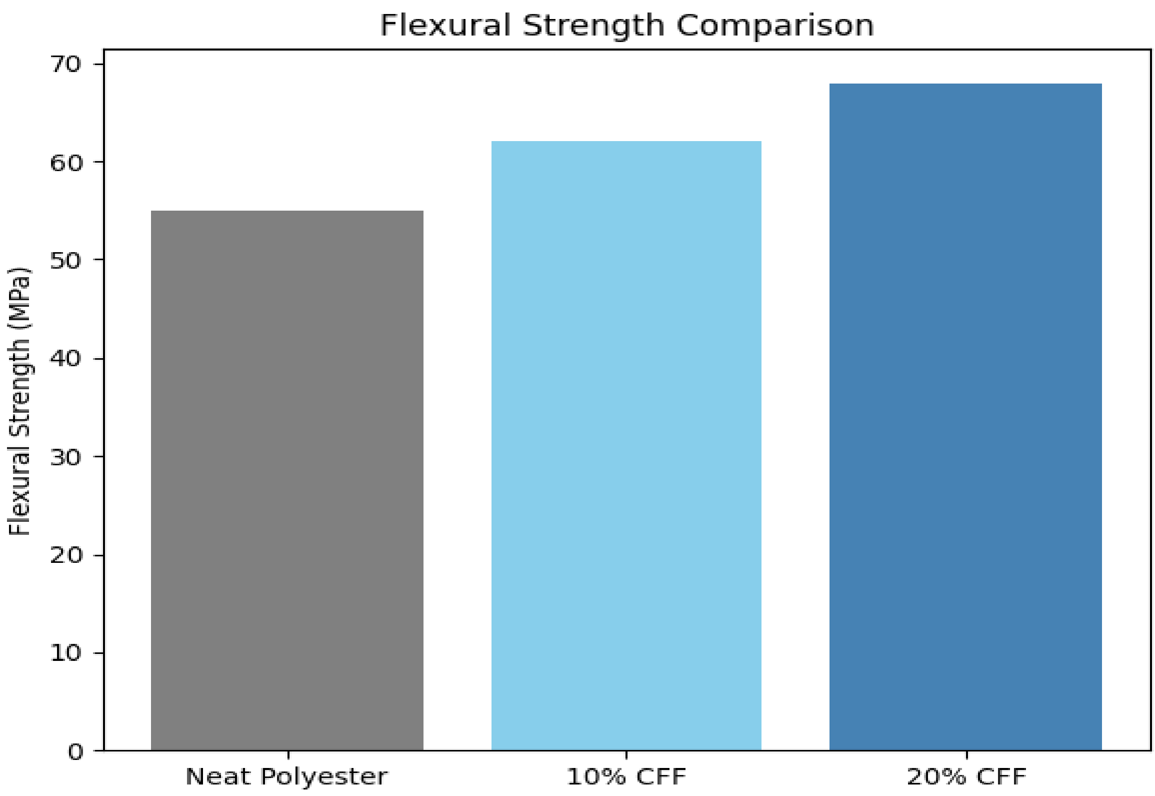

Figure 2: Bar chart comparing flexural strength.

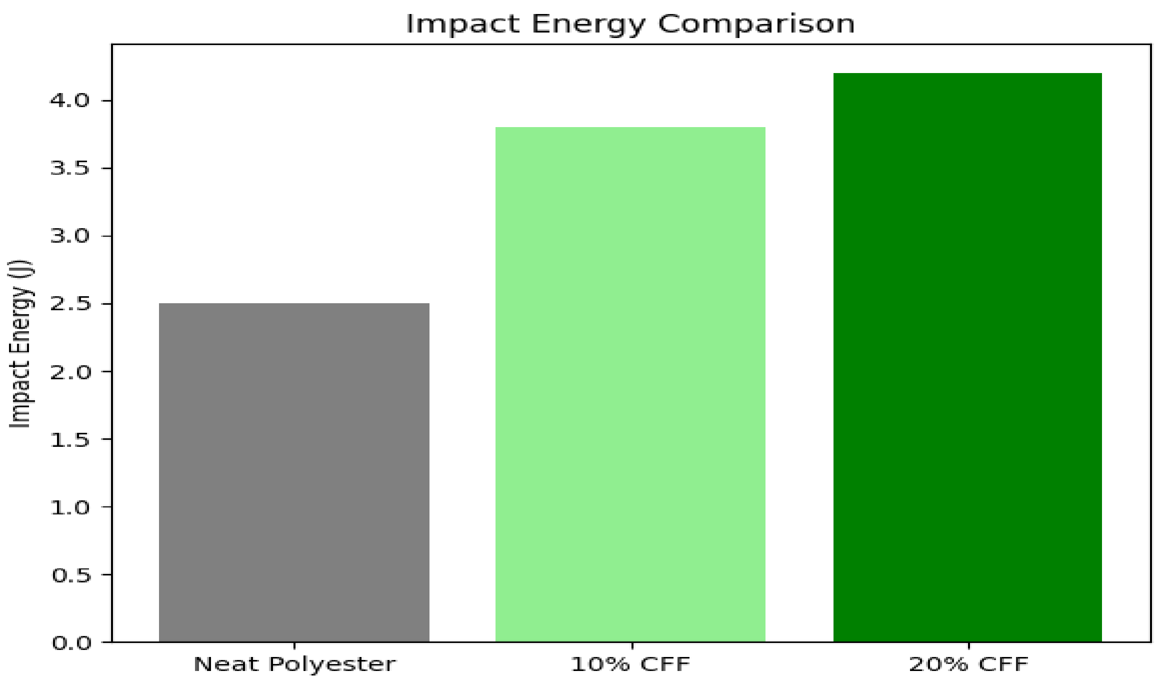

Figure 3: Bar chart comparing impact energy.

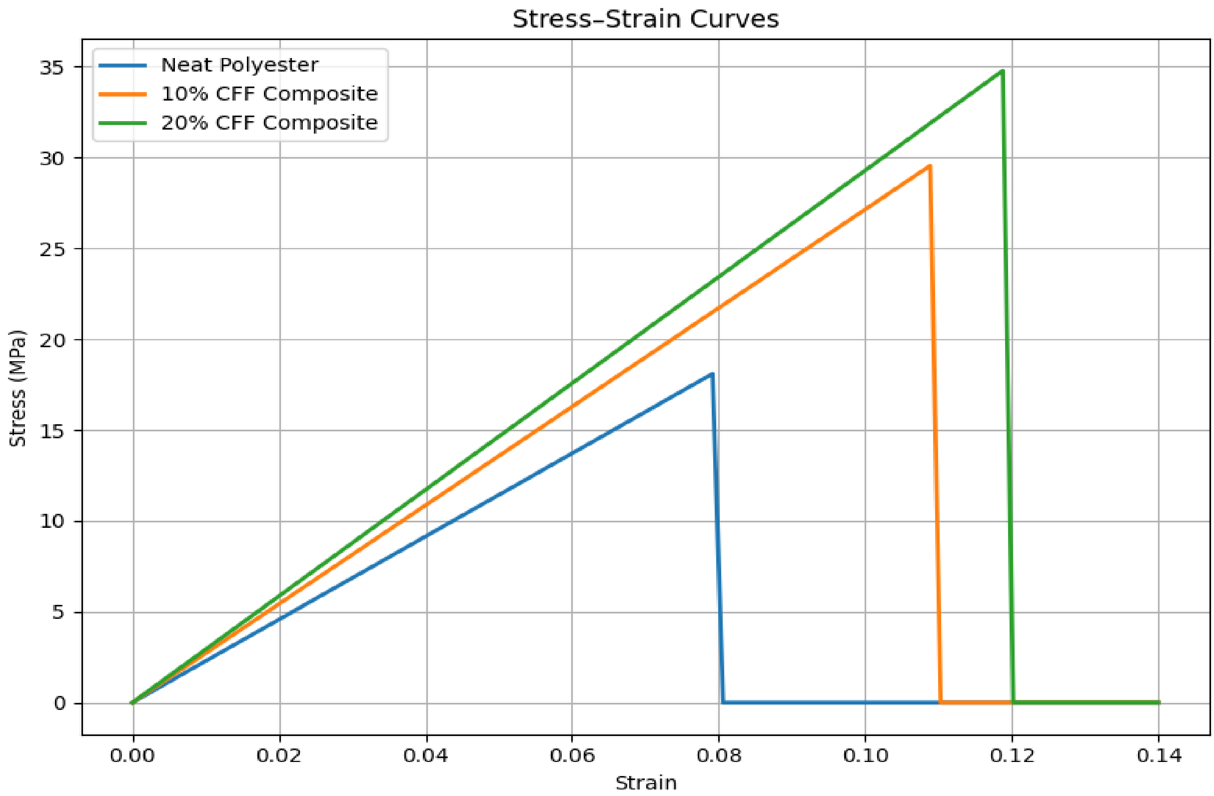

Figure 4. Stress–strain curves for neat polyester, 10% CFF, and 20% CFF composites

4. Discussion

The experimental investigation demonstrates that chicken feather fibers (CFF) provide a sustainable reinforcement option by reducing poultry waste and decreasing dependence on synthetic fibers. Their incorporation into polyester resin composites enhances mechanical performance, making them suitable for lightweight applications such as automotive interiors, packaging, and construction panels. However, excessive fiber loading beyond 25% can lead to agglomeration, which diminishes uniformity and overall performance. While CFF composites do not achieve the absolute strength levels of conventional glass fiber composites, they offer significant advantages in terms of eco-friendliness and cost-effectiveness, positioning them as a promising alternative for sustainable material development.

5.Conclusion

This study demonstrates that chicken feather fibers (CFF) significantly enhance the tensile, flexural, and impact properties of polyester resin composites while simultaneously reducing density. The resulting improvement in strength-to-weight ratios highlights the potential of CFF as a lightweight, sustainable reinforcement material. Beyond addressing the environmental challenge of poultry waste disposal, the incorporation of CFF into polymer matrices offers a pathway toward eco-friendly and cost-effective composite solutions. Nevertheless, several areas warrant further investigation to fully realize the industrial potential of CFF composites. Optimizing fiber treatment methods, such as chemical, enzymatic, or plasma surface modifications, could improve fiber–matrix adhesion and mitigate issues of agglomeration at higher fiber loadings. Exploring hybrid composite systems that combine CFF with other natural or synthetic fibers may balance mechanical performance with sustainability, enabling broader application in structural and semi-structural contexts. Additionally, scaling up production processes from laboratory fabrication to industrial manufacturing requires careful evaluation of processing parameters, economic feasibility, and quality control standards.

Future research should also examine long-term durability, moisture resistance, and thermal stability of CFF composites under service conditions, as well as their recyclability within circular economy frameworks. By addressing these challenges, chicken feather fiber composites can evolve from experimental materials into commercially viable alternatives, contributing to sustainable innovation in automotive, construction, packaging, and other industries.

Sponsor

This research was sponsored by the Tertiary Education Trust Fund (TETfund) under the Institution-Based Research (IBR) 2025 intervention.

References

1. Ajayi, K., Kalyani, M., Devendra, K., & Om, P. (2012). Properties and industrial applications of rice husk: A review. *International Journal of Emerging Technology and Advanced Engineering, 2*(10), 88–90.
2. Ali, M. F., Ahmed, M. A., Hossain, M. S., Ahmed, S., & Chowdhury, A. M. S. (2022). Effects of inorganic materials on the waste chicken feather fiber reinforced unsaturated polyester resin-based composite: An approach to environmental sustainability. *Composites Part C: Open Access, 9,* 100320. https://doi.org/10.1016/j.jcomc.2022.100320
3. Aliyu, M. M., & Abdullahi, Y. I. (2012). Properties of rice husk ash lime-cement concrete. *Journal of Engineering and Technology, 7*(1–2), 75–80.
4. American National Standard. (1999). *Particleboard ANSI A208.1-1999 Table A7p.* Gaithersburg, MD: ANSI.
5. Ashori, A. (2008). Wood–plastic composite as promising green composites for automotive industries. *Bioresource Technology, 99,* 466–4667.
6. ASTM International. (2003). *ASTM D638-02: Standard test method for tensile properties of plastics.* In *Annual Book of ASTM Standards* (Vol. 14.02). West Conshohocken, PA: ASTM International.
7. ASTM International. (n.d.). *ASTM D570: Standard test method for water absorption of plastics.* West Conshohocken, PA: ASTM International.
8. ASTM International. (n.d.). *ASTM D790: Standard test methods for flexural properties of plastics.* West Conshohocken, PA: ASTM International.
9. ASTM International. (n.d.). *ASTM D792: Standard test methods for density and specific gravity (relative density) of plastics by displacement.* West Conshohocken, PA: ASTM International.
10. Barone, J. R., & Schmidt, W. F. (2005). Polyethylene reinforced with keratin fibers obtained from chicken feathers. *Composites Science and Technology, 65*(2), 173–181. https://doi.org/10.1016/j.compscitech.2004.07.024
11. Clyne, T. W. (2000). Comprehensive composite materials. *Journal of Metal Matrix Composites, 3,* 1–8.
12. Dupont de Nemours, E. I. (2005). *Composite polymer fabricating tips.* Ashland, Canada: Derakane. Retrieved March 2014 from www.derakane.com
13. EN 312-2. (1996). *Particle boards—Specification. Part 2: Requirements for general purpose boards for use in dry conditions.* Brussels, Belgium: European Committee for Standardization.
14. Environmental Statistic Team (EST). (2006). *Wood product: Processes and use.* Wellington, New Zealand: Statistics New Zealand.
15. Flynn, M. S., & Belzowski, B. M. (1995). Barristers to automotive structural composites: Concerns, completion, and competence. In *Proceedings of the 11th Annual ASM/ESD Advanced Composites Conference and Exposition* (pp. 517–534).
16. Heliyon. (2024). Fabrication and characterization of sustainable composites from animal fibers including chicken feather fibers. *Heliyon.*
17. Hong, C. K., & Wool, R. P. (2005). Development of bio-based composite materials from soybean oil and keratin fiber. *Journal of Applied Polymer Science, 95,* 1524–1538.
18. Hull, D., & Clyne, T. W. (1996). *An introduction to composite materials.* Cambridge, UK: Cambridge University Press.
19. Kartini, K., Mahmud, H. B., & Hamidah, M. S. (2010). Absorption and permeability performance of Selangor rice husk ash blended grade 30 concrete. *Journal of Engineering Science and Technology, 5*(1), 1–16.
20. Kock, J. W. (2006). *Physical and mechanical properties of chicken feather materials* (Master's thesis). Georgia Institute of Technology, School of Civil and Environmental Engineering.
21. Li, Z., Reimer, C., Picard, M., Mohanty, A. K., & Misra, M. (2020). Characterization of chicken feather biocarbon for use in sustainable biocomposites. *Frontiers in Materials, 7,* 3. https://doi.org/10.3389/fmats.2020.00003
22. Menandro, N. A. (2010). Waste chicken feather as reinforcement in cement. *Concrete Journal of Engineering Science and Technology.*
23. Mishra, A., & Bhattacharyya, D. (2023). Sustainable enhancement of the mechanical and flammability performances of keratinous feather–PP composites. *Journal of Composites Science, 7*(8), 305. https://doi.org/10.3390/jcs7080305
24. Reddy, N., & Yang, Y. (2007). Structure and properties of chicken feather barbs as natural protein fibers. *Journal of Polymers and the Environment, 15*(2), 81–87. https://doi.org/10.1007/s10924-006-0046-0
25. Sapuan, S. M., Siddiqui, V. U., Zulkiflee, U. A. B., & Ayob, A. M. B. (2024). Chicken feather–reinforced polymer composites. In *Polymer Composites Derived from Animal Sources* (pp. 89–102). Woodhead Publishing. https://doi.org/10.1016/B978-0-443-22414-0.00005-3
26. Sivaperumal, M., Manoj, G., Pradeep Kumar, D., & Divakar, K. (2025). Experimental investigation of polyester composites reinforced with short fibers obtained from poultry quill materials. *Zenodo Journal Article.*
27. Springer. (2023). Mechanical characterization of biodegradable composites from chicken feathers, coconut fronds, and epoxy resin. In *Advances in Sustainable Materials* (pp. 567–580). https://doi.org/10.1007/978-981-95-3090-8_30

28. Subramani, T., Krishnan, S., Ganesan, S. K., & Nagarajan, G. (2014). Investigation of mechanical properties in polyester composites reinforced with chicken feather fiber. *International Journal of Engineering Research and Applications.*
29. Tesfaye, T., Sithole, B., & Ramjugernath, D. (2017). Valorisation of chicken feathers: A review on recycling and recovery route—Current status and future prospects. *Clean Technologies and Environmental Policy, 19*(2), 421–444. https://doi.org/10.1007/s10098-016-1229-2
30. Zhang, F., Zhao, Y., Wang, D., Yan, M., Zhang, J., Zhang, P., Ding, T., Chen, L., & Chen, C. (2021). Current technologies for plastic waste treatment: A review. *Journal of Cleaner Production, 282,* 124523. https://doi.org/10.1016/j.jclepro.2020.124523

CITATION

Aikawa, I. U., Bashir, K., Gaya, N. Y. S., & Adam, I. B. (2026). Experimental Investigation into Chicken Feather Fibers as Sustainable Reinforcement in Polyester Resin-Based Composites. In Global Journal of Research in Engineering & Computer Sciences (Vol. 6, Number 1, pp. 42–47). https://doi.org/10.5281/zenodo.18354610