From Trash to Treasure: Fighting Desertification With Sustainable Soil Amending Hydrogels Synthesized From Food Waste

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National Geographic reports that desertification threatens the well-being of billions of people, as four million square kilometers of fertile land are degraded annually. Exacerbated by climate change, the problem is worsening. To mitigate desertification, water-absorbing hydrogels can be added to soil, bolstering water retention. However, these hydrogels are made from unsustainable synthetic superabsorbent polymers (SAPs). Previously, orange peels have been identified as sustainable alternatives thanks to abundant hydrogel-forming pectin. However, oranges are not grown in many desertification-affected regions, so I sought to find alternative pectin-rich plants to make hydrogels from. I used bioinformatics tools (BLASTp, AlphaFold) to identify plants with enzymes that were highly similar to orange pectin biosynthesis enzymes. Based on the results, I extracted pectin from three new plants' peels (apple, mango, pomegranate), synthesized hydrogels, and monitored their ability to retain soil moisture compared to a commercial SAP and orange peel hydrogels. Using an Arduino sensor, I observed that the pomegranate hydrogel and apple hydrogel respectively retained 75.3% and 73.0% of moisture over seven days with 24/7 exposure to heat. The pomegranate hydrogel retained significantly more moisture than the commercial SAP hydrogel ($p=0.0021$, two-tailed t-test). Mathematical modeling revealed that initial moisture loss closely follows an exponential decay pattern. Finally, to help stakeholders monitor soil moisture over large areas through remote sensing, I trained machine learning models to predict soil moisture from hyperspectral data ($R2=0.92$). My research provides a novel, low-cost, and sustainable solution for agricultural and natural land threatened by desertification.