WERC: Renewable Energy Solution for Water & Environmental Restoration

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35th WERC Environmental Design Contest

Mission/Statement of Work

Inspired by the challenges faced by the San Elias community in Guachochi, Chihuahua, our project harnesses wind power and natural filtration to restore soil and water contaminated by wildfires and herbicides.

- **Sustainable & Low-Cost:** Utilizes renewable energy and natural filtration media.
- **Community-Driven:** Empowers local communities to take charge of environmental restoration, fostering self-reliance and resilience.
- **Impact-Focused:** Rejuvenates soil and water quality, supporting ecosystem recovery.

Key Deliverables:

1. Demonstrate efficient filtration and reliable renewable energy use
2. Validate improvements in water quality and soil moisture retention
3. Design is adaptable and scalable to a variety of locations

Research

🔥 Wildfire Impact on Soil & Water

- Post-fire runoff carries heavy metals (lead, arsenic, cadmium), organic toxins, and debris that degrade soil and water quality..
- Without intervention, natural soil recovery can exceed 20 years (Smith et al., 2018).

💧 Natural Filtration for Post-Fire Recovery

- Studies show that activated charcoal removes over 90% of heavy metal contaminants via adsorption (Wang et al., 2018; Kumar et al., 2017).
- Sand & gravel layers provide mechanical filtration.

Soil Moisture Monitoring & Recovery

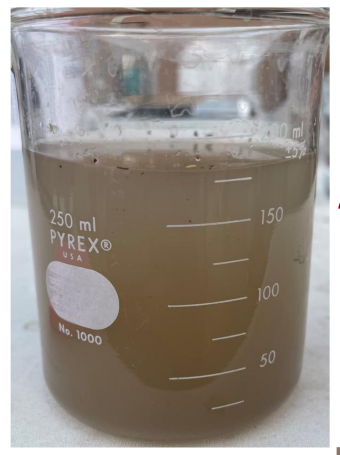
- Low-cost sensors typically achieve ±3–5% accuracy, offering reliable real-time data for moisture management (Jones et al., 2019).
- Helps reduce recovery time from 20-25 years to 5-10 years. (Johnson et al., 2020)

📊 Market & Funding Potential

- $41.2B Disaster Restoration Market (5.7% growth annually).
- Government & NGO funding prioritize low-cost, scalable recovery solutions.

Final Design & Results

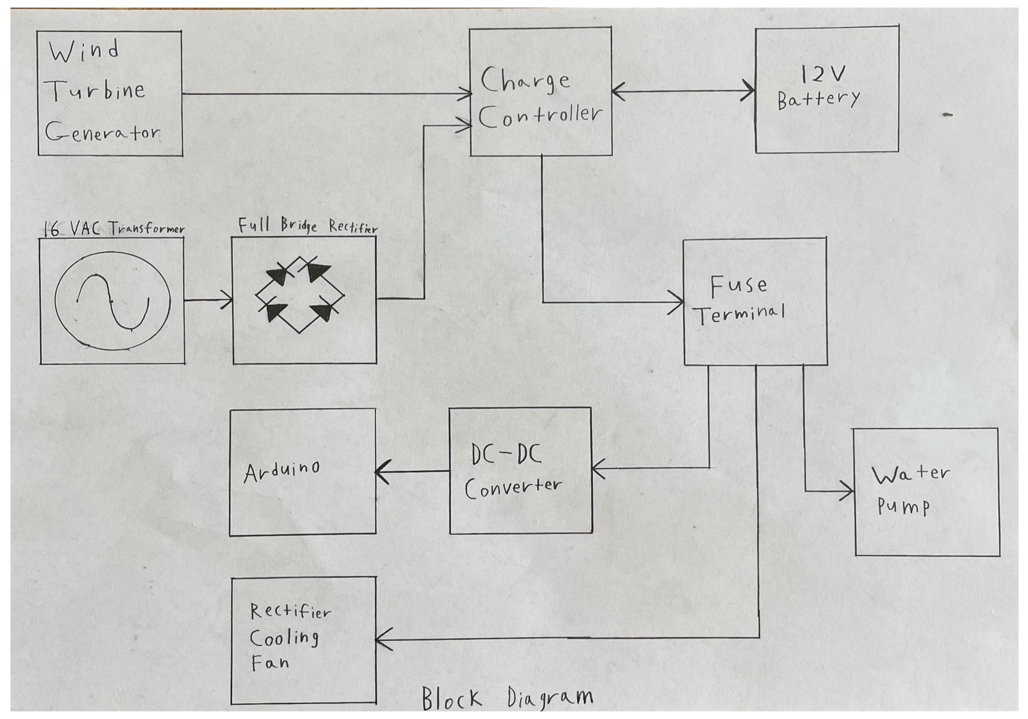
The table below highlights the key performance metrics measured before and after filtration. We tracked flow rate, turbidity, pH, conductivity, soil moisture, and heavy metal presence to evaluate our system's effectiveness. As shown, the final design meets or exceeds several targets (particularly in turbidity reduction and soil moisture improvement) while also demonstrating reliable operation under renewable power.



Metric	Before	After	Observation
Flow Rate	–	2.90 L/min	Met design criteria for continuous operation
Turbidity	733.14 NTU	11.17 NTU	~98.5% reduction in suspended solids
Conductivity	999.14 µS	1401.57 µS	Moderate increase; consistent with leaching
Soil Moisture	Dry	+15–20%	Substantial hydration improvement
Lead Presence	Detected (Day 1)	Lower (Day 3+)	Reduced after charcoal conditioning

System Components

- **Wind-Powered Energy Generation**
  - Vertical-axis wind turbine on a mobile tripod
  - Energy routed to a 12V charge controller and LiFePO4 battery
  - Powers data monitoring system & water pump
- **Multi-Stage Filtration**
  - Gravel & sand for mechanical filtration
  - Activated charcoal for ≥90% contaminant adsorption
  - Cotton & lava rock for layer stabilization and bacteria introduction
- **Contaminated Soil Box**
  - 210 L wooden soil box simulating post-fire, contaminated soil
  - Incorporates garden lime, organic compost, herbicides, and charcoal to represent unhealthy soil
- **Real-Time Monitoring & Data Logging**
  - Arduino/ESP8266-based system with capacitive soil moisture sensor
  - Enables remote monitoring for timely irrigation and remediation adjustments
- **Electrical Control Panel**
  - Delivers power to system components
  - Integrates renewable and AC power sources
  - Features a robust charge controller, overcurrent protection, and a switch for pump operation



Concept Development

Initial Vision

- **Full-Scale Solution:** Planned to build an integrated, large-scale system with an in-ground layered filter.
- **Mechanical Windmill:** Intended to use a traditional windmill to mechanically force water through the filter.
- **Drinking Water Goal:** Explored incorporating cactus pith for purifying water for direct consumption.

Adjustments Made

- **Prototype Scale:** Shifted focus to a bench-scale prototype for realistic construction and testing.
- **Filter Configuration:** Separated the dirty water collection bin from the layered filter for easier maintenance and improved test reliability.
- **Energy Source:** Replaced the complex mechanical windmill with a wind-powered pump to better control flow and protect filter performance.
- **Water Quality Target:** Refined the objective to produce irrigation-quality water, simplifying regulatory concerns while still offering potential for future upgrades toward drinking water standards.

Recognition

Terry McManus Outstanding Student Award

- Awarded to team lead Naiqui Armendariz for her commitment to environmental excellence and pursuit of global environmental improvements

References

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