Removing Emerging Contaminants in the Drinking Water by A Novel Carbon-based Enzymatic Reactor

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Chung-Ho Lin, PhD
Research Associate Professor
Biorremediaion and Phytochemistry
MU Center for Agroforestry, School of Natural Resources
University of Missouri
Contamination of Drinking Water Sources by Herbicides (e.g., atrazine) in the Midwest

Estimated maximum 21-day moving average concentration of atrazine (micrograms per liter):

- Not modeled
- Less than 0.05
- 0.5 to 5
- 5 or more

Source: U.S. Geological Survey
FIGURE 1: ATRAZINE SPIKES EXCEED EPA LIMIT

TAP WATER

SOURCE WATER

Source: EWG, from the EPA’s Atrazine Monitoring Program data.
85 Pharmaceuticals and Personal Care Products (PPCPs) and Agrochemicals Found in the Drinking Water Sources

- Antibiotics (15)
- Anti-depressants (8)
- Estrogens (2)
- \(\beta\)-blocker (3)
- Anti-inflammatory (15)
- Anti-retroviral (10)
- Anticoagulant (6)
- Antifungal (7)
- Recreational (5)
- Anti-seizure (6)
- Lipid lowering (3)
- X-ray contrast agents (5)
- Steroids (3)
- Anesthetic agents (5)
- Anti-hypertension (3)
- Pesticides & herbicides
- Others (>200)
Advantages

1. Programmable gene cassette
2. Reusable
3. Eliminate expensive purification process
4. Eliminate expensive and labor intensive chemical processes
5. High purity of enzymes
6. The system can be easily regenerated
7. Multi-enzyme system
8. Enhance the stability of the enzymes

(carbon fibers, polypropylene, polystyrene, nylon, glass fiber, carbon nanotubes, magnetic particles)
Bioactive Fibers
Removal of Atrazine by Enzymes Immobilized on Carbon Fibers

![Bar chart showing the removal of Atrazine in water over time. The chart compares the percentage of Atrazine remaining in water with the degradation product over 21 hours.](chart_image)

- **X-axis**: Time (hrs)
- **Y-axis**: Atrazine in Water (%)

- **Red bars** represent Atrazine.
- **Blue bars** represent Degradation Product.

At each time point:
- 0 hrs: 100% Atrazine
- 1 hr: 30% Atrazine, 70% Degradation Product
- 2.5 hrs: 50% Atrazine, 50% Degradation Product
- 4.75 hrs: 40% Atrazine, 60% Degradation Product
- 8.5 hrs: 30% Atrazine, 70% Degradation Product
- 21 hrs: 20% Atrazine, 80% Degradation Product

As time progresses, the percentage of Atrazine decreases, while the degradation product increases.
Remediation of the Contamination of Atrazine in Water by the Bioactive Fibers
Immobilize the Enzymes on Magnetic Particles (Carbon-Iron)
Current Uses and Market Price of Biochar

1. Energy production: bio-oil and syngas
2. Soil amendment
3. Water retention
4. Activated carbon (water treatment and air filter)
5. Carbon sequestration

**Current Price**: $500/ton or $12.5/50 lbs + shipping

*U.S. Biochar initiative*
1. Biofuel
2. Bioremediation
3. Water treatment
4. Blood type conversion
5. Specialty Chemicals