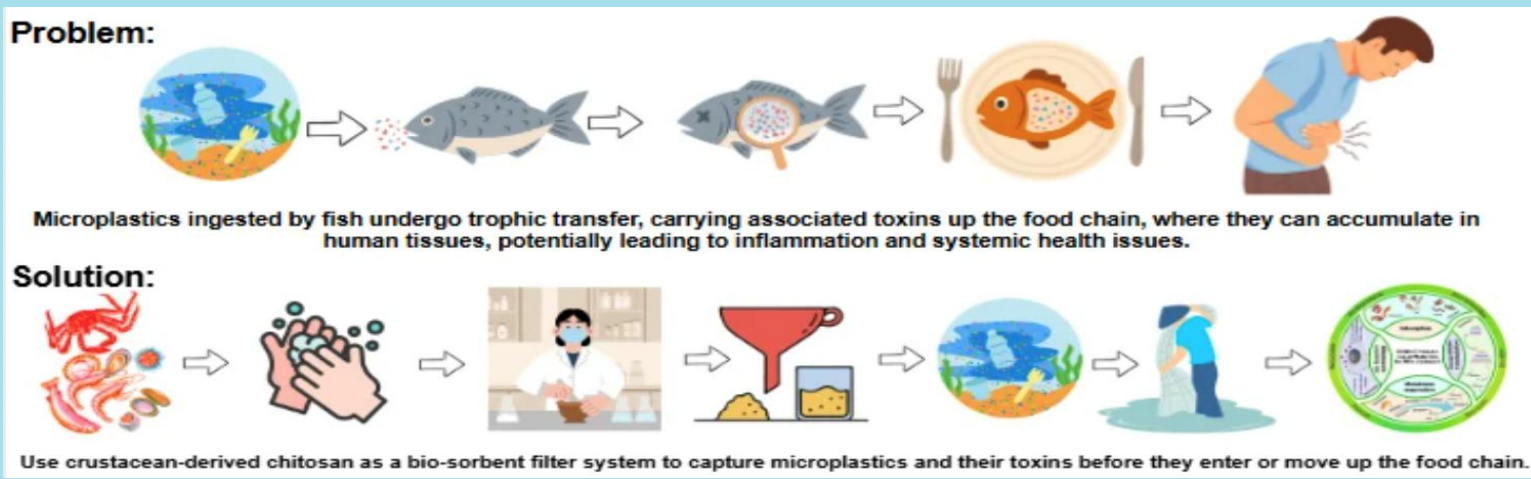


Introduction

Microplastics have become one of the most persistent pollutants in marine and coastal ecosystems, accumulating in seawater, sediments, and the bodies of shellfish, shrimp, and other crustaceans. These particles absorb toxic chemicals and spread them through the food web.

Crustaceans play a key role in natural ecosystem recycling. When shrimp, crabs, and other shellfish die, their shells break down into chitin—a biopolymer that can be converted into chitosan. Chitosan is biodegradable, non-toxic, and has a unique ability to bind and coagulate microplastics suspended in water.

Using chitosan derived from shellfish waste offers a sustainable strategy to reduce microplastic loads in aquatic environments. By mimicking and enhancing natural crustacean recycling processes, chitosan-based filtration provides an eco-friendly method to help restore water quality, protect marine organisms, and reduce human exposure to microplastic-contaminated seafood and water sources.



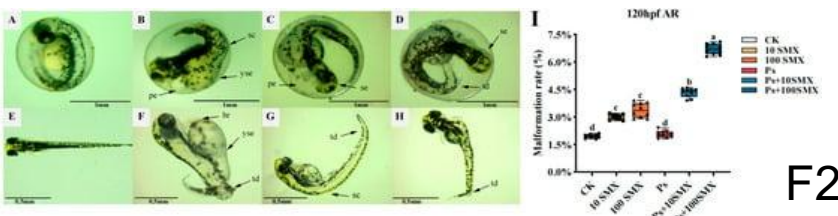
F1

Review of Literature

“Microplastics Causing Developmental Toxicity in Zebrafish Embryos”
Park, S. H., & Kim, K. (2022). Microplastics induced developmental toxicity with microcirculation dysfunction in zebrafish embryos. *Chemosphere*, 286, 131868. <https://doi.org/10.1016/j.chemosphere.2021.131868>

Goal:
To find out how exposure to polystyrene microplastics affects the growth, brain development, and overall health of zebrafish embryos and larvae during their early stages of life

Findings:
The study found that microplastics can harm young zebrafish by affecting the way their brains and nervous systems develop. The microplastics also lowered important chemicals in the fish's body, which may lead to problems with growth, movement, and behavior.

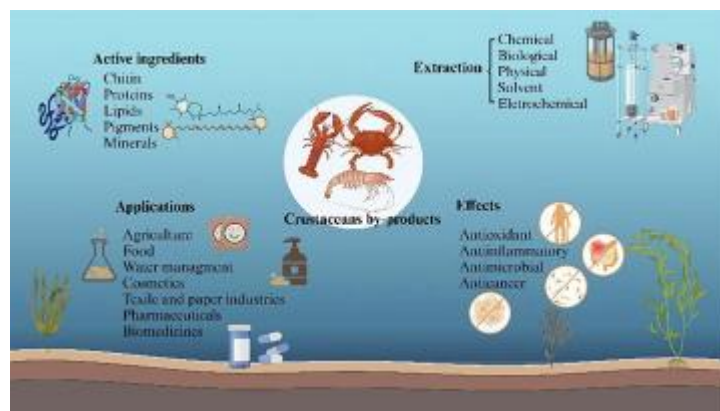


F2

“Maximizing Crustaceans...by products value for optimum valorization practices...”
Zhang, Z., Ma, Z., Song, L., & Farag, M. A. (2023). Maximizing crustaceans (shrimp, crab, and lobster) by-products value for optimum valorization practices: A comparative review of their active ingredients, extraction, bioprocesses and applications. *Journal of Advanced Research*, 57(2090–1232). <https://doi.org/10.1016/j.jare.2023.11.002>

Goal:
To explore strategies for reducing waste by extracting biomaterials from CBPs for potential use in various fields.

Finding:
Biomaterials obtained from CBPs, either directly or after further processing, can yield valuable compounds with exceptional biological properties suitable for diverse applications.

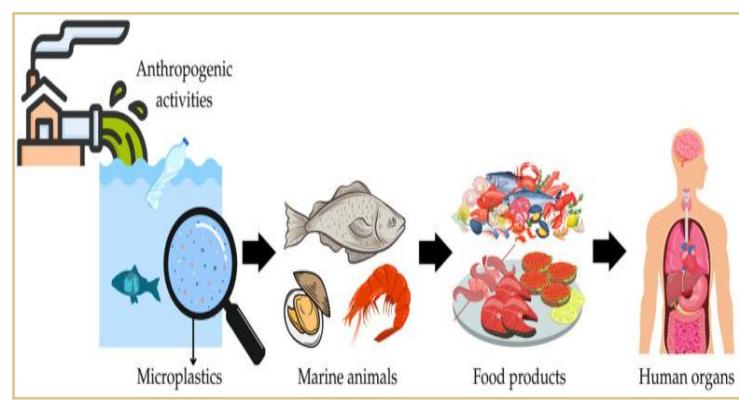


F3

“Microplastics in Fish and Fishery Products and Risks for Human Health: A Review”
Alberghini, L., Truant, A., Santonicola, S., Colavita, G., & Giaccone, V. (2023). Microplastics in Fish and Fishery Products and Risks for Human Health: A Review. *International Journal of Environmental Research and Public Health*, 20(1), 789. <https://doi.org/10.3390/ijerph20010789>

Goal:
To review the presence of microplastics in fish and fishery products and examine their potential pathways into the human food supply, as well as the possible health risks associated with exposure.

Finding:
Microplastics have been detected in numerous fish species and fishery products, with particles found predominantly in the digestive tract and less frequently in edible muscle tissue.



F4

Problem Statements

• **Microplastic pollution is rapidly accumulating in rivers and freshwater systems**, exposing aquatic embryos and juvenile fish to toxic particles that disrupt growth, organ development, and survival.

• **Current community-level filtration systems cannot remove small microplastics (<50 µm)**, allowing them to bypass treatment, enter streams, and accumulate in the food chain.

• **There is an urgent need for a low-cost, biologically validated filtration method** that demonstrates measurable reductions in microplastic toxicity on aquatic organisms, especially during early developmental stages.

Hypothesis

H1: Chitosan-based filtration will significantly reduce microplastic concentration and restore embryo development to near-normal levels.

H0: Filtration will not reduce microplastics or improve embryo developmental outcomes compared to unfiltered microplastic water

Goals

• Examine the biological role of chitosan, derived from crustacean shells, as a natural material capable of binding and reducing microplastic particles.

• Use early-stage zebrafish embryos (non-vertebrate stage) as biological indicators to evaluate whether chitosan-treated water shows reduced developmental stress compared to untreated water

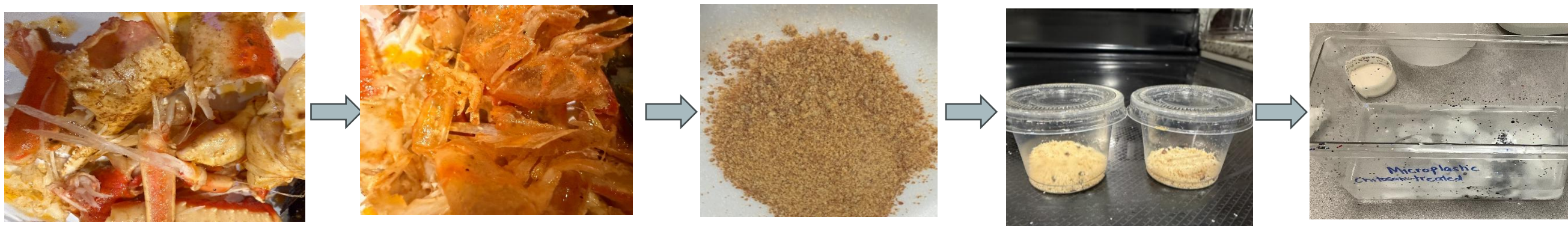
• Determine whether shellfish-derived chitosan can enhance natural filtration processes that support healthier aquatic animal ecosystems..

• .

Shellfish Contributions to Ecosystem and Human Health: Evaluating Chitosan’s Natural Ability to Remove Microplastics

Methodology

PHASE 1: MATERIAL PREPARATION & CHARACTERIZATION



What was done:

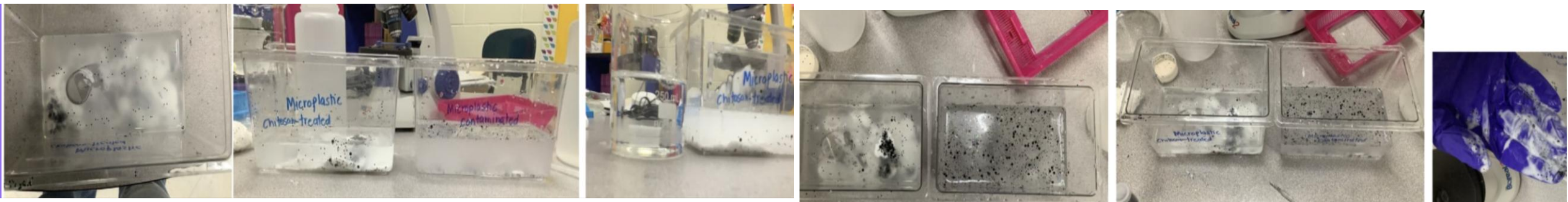
- Collected discarded shellfish shells from local restaurants.
- Cleaned, dried, and processed the shells into a powdered material.
- Prepared the shellfish-derived chitosan used in subsequent experiments.
- Established untreated samples as experimental controls.
- Conducted preliminary particle-capture testing using glitter as a model particle.

•Measured: Particle capture efficiency (%)

•Preliminary finding: Chitosan captured approximately 55–75% of the model particles during preliminary testing.

F8

PHASE 2: CONTROLLED MICROPLASTIC/PARTICLE REMOVAL



What was done:

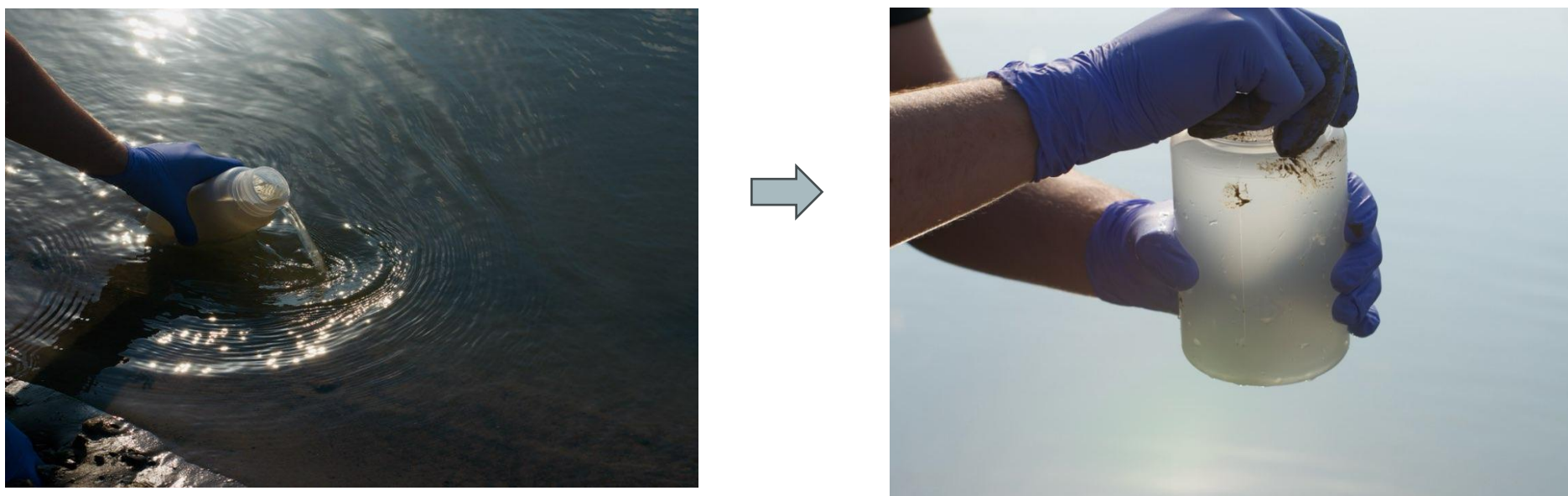
- Prepared water samples containing a known concentration of model particles.
- Created untreated control and multiple chitosan-treatment groups.
- Applied different chitosan concentrations under standardized conditions.
- Allowed suspended particles to coagulate.
- Filtered the samples and quantified remaining particles.

Measured:

- Particle concentration before and after treatment
- Removal efficiency (%)
- Turbidity

F9

PHASE 3: ENVIRONMENTAL WATER & BIOLOGICAL VALIDATION



What was done:

- Collected water samples from the Rio Grande.
- Compared untreated samples with chitosan-treated samples.
- Allowed chitosan to coagulate suspended material before filtration.
- Measured pH, TDS, and turbidity using Arduino-based sensors.
- Exposed *Danio rerio* embryos to the experimental water conditions.
- Observed embryo survival and development for four days.

Measured:

- Turbidity
- TDS
- pH
- Embryo survival and Embryonic development

F10

DATA & RESULTS

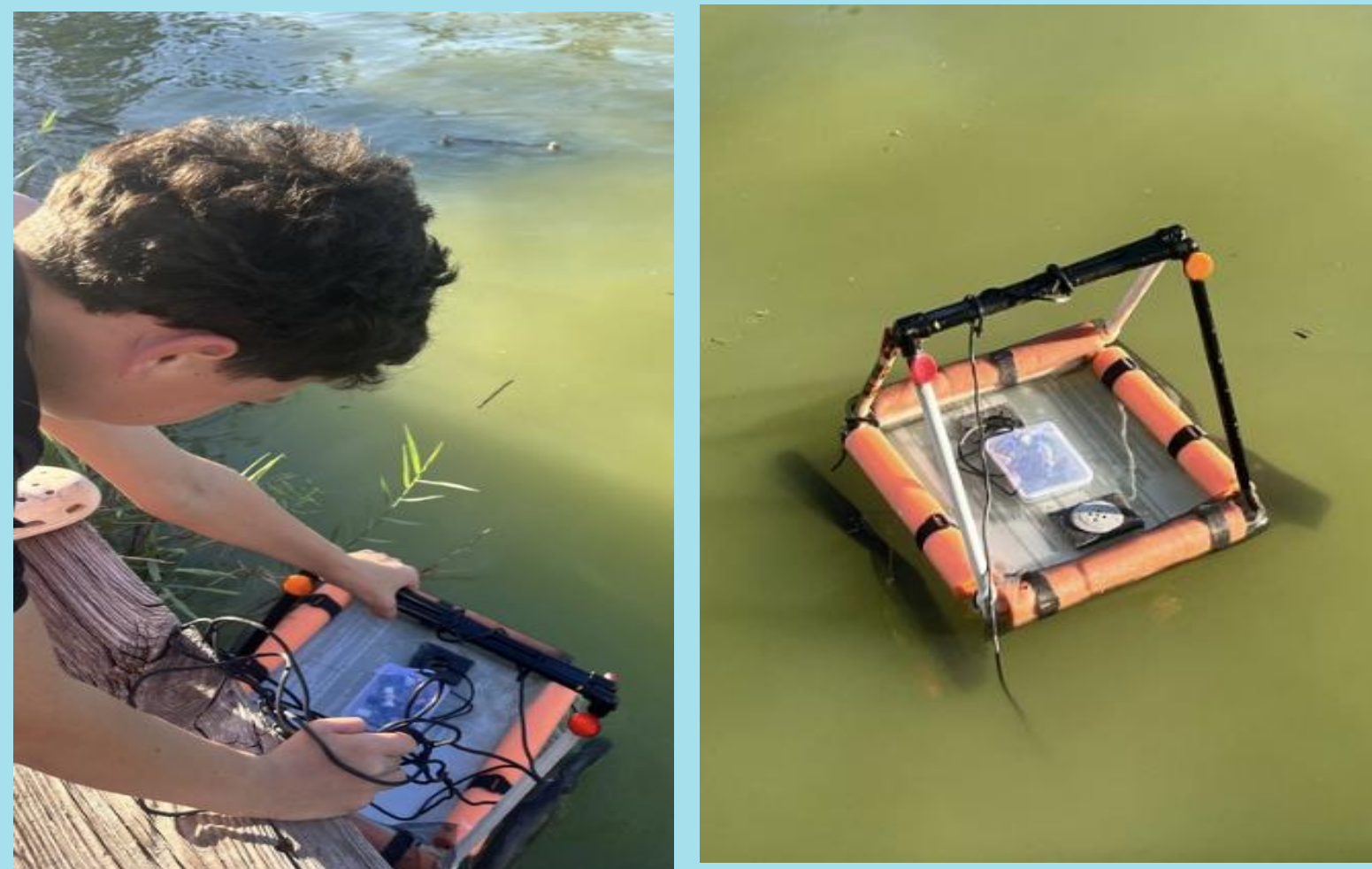
RESULTS

- Deformities (curved spine, edema, delayed growth) increased in unfiltered microplastic water.
- Deformities decreased consistently after filtration, with chitosan 30 mg/L showing the lowest rate among treatments.

ANALYSIS

A clear inverse relationship exist **higher microplastic removal → lower deformity rate**. This supports a strong biological link between particle pollution and developmental health.

FINAL STAGE: FIELD TESTING AUTONOMOUS RAFT SYSTEM

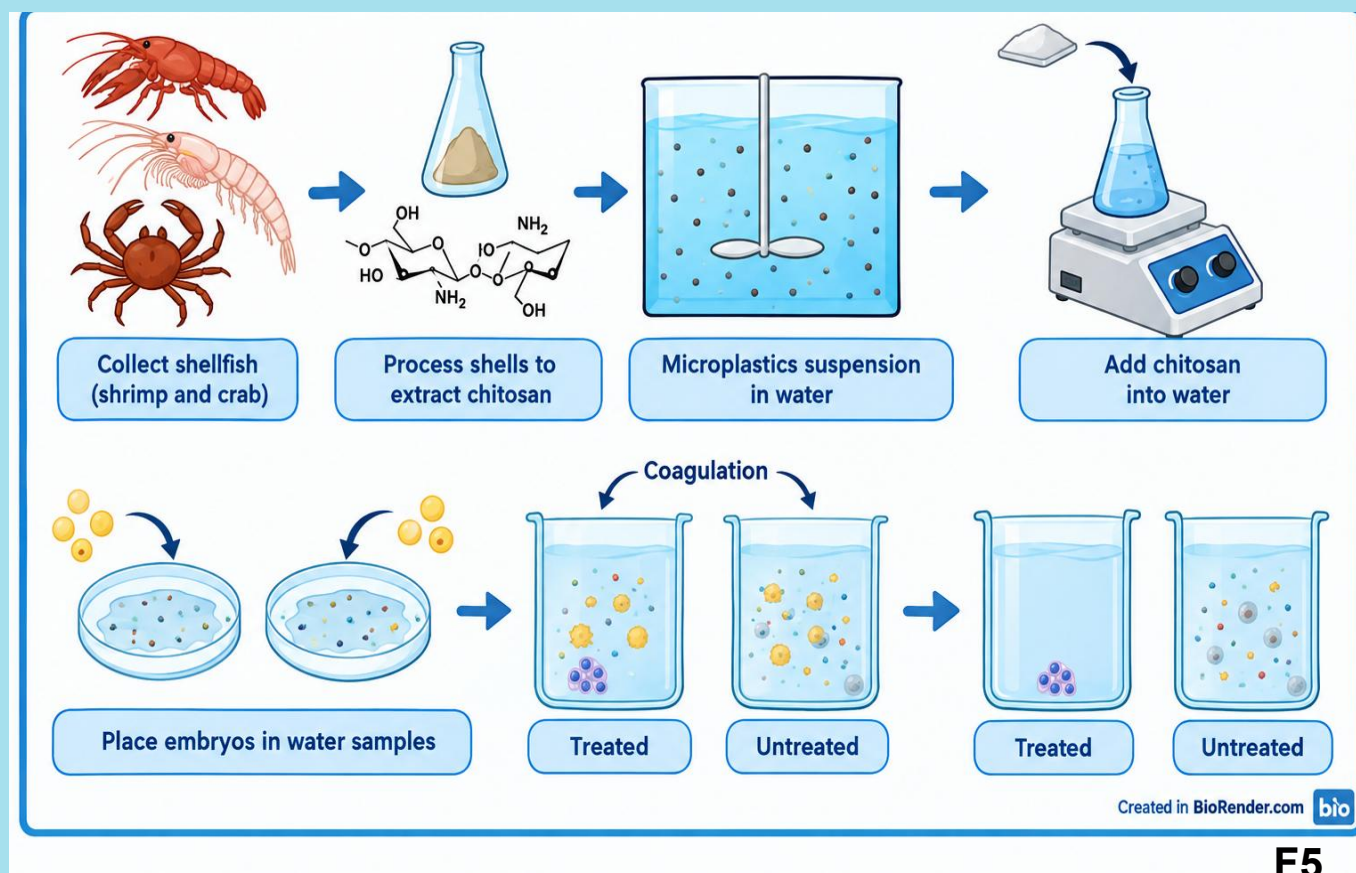


What was done:

- Designed an autonomous raft equipped with Arduino-based water-quality sensors.
- Integrated sensors for pH, TDS, and turbidity.
- Programmed the Arduino to receive and analyze sensor measurements.
- Developed a chitosan-delivery mechanism controlled by the system.
- Tested the prototype's ability to monitor water conditions and activate treatment.

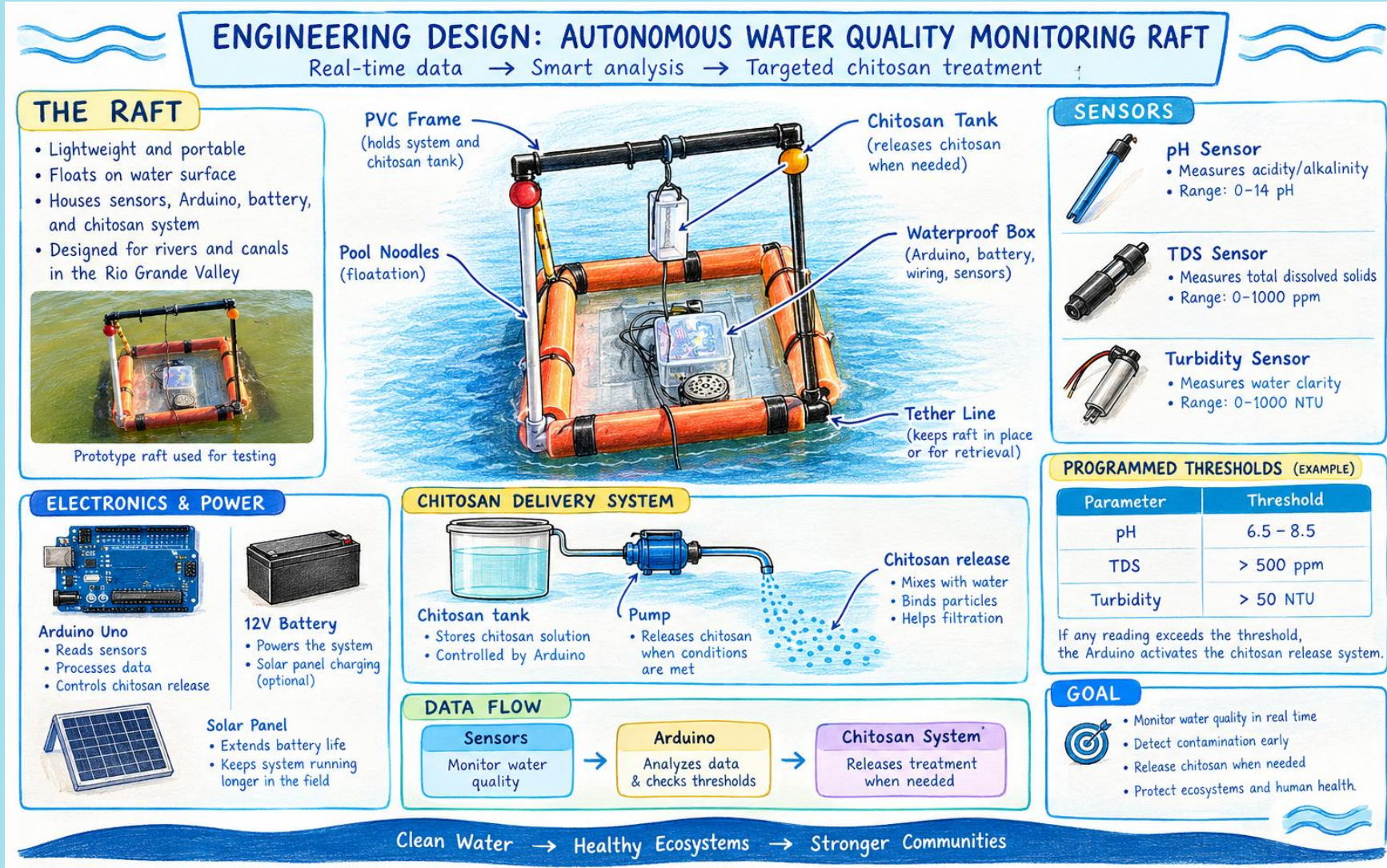
Results: Microplastics were bonded into the chitosan and removed from the river 6/6 times in different areas tested.

Workflow



F12

Engineering Design



F6

RIO GRANDE RIVER SAMPLES FILTERED AND UNFILTERED:



F7

TREATED COLOR IS VISIBLY CLEARER AS THE CHITOSAN COAGULATES AND BINDS MICROPLASTICS

Practical Applications

• **Ecosystem Protection:**
The microplastic filtration system helps reduce particle pollution in rivers and ponds, protecting fish embryos and restoring healthier aquatic ecosystems before long-term damage spreads through the food chain.

• **Human Health Awareness:**
This project shows how microplastics in contaminated water can impact early development in fish, highlighting similar risks for human exposure through drinking water and seafood. It encourages communities to monitor and reduce microplastic contamination to protect public health.

• **Sustainable Microplastic Remediation:**
Using biodegradable chitosan and low-cost Arduino sensors creates an eco-friendly model for removing microplastics that can be scaled to homes, schools, and community water systems, supporting long-term environmental resilience and cleaner water access.

Conclusion

This project showed that chitosan derived from crustacean and shellfish shells can significantly reduce microplastic levels in water, demonstrating an important biological pathway for improving aquatic ecosystem health.

Goal:
The study successfully evaluated whether an animal-derived biopolymer could mitigate microplastic pollution and support cleaner habitat conditions for aquatic species.

Methodology:
Microplastic levels were measured before and after chitosan treatment, and early-stage zebrafish embryos (observed only within the non-vertebrate period) were used as biological indicators of water quality and developmental stress.

Findings:
Higher microplastic concentrations corresponded with increased turbidity and greater developmental stress in embryos. After chitosan treatment, microplastic levels and turbidity dropped, and biological stress indicators improved. These results show that shellfish-based chitosan can naturally bind and remove microplastics, helping protect aquatic animals and reduce ecological contamination

Future Research

In July of 2026 I will:

- Scale to larger systems, such as small community filters or riverbank treatment units protecting local ecosystems.
- Add more sensors (like conductivity, pH, or particle-size detectors) to improve real-time water quality monitoring.
- Test with additional biological models to see how filtration helps other aquatic species affected by microplastic.

Works Cited

• F1: Diagram Created by N.Montelongo using canva.com
• F2:Park, S. H., & Kim, K. (2022). Microplastics induced developmental toxicity with microcirculation dysfunction in zebrafish embryos. *Chemosphere*, 286, 131868. <https://doi.org/10.1016/j.chemosphere.2021.131868>
• F3: Zhang, Z., Ma, Z., Song, L., & Farag, M. A. (2023). Maximizing crustaceans (shrimp, crab, and lobster) by-products value for optimum valorization practices: A comparative review of their active ingredients, extraction, bioprocesses and applications. *Journal of Advanced Research*, 57(2090–1232). <https://doi.org/10.1016/j.jare.2023.11.002>
• F4: Alberghini, L., Truant, A., Santonicola, S., Colavita, G., & Giaccone, V. (2023). Microplastics in Fish and Fishery Products and Risks for Human Health: A Review. *International Journal of Environmental Research and Public Health*, 20(1), 789. <https://doi.org/10.3390/ijerph20010789>
• F5: Diagram created using BioRender.com
• F6: Diagram created using Microsoft Copilot.
• F7:Photos taken by finalist N. Montelongo
• F8: Photos taken by finalist, graph made by finalist using GoogleColab, 2026.
• F9:Photos taken by finalist, graph made by finalist using GoogleColab, 2026.
• F10: Photos taken by finalist, graph made by finalist using GoogleColab, 2026.
• F11: Photo Credit:Photos taken by N. Montelongo and N.Garcia.
• F12: Data & Results Graphs created by N.Montelongo using experimental data gathered with arduino sensors using Google Colab
• Ling, F., Sertifi Supri, Heder Djamiludin, Rahmi Nurdiani, Seng, L. L., Yin, K. W., & Koban Rovina. (2024). Turning waste into value: Extraction and effective valorization strategies of seafood by-products. *Waste Management Bulletin*, 2(3), 84–100. <https://doi.org/10.1016/j.wmb.2024.06.008>
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