BIOGNOSIS CHALLENGE

DEFINE

The problem which I want to solve is **water pollution**. Water pollution is a significant environmental problem that can have serious consequences for human health and the health of ecosystems. It occurs when pollutants are introduced into bodies of water, making the water unsafe to use and harmful to the plants and animals living in and around it. There are many sources of water pollution, including agricultural and industrial waste, sewage and wastewater, and oil spills. Water pollution can severely impact human activities that rely on the ocean. Clean water is essential for everyone, and water pollution can make it difficult for everyone to operate.

This problem is related to **SDG goal 14 - Life Below Water.** Sustainable Development Goal 14 (SDG 14) is about conserving and sustainably using the oceans, seas, and marine resources for sustainable development. Its main focus is to protect marine ecosystems, reduce marine pollution, and preserve the diversity of marine life. Addressing water pollution is an important part of SDG goal 14 and reducing it can help overcome multiple challenges targeted by this goal.

BIOLOGIZE

My idea is based on how **aquatic organisms tackle this issue of water pollution**. One of the most common ways is **feeding off polluting organisms** like certain algae, bacteria, and other microorganisms. These microorganisms are very much responsible for spreading pollution underwater. And not just these, some organisms feed on wastes released in water bodies due to sewage and other exterior pollutants. Different aquatic organisms do this feeding mechanism in different ways. Some do this by directly feeding and sucking wastes, while others have specialized body parts like tentacles to do this task. Some aquatic plants also clean water by absorbing impurities using different body parts. This acts as a nutrient for their growth. In this way, aquatic plants help reduce aquatic contamination by bioaccumulating contaminants in their body tissues.

DISCOVER

Some aquatic organisms and their functions that I have tried to mimic are as follows:-

1.) Tilapia fish is commonly used in wastewater treatment systems, particularly in constructed wetlands. In these systems, tilapia are used to consume organic matter and other pollutants like algae, plants, and other aquatic life in the wastewater, which helps to improve the water quality. They generally feed off algae that they filter from the water by using tiny combs inside their gills or duckweed they find on the water's surface. In 2016, these fish were released in Kshipra and could significantly clean the water, demonstrating their ability to clean water.

Tilapia Fish

2.) Coral reef and its tentacles - Coral polyps, small organisms, form coral reefs. Each polyp has an opening called the mouth, surrounded by a circle of tentacles. The polyp uses these tentacles for defense, to capture small animals for food, and to clear away debris. The tentacles are covered with small, hair-like structures called cilia, which help to move water over the surface of the coral, providing it with oxygen and helping in its waste management. The tentacles of coral polyps play a vital role in the survival and functioning of coral reefs, as they act like their grippers.

Tentacles of Coral Reefs

3.) Aquatic plants like Azolla, Eichhornia, Lemna, Potamogeton, Spirodela, Wolfia, and Wolfialla - These plants have been reported as phytoremediators, and they are highly efficient in reducing aquatic contamination through the bioaccumulation of contaminants in their body tissues. They can reduce water pollution by absorbing certain pollutants through their roots, leaves, or any other part. The plants can then store the pollutants in their tissues, preventing them from causing harm to aquatic life or humans. **Their absorption mechanism inspires me to collect wastewater from bodies of water in a small tank with my soft robotic fish.**

ABSTRACT

The above-mentioned biological strategies can be converted into design strategies as follows: -

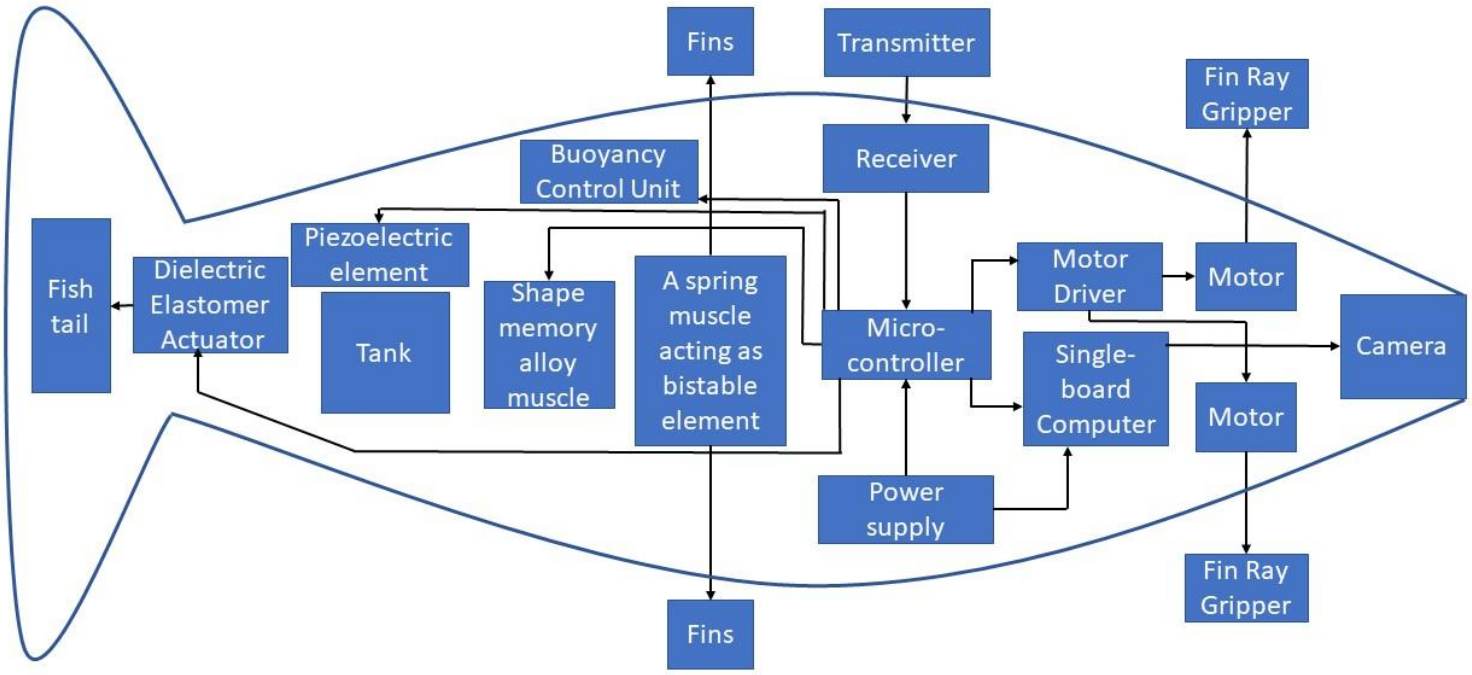
1.) The Tilapia fish gave me the idea to design a soft robotic fish. It will be best if a familiar aquatic animal solves the issue of underwater waste management. A fish's body's aerodynamic shape is ideal for widespread swimming underwater with high resistive drag. The familiar design of a fish also provides a base to think about what other components are necessary and where to place them. Also,

the consuming mechanism of the Tilapia fish got me thinking that **to remove or filter waste, some exterior part is necessary, like the tiny combs inside their gills.**

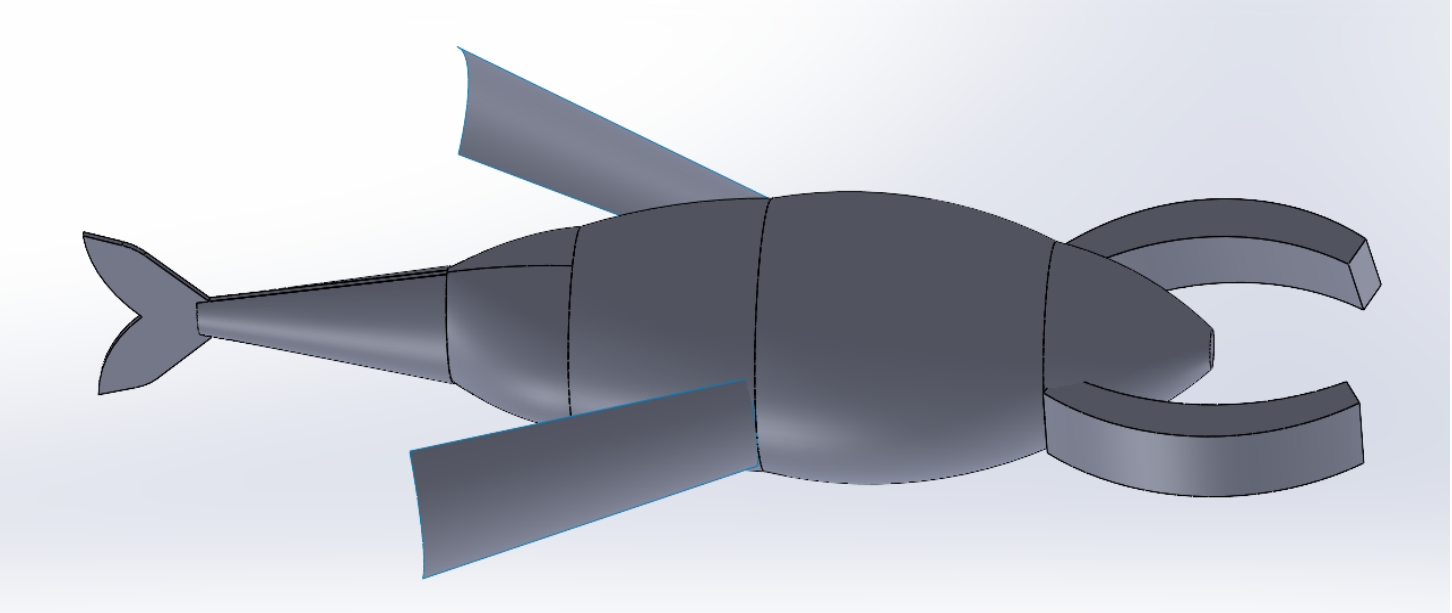
2.) The tentacles of Coral reefs gave me the idea of using grippers in my design to grab waste such as plastic bags, cans, and other items. I consider using an elastic material for these grippers to make them as flexible as coral reef tentacles, allowing them to move up to a wide range of angles and pick various sizes of items. Not only will the material be important, but so will the mechanism for controlling these grippers.

3.) The phytoremediators, aquatic plants, gave me the idea of treating solid wastes, liquid wastes, and small pollutant particles. The issue of storing liquid waste can be solved by inserting a small tank into my soft robotic fish. While 3D-printed TPU with an inner covering of TPU film can be used to treat small pollutant particles, because the bodywork will be 3D printed, there will be some porosity for the pollutant particles to attach to. As there will be an inner covering of TPU film, these particles will not enter the inner layers and can be separated later. Both of these ideas come from **the absorbing mechanisms of these aquatic plants.**

EMULATE



Signal Flow within the Soft Robotic Fish



CAD model of soft robotic fish

Use smart materials instead of electronics in a lot of parts. The major reason for this is that I am proposing an underwater robot, so my target is to use as few electronic components as possible. This will reduce both the dangers as well as the weight. Making this robot manually controlled with the help of a transmitter and receiver is necessary to avoid obstacles and achieve optimum control. The above flowchart is an overview of the inner workings of my soft robotic fish design. There are some major components to this. In the following points, I will explain each major component in detail, including its purpose and why I chose a specific material.

Major Components of soft robotic fish -

1.) Bodyworks of 3D printed TPU with an inner coating of thin TPU films

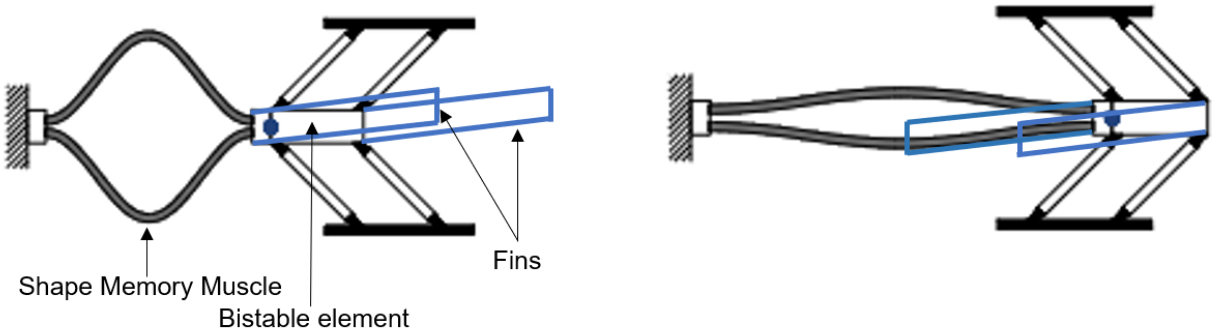
Thermoplastic polyurethane (TPU) is a material developed especially for 3D printing that does not absorb moisture. The reason for using 3D-printed materials for bodywork is that 3D printing produces lightweight bodywork and some porosity. Now, if I provide a TPU sheet as the inner covering, these little pores can be used as absorbents for pollutant particles. As a result, this bodywork is lightweight, acts as an insulator against outside temperature, and absorbs small pollutants.

2.) Fin ray soft robotic gripper

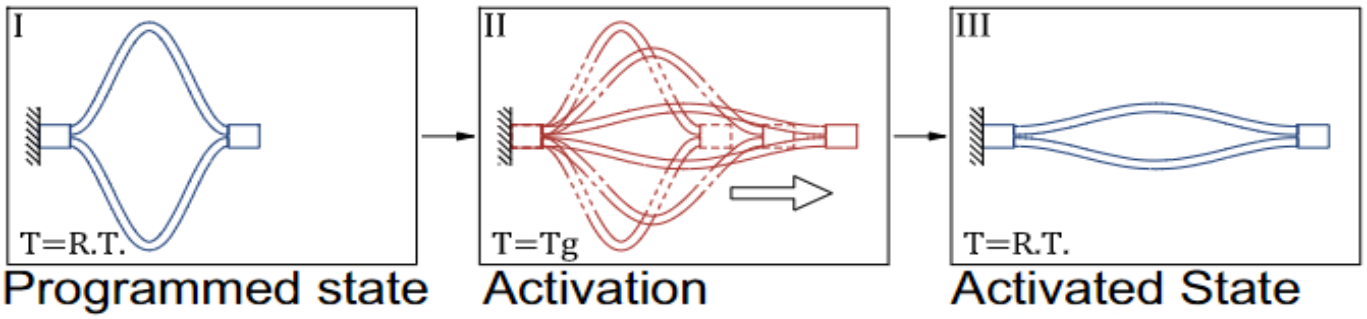
There are a wide variety of grippers to choose from. I choose fin-ray grippers because of their special property of changing shape according to the object they grip. I think of attaching these grippers to motors to move them within contact with objects. The purpose of attaching these grippers is that they should be able to pick up solid wastes to treat them.

3.) Shape memory alloy muscle-driven fins

The movement of Fins



Shape memory alloys are smart materials showing mechanical strain on temperature change. They can change their shape when the temperature increases to their transition temperature. Elongation and compression occur due to this change in shape. If we attach a bistable element, such as a spring muscle, and fins to those spring muscles, then when shape memory alloys move, the spring muscles move, causing the fins to move. Thus, simply by controlling temperature, this setup will ensure the fish's forward and backward movement. Now we will control temperature by wrapping wire around shape-memory muscle and controlling that current. As current generates heat, if we increase or decrease the current flow, the temperature will increase or decrease correspondingly. The diagram below shows how temperature changes from room temperature (R.T.) to transitional temperature (T.G.) dictate the movement of shape-memory alloy muscle.



4.) A Dielectric Elastomer Actuator

This is a smart material that, on receiving electrical input, shows mechanical movement. This thing is attached to a fishtail. Its purpose is that, on getting electrical input, it will move at a high frequency, which will cause the fishtail to move, due to which the fish can change its direction. The advantage of DEAs is that they require very little electrical energy and produce mechanical strain at a high frequency. This will result in quick body movements. As a result, just as fish fins control forward and backward movement, fish tails control left and right directional movement.

5.) Piezoelectric element above the tank

A piezoelectric element is a smart material that shows the mechanical strain on receiving electrical input. I have used this as an opening and closing valve on a tank. When we pass electrical input to it, it will move accordingly, opening the tank and allowing the liquid waste to enter. We can close the tank by similarly controlling this electrical input.

6.) Activated carbon mesh within the tank

Activated carbon is a material that has the properties of a large surface area and porosity, due to which it can absorb large amounts of waste. I'm considering using this material for my mesh and liquid waste collection tank. Due to this, it will collect the maximum amount of liquid waste. Activated carbon is perfect for this purpose because it is used worldwide for wastewater treatment.

7.) Buoyancy Control Unit

Using a buoyancy control unit (BCU) to control the diving depth for fish is a good idea. As I collect liquid waste, its weight will increase, and to properly manage that, I have used a buoyancy control unit (BCU). It will act as a syringe, which, based on its depth, will release water and thus control at what depth the fish will be.

8.) Fish-eye camera

I suggest using a fish-eye camera for a wide-angle view in which underwater computer vision can be integrated. It is necessary because it will aid in its navigation and help detect obstacles for its path planning.

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4.)https://drive.google.com/drive/folders/17S4LLmM9RX7XYVoHj3rc4bXtof0ufd3e?usp= sharing - CAD model of soft robotic fish