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# Analysis of Marine Pollution Using IOT

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**Abstract -** *In today's modern era, Marine Pollution is the most compelling problem that has been affecting all the oceans throughout the decenniums. It has been influenced by human movements such as the disposal of sludge, Oil flow, agricultural wastes into the ocean, etc. without disciplinary measures. The consequence of Oceanic pollution is destruction and impacts Ocean Life, the environment, and finally Humans. IoT in the modern world have played an important role in solving the critical problem of marine pollution detection and prevention. By integrating IoT technologies into marine pollution monitoring, several sensors, devices, and data analytics systems work together to improve our ability to detect, monitor, and respond to pollution events. Then, we propose an IoT system called 'SmartComputingSensor' using technical detectors and intelligent computing tools, specifically designed for onsite observation of microplastics in natural submarine surroundings. Controlling marine pollution needs carrying out various methods, activities, and certain measures. Primarily, we must reduce the usage of plastic as it threatens marine life. Through certain management techniques, the government ensures that proper waste disposal facilities are available. Next, Clean-up measures are essential. By clearing marine debris such as plastic covers, nets for fishing, and other remains there will be a decrease in pollutants. Various policy measures play a vital role in preventing and controlling marine pollution.*

***Key Words:*** **Marine Pollution, Internet-of-Things, sensors, detection, control, microplastics, IOT Smart Buoy**

## 1. Introduction

Oceanic pollution is a blend of chemicals and residuals, the utmost of which appear on land and are washed down or thrown into the ocean along with the increasing threat of marine pollution caused by disposable plastics, like bottles, straws, plastic bags, and packaging materials. The ecology, the health of all living things, and the global economic system are all adversely affected by this pollution. Marine pollution exploration has been conducted for over 20 years.

Marine pollution is a global issue in many ways. This has implications for the world's ocean life, regardless of the country's level of development. In addition, each country has a say in certain parts of the situation [22]. Our ocean is inundated with two categories of pollutants, chemicals, and garbage. Chemical or nutrient contamination is a problem for the environment, human health, and business profitability. This type of pollution occurs when lethal conditioning, particularly the use of toxins on farms, causes chemicals to leak into aqueducts that eventually flow into the ocean. Because of the widespread usage of agricultural chemicals for different applications, pesticide residues may present a main source of pollution, which poses risks to human health, animals, and plants. Fungicides are the category of pesticides with the greatest potential risk to humans, as approximately 90 percent of fungicides currently or in the recent past have demonstrated carcinogenic effects in animal studies [24].

The increased attention to chemicals analogous to nitrogen and phosphorus in coastal swell encourages the development of algal blooms, which can be toxic to wildlife and dangerous to humans. With the increasing reliance on plastics as everyday objects and the rapid increase in the amount of plastics consumed, it is a serious problem to consider the environmental impact of plastics in their manufacturing and subsequent disposal. There are various advantages of plastics similar as persistence and objection to deterioration, which conversely affect the environment [16]. One of the most commonly seen pollutants in the sea is microplastics. The phrase microplastics was coined in 2004 to characterize very minuscule fragments of plastic contained within the water's column and detritus at a depth of 50 meters. Microplastic particles include microscopic-sized manufactured plastics such as Scrubbers, or industrial pellets. Microplastics consist of a very heterogeneous collection of parts that differ in size, color, shape, specific gravity, chemical constituents, and other attributes. Plastic degradation processes are extremely slow, so microplastics may remain in the aquatic ecosystem for a very long time [13]. Microplastics have been practically discovered everywhere in the open and closed seas, including beaches, surface waters, water columns, and the deep-sea floor [16].

Microplastics generally fall into two kinds: primary and secondary.

*Primary microplastic* is the microplastic that the manufacturer creates in a specific small size for a specific function. Typically, what we've heard most about is microbeads. These are microscopic plastic beads used to exfoliate or scrub in face washes, cosmetics, and toothpaste. Typically, polyethylene (polypropylene, polyethylene terephthalate, or nylon) is used. Microspheres, capsules, fibers, and granules, among others, are instances of primary microplastics.

*Secondary microplastic* is microplastic that is liberated into the environment when larger fragments of plastic degrade over time. The plastic is shattered into smaller fragments by environmental factors such as waves, sunlight, and other physical stresses. Typically, it originates from improperly managed refuse. Cosmetics, personal care products, cleaning brushes, textiles, virgin resin pellets, water and beverage receptacles, food containers, and plastic bags are instances of secondary microplastics. [6]

Numerous consequences of ocean pollution have direct and indirect effects on marine life and humans. Here are some of the most prevalent impacts on marine life.

*Fish:*

Recent NPCG studies indicate that mesopelagic fish consume microplastics (fibers, fragments, and coatings). Estuarine ecosystems and their inhabitants such as fish include catfish, Ariidae (23% of examined individuals), and estuarine drums, which live their entire lives in estuaries are also susceptible to plastic pollution.

*Sea Birds:*

Numerous studies have addressed the consumption of marine debris by seabirds. Microplastics and small plastic particles have been segregated from birds as well as from their cadavers, regurgitated samples, and feces. Nearly 50 species of Procellariiformes (fulmars, petrels, shearwaters, albatrosses) that are known to feed opportunistically at the surface of the ocean contained microplastics in their intestines.

*Marine Mammals:*

It is valued that marine plastics contribute to the mortality of over one hundred thousand marine mammals annually. Plastic can impact marine life in numerous ways, including entanglement, injury, ingestion, and hazardous contamination. The primary determinant is the quantity of plastic, which can negatively affect various species in various ways and over varying timescales.

To date, only a single study has been published on marine mammals' microplastic ingestion. In 2013, Bravo Rebolledo et al. discovered microplastics in the stomachs and intestines of harbor(common) seals (Phoca vitulina). Other marine mammal species have not been observed directly ingesting microplastics. Nonetheless, bulkier plastic objects were discovered in the abdomens of several cetaceans. It may also happen via filter feeding, inhalation at the water-air interface, or trophic transmission from prey. Baleen whales (Mysticetes) may unintentionally catch microplastics as they strain water between their baleen plates to catch planktonic creatures and small fish (Nemoto, 1970). Additionally, oceanic mammals may be exposed to microplastics through trophic transfer from prey species. For instance, microplastics were found in the feces of fur seals (Arctocephalus spp.), which are thought to have started from lanternfish (Electrona subasperma).

*Sea Turtles:*

Although every sea turtle species consume macroplastic, only one study has found plastic particles in the stomachs of herbivorous green turtles (Chelonia mydas). Depending on their dietary preferences, it is highly probable that other sea turtle species also ingest microplastics, either directly or indirectly. Carnivorous turtles such as the loggerhead's (Caretta caretta) and the Kemps ridley (Lepidochelys kempii) feed on crustaceans and mussels that have consumed microplastics.

*Microplastic Effect on Habitats:*

Floating organisms inhabit the surfaces of microplastics that are buoyant. Similarly, plastics provide a habitat for bacterial colonization on the surface of water. Microorganisms such as Bacillus bacteria and diatoms have been detected on plastic objects found in the Northern Pacific Gyre. Due to the reality that microplastics increase substrate permeability and decrease thermal diffusivity, they may have significant consequences for marine life. This may affect processes that are temperature-dependent. For instance, alterations in incubation temperatures can influence the sex ratios of sea turtle embryos. At 30 °C, an equal number of male embryo and female embryo develop, whereas at 28 °C, only male embryos develop.

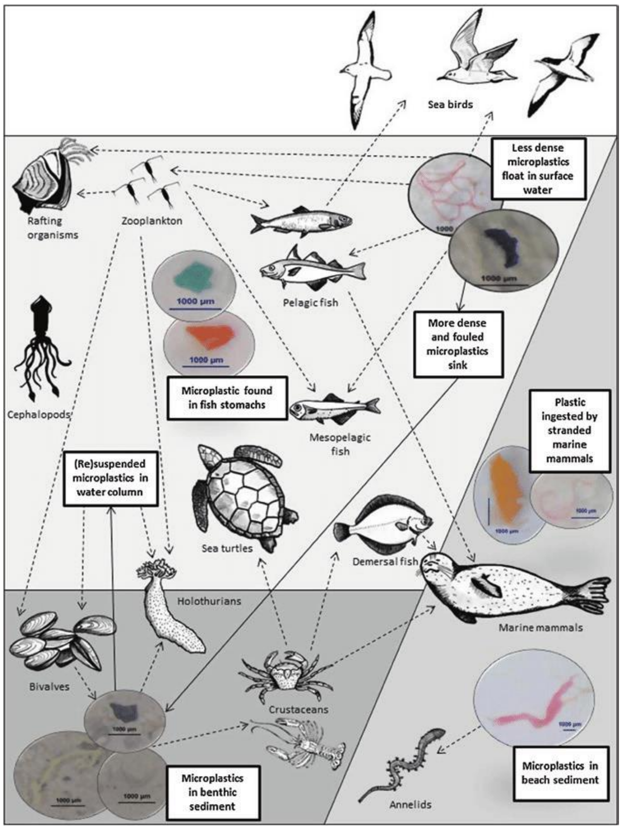

Figure 1. Marine life interaction with microplastics

Changes in sediment temperature may also have an impact on infaunal organisms by altering enzymatic and any other physiological methods, feeding and progression rates, locomotory velocities, reproduction, and ultimately community dynamics.

In addition to the characteristics of each plastic polymer, environmental factors such as ocean currents, horizontal and vertical mixing, wind mixing, and biofilm formation affect the spread of microplastics. [16]

### 1.1 Detection process/methods

Currently, laboratory-based methods [13] for monitoring microplastics are extremely popular and require traveling to various locations to obtain water samples for further analysis. This approach can occupy a considerable amount of time and other resources, and its success rate is uncertain.

Very few tries have been conducted to monitor microplastic debris in marine environments using multimodal computer vision that integrates visual (VI), infrared (IR), and ultraviolet (UV) spectral bands [21]. Here, I offer a smart administration system called SmartComputingSensor (plastic monitoring using smart sensors and intelligent computing). The SmartComputingSensor system will be using an 'Internet of Things (IoT)' architecture along with smart machine-learning algorithms.

In this architecture, feature selection techniques that combine growth algorithms can be used to effectively deal with pollution material (objects) that are difficult to localize, detect, and classify in a dynamic and perpetually changing water environment.

### 1.2 Controlling Marine Pollution

Layer chromatography, gas chromatography, and high-implementation liquid chromatography are some of the most popular instrumental approaches utilized to address challenging issue of marine pollution. However, if they are being used, additional factors such as the necessity for substance pre-treatment, cost, time, and analytical complexity must also be taken into account. Chemometric techniques, such as UNMIX and PMF (positive matrix factorization), are alternatives to instrumental techniques.

Recommendations for plastic pollution reduction:

1)Encourage Use of Recyclable Plastics:

To reduce the usage of single-use plastics, use fewer items like bags, water bottles, straws, cups, cutlery, and takeout containers. Purchase reusable versions of these items to persuade businesses to offer substitutes. Avoid using single-use plastics that aren't needed and encourage businesses to offer substitutes. You might decrease your everyday impact on the environment by doing this.

2)Promote laws that reduce the use of plastics and waste:

To combat ocean plastic pollution, legislation must be introduced to reduce plastic production, improve waste management, and make plastic producers accountable. Support local, national, and international legislation to address plastic pollution. The 2021 Plastic-Pollution Break-Free Act in the US and state-level initiatives to introduce extended producer responsibility (EPR) legislation make plastic producers and distributors liable for their products and packing. A global plastics treaty and legislation limiting Individual use of plastic items, such as bags and foodware, have been successful in reducing pollution.

3)Responsible Recycling:

Recycle single-use plastics because just 9% of plastic is recycled globally. Recycling helps to keep plastic out of the water and reduces the creation of new plastic. Consult Earth911's recycling directory for a list of nearby recycling facilities and details on whether they accept specific types of plastic.

4)Participation in River and Marine Cleanup:

Join or lead beach or waterway clean-ups to help reduce ocean plastic waste. This straightforward and fruitful strategy includes gathering plastic debris on your own or with companions, as well as participating in regional groups or global activities like the Global Ocean Cleanup or the International Coastal Cleanup.

5)Avoid using items that contain microbeads.:

Microbeads, tiny plastic particles, are a significant source of ocean plastic pollution. They are found in face cleansers, toothpaste, and bodywashes, entering oceans and waterways through drainage systems. To avoid plastic microbeads, check ingredient labels for "polyethylene" and "polypropylene" in cosmetic products.

6)Promote awareness:

We can educate everyone about plastic pollution and raise consciousnessby sharing information, organizing screenings, or watching documentaries such as A Plastic Ocean, Junk Island, Bag It, Addicted to Plastic, or Garbage Island. In addition to IT technology, continued advanced technologies include sensor use, better waste management, and the creation of novel materials including remote sensing, big data analytics, artificial intelligence, and real-world simulations.

7) Help Organizations Fighting Plastic Pollution:

The Plastic Pollution Coalition, 5 Gyres, Algalita, and the Plastic Soup Foundation are just a few of the charity organizations that are helping to reduce ocean plastic pollution. In order to address the growing issues, we can join the Blue Habits Club, which is committed to taking daily actions to support ocean health.

8) Through governmental initiatives, public education, and regular use of primarily biodegradable materials.

## 2. Literature Review

The authors **Usha Jain and Muzzammil Hussain, in** [14] examines the significance of real-time observing of maritime homes and borders for nonmilitary operations, boundary protection, and the conservation of marine resources. It emphasizes the difficulties associated with maritime surveillance, analogous to enormous abysms, ever-changing surroundings, and the need for continuous surveillance. The authors propose a security medium for wireless sensor networks that focuses on sensor knot configuration, communication protocols, and advanced data recycling ways for trouble discovery. The system employs anomaly discovery algorithms and data analytics to identify implicit hazards and notify nonmilitary authorities. The authors illuminate the benefits of WSN-predicated surveillance for enhancing situational awareness, preventing maritime hazards, and speeding up response strategies.

The authors **Arijit Khan and Lawrence Jenkins, in** [15] discusses the importance of preventing ocean pollution and the negative impact of human activities on marine ecosystems. It highlights the drawbacks of conventional monitoring techniques and proposes the adoption of Undersea Wireless Sensor Networks as a practical approach. The network consists of strategically placed underwater sensor nodes gathering environmental data, such as water quality, temperature, salinity, and pollutants. The authors emphasize the significance of real-time data collection and observation, as well as a pollution detection and alarm system integrated into Undersea Wireless Sensor Networks. Data visualization and decision-support tools are crucial for understanding pollution trends and identifying hotspot areas.

The authors **Han et al., in** [12] discusses the importance of routing techniques in aquatic wireless sensor networks, addressing challenges like restricted bandwidth, long propagation delay, and challenging channel necessities. It also discusses the challenges of routing data in the constantly changing aquatic environment, node mobility, limited communication range, energy limitations, and network connectivity during node failures. The authors classify routing rules into flat-based, location-based, and hierarchical-based categories, evaluating their effectiveness through simulations and comparisons. The authors emphasize the need for selecting suitable routing strategies that align with specific application needs and underwater environment characteristics.

In order to assure effective data gathering, the authors **Nasrin et al. in** [18] emphasizes the relevance of spotting anomalies in aquatic wireless sensor networks. Due to noise, a large propagation delay, and a limited bandwidth, anomaly detection in underwater situations is challenging. To precisely identify abnormalities, the authors describe a novel method that combines statistical analysis and machine learning methods. Using labeled data, the model is taught to recognize typical behavior conditions and spot irregularities. The authors examine real-world aquatic sensor data and contrast it with methods currently in use to evaluate the efficacy of their suggested anomaly discovery method.

In [11] by **Gkikopouli et al., t**he Undersea Sensor Network is crucial for marine monitoring and exploration, but it faces challenges such as restricted bandwidth, propagation delay, and severe underwater conditions. Designing aquatic sensor nodes is essential, and strong, waterproof enclosures are essential. Communication techniques include acoustic and hybrid methods, and energy-saving tactics like duty cycling and adaptive power control are discussed. Localization and placement techniques are crucial for tracking underwater sensor nodes, and solutions like ranging and trilateration are suggested. The survey investigates data collection and routing techniques to reduce transmission and prolong the network's lifespan. Overall, this research paper is valuable for researchers, engineers, and practitioners in the field of aquatic wireless sensor networks, contributing to the enhancement of aquatic exploration and monitoring capabilities.

The authors **Xu et al., in** [27] highlights the use of Wireless sensor-network in marine systems and the importance of managing the marine environment and protecting ecosystems. It explores methods of collecting data, assessing water quality standards, studying marine pollution, and observing marine biodiversity. Focusing on acoustic communication and state-of-art surface propagation pathways, this article reviews sensor node design, deployment, message rules, and data transmission strategies for underwater surveillance. Wireless sensor networks may be deployed to improve marine research and data collection for mission-critical marine protection and operational tasks

In [9] by **Fattah et al.,** the significance of aquatic wireless sensor networks in a number of fields, such as environmental monitoring, marine exploration, and disaster avoidance, is highlighted in this research. It deals with issues like long propagation delays, bandwidth restrictions, and harsh underwater environments. Aquatic wireless sensor network components and processes are categorized by the taxonomy, and more recent developments include energy-efficient algorithms, localisation strategies, and flexible whipping schemes. In order to optimize aquatic wireless sensor networks in realistic scenarios, the authors underline both the advantages and difficulties of these novel strategies. They also stress the need for continued study.

The authors **Zhang et al., in** [28] explain the significance of maritime research and pollution monitoring is emphasized in this paper, along with the difficulties in obtaining current data from a variety of marine fields. WSNs, or wireless sensor networks, have benefits like real-time data collecting, adaptation to various environmental conditions, and economical management. Beacon clustering improves network coverage while using less energy. Recycling ideas provide continual maritime environment observation while ensuring network sustainability and long-term usability. WSNs are crucial for managing maritime resources, protecting the environment, enhancing our understanding of the ocean, and reducing pollution.

The authors **Ramamoorthy and Loganathan** in [20] for secured Data Transmission in Military Applications using video steganography concept, security level improved by 24 percent.

The authors **Schnurr et al., in** [23] emphasizes the rising danger of marine contamination brought on by individual-use plastics including bottles, straws, bags, and packaging supplies. It draws attention to the negative ecological effects of individual-use plastics on marine life, such as entanglement, ingestion, and habitat destruction. For plastic pollution to be reduced, behavioral change and public awareness are essential. To stop individual-use plastics from polluting the ocean, the authors stress the value of international agreements, collaborations, and concerted action.

The authors **Xanthos and Walker, in** [26] discusses plastic marine pollution, highlighting the negative effects of disposable plastics on aquatic ecosystems, wildlife, and humans well-being. It analyzes successful policy implementations, including bans, taxes, levies, and regulations, and evaluates their effectiveness in reducing plastic bag waste. It also discusses microbeads in cosmetic products and their contribution to marine pollution, highlighting the need for coordinated international standards. The paper also discusses international agreements and initiatives like the Basel Convention, Clean Seas Programme, and Stockholm Convention, fostering cooperation among nations to battle plastic pollution. Challenges include resistance from the industry, inconsistent enforcement mechanisms, and improved waste minimization and recycling infrastructure. The paper emphasizes the importance of global cooperation and coordinated action to combat plastic marine pollution from single-use plastics.

## 3. Proposed Method

### 3.1 SmartComputingSensor Architecture and Logic for Microplastics Detection

SmartComputingSensor will incorporate multifaceted data fusion, intelligent computation strategies, and a control system to detect the microplastics in the ocean. Data fusion will employ images in the visible, infrared, and ultraviolet spectral bands as well as a variety of particular sensors to facilitate the measurement of various physical and chemical attributes in dynamic environments. In addition, the proposed design must be highly scalable and expandable for massive geographical areas.

*Propagation and Screening Methods:*

The following are two potential design alternatives for the system:

*In-situ observation and detection:* This strategy aims to reduce transmission costs by detecting and analyzing signals on-site. This method can be very useful when deploying a huge quantity of sensors over a large geographical area. In this case, the limitation is the need to connect and deploy potent processing computer hardware at every location. In-situ sensing and processing are now more feasible with recent developments.

*Monitoring in-place and server-based detection:* In this implementation, signal processing is performed on a server located remotely from the measuring instruments. Advantages include a comparatively simple architecture and minimal signal processing on-site. In the case of high-volume signals, the greatest drawback of this method can be a prohibitively expensive transmission fee.

Finally, the implementation of such hardware is rather inexpensive and readily accessible.

**SMARTCOMPUTINGSENSOR ARCHITECTURE**

The development of the SmartComputingSensor system can benefit from a number of structural and computational ideas. The two most complementary strategies that can be used are presented below.

*Portable Sensors with Internet of Things (IoT)*: Wireless sensors are efficient of being equipped with various types of sensors to observe temperature, salinity, etc or two-dimensional (images) variables. Batteries and wireless transceivers power these sensors so electrical cables involved. IoT and wireless sensors are a significant part of the solution to an issue like marine small particle monitoring.

*Multimodal camera-based detection techniques*: In situations with limited illumination and other visual restrictions, a single camera may not be sufficient. Additional modalities, such as infrared and ultraviolet, enhance the detection process by expanding the available spectrum. Several computational techniques, such as data fusion and learning classifiers, can be utilized to address data processing problems.

### 3.2 IoT-Enabled Smart Buoys for Controlling Marine Pollution

IoT-Enabled Smart Buoys are sophisticated marine monitoring systems that utilize the IoT (Internet of Things) to collect, transmit, and analyze environmental data from oceans, rivers, and other water sources. These buoys are outfitted with an assortment of sensors and communication devices that provide real-time data on water quality, weather conditions, pollution levels, and other pertinent parameters. Here is a more comprehensive explanation of how IoT-enabled Smart Buoys function and their benefits:

***Functional Components:***

Sensors: The sensors on smart vessels include pH sensors, temperature sensors, dissolved oxygen sensors, and turbidity sensors, among others. These sensors perpetually collect water quality-related data.

Communication Devices: These vessels are equipped with communication devices such as cell modules, satellite modems, and radio transceivers. These devices allow vessels to transmit data to remote servers or control centers.

Data Processing: The collected data is sent to the cloud or a centralized server for processing, analysis, and visualization. Using sophisticated data analytics techniques and machine learning methods, it is possible to extract insights from the data.

Real-time Monitoring: Researchers, scientists, and environmental authorities have remote, real-time access to the data. This enables the monitoring of real-time changes in water quality, pollution levels, and other parameters.

**Advantages and Applications**

Early Pollution Detection: Intelligent buoys can detect pollution incidents such as oil-spills, chemical leakage, and excessive nutrient levels. Early detection allows for prompt response and mitigation measures.

Environmental Monitoring: These buoys provide a wealth of information for assessing the condition of ocean and marine ecosystems. They contribute to the comprehension of the effects of climate change, pollution, and other factors on marine life.

Research and Analysis: The collected data can be used for researching long-term trends, predicting the behavior of marine ecosystems, and formulating effective conservation strategies.

Emergency Response: In the event of natural calamities such as tsunamis or hurricanes, intelligent buoys can provide vital information for assessing the situation and predicting potential impacts on coastal areas.

Data-Driven Decision Making: Smart buoy data enables authorities to make informed judgments regarding marine resource management, pollution control, and emergency response.

Public Awareness: Sharing visualizations and reports derived from the data collected by smart buoys can increase public awareness of marine environmental concerns.

## 4. Experimental Setup

### 4.1 MDCS System for detection of marine pollution

The meaning of the acronym MDCS is " Multidimensional Data Capture System."

It provides the design and implementation of a multifaceted surveillance system at both the software and hardware levels. In this architecture, spectral cameras, as well as illuminators, are utilized. These cameras are linked to computer components via USB connections. This computer functions as a server and is responsible for all data acquisition software implementation. Matlab software libraries are utilized for the evaluation of data. The primary component of the HMDAS system (see Fig. 2) is a multi-camera device that includes the microscope camera(s). Cameras are equipped with the proper illuminators and lenses. These cameras communicate with the controller subsystem through standard I/O communication ports (USB, Wi-Fi, etc.).

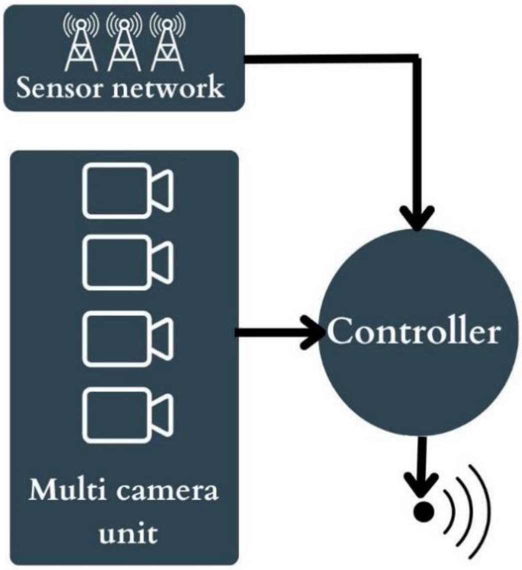

Figure 2. Microscope-relied monitoring node integrated into a multi-camera unit.

The MDCS architecture employs a layered approach for various data processing operations.

The architecture's topmost stratum is responsible for data acquisition via multiple cameras and/or wireless sensors. In contrast, the subsequent layers are implemented with feature extraction, optimization, and classification techniques. The base layer is a repository that stores data in raw, feature, and result formats. A suitable user interface will be created to conclude this adoption procedure. Thus, for microplastics, a complete system with data surveillance can be ensured.

### IoT Utilization

An Internet of Things (IoT) strategy was created in order to provide a geographically extensive detection system. multiple MDCS systems where each unit will be outfitted with a 5G mobile gateway to establish connectivity with a cloud-based application server . In this study, we also employ a similar strategy for data collection, which consists of a cluster of MDCS data acquisition subsystems. This method assures the scalability of the monitoring solution for microplastics in aquatic systems.

SmartComputingSensor's IoT-based architecture consists of four main software and hardware layers (Fig. 3). The bottom layer facilitates the deployment of MDCS sensory nodes in the field. The communication layer facilitates the transmission of data to the layers above. This layer generates a vast quantity of data that is converted into feature form and then processed using intelligent computation techniques to detect the presence of microplastic particles. The topmost layer employs presentation and analytic capabilities to visualize the results of the discovery. The architecture seeks to provide a fullproof solution by addressing security, load-balancing, and fault-recovery mechanisms. The proposed IoT construction may be a viable method for detecting the presence of microplastics in water columns.

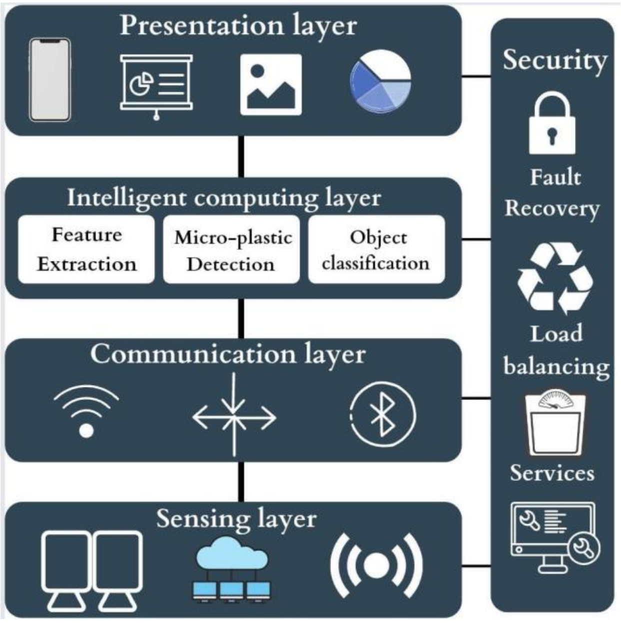

Figure 3. SmartComputingSensor's layered design is built on the Internet of Things.

### Detection Results:

| **Location** | **Type/Equipment Used** | **Amount(±SD)** |
|---|---|---|
| **Pacific Ocean** | | |
| Heugnam Beach, South Korea | PS spheres<br>Fragments<br>Pellets | 874 (±377)m$^{-2}$<br>25 (±10) m$^{-2}$<br>41 (±19) m$^{-2}$ |
| Coastal beaches, New Zealand | Pellets | >1,000 m$^{-1}$ |

| | | |
|---|---|---|
| Easter Island, Chile | Fragments and pellets 1–10 mm | 805 m$^{-2}$ |
| **Atlantic Ocean** | | |
| North Atlantic | Continuous plankton recorder (CPR) | 1960–1980: 0.01 m$^{-3}$<br>1980–2000: 0.04 m$^{-3}$ |
| Caribbean | Neuston net | 60.6–180 km$^{-2}$ |
| South Atlantic Bight | Neuston net | Mean weight: 0.03–0.08 mg m$^{-2}$ |
| **North Sea** | | |
| Harbor sediment, Sweden | Fragments | 20 and 50 kg$^{-1}$ |
| **Arabian Sea and Indian Ocean** | | |
| Mumbai, India | Fragments | 41.85 % of total plastics |
| Coastline, Singapore | Fibres, grains, fragments | 36.8 ± 23.6 kg$^{-1}$ |
| Gulf of Oman | Pellets | >50–200 m$^{-2}$ |
| Arabian Gulf | Pellets | >50–80,000 m$^{-2}$ |

Table 1: Mean microplastic abundance (±SD) in sediments from various seas and oceans

| **Species** | **Number Studied** | **Percentage with plastics(%)** | **Mean number of particles per individual(±SD)** | **Type and Size ingested(mm)** | **Location** |
|---|---|---|---|---|---|
| Green turtle (Chelonia mydas) | 24 | / | Total: 11 pellets | <5 mm | Rio Grande do Sul, Brazil |
| Longnosed lancetfish (Alepisaurus ferox) | 144 | 24 | 2.7 (±2.0) | 68.3 (±91.1) | North Pacific |
| Pearly lanternfish (Myctophum nitidulum) | 25 | 16 | 1.5 | Longest dimension 5.46 | North Pacific |
| Cat fish(Cathorops spp.) | 60 | 33.3 | 0.55 | 1-4 | Goiana estuary, Brazil |
| Brown shrimp(Crangon crangon) | 110 | / | 11.5 fibres per 10g shrimp | 95% fibres,<br>5% films<br>300-1000 µm | Belgium |

Table 2: Interactions of Microplastics with Marine Organisms

### 4.2 The Architecture of IoT-Enabled Smart Buoys

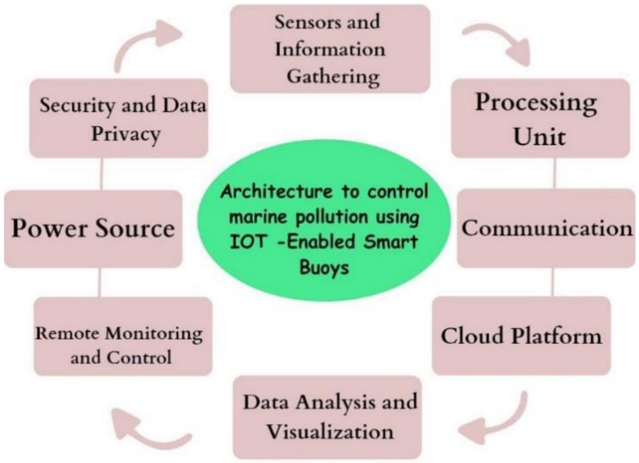

Figure 4. The IoT- Enabled Smart Buoys architecture.

IoT- Enabled Smart Buoys are designed with an armature that facilitates the collection, transmission, and analysis of environmental data from marine and submarine surroundings. These buoys use Internet of effects( IoT) technology to construct a networked system that provides real-time data on water quality, rainfall conditions, and pollution situations, among other variables. The architecture is classified as:

*Sensors and Information Gathering:*

Sensor Array: The detectors on smart vessels include pH detectors, temperature detectors, turbidity detectors, saltness detectors, and dissolved oxygen detectors, among others. varied environmental parameters are measured by these detectors.

Data Collection: Detectors measure the physical and chemical characteristics of the ambient water in a nonstop manner. This information is also digitized and made transmission-ready.

*Processing Unit*

Microcontroller/Processor: A microcontroller or processor is embedded in the container to reuse detector data and prepare it for transmission. It can also perform the necessary data pre-processing and aggregation.

*Communication:*

Communication Modules: Communication modules similar to cellular modems, satellite transceivers, and radio communication bias are installed in intelligent buoys. These modules allow vessels to connect to remote waiters or command centers.

Data Transmission: Through the communication modules, reused data is transmitted to centralized waiters or all platforms.

*Cloud Platform:*

Cloud Servers: Multiple vessels transmit their data to cloud servers for storage and analysis. The scalability of cloud platforms is required to manage large volumes of data from numerous vessels.

Data Processing: The collected cloud-based data can be analyzed using sophisticated techniques and algorithms. It is possible to train machine learning models to identify patterns and anomalies in data.

*Data Analysis and Visualization:*

Data Analytics: Data analysis can yield insights regarding water quality, pollution levels, and weather patterns, among other topics. Trends and correlations can be uncovered with the aid of statistical analysis and machine learning algorithms.

Visualization: Through interfaces, graphs, and maps, data insights can be visualized. This makes it easy for researchers, scientists, and stakeholders to comprehend the information.

*Remote Monitoring and Control:*

Web and Mobile Interfaces: Users can remotely access collected data via web and mobile applications. They are able to monitor real-time data, observe historical trends, and receive alerts for important events.

Control and Commands: Some intelligent vessels may be able to receive remote commands. Adjustments to sensor settings and communication frequency, for instance, can be made via a centralized control interface.

*Power Source:*

Power Supply: Solar panels, batteries, or a combination of both power smart vessels. To ensure continuous data collection and transmission, efficient power management is crucial.

*Security and Data Privacy:*

Encryption: Encryption protocols are used to safeguard data transmission and storage from unauthorized access.

Authentication: Authentication mechanisms restrict system access, ensuring that only authorized personnel can interact with buoys and data.

IoT-Enabled Smart Buoys' architecture incorporates sensors, communication technologies, cloud platforms, data analytics, and visualization to create a comprehensive marine monitoring system. This system improves our knowledge of marine ecosystems, aides in pollution control, and facilitates scientific research and decision-making.

## 5. Conclusion

Microplastics have been discovered in practically all marine habitats on Earth, and the consistency of the plastic, ocean currents, and other surrounding factors all appear to have substantial outcomes on how broadly they are classified. Concerns about the interactions and potential impacts of microplastics on aquatic life are raised by their widespread distribution and accumulation. Here, a concept for an IoT-based architecture, its justification, and an introductory assessment of the classification of microplastics are described. In order to show the system proficiencies that are to be implemented in the problem environment, the ideas of the Internet of Things and multimodal computer vision are presented. The suggested IoT-based system architecture can be constructed extremely fast using commercial off-the-shelf and open-source hardware and software components. Using the explained MDCS data collection system, we can easily monitor and find microplastics in coastal areas, rivers and streams, coral reefs, and the deep sea. With the many methods and approaches mentioned, we can tackle marine pollution and by implementing the latest new technologies we can stop the pollution of open oceans and water surfaces with microplastics. Finally, the purpose of this study project is to provide a comprehensive analysis of how to lower marine pollution. It aims to support ongoing efforts to preserve the integrity of our marine ecosystems by studying their causes and impacts.

## Reference

[1] Afonso-Olivares, Cristina, et al. “Analytical Tools Employed to Determine Pharmaceutical Compounds in Wastewaters After Application of Advanced Oxidation Processes.” Environmental Science and Pollution Research, vol. 23, no. 24, Springer Science and Business Media LLC, Aug. 2016, pp. 24476–94. Crossref, https://doi.org/10.1007/s11356-016-7325-6.

[2] Alam, Muhammad, and Elyes Hamida. “Wearable Wireless Sensor Networks: Applications, Standards, and Research Trends.” Emerging Communication Technologies Based on Wireless Sensor Networks, CRC Press, Apr. 2016, pp. 59–88. Crossref, https://doi.org/10.1201/b20085-6.

[3] Ansari, T. M., et al. “Heavy Metals in Marine Pollution Perspective–A Mini Review.” Journal of Applied Sciences, vol. 4, no. 1, Science Alert, Dec. 2003, pp. 1–20. Crossref, https://doi.org/10.3923/jas.2004.1.20.

[4] Armbrust, Michael, et al. “A View of Cloud Computing.” Communications of the ACM, vol. 53, no. 4, Association for Computing Machinery (ACM), Apr. 2010, pp. 50–58. Crossref, https://doi.org/10.1145/1721654.1721672.

[5] Borowik, Grzegorz, et al., editors. “Computational Intelligence and Efficiency in Engineering Systems.” Studies in Computational Intelligence, Springer International Publishing, 2015. Crossref, https://doi.org/10.1007/978-3-319-15720-7.

[6] Chaczko, Zenon, et al. “Towards an IOT Based System for Detection and Monitoring of Microplastics in Aquatic Environments.” 2018 IEEE 22nd International Conference on Intelligent Engineering Systems (INES), IEEE, June 2018. Crossref, https://doi.org/10.1109/ines.2018.8523957.

[7] Clark, Robert Bernard, Chris Frid, and Martin Attrill. Marine pollution. Vol. 4. Oxford: Clarendon press, 1997.

[8] DUBINSKY, ZVY, and NOGA STAMBLER. “Marine Pollution and Coral Reefs.” Global Change Biology, vol. 2, no. 6, Wiley, Dec. 1996, pp. 511–26. Crossref, https://doi.org/10.1111/j.1365-2486.1996.tb00064.x.

[9] Fattah, Salmah, et al. “A Survey on Underwater Wireless Sensor Networks: Requirements, Taxonomy, Recent Advances, and Open Research Challenges.” Sensors, vol. 20, no. 18, MDPI AG, Sept. 2020, p. 5393. Crossref, https://doi.org/10.3390/s20185393.

[10] Galgani, Francois, et al. “Marine Pollution: Let Us Not Forget Beach Sand.” Environmental Sciences Europe, vol. 23, no. 1, Springer Science and Business Media LLC, Dec. 2011. Crossref, https://doi.org/10.1186/2190-4715-23-40.

[11] Gkikopouli, A., et al. “A Survey on Underwater Wireless Sensor Networks and Applications.” 2012 20th Mediterranean Conference on Control & Automation (MED), IEEE, July 2012. Crossref, https://doi.org/10.1109/med.2012.6265793.

[12] Han, Guangjie, et al. “Routing Protocols for Underwater Wireless Sensor Networks.” IEEE Communications Magazine, vol. 53, no. 11, Institute of Electrical and Electronics Engineers (IEEE), Nov. 2015, pp. 72–78.Crossref, https://doi.org/10.1109/mcom.2015.7321974.

[13] Hidalgo-Ruz, Valeria, et al. “Microplastics in the Marine Environment: A Review of the Methods Used for Identification and Quantification.” Environmental Science & Technology, vol. 46, no. 6, American Chemical Society (ACS), Mar. 2012, pp. 3060–75. Crossref, https://doi.org/10.1021/es2031505.

[14] Jain, Usha, and Muzzammil Hussain. "Security Mechanism for Maritime Territory and Frontier Surveillance in Naval Operations Using Wireless Sensor Networks." Concurrency and Computation: Practice and Experience, vol. 33, no. 17, Wiley, Apr. 2021. Crossref, https://doi.org/10.1002/cpe.6300.

[15] Khan, Arijit, and Lawrence Jenkins. "Undersea Wireless Sensor Network for Ocean Pollution Prevention." 2008 3rd International Conference on Communication Systems Software and Middleware and Workshops (COMSWARE '08), IEEE, Jan. 2008. Crossref, https://doi.org/10.1109/comswa.2008.4554369.

[16] Lusher, Amy. "Microplastics in the Marine Environment: Distribution, Interactions and Effects." Marine Anthropogenic Litter, Springer International Publishing, 2015, pp. 245–307. Crossref, https://doi.org/10.1007/978-3-319-16510-3_10.

[17] Mearns, Alan J., et al. "Effects of Pollution on Marine Organisms." Water Environment Research, vol.89, no.10, Wiley, Oct. 2017, pp.1704–98. Crossref,https://doi.org/10.2175/106143017x15023776 270647.

[18] Nasrin, Fatema, et al. "Anomaly Detection Method for Sensor Network in Under Water Environment." 2021 International Conference on Information and Communication Technology for Sustainable Development (ICICT4SD), IEEE, Feb. 2021.Crossref, https://doi.org/10.1109/icict4sd50815.2021.9396943.

[19] Nuseibeh, B. "Weaving Together Requirements and Architectures." Computer, vol. 34, no. 3, Institute of Electrical and Electronics Engineers (IEEE), Mar. 2001,pp.115–19. Crossref, https://doi.org/10.1109/2.910904.

[20] Ramamoorthy, Umadevi, and Aruna Loganathan. "Analysis of Video Steganography in Military Applications on Cloud." The International Arab Journal of Information Technology, vol. 19, no. 6, Zarqa University, 2022. Crossref, https://doi.org/10.34028/iajit/19/6/7.

[21] Ritchie, Jerry C., et al. "Remote Sensing Techniques to Assess Water Quality." Photogrammetric Engineering & Remote Sensing, vol. 69, no. 6, American Society for Photogrammetry and Remote Sensing, June 2003, pp. 695–704. Crossref, https://doi.org/10.14358/pers.69.6.695.

[22] Schachter, Oscar, and Daniel Serwer. "Marine Pollution Problems and Remedies." American Journal of International Law, vol. 65, no. 1, Cambridge UP (CUP), Jan. 1971, pp. 84–111. Crossref, https://doi.org/10.2307/2199296.

[23] Schnurr, Riley E. J., et al. "Reducing Marine Pollution From Single-use Plastics (SUPs): A Review." Marine Pollution Bulletin, vol. 137, Elsevier BV, Dec. 2018, pp. 157–71. Crossref, https://doi.org/10.1016/j.marpolbul.2018.10.001.

[24] Suárez-Araujo, Carmen Paz, et al. "Supervised Neural Computing Solutions for Fluorescence Identification of Benzimidazole Fungicides. Data and Decision Fusion Strategies." Environmental Science and Pollution Research, vol. 23, no. 24, Springer Science and Business Media LLC, July 2016, pp. 24547–59. Crossref, https://doi.org/10.1007/s11356-016-7129-8.

[25] Valentukevičienė, Marina, and Evelina Brannvall. "Marine Pollution: An Overview." Geologija, vol. 50, no. 1, Portico, Jan. 2008, pp. 17–23. Crossref, https://doi.org/10.2478/v10056-008-0002-9.

[26] Xanthos, Dirk, and Tony R. Walker. "International Policies to Reduce Plastic Marine Pollution From Single-use Plastics (Plastic Bags and Microbeads): A Review." Marine Pollution Bulletin, vol. 118, no. 1–2, Elsevier BV, May 2017, pp.17–26.Crossref, https://doi.org/10.1016/j.marpolbul.2017.02.048.

[27] Xu, Guobao, et al. "Applications of Wireless Sensor Networks in Marine Environment Monitoring: A Survey." Sensors, vol. 14, no. 9, MDPI AG, Sept. 2014, pp. 16932–54. Crossref, https://doi.org/10.3390/s140916932.

[28] Zhang, et al. "Marine Observation Beacon Clustering and Recycling Technology Based on Wireless Sensor Networks." Sensors, vol. 19, no. 17, MDPI AG, Aug. 2019, p. 3726. Crossref, https://doi.org/10.3390/s19173726.

[29] Zubir Din . (1996)."Coastal marine pollution and toxicology : overview of current research and future needs." First national conference on environmental health research - state of the art in Malaysia today : proceedings : Vol II, (p. 599). Malaysia: Ministry of Health Malaysia.