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# A review study on machine learning to investigate the issue of plastic pollution in oceans

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**Abstract**
Significant challenges are occurring more frequently, especially in the current climate. Many environmental challenges are currently facing the world. One of the most significant issues we face today is water contamination. Challenges that may threaten future well-being. Throughout some areas of the planet, an unpleasant, slimy layer blanket the water, which is harmful to both aquatic animals and humans. In this Paper, we present a new approach that leverages machine learning for the automation of processing tasks. Today, exploring the link between artificial intelligence and environmental protection is a significant area of investigation due to swift technological developments and serious worldwide issues. This work looks at how machine learning models can help solve the important problem of managing plastic waste in the ocean.

**Keywords:** Machine leaming, plastic pollution, ocean pollution, environmental monitoring, waste management

## Introduction
Aquatic ecosystems play a crucial role in the lives of individuals. The activities in factories, energy generation, fishing, water management, agriculture, and additional domains are dependent on them. The activities of individuals significantly impact the well-being of aquatic ecosystems. One major factor pollution today is the widespread use of plastic. Rivers serve as the largest conduits for plastic pollution to reach the ocean. The ocean can become polluted with plastic due to fishing and shipping activities, along with people who unlawfully discard garbage into the water [1]. Every year, about 4.4 to 12.7 million tons of plastic are produced and put into the oceans. A study from 2014 found that about 5. 25 trillion pieces of plastic, weighing 269,000 tons, are floating in the ocean. Both small plastics (less than 5 mm) and large plastics (more than 5 mm) seriously harm the ocean. An ecosystem is a community living things, like plants and animals that interact with each other and their environment. Studies have often shown that marine animals get caught in old fishing nets and eat tiny pieces of plastic by birds and turtles [2]. It's clear that these waterways filled with plastic are not just a health risk for people nearby but also for the aquatic animals. Issues related to the environment present a significant risk to the blue economy on a worldwide scale. During the rainy season, severe weather conditions and flooding may occur. Because of these events, it is believed that more plastic is getting into rivers, which then ends up in the shallow sea and the ocean. After floods or high tides, plastic waste washes up on the beach or gets caught in plants, while some of it is carried out to sea. We should fight against plastic pollution in rivers or even before it gets into the water [3]. We present a new approach that leverages machine leaming for the automation of processing tasks. Today, exploring the link between artificial intelligence and environmental protection is a significant area of investigation due to swift technological developments and serious worldwide issues. This work looks at how machine learning models can help solve the important problem of managing plastic waste in the ocean [15-16]. To monitor large expanses of floating objects, we utilize satellite imagery. Images captured by the Sentinel 2 satellite are displayed in a range of colours. Photographs containing a variety of thirteen different light colours can prove to be useful. Publicly available images have a resolution of 10 meters per pixel in visible areas, which isn't very precise, yet it's suitable for larger objects. By identifying, measuring, and supervising large amounts of ocean debris, automated vision technology plays a crucial role in fighting against marine pollution [4].

The old techniques for measuring and curbing plastic pollution, like hand-collecting samples and inspecting for litter, are generally challenging, expensive, and cover only a small area [7]. Machine learning (ML) has gained recognition in the last few years as a practical method for overcoming challenging environmental problems. It helps by looking at big sets of data, finding patterns, and making predictions [9]. By utilizing machine learning approaches, we can gain insights into plastic pollution, refine our tracking and surveillance efforts, and formulate solutions to reduce its consequences. The integration of automation and real-time analysis in machine learning can considerably boost the accuracy and efficiency of monitoring marine ecosystems [12-13]. This investigation explores the potential of machine learning to improve our insights into plastic pollution in marine ecosystems. It looks at different machine learning models and methods that can be used to find plastic waste, forecast pollution patterns, and pinpoint sources of contamination. By using satellite pictures, ocean data, and sensors placed in the field, machine learning creates new ways to study and fight plastic pollution. This research aims to help find a better and more workable way tackle this important environmental problem.

**Machine Learning Techniques Applied to Plastic Pollution**

1. Satellite Imagery Analysis.
2. Data Fusion and Sensor Networks.
3. Predictive Modeling and Ocean Circulation Analysis.
4. Machine Learning for Cleanup Strategies.

**1. Satellite Imagery Analysis**

The use of satellite data for observing shifts in the environment is common, and the integration machine learning has vastly improved our ability to interpret this information. Techniques in machine learning, particularly those designed for image recognition and segmentation, have been employed detect plastic debris in ocean waters. For example, special computer systems called convolutional neural networks (CNNs) have been used to look at satellite pictures to find patterns related to were plastic waste builds up. These models can determine plastic waste apart from natural materials and other things in the ocean, which helps make detection more accurate.

**2. Data Fusion and Sensor Networks**

Using data from different sensors like drones, buoys, and ships in machine leaming models helps to find plastic waste more accurately and in specific areas. Data fusion methods help combine different sets of information to enhance the clarity and ability to find plastic in monitoring systems. Researchers use machine leaming to study sensor data. This helps them figure out how much plastic is in the water, find areas with a lot of plastic, and predict how plastic moves with ocean currents.

**3. Predictive Modeling and Ocean Circulation Analysis**

One of the main advantages of machine leaming in this area is that it can understand complicated systems and guess future patterns. By utilizing oceanic information such as currents, temperature, and wind in conjunction with machine learning, models can forecast the movement of plastic waste in the sea.

**4. Machine Learning for Cleanup Strategies**

In addition to identifying issues, machine learning is also enhancing cleanup initiatives. Finding the best paths for ocean cleanup boats and guessing where plastic waste will collect can save a lot of time and money for these efforts. Researchers are using reinforcement leaming algorithms to improve how decisions are made during marine cleanup activities. This helps make the process more efficient and reduces harm to the environment.

**Literature Review**

**Aleksandr Danilov, Elizaveta Serdiukova et. al. 2024**

He findings of this review emphasize key initiatives and studies dedicated to tackling the issue of plastic pollution. This article outlines the key approaches for data collection and highlights the top deep learning algorithms. This analysis reviews the complications involved in working with space imagery and recommends strategies for addressing them.

**Srikanta Sannigrahi, Bidroha Basu et. al. 2022**

His paper shows that using detailed satellite images and automated machine learning models can be a useful and affordable way to detect MFP. Future investigations will concentrate on assembling effective training data to build powerful automated models. This will help make a collection of different types of plastic objects to tell plastic apart from other trash in the ocean. The goal is to advance research on marine plastic pollution by leveraging existing open-source data and cutting-edge technology [3]. Mattis Wolfl, Katelijn van den Berg *et al.* 2020 The findings of this paper indicate that incorporating a scientifically-backed machine learning technique can significantly improve the assessment of plastic waste through collaboration with net trawl surveys, field experiments, and cleanup activities. APLASTIC-Q is an intelligent software tool that efficiently and automatically identifies and counts plastic pollution in water bodies and on beaches by utilizing imagery obtained from high-altitude balloons and space missions.

**Fernando Martín-Rodríguez, Orentino Mojón-Ojea *et al.* 2021**

In this research, they design a device that can detect the presence of plastic. They begin with a picture that shows a lot of "non-floating" plastic in Almería. They performed an experiment utilizing specialized distance measurements, but their outcomes improved significantly when we incorporated all thirteen wavelengths and employed Machine Learning techniques like Neural Networks.

**Srikanta Sannigrahi, Bidroha Basu *et al.* 2021**

This paper shows that using detailed satellite images and automated machine learning models can be a good and cheaper way to find plastic floating in the ocean. Future research will focus on gathering good training data to create strong automated models. It will also involve making a collection of information about different plastic items to help identify plastic among other floating trash in the ocean.

**Ali Jamali and Masoud Mahdianpari *et al.* 2021**

In this paper, they created a system that uses cloud technology to help find marine pollution on a large scale. This system combines images from Sentinel-2 satellites with advanced machine learning tools using the Sentinel Hub cloud service. They tested how well two simple machine learning methods, random forest (RF) and support vector machine (SVM), work along with a more complex deep leaning method called generative adversarial network-random forest (GAN-RF) to identify plastic in the ocean at a test site on Mytilene Island, Greece.

**Nisha Maharjan, Hiroyuki Miyazaki *et al.* 2022**
In this paper they look at the method used in two places: the Houay Mak Hiao River, a smaller river that flows into the Mekong River in Vientiane, Laos, and the Khlong Nueng canal in Talad Thai, Khlong Luang, Pathum Thani, Thailand. Detection models are systems that identify and recognize patterns or objects in data. The YOLO group is measured based on how fast it runs and how accurate its results are, using a method called Intersection over Union (IoU) to find the mean average precision (mAP).

**Kyriaki Kylili & Ioannis Kyriakides *et al.* 2019**
This study focuses on quantifying large plastics in the oceans globally, highlighting a prominent environmental challenge of our time. Current methods for measuring the amount of floating plastic waste are usually done by hand, which takes a lot of time and only covers small areas. Using deep leaming, we suggest a quick, scalable, and possibly affordable solution.

**Sophie Armitage, Katie Awty-Carroll *et al.* 2022**
This paper says that we can better tell different types of objects apart by making sure the plastic object takes up more space in the picture. In summary, these findings show that affordable cameras on boats, used with machine learning, could effectively collect important data about the amount and spread of plastic waste in oceans worldwide.

**Harsh Panwar, P.K. Gupta *et al.* 2020**
This study presents a new dataset named Aqua Trash, derived from the TACO dataset. We applied a state-of-the-art deep leaning model referred to as Aqua Vision for object detection in the Aqua Trash dataset. The described model locates and ranks different kinds of pollution and toxic waste both in oceans and on beaches, with an accuracy achievement of 0.8148.

**Ahed Alboody, Nicolas Vandenbroucke *et al.* 2023**
In this research, the authors examined the effectiveness of our original system, RHIS, in its ability to autonomously detect different categories a plastic waste. Did this by using various machine leaming techniques on a collection of images showing marine litter. The results showed that they can classify plastic waste with about 90% accuracy. This paper showed that the new RHIS combined with the UAD is a good way to find plastic waste in water.

**Edgar Ramos, Arminda Guerra Lopes et at. 2024**
This research investigates the utilization of machine learning (ML) models to deal with the important problem of managing plastic waste. This research focuses identifying the most efficient methods through a technique called snowballing to assess the effectiveness of machine learning in detecting and classifying PW. According to this article, rising environmental anxieties and the potential for data handling indicate that machine learning models may contribute to better sustainability in wastewater management practices.

**Cecilia Martin, Qiannan Zhang *et al.* 2021**
This article highlights that assessing litter on beaches requires significant time and financial resources, which complicates obtaining a precise tally of the waste present on coastlines around the globe. They have developed an innovative approach utilizing drones to obtain clear photographs of beaches. After that, the photos undergo automatic processing using machine learning algorithms. The goal is to complete the first nationwide survey of beach trash done by just one person.

**Samantha Lavender 2022**
This study looked at how well a combination of Sentinel-1 and Sentinel-2 satellite data can be used to find plastic waste. It used a Sequential model built with Keras, which is a user-friendly tool that works with TensorFlow in Python to set up an Artificial Neural Network (ANN).

**Ornelta GOXHAJ, Nilay Gul YILMAZ *et al*. 2022**
The article begins by detailing what mucilage is and the reasons behind production. Subsequently, the conversation shifts tackling water pollution by exploring cleaning systems that incorporate image detection and machine learning for the classification of images. This study showcases the implementation of machine learning and classification, concentrating on the superior methods for convolutional neural networks and region-based convolutional neural networks.

**Challenges and Limitations**
1. Data Availability and Quality.
2. Generalization and Scalability.
3. Computational Resources.

**1. Data Availability and Quality**
One major challenge in applying machine learning to investigate plastic pollution in the ocean is the scarcity of high-quality data. Satellite images and sensor networks give helpful information, but they have some limitations. They may not have clear enough detail, cover all areas, and it can be hard to tell plastic from other materials. Data that is missing or unreliable can impact how well machine learning models work.

**2. Generalization and Scalability**
Models of machine learning that are developed using data from particular locations might struggle to operate efficiently elsewhere. This makes it hard to use these methods worldwide. Also, many machine learning programs need a lot of data to learn, and getting this data for the oceans is hard because ocean conditions change all the time.

**3. Computational Resources**
Marine environments are complicated, and the large amount of data from satellite images and sensors needs a lot of computer power to process. Having strong computer systems is often needed to train and use machine learning models effectively, which can be a challenge for many research teams and smaller organizations.

**Future Directions**

1. Advancements in Deep Learning and AI.
2. Interdisciplinary Collaboration.
3. Policy and Public Engagement.

**1. Advancements in Deep Learning and Al**

As machine leaming improves, especially in the realm of deep learning, it is anticipated to play a greater role in tracking plastic pollution. Advancements in approaches that allow for learning without labelled data, as well as methods that can leverage knowledge from one scenario to another, could assist image segmentation techniques could facilitate the overcoming data shortages. Advancements identification of tiny and widely distributed pieces of plastic.

**2. Interdisciplinary Collaboration**

Addressing plastic pollution through machine learning requires collaboration across various disciplines. This includes areas like environmental science, ocean studies, computer science, and engineering. Bringing together ideas from different areas can help create better solutions, like self-operating systems that use machine learning to find and gather plastic waste quickly.

**3. Policy and Public Engagement**

Maximizing the benefits of machine learning requires a strong connection between scientific research and the formulation of public policy. We should use what we learn from machine learning to help countries and global efforts reduce plastic waste and encourage better environmental habits. Getting the public involved in citizen science projects can help collect information and increase awareness.

**Conclusion**

The application of machine learning to explore oceanic plastic pollution has the potential to greatly enhance our ability to identify, trace, and diminish this substantial environmental concern. There are some problems with finding enough data, handling large amounts information, and the need for strong computers. Nevertheless, advancements in machine learning and collaboration among various disciplines could lead to more effective and valuable solutions. The findings presented in this review illustrate the significance of machine learning in combating plastic pollution while underscoring the importance of sustained innovation and interdisciplinary work.

**References**

1. Danilov A, Serdiukova E. Review of methods for automatic plastic detection in water areas using satellite images and machine learning. Sensors. 2024;24(16):5089. https://doi.org/10.3390/s24165089
2. Sannigrahi S, Basu B. Development of automated marine floating plastic detection system using Sentinel-2 imagery and machine learning models. Marine Pollution Bulletin. 2022;183:113527. https://doi.org/10.1016/j.marpolbul.2022.113527
3. Wollf M, van den Berg K. Machine learning for aquatic plastic litter detection, classification and quantification (APLASTIC-Q). Environmental Research Letters. 2020;15(11):114042. https://doi.org/10.1088/1748-9326/abbd01
4. Martín-Rodríguez F, Mojón-Ojea O. Big plastic masses detection using satellite images and machine learning. Instrumentation Viewpoint. 2021;20:62-64.
5. Sannigrahi S, Basu B. Detection of marine floating plastic using Sentinel-2 imagery and machine learning models. Unpublished or conference abstract. 2021.
6. Jamali A, Mahdianpari M. A cloud-based framework for large-scale monitoring of ocean plastics using multi-spectral satellite imagery and generative adversarial network. Water. 2021;13(18):2553. https://doi.org/10.3390/w13182553
7. Maharjan N, Miyazaki H. Detection of river plastic using UAV sensor data and deep learning. Remote Sensing. 2022;14(13):3049. https://doi.org/10.3390/rs14133049
8. Kylili K, Kyriakides I. Identifying floating plastic marine debris using a deep learning approach. Environmental Science and Pollution Research. 2020;27(36):45360-45371. https://doi.org/10.1007/s11356-019-05148-4
9. Armitage S, Awty-Carroll K. Detection and classification of floating plastic litter using a vessel-mounted video camera and deep learning. Remote Sensing. 2022;14(14):3425. https://doi.org/10.3390/rs14143425
10. Panwar H, Gupta PK. Aqua vision: Automating the detection of waste in water bodies using deep transfer learning. Case Studies in Chemical and Environmental Engineering. 2020;2:100026. https://doi.org/10.1016/j.cscee.2020.100026
11. Alboody A, Vandenbroucke N. A new remote hyperspectral imaging system embedded on an unmanned aquatic drone for the detection and identification of floating plastic litter using machine learning. Remote Sensing. 2023;15(14):3455. https://doi.org/10.3390/rs15143455
12. Ramos E, Lopes AG. Application of machine learning in plastic waste detection and classification: A systematic review. Processes. 2024;12(8):1632. https://doi.org/10.3390/pr12081632
13. Martin C, Zhang Q. Enabling a large-scale assessment of litter along Saudi Arabian Red Sea shores by combining drones and machine learning. Environmental Pollution. 2021;277:116730. https://doi.org/10.1016/j.envpol.2021.116730
14. Lavender S. Detection of waste plastics in the environment: Application of Copernicus Earth Observation Data. Remote Sensing. 2022;14(19):4772. https://doi.org/10.3390/rs14194772
15. Goxhaj O, Yilmaz NG. Underwater image detection for cleaning purposes; techniques used for detection based on machine learning. Acta Marisiensis. Seria Technologica. 2022;19(1):35-42. ISSN 2668-4217. https://doi.org/10.2478/amset-2022-0005