Harnessing Artificial Intelligence to Protect the Arabian Gulf:

Tackling Biofouling, Litter, and Microplastics

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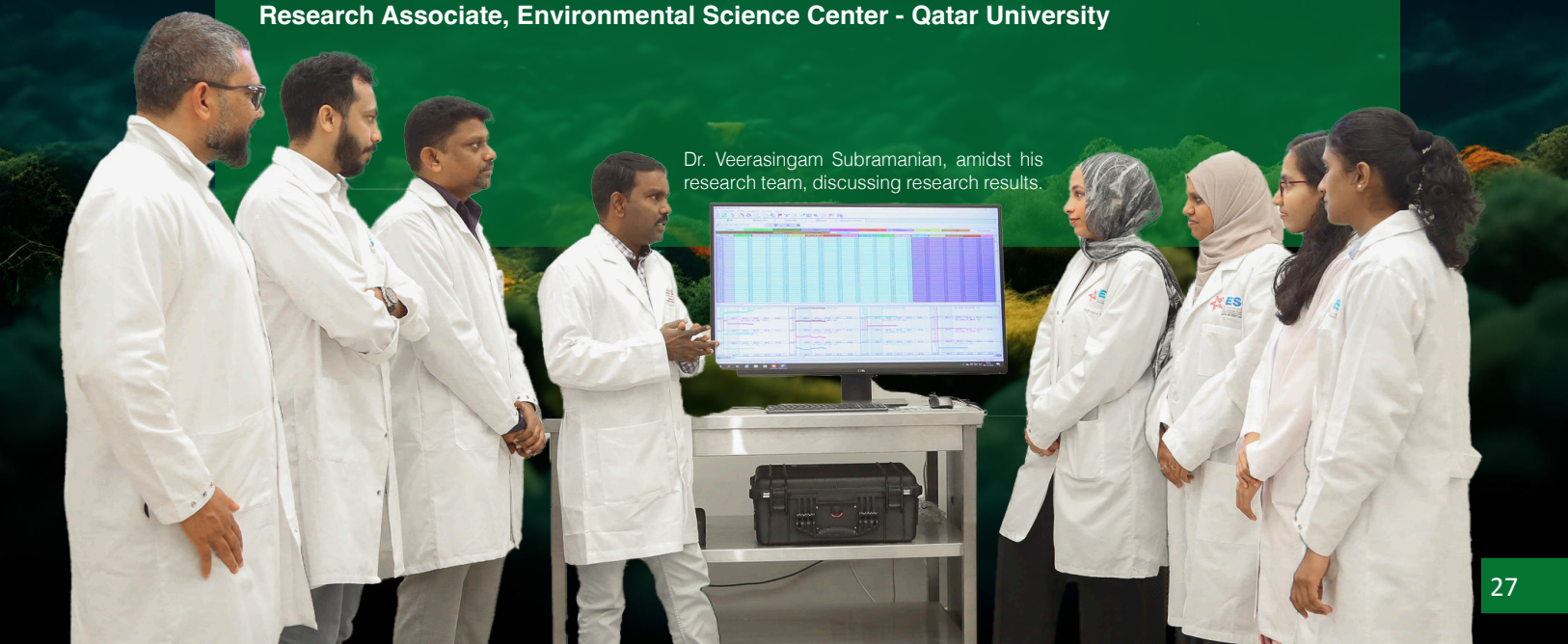

Dr. Veerasingam Subramanian, amidst his research team, discussing research results.

The Arabian Gulf is one of the world's most ecologically and economically rich marine regions, providing habitat for diverse marine species and supporting commercial fisheries, tourism, and international shipping routes. However, this region faces several natural and anthropogenic pressures, such as biofouling, marine litter, and microplastics, threatening marine health, biodiversity, and human well-being. Traditional monitoring and management approaches are costly, labor-intensive, and limited in scale, highlighting the demand for more innovative and efficient solutions.

Artificial intelligence (AI) offers revolutionary possibilities for enhancing environmental management, particularly through advanced data analytics, real-time monitoring, and predictive models. AI technologies such as machine learning (ML), deep learning (DL), and computer vision (CV) have proven effective in various fields, such as marine conservation. To address these challenges, researchers at the Environmental Science Center (ESC) are applying advanced AI techniques with funding from Qatar University.

Tackling Biofouling with AI

Biofouling, the accumulation of sessile organisms on submerged surfaces such as ship hulls, marine structures, harbor/port facilities, and aquaculture installations, is a notable issue in the Arabian Gulf due to its warm and nutrient-rich waters. Biofouling increases fuel consumption and greenhouse gas emissions in ships, and damages marine infrastructure. Additionally, it contributes to the spread of invasive species, disrupting local ecosystems. Our team examined the level of biofouling on the hull and propellers of the QU research vessel Janan (Figure 1a). During dry-docking, extensive fouling organisms were removed using mechanical cleaning and antifouling coating techniques, both costly and time-consuming. Therefore, we conducted a biofouling monitoring survey using a remotely operated vehicle (ROV) to generate a preliminary biofouling dataset for the research vessel Janan (Figure 1b-d). An AI-based computer vision model integrated with the ROV is in development to create an autonomous hull-cleaning robot that uses reinforcement learning to adapt and improve its cleaning efficiency in the Arabian Gulf's marine environment.

Combating Marine Litter with AI

Marine litter, such as plastics, discarded fishing gear, and other debris, poses a major threat to marine life and ecosystems in the Arabian Gulf. It causes physical harm, entanglement, ingestion, and habitat destruction, ultimately resulting in reduced biodiversity and ecological health. Recently, we found that marine litter facilitates aide the transfer of non-native species across the Arabian Gulf by allowing organisms to 'hitchhike' to new environments (Figure 1e). Our team conducted a marine litter survey using smartphone video recordings along the mainland and islands of exclusive economic zone (EEZ) of Qatar (Figure 1f). These videos were analyzed using the AI-based real-time object detection model 'YOLO' (You Only Look Once) to identify and classify marine litter (Figure 1g, h). Expanding this AI-based model across all Gulf countries would enable real-time monitoring, swift response actions, and better collaboration among neighboring countries.

Addressing Microplastics through AI

Microplastics, tiny plastic particles ranging from 0.1 µm to 5 mm, have become a major global environmental concern, especially in semi-enclosed seas like the Arabian Gulf, where they pose a significant threat to ecosystems and human health. Microplastics originate from various sources, including the breakdown of larger plastic items, wastewater discharges, and industrial activities. Microplastics have been reported in air/atmospheric dust, water, soil/sediment, biota, and table salt in countries along the Arabian Gulf. Our team conducted outreach activities to raise awareness about microplastic pollution and train high school students through a Qatar Research Development and Innovation Council (QRDI) funded research project (HSREP04-1018-220008). Activities included hands-on workshops, laboratory demonstrations, and mentorship programs to introduce students to scientific research and environmental conservation. We studied microplastics in four different commercial fish species purchased from supermarkets in the State of Qatar (Figure 1 i-l), automatically counting their presence using an AI-based object detection model (YOLO). Various AI algorithms, to improve microplastic detection accuracy in environmental matrices like water, sediment, fish, salt, and atmospheric dust.

Atmospheric deposition is a key pathway for microplastics to enter the ocean, contributing to the increasing concentration of plastic particles in the marine environments. These particles can affect ocean biogeochemical processes, such as carbon cycling. To address this issue in the EEZ of Qatar, we recently initiated a study to examine the influence of dust activities on the indoor and outdoor microplastics and radionuclides in Qatar using geochemical, spectroscopic and AI techniques, under the QRDI funded project (CCEC01-1029-230098).

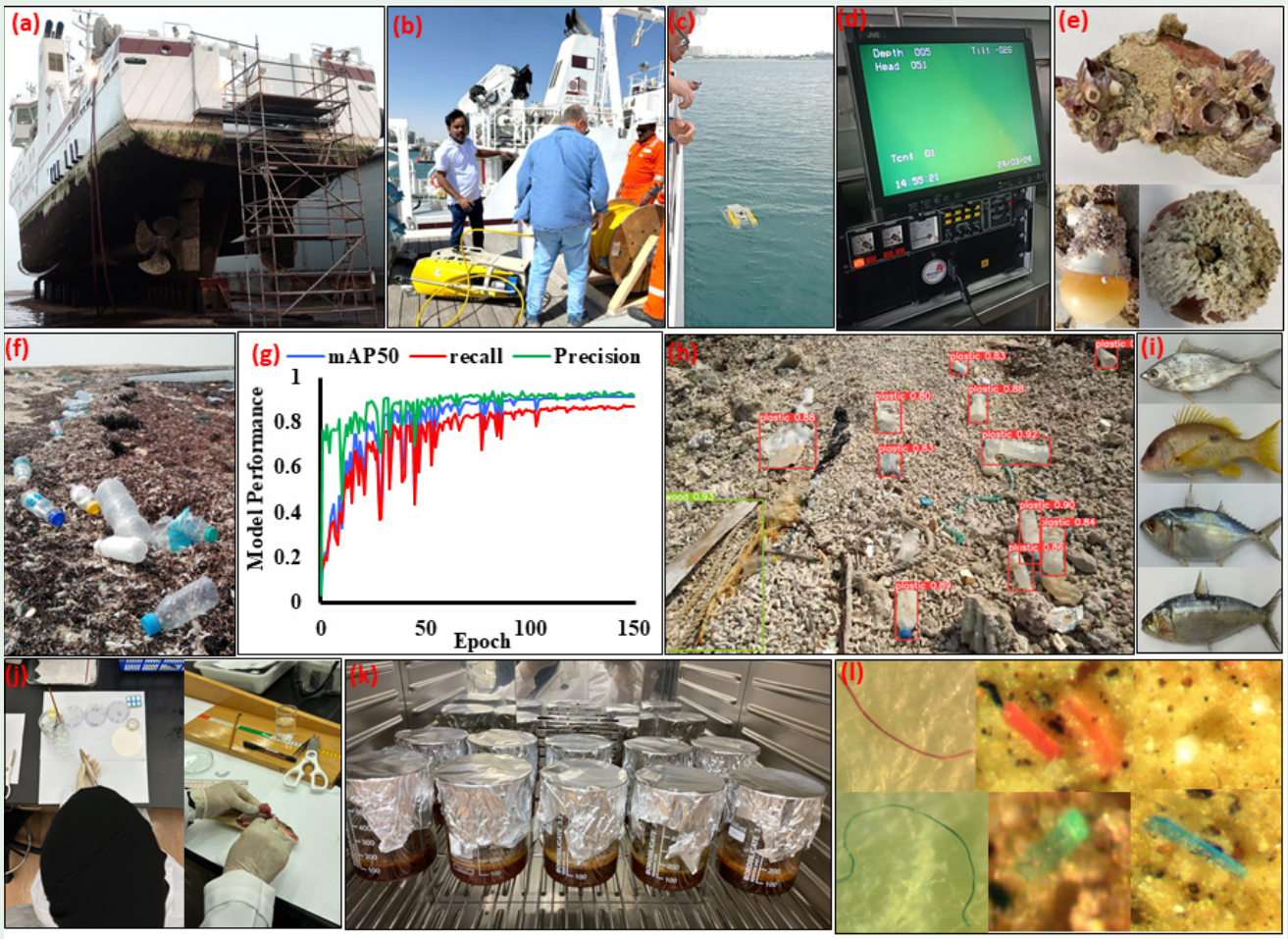

Figure 1: Application of artificial intelligence to tackle biofouling, marine litter and microplastics: (a) Biofouling on research vessel Janan; (b-d) ROV survey of hull and propellers; (e) Hitchhiking organisms on marine litter; (f) Marine litter deposition along the Qatar coast; (g, h) AI-based object detection for marine litter; (i-l) Detection of microplastics in fish species

Microplastics have been detected in sea salt worldwide, highlighting their presence in the ocean and their potential entry into the human food chain. While the use of AI to detect microplastics in food products raises concerns about human exposure, it also presents solutions by enabling large-scale, automated detection and classification of microplastic particles. We have purchased various types of commercial table salts from supermarkets in Qatar under the UREP30-024-1-003 project and examined microplastic levels using spectroscopic and AI techniques. An object detection model was applied to count microplastics extracted from table salts and examined under a stereomicroscope. FTIR spectra of these microplastics were analyzed using various ML models to enhance the accuracy polymer type detection.

Future Potential of AI in Marine Management

AI has the potential to revolutionize the management of marine threats in the Arabian Gulf, offering innovative solutions for tackling biofouling, marine litter, and microplastics. Integrating AI technologies such as CV, DL, and ML with traditional environmental monitoring techniques enhances detection, quantification, and analysis capabilities. Future developments may include predictive models for biofouling growth and the spread of invasive species, real-time monitoring with AI-powered drones and underwater robots, automated waste sorting and recycling systems, and AI-driven policy recommendations. Although challenges in data collection and model training persist, the future of AI in marine conservation is promising, with the potential to substantially improve the health and sustainability of the marine environment in the Arabian Gulf.

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