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Research article

Review of studies on Sargassum spp. (Sargassaceae) in Cuba (^{2011}_^{2026})

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Abstract

Since 2011, the Caribbean region has experienced drastic changes in its ecological and socioeconomic dynamics due to the massive influx of macroalgae of the genus Sargassum. In Cuba, this problem began to manifest itself atypically in 2012. Upon reaching shallow coastal areas, their accumulation and decomposition generate "brown tides," releasing toxic gases such as hydrogen sulfide (H_2S) and methane. These disturbances degrade critical ecosystems such as coral reefs and seagrass beds, and severely impact economic sectors like artisanal fishing and tourism. Faced with this emergency, a new paradigm has emerged: the shift from considering sargassum as "beach litter" to viewing it as a resource for the circular economy. This paper aims to synthesize the current state of knowledge on sargassum dynamics in Cuba, analyzing its impact and the research conducted in the country. A total of 19 Cuban scientific publications were analyzed, focusing primarily on the use of sargassum as a biofertilizer and on monitoring sargassum influxes. No studies were found addressing other uses of the seaweed or examining the presence of contaminants within it.

Introduction

Since 2011, the Greater Caribbean region has experienced a drastic change in its ecological and socioeconomic dynamics due to the massive and recurring influx of pelagic macroalgae of the genus Sargassum [1]. These influxes, originating from the New Sargasso Sea or Greater Atlantic Sargassum Belt, have increased over the years. In 2018, approximately 20 million tons of algae were observed offshore, eventually reaching the Caribbean and the Gulf of Mexico [2]. In Cuba, this problem began to manifest itself in an atypical way from 2012 onwards with reports mainly on the South coast, followed by severe arrivals on the Guanahacabibes Peninsula in 2015, where accumulations of up to 1.5 m in height reduced the nesting success of sea turtles by 50% [3,4]. This phenomenon is also monitored in other areas of the Caribbean such as the Gulf of Mexico, Puerto Rico, and Costa Rica due to the frequency of the events and the effects they have on the affected areas [5-9]. This situation is linked to anthropogenic forces and climatological events, such as cyclones and the influence of Atlantic anticyclones, ocean currents altered by temperature changes and an increase in tropical storms [10,11]. Prior to the 2011-2026 period, studies on the genus Sargassum had been conducted in Cuba. These focused on its distribution and taxonomy, as up to that point it did not represent a danger to the Caribbean coasts (Moreira and Cabrera, 2007).The dominant holopelagic species in the uplands, Sargassum natans (Linnaeus) Gaillon (forms I and VIII) and S. fluitans (Børgesen) Børgesen (Form III) are characterized by completing their entire life cycle floating in the open ocean, reproducing primarily vegetatively, and being transported by the complex interaction of surface currents and winds. Upon reaching shallow coastal areas, their accumulation and subsequent decomposition generate what are known as "brown tides," which induce anoxia and hypoxia, releasing toxic gases such as hydrogen sulfide (H_2S) and methane.

These chemical alterations degrade critical ecosystems such as coral reefs and seagrass beds (Thalassia testudinum), in addition to severely impacting vital economic sectors such as artisanal fishing and tourism, where significant infrastructure losses and a drastic drop in visitor numbers have been recorded throughout the region [12].In response to this environmental emergency, a new paradigm has emerged: the shift from viewing sargassum as "beach litter" to seeing it as a strategic resource within a circular economy framework. Sargassum biomass has high potential for the biotechnology industry, particularly for the production of organic biofertilizers, nutritional supplements for livestock, the extraction of industrially valuable alginates, and the generation of renewable energy sources such as methane-rich biogas and bioethanol [13].

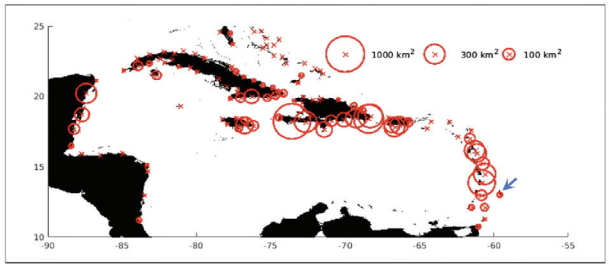
Although these and other uses have been suggested to reduce the harmful impact of large waves of sargassum in the seas of the insular and continental Caribbean, it remains to this day an unsolved problem that does not require the interest and attention of a single State, but of the entire community of countries with affected coasts in the region.The present work aims to synthesize the state of knowledge on the dynamics of Sargassum in Cuba, analyzing its impact and the research carried out in the country for the period between 2011 and 2026.

Materials and methods

A review of the scientific literature was conducted using Google Scholar, SciELO, DOAJ (Directory of Open Access Journals), PubMed Central, and Aqua Docs, as these repositories offer broad coverage. Special emphasis was placed on specialized technical literature and graduate theses from leading institutions, which contain high-value primary data.

Study area

In Cuba, the areas most affected by sargassum influxes are in the Eastern region, although, as can be seen in Figure 1, the Western and Central areas have also received influxes of these algae.



(Figure 1): Amount of Sargassum assessed on 127 coasts and islands of the Caribbean region. The associated circled area is proportional to the amount of sargassum accumulated on the beaches in 2020 [12].

(Figure 2): Sargassum tides on the coast of Havana, March, 2019, (Arencibia-Carballo, ***et al.*** , 2020).

(Figure 3): Sargassum influxes in Punta de Maisí, August, 2024, [14].

Results

A global search for the phrase "sargassum Cuba" on Google Scholar yielded 1,660 publications, including those in languages other than Spanish and bibliographic citations. To narrow the search and focus it on results and publications from the island, the following filters were applied: bibliographic citations were removed, results were restricted to Spanish (although several analyzed works appeared in English even after the filter was applied), the search was limited to research published between 2011 and 2026, and the exact phrase "Cuba" was added to the advanced search. The final result was a total of 652 publications.19 publications were obtained , focusing on original Cuban research and literature reviews on the use of sargassum, sargassum influxes, and their consequences. These publications are located in 12 journals [Table 1].The other 633 publications were discarded because they were related to social sciences, Cuban literature, or research outside the island.

[Table 1]: Journals where works related to Sargassum in Cuba have been published to date (March 15, 2026). The number of publications per year is highlighted in parentheses. Years highlighted in red indicate literature review articles.

Magazine name	Number of publications	Years of publication
Cuban Journal of Meteorology	3	2024, 2025 (2)
Cuban Journal of Chemistry	2	2023, 2024
Tropical Crops	4	2022 (2), 2024, 2025
JAINA coasts and seas in the face of climate change	1	2020
Man, Science and Technology Magazine	1	2025
Annals of the Cuban Academy of Sciences	1	2025
Advances Magazine	2	2024
Chemical Technology	1	2024
Journal of Marine Research	4	2013, 2016, 2019, 2020
72nd Gulf and Caribbean Fisheries Institute Magazine	1	2020
Agricultural Engineering Magazine	1	2025
Plant Biotechnology Journal	1	2020

[Table 1] shows that most of the published works correspond to results of original research, focused on the use of extracts of sargassum and other algae as fertilizers to promote the growth of crops such as rice, corn, tomato and common bean [15-18]. Of the total publications analyzed, 4 correspond to reports of sightings of the arrivals, or summaries of the occurrence of these phenomena for different time periods [4,14,19] Torres-Conde and Martínez-Daranas, 2020; Arencibia-Carballo, et al., 2020. Of the total analyzed, 4 articles are explicitly published as review articles.The remaining work focuses on methodologies for obtaining extracts from these algae, chemical characterizations of sargassum, and the impact they have had on specific sites.A search of the Aqua Docs repository yielded 17 results for the word "sargassum," limited to publications from Cuba between 2011 and 2026. Of these, 11 results aligned with other research topics and were discarded. The remaining 5 works consisted of 4 original research papers and 1 master's thesis; all 5 were among the top results obtained in Google Scholar.DOAJ returned six publications for "sargassum Cuba," one of which was repeated in both Spanish and English, and another unrelated. SciELO yielded four results for "sargassum Cuba." All of these matched results previously observed in Google Scholar.The works provided by PubMed Central, for "sargassum Cuba", were 4. They were not related to research within the island, but to mapping of sargassum biomass on beaches in Mexico, mainly.

Discussion

Within the island, meteorological studies indicate that the arrival of the strandings occurs mostly between May and October, coinciding with the rainy season, with peaks in June and September [10,20]. These studies also conclude that the eastern region is the most affected, although there are reports for other areas of the island. Furthermore, they state that the arrival of sargassum to the North and South coasts has the same origin in the Great Atlantic Sargassum Belt, which, moved towards the Caribbean by the interaction of the North Atlantic Oscillation (NAO) and the Sargassum Circulation System, brings the algae closer to the region. They reach the North coast pushed by winds greater than 8 km/h from the North associated with the Migratory Continental Anticyclone, while in the South the Extended Anticyclonic Flow mainly influences, which generates marine currents that transport the biomass in question [10,11; 19,20]. All these studies allow us to predict to some extent the arrival of sargassum in Cuba, but while the island continues to study oceanographic or climatological conditions, in other countries such as Mexico

they already allow us to approach the monitoring of sargassum biomasses by satellite, and incorporate computational sciences and civil collaboration through the application of the concept of citizen science [21, 22]; Lazcano-Hernández, et al., 2023. On the island, these studies are not feasible mainly due to a lack of technological infrastructure and institutional priority .Considering the pattern of sargassum influxes in recent years, and including the events of January and February 2026 in countries like Mexico and Honduras, large masses of this seaweed are expected on the Caribbean coasts. However, scientists warn that although significant sargassum biomasses have been sighted in the Atlantic Sargassum Belt at the beginning of the year, this does not mean that it will all reach the Caribbean region. Even so, they urge authorities to plan for the protection of the areas most exposed to these influxes [23]. On the other hand, Cuba is gradually carrying out beach cleanups that help reduce the effects of sargassum accumulation and decomposition (Arencibia-Carballo, et al. , 2020). These actions are also being carried out in different Caribbean countries such as Mexico, where beach management includes cleaning [24]. The United Nations document entitled " Sargassum Outbreak in the Caribbean: Challenges, Opportunities and Regional Situations " (2018) states that sargassum removal from Caribbean beaches is mostly carried out using heavy machinery and manual labor. It also comments on indications that some countries are attempting to capture the seaweed before it reaches the coast, warning about the benefits of this technique and the dangers it can pose to wildlife associated with Sargassum.Studies conducted on Caribbean beaches indicate that the use of heavy machinery to collect sargassum using sargassum harvesters, in conjunction with the collection of other algae, implies a considerable loss of sandy sediments compared to manual techniques, which do not return to the environment, contributing to the erosion of the ecosystem[25,26]. In Cuba, the manual collection of sargassum, as well as other items recognized as "beach litter," is carried out with minimal or no safety equipment due to the lack of coordination between state resources and the volunteer groups that perform these tasks. This is not an isolated incident but rather a common practice, documented in Mexican research. Fraga and Robledo (2022) note that each year more than 11,000 people are involved in collecting this seaweed without using the necessary sanitary equipment, while also stating that the sargassum situation in the Mexican Caribbean has been addressed primarily from the perspective of protecting tourist beaches.Their work also reflects how most of the people interviewed in their research recognize this "lack of protection," seeing themselves as vulnerable to the potential toxicity of sargassum and the trash that washes up with the biomass on the beaches. No publications were found for Cuba aimed at establishing the level of knowledge among the population about sargassum and its effects on health or ecosystems.The collection of sargassum seaweed aims to recover the areas affected by the influx, but also intends to give other uses to this waste, with a view to achieving a circular economy that mainly benefits the affected localities.Espinosa-Antón and collaborators (2024) agree that sargassum represents a source of opportunities for agricultural development, given its use as biofertilizers, biostimulants and soil improvers in Mexico. In Cuba, the effect of aqueous extracts prepared using fresh samples of Sargassum fluitans on high-value vegetables (chard, lettuce, and cabbage) was tested. It was concluded that applying 1% extracts resulted in improvements in germination and plant development [27]. Other studies obtained different results. [15,16], when applying extracts of the same macroalga species to tomato and rice seeds , found an increase in the dry mass of the plants but not an increase in the percentage of seed germination.Gutierrez Almeida et al. (2024) performed the chemical characterization of different sargassum extracts, evaluated their metabolic activity, and measured their effect on tomato seeds. Unlike [15], they found that the studied extracts significantly and positively influenced all germination and growth indices.However, the application of an extract based on S. natas and S. fluitans on corn did stimulate the vegetative growth of the plants with a doubling of their agricultural yield, and increased the production of grains in bean crops [15,17]. In the Caribbean, most of the studies found within the analyzed period on the use of sargassum as a raw material are Mexican. These are primarily aimed at obtaining biofuels, bioremediators, and industrial materials [13; 28,29] and López Arreola, 2025. The conversion of sargassum biomass into activated carbon and its capacity to retain particles such as microplastics for bioremediation are some examples Aketchi, et al., 2026 and [30]. Studies with these objectives were not found for Cuba .In addition to the previous research, Mexico has studies focused on detecting heavy metals and microplastics in sargassum biomass arriving in the Mexican Caribbean [31,32]. In both studies, the samples were taken on the seashore.For Cuba, there is one reference on heavy metal concentrations in sargassum, with results from more than a decade ago [33], and no studies on microplastics in brown algae were found . However, between 2011 and 2026, no publications were found for the island on the determination of Polycyclic Aromatic Hydrocarbons (PAHs), pesticides, or other emerging contaminants.At a regional level, attention to organic and inorganic pollutants in Caribbean algae has been limited, with only a few isolated studies by authors such as Mohammed et al. (2017) and Rodríguez-González et al. (2022) demonstrating the magnitude of the risk. Mohammed and colleagues found average concentrations of 16 PAHs between 287 and 605 ng/g of dry weight of benthic Sargassum in Trinidad and Tobago, while Rodríguez-González detected PAHs between 150 and 450 ng/g in pelagic sargassum stranded in Quintana Roo, Mexico. In 2025, García-Ruelas et al. demonstrated that the decomposition of sargassum releases these hydrocarbons into the water column, posing serious risks to the coastal ecosystem. Recently, [34]. assessed the health risks to children from arsenic exposure during recreational play on beaches with sargassum influxes in Southeast Florida. Using a risk analysis that considered oral, dermal, and inhalation routes, they found that the non-carcinogenic risk was low, but the cumulative lifetime carcinogenic risk reached levels of 10^{-4} (low risk increased). Leaching assays using the SPLP protocol showed that arsenic present in fresh sargassum was released into the liquid phase, demonstrating its high bioavailability. The authors emphasized the need for awareness campaigns, especially to prevent sargassum ingestion by children with pica behaviour, as well as the use of protective equipment during clean-up efforts. These findings, although focused on arsenic, can be extrapolated to the range of contaminants potentially present in biomass used as fertilizer or managed manually. They reinforce the urgent need to implement studies in Cuba to determine not only PAHs, but also arsenic and other trace elements in sargassum, especially considering its use in short-cycle crops without prior chemical characterization.

Conclusions

In Cuba, studies on sargassum have focused on its use as biofertilizers, providing encouraging results regarding its application in agriculture.The collection of Sargassum biomass on the island is done manually, which , although less aggressive for sandy soils , constitutes a risk for the personnel who carry it out due to their level of exposure Most of the sargassum seaweed that arrives on Cuban coasts and beaches is wasted due to a lack of resources and research aimed at its recovery and use.No studies have been found on the detection of contaminants in the sargassum that arrives in Cuba, which, when used within the agricultural industry, could pose significant health risks.

Recommendations

It is recommended to dedicate efforts to improving the monitoring of sargassum arrivals to Cuba, through the education of the population closest to the points where these arrivals occur and the implementation of new technologies.It is also estimated that new ways of using the large masses of sargassum that accumulate, mainly in the Eastern region, will be sought, which would allow taking advantage of a resource that is currently not exploited.Studies are important to determine if microplastics, heavy metals, and other contaminants are present in sargassum, given its use in the agricultural industry and the potential expansion of its uses.

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