Ciencia & Futuro V. 15 No. 3. September-November 2025 p. 311-320 ISSN: 2306-823X
Leyva Corney, A.J., Rodríguez Cabrera, M., Torres Batista, Y., Calzadilla Milian, O., García Naún, D.
. Received: 4/5/2025/ Accepted: 29/7/2025

Tools for sustainable environmental management at Puerto Moa Company

Herramientas para la gestión ambiental sostenible de la empresa Puerto Moa

Adolis José Leyva Corney aleyva@epm.mpa.minen.cu (1)
https://orcid.org/0009-0001-0964-0878

Mariolis Rodríguez Cabrera mrodriguez@ismm.edu.cu (2)
https://orcid.org/0000-0002-4294-8508

Yordanis Torres Batista ytbatista@ismm.edu.cu (2)
https://orcid.org/0000-0003-1954-7447

Oneida Calzadilla Milian oneviti80@gmail.com (3)
https://orcid.org/0000-0001-8461-8737

Dalay García Naún dgnaun@ismm.edu.cu (2)
https://orcid.org/0000-0003-2844-1345

(1) Puerto Moa Company, Moa, Cuba (2) University of Moa, Moa, Cuba (3) University of Cienfuegos, Cienfuegos, Cuba

Abstract: This research is aimed at designing actions that contribute to preventing and minimizing the environmental impacts caused by port activity of Puerto Moa Company. In order to develop it, unstructured interviews with specialists, Puerto Moa Company's manager, and residents of neighboring communities were conducted. The environmental impacts caused by port activity in this locality were identified. As a result, coastal ecosystem recovery actions to be implemented by Puerto Moa Company are proposed.

Keywords: port activity, industrial port, port sustainability

Resumen: La investigación tiene como objetivo diseñar acciones que contribuyan a prevenir y minimizar los impactos ambientales provocados por la actividad portuaria de la empresa Puerto Moa. Para su desarrollo se realizaron entrevistas no estructurada a especialistas, jefe de la Empresa Puerto Moa y residentes en comunidades aledañas y se procedió a la identificación de los impactos ambientales que provoca la actividad portuaria en esta localidad.

Como resultado se propone las acciones para la recuperación del ecosistema costero que deberá implementar la empresa Puerto Moa.

Palabras claves: actividad portuaria, puerto industrial, sustentabilidad portuaria

Introduction

Ports play a leading role in the development of society, as they contribute to economic development and strategic positioning of any country in the world. These maritime zones and their coastal ecosystem resources are a heritage for economic diversification, offering opportunities for tourism, aquaculture, and maritime transport (Acciaro, Renken & El Khadiri, 2020). However, human activity in their surroundings, as well as the port activity itself, generate a strong impact on both water quality and the coastline (Peña Cassio & Valdés Martínez, 2015).

The alteration of natural waters and the construction of artificial structures can cause damage to the existing water body and lead to direct and indirect impacts on ecosystems and communities settled near ports. Operations such as dredging, materials' creation and disposal, beach areas development, and maritime and vehicular traffic in the port can lead to natural and anthropogenic pollutants releasing into the environment (Viñas et al., 2001; Guédez *et al.,* 2003).

Authors such as Vega *et al.* (2018); Serrano *et al.* (2021), Buenrostro Aguilar & Domínguez (2023), Hinojosa-Montañez, Santamaria-Ruiz y Troncoso-Palacio (2023) and Guerrero Molina & Álvarez Patiño (2024), support the idea of port sustainability importance due to the significance of maritime transport to society's economic development.

Ports generate pollutants that affect the marine environment and bordering communities (Pulido *et al.,* 2016; Molina-Castro, Gómez-Ronquillo & de la Cruz-Lozado, 2021, Ramírez & Domínguez, 2022; Guillama Barroso *et al.*, 2022). Port areas receive discharges from effluents (Quintero Rendón *et al.*, 2010) and waste from maritime transports (Correa, 2022; Pérez Jiménez *et al*., 2023). Furthermore, loading and unloading operations result in excessive noise and exhaust fumes (Alvarado-Barrera, 2024; Villarreal & Araúz, 2025).

According to Torres González (2015), several types of risks can be identified at Puerto Moa Company, which bring unfavorable consequences for both workers and the neighboring

community. It is also recognized that the population lacks sufficient knowledge to encourage the prevention of these risks. Rojas, Guilarte & Reynaldo (2022) identified the company's socioeconomic processes that generate polluting products such as hydrocarbon mixtures, oily waters, and other combustible substances resulting from the storage, tank cleaning, and maintenance processes. Other problems such as liquid sulfur dumping, ammonia emissions, and tree species indiscriminate logging have been reported by Durán Morales (2005) and García Hidalgo (2013).

Maritime port activities carried out at Moa's port produce negative impacts on the coastal ecosystem, which is associated with anthropogenic actions, technological problems, and absence of timely corrective measures allowing to confront the possible environmental impacts generated by its economic activity. Besides, oil spills during vessel unloading cause damage to the natural habitat and changes in the chemical composition and circulation of water. Guilarte *et al.* (2015) declare the important natural, sociocultural, and socioeconomic role of this institution and propose implementing adequate environmental management for the company.

In this sense, this work proposes the designing of tools to prevent, reverse, or mitigate the environmental pollution generated at Puerto Moa Company in order to minimize the environmental impacts caused by port activity on the environment.

Methodology

To fulfill the proposed objective, an analysis of the main elements from Puerto Moa Company that are causing environmental damage was conducted. Likewise, documents evaluating the main pollutants generated by this institution were consulted.

Port workers and specialists from Puerto Moa Company were interviewed to identify the environmental impacts caused by port activities to the ecosystem. Residents of neighboring communities were also inquired to understand the level of damage caused by the different port pollutants.

The port facility was toured, and the waters, the dock, and the vegetation cover were monitored. Solid, liquid, and gaseous emissions were verified and analyzed to acknowledge the aforementioned environmental impacts and design corrective measures.

Characteristics of Puerto Moa Company

Moa's port is classified as industrial. It is an artificial dock whose construction was finished in 1956. It is associated with the prospects for exploiting nickel deposits near the coast. It consists of a signaling system marking the entrance and the shallows existing in the area, in accordance with international regulations (Durán Morales, 2005; Bell Batista, 2016).

Puerto Moa Company's main function is the reception and storage of imported products or supplies for industrial consumption by nickel companies in the territory and the export of finished products from producing industries (Guilarte *et al*., 2015).

Moa's port paramount function is nickel export and supplies import for industries consumption and the industrial development of the area, aiming at assisting in the provision of services for loading, unloading, reception, and delivery of nickel to the companies involved in this activity. Among its objectives is to guarantee the efficient and timely development of maritime commerce to generate foreign currency for the country's economy. It provides services such as dredging, raw materials (coal, ammonia, fuels, sulfur) storage and distribution, merchandise storage, coral mining and transportation, among others.

The submarine oil pipeline consists of a line with a DN 600-mm diameter, 12.7-mm wall thickness, and an approximate length of 1000 m to the coast, where it connects with the land oil pipeline. A Pipeline End Manifold (PLEM) is installed at the submerged end. On both sides of this pipeline and behind the disk, two branches of DN 250-mm pipes emerge, where unloading hoses, with the same diameter and 62 m length, are connected. They feature a valve and a check valve on the side connecting to the ship.

The land pipeline was built using leftover pipes from Matanzas supertanker base investment, which forced the design of a double pipeline since its diameter was smaller than required. It consists of two parallel pipelines, each with a DN 500 mm diameter, a 12 mm wall thickness, and an approximate length of 2,400 m. Upon entering the fuel base, both pipelines converge into a single 500 mm diameter line, which extends to a 400 mm-diameter pipeline network that enters the Fuel or Crude Oil storage tanks.

Main Pollutants Related to port Activity in Puerto Moa and Corrective Measures

Environmental impacts of maritime ports affect all surrounding components; water, soil, air, and living beings in the area, both terrestrial and aquatic. They increase with the scale or expansion of the installation and the intensity of loading and unloading activities (Villarreal & Araúz, 2025). The tasks carried out in the port significantly affect all natural elements, making it necessary to design effective and comprehensive tools to reverse or reduce their impacts, based primarily on the management of wastes from the port environment´s biotic and abiotic components.

Among the pollutants detected at Puerto Moa Company during the course of the research are listed:
Emissions from ships
Emissions during loading and unloading operations
Emissions from land vehicles
Spills of substances
Deforestation
Hydrocarbon spillage is one of the main elements affecting coastal environments where ports are located. To minimize this damage, the implementation of permanent training programs for all personnel involved in port management is necessary. To achieve this task, specially designed educational materials must be available. It is also necessary to:
Create new channeling and drainage systems
Systematic cleaning of the carbonated sludge pond
Cleaning of other contaminated areas

In addition to hydrocarbon spills, the waters of the dock are affected by wastewater discharges from Nickel Sulfide Plant, a phenomenon reported by Durán Morales (2005). At the same time, during sulfur unloading at dock 1, considerable quantities of this element are dumped into the sea, forming a suspension layer. For this reason, the installation of an ecological hopper to unload raw materials is proposed.

Liquid sulfur dumping must be avoided due to its polluting impact on water and land. It is proposed to remedy this problem by constructing channels to collect the pollutant liquid, and by constructing and cleaning sludge ponds continuously, as well as the design of sludge settlers.

To cope with solid particles dispersion, it is necessary to install tarp covers, avoid overfilling trucks, and limit their speed to 20 km/h. It is recommended to continuously wet the roadways, create live natural barriers, and increase vegetation cover to minimize particle dispersion according to current national regulations.

Mangroves and vegetation cover loss can be mitigated by creating mangrove plots with selected species, implementing a bioremediation project, as well as conducting constant monitoring of mangrove survival. For adjacent areas reforestation, tree or shrub plant species should be selected.

Discussion

Puerto Moa Company must align its environmental policy with its economic and social roles. This means guaranteeing not only commercial and economic activities, but also upholding environmental standards that promote sustainable development in the port area and the city. Each action must adhere to an environmental protocol established to ensure necessary balance.

Permanent monitoring and the implementation of an early warning system for any event constituting an environmental hazard are necessary to assure the proposed measures effectiveness.

A sustainability approach must be incorporated into all port activities through a policy that covers the design, execution, and measures that prevent or mitigate the causes of environmental impact.

Increasing the level of environmental awareness among port workers through policies that include strategies for the protection and conservation of the environment is essential for the region's environmental balance. Environmental education should include both port workers and residents of neighboring communities to secure the proposed measures effectiveness.

Furthermore, environmental audits must be conducted to ensure environmental care and to oversee compliance with the methodology and use of evaluation indicators.

Finally, the port terminal must have an emergency plan for disasters, allowing the rapid and effective action of the involved agents to prevent greater risks and to reverse the problem in less time and with efficacy.

Environmental responsibility in the port facility itself must be an essential part of the company's tasks, which must assume strategies committed to economic development and the quality of life of all society members.

Conclusions

The analysis carried out at Puerto Moa Company allowed to identify existing environmental impacts and the externalities caused by port activity.

The proposed actions contribute to sustainable development implementation within Puerto Moa Company and to raise awareness among workers on the need to care for and protect the environment and its resources.

Bibliographic References

Acciaro, M., Renken, K., & El Khadiri, N. (2020). Technological change and logistics development in European ports. *European port cities in transition: Moving towards more sustainable sea transport hubs*, 73-88. https://doi.org/10.1007/978-3-030-36464-9_5

Alvarado-Barrera, L. F., Félix-Zambrano, M. V., Carvajal-Valencia, P.F., & Soria-Morán, M. (2024). Estudio del transporte marítimo en el comercio internacional, su incremento de CO_2 y su afectación al medio ambiente. *Journal Scientific MQRInvestigar*, *8*(2), 3408-3423. https://doi.org/10.56048/MQR20225.8.2.2024.3408-3423

Bell Batista, Y. (2016). Indicadores para el análisis de la eficiencia del transporte de carga para empresas de servicios. Caso de estudio Empresa Puerto Moa "Cdte. Raúl Díaz Argüelles". *Revista Caribeña de Ciencias Sociales*. https://www.eumed.net/rev/caribe/2016/02/carga.html

Buenrostro Aguilar, H.J. & Domínguez, N.S. (2023). Propuesta de Categorías Para la Medición de la Sustentabilidad Portuaria a Través de la Metodología Fuzzy-Delphi. *European Scientific Journal, ESJ, 19*(37). https://doi.org/10.19044/esj.2023.v19n37p174

Correa, A. (2022). El impacto de los negocios internacionales en la contaminación de los lechos marinos. *Ágora Revista Virtual de Estudiantes,* 10(14), 1-23. https://ojs.tdea.edu.co/index.php/agora/article/view/1281

Durán Morales, A. (2005). *Estudio de la calidad de las aguas de la dársena del Puerto de Moa*. (Undergraduate Thesis, Mining and Metallurgical Higher Institute, Moa, Cuba). http://ninive.ismm.edu.cu/handle/123456789/1331

García Hidalgo, L. (2013). *Impacto Sociocultural de la Situación Medioambiental en la Empresa Puerto Moa*. (Undergraduate Thesis, Mining and Metallurgical Higher Institute, Moa, Cuba). http://ninive.ismm.edu.cu/handle/123456789/2779

Guédez, C., De Armas, D., Reyes, R., & Galván, L. (2003). Los sistemas de gestión ambiental en la industria petrolera internacional. *Interciencia, 28*(9), 528-533. https://www.redalyc.org/pdf/339/33908406.pdf

Guerrero Molina, M. I., & Álvarez Patiño, J. V. (2024). El transporte marítimo y su impacto en la sostenibilidad: revisión de la bibliografía. *Revista de Relaciones Internacionales, Estrategia y Seguridad, 19*(1), 47-66. https://doi.org/10.18359/ries.6764

Guilarte, A., Díaz, A., Nápoles, J., Fernández, O., Abalos, A., & Pérez, R.M. (2015). Valoración de impacto ambiental en el Puerto Moa-Holguín. *Revista colombiana de biotecnología,* XVII(2), 129-139. https://doi.org/10.15446/rev.colomb.biote.v17n2.54287

Guillama Barroso, G., Ramos Delgado, N.A., Sanjuan Galindo, R., Herrera Mendoza, R., Rivera Haro, J.A., & Quevedo Álvarez, O. (2022). Evaluación de la contaminación por As, Ni, Cu, Pb, Zn y Cr en sedimentos de la zona marino-costera asociada a la terminal marítima de Nuevitas, Cuba. *Revista Internacional de Contaminación Ambiental, 38,* 81-94. https://doi.org/10.20937/RICA.54080

Hinojosa-Montañez, S., Santamaria-Ruiz M., & Troncoso-Palacio, A. (2023). Desarrollo Sostenible en el Entorno Marítimo y Portuario. Una Mirada Desde el Siglo XXI. *Boletín de Innovación, Logística y Operaciones*, *5*(2), 10-30. https://revistascientificas.cuc.edu.co/bilo/article/view/5379

Molina-Castro, R. E., Gómez-Ronquillo, W. J., & de la Cruz-Lozado, J. (2021). Contaminación marina por desechos plásticos en países del perfil costero del Pacífico Sur, 2016-2021. *Revista Polo del Conocimiento*, *6*(5). https://polodelconocimiento.com/ojs/index.php/es/article/view/2671/html

Peña Cassio, R. & Valdés Martínez, M. (6-16 noviembre de 2015). *Evaluación de la gestión ambiental en el ecosistema de la bahía Cienfuegos*. MARCUBA 2015, Cuba. https://doi.org/10.13140/RG.2.2.15513.47208

Pérez Jiménez, J.C., Morales Jiménez, C., Lango Reynoso, F., & Castañeda Chávez, M.R. (2023). Fuentes de contaminación terrestre con impactos en arrecifes coralinos de la zona centro del Golfo de México. *BIOCYT, Biología, Ciencia & Tecnología, 16*, 1146-1152. https://doi.10.22201/fesi.20072082e.2023.16.86071

Pulido, A., Díaz, M., Díaz, L., & Alonso, C. (2016). Evaluación de la contaminación en sedimentos objeto de dragado en el recinto portuario de la bahía de Cienfuegos (Cuba). *Centro Azúcar, 43*(2), 12-23. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2223-48612016000200002&lng=es&nrm=iso

Quintero Rendón, L.A., Agudelo, E.A., Quintana, Y.A., & Cardona, A.A. (2010). Determinación de indicadores para la calidad del agua, sedimentos y suelos marinos y costeros en puertos colombianos. *Gestión y ambiente, 13*(3), 51-64. https://revistas.unal.edu.co/index.php/gestion/article/view/25414

Ramírez, A. & Domínguez, L. (2022). Gestión portuaria de las mineras de Marcona y su objetivo de desarrollo sobre vida submarina. *Revista del Instituto de Investigaciones de la Facultad de minas, metalurgia y ciencias geográficas, 25*(50), 309-320. https://doi.org/10.15381/iigeo.v25i50.24254

Rojas, J. A., Guilarte, A., & Reynaldo, C.L. (2022). Valoración ambiental y gestión de los residuales de la base terminal de combustibles de Moa. *Ciencia & Futuro, 12*(3), 371-386. https://revista.ismm.edu.cu/index.php/revistacyf/article/view/2191

Serrano, B. M., González, N., Soler, F. & Santos, A. E. (2021). Análisis Business Observation Tool de la sostenibilidad portuaria. Aplicación al sistema portuario español. *Revista Transporte y Territorio*, *25*. https://doi.org/10.34096/rtt.i25.8070

Torres González, D. (2015). La información y la comunicación del riesgo de origen tecnológico en la empresa Puerto Moa. La información y la comunicación del riesgo de origen tecnológico en la empresa Puerto Moa. *Ciencia & Futuro*, *5*(1), 104-122. https://revista.ismm.edu.cu/index.php/revistacyf/article/view/1031

Vega, M. I., Bearzotti, L. Escobedo, Y., & González-Ramírez, R. G. (2018). Una propuesta de indicadores para el análisis de la sustentabilidad en puertos. *Panorama Económico, 26*(2), *165-186*. https://dialnet.unirioja.es/servlet/articulo?codigo=7427852

Villarreal, C., & Araúz, P. (2025). Plan de Desarrollo de Gestión Ambiental en Puertos y Áreas Circundante. *Mesoamericana,* 27(1), 52-58. https://doi.org/10.48204/j.mesoamericana.v27n1.a7370

Viñas, M., Sabaté, J., Grifoll, M., & Solanas, M. (2001). Ensayos de tratabilidad en la recuperación de suelos contaminados por la tecnología de la biorremediación. *Residuos. Revista Técnica,* 59, 78–82. https://www.osti.gov/etdeweb/biblio/20173548