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Enhancing Environmental Awareness in Maritime Education through the Introduction of the Eco-Friendly PF-SCWSCBR Incinerator and Manual Book

Budi Riyanto [1*], Arya Widiatmaja [1], Kurniawan Abadi [1], Syafni Yelvi Siska [1], Dedi [2], Lusi Englita [2]
[1] *Politeknik Pelayaran Sumatera Barat, Indonesia*
[2] *Akademi Maritim Sapta Samudera, Indonesia*

budiriyantobr31@gmail.com*

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Abstract

This community service program aimed to enhance the understanding and readiness of AMSS Padang students to use the PF-SCWSCBR eco-friendly incinerator properly, safely, and in an environmentally responsible manner, while utilizing the manual book as a supplementary learning resource. The program was conducted on September 29, 2026, at the West Sumatera Merchant Marine Polytechnic and involved lecturers and students from AMSS Padang through a series of activities, including participant transportation, registration, opening session, education and dissemination, interactive discussions, question-and-answer sessions, souvenir distribution, and closing. The materials covered the functions of the incinerator, operating principles, operational procedures, safety aspects, characteristics of waste suitable for processing, and the use of the manual book. The evaluation results showed that the three participating lecturers gave a 100% positive assessment across all evaluation indicators. Student evaluation yielded an average achievement rate of 97.93%, with four indicators reaching 100%, namely understanding of the materials, understanding of the manual book, perceived benefits of the program, and satisfaction with the activity. These findings indicate that the program effectively enhanced participants' understanding of waste-processing technology and supported the integration of applied technology into maritime education. The activity also provides opportunities for further research and community service through technological refinement, manual book development, performance and emission testing, and broader implementation in educational and maritime settings.

Keywords: Eco-Friendly Incinerator; Waste Management; Manual Book; Maritime Education Training (Met); Community Service.

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INTRODUCTION

Sustainable waste management has become an increasingly important concern in educational institutions, particularly in vocational and maritime education where learning is closely associated with practical skills, applied technologies, occupational safety, and environmental responsibility (Widiatmaja et al., 2026). Educational institutions are not

only expected to transfer technical competencies but also to prepare students to respond to environmental challenges encountered in professional practice. In maritime settings, this concern is particularly relevant because waste generated during shipboard operations requires controlled treatment and cannot be managed solely through conventional disposal practices (Balcha et al., 2025). The International Maritime Organization (IMO) regulates shipboard incineration under MARPOL Regulation 16, including restrictions on materials that may be incinerated and requirements for appropriate equipment, operating manuals, and operator training (Syafrudin et al., 2025). Consequently, introducing environmentally responsible waste-processing technologies during maritime education is important for connecting environmental awareness with the practical competencies required of future maritime professionals.

AMSS Padang, or Akademi Maritim Sapta Samudra Padang, is a maritime higher education institution offering vocational diploma programs in Nautical Studies, Marine Engineering, and Port and Shipping Management. Its educational orientation emphasizes practical competence, discipline, safety, and technology-based professional preparation, making it a relevant setting for the dissemination of applied environmental technologies. Previous research in maritime education has demonstrated the importance of integrating environmental science, resource management, and sustainable development into maritime curricula, although the extent of practical implementation may differ across maritime programs and learning contexts (Garay-rondero & Issa-zadeh, 2025). In addition, experiential and active learning approaches have been shown to strengthen students' engagement with sustainability issues by connecting academic knowledge with authentic maritime activities (Sankar & Butt, 2025). Therefore, AMSS Padang represents an appropriate educational context in which waste-treatment technology can be introduced not merely as a technical device but as a learning resource supporting environmental competence in maritime education.

The need for this program was identified through preliminary interviews with lecturers and field observations involving students at AMSS Padang. The lecturer interviews indicated three principal problems: uneven student understanding of the working principles and operating procedures of the PF-SCWSCBR eco-friendly incinerator, limited availability of practical and systematic instructional materials, and insufficient integration of waste-processing technology into learning activities. Field observations further indicated that students had limited understanding of the complete operating sequence, required clearer guidance concerning equipment functions and safety procedures, and had relatively limited opportunities to connect theoretical knowledge with direct experience in environmentally friendly waste-processing technology. These conditions indicate that the challenge is not simply a lack of technological availability but also a gap between technology, instructional resources, and practical learning experiences. Similar community-service initiatives have shown that socialization, demonstrations, and practical training can improve participants' knowledge of waste classification, waste treatment, and environmentally responsible technology use. Thus, a structured educational intervention supported by an operating manual is needed to bridge the gap between technological innovation and its meaningful use in maritime learning.

The existing state of the art indicates that waste-management education and incinerator dissemination have generally been directed toward communities, schools, boarding institutions, or general environmental programs, with emphasis on waste awareness, waste segregation, and the introduction or construction of simple incinerators (Rahmawati et al., 2025). Research on incineration also demonstrates that waste characteristics and operating conditions substantially influence combustion performance and emission profiles, highlighting the importance of proper waste classification and controlled operation. Meanwhile, maritime education research has emphasized environmental science and sustainability competencies but has generally focused on

curriculum integration and student experiences rather than on the pedagogical dissemination of a specific waste-processing technology accompanied by a dedicated operating manual (Yusuf & Fajri, 2022). These strands of research collectively establish the relevance of environmental education, practical learning, and controlled waste-processing technologies, but they have not sufficiently addressed the intersection of these elements in a maritime higher-education context. This distinction provides the basis for the present community-service intervention.

The principal gap addressed by this study is the limited application of an environmentally oriented incinerator as a structured learning resource for maritime students, particularly when the technology is accompanied by a manual book designed to support systematic understanding and safe operation. The novelty of this work lies in integrating three components within a single intervention: dissemination of the PF-SCWSCBR eco-friendly incinerator, contextualized education on its operation and environmental safety, and socialization of a manual book as a supplementary learning resource for maritime students and lecturers. This approach differs from previous community-service programs that primarily emphasized waste awareness or the construction and demonstration of incinerators without specifically positioning the technology within maritime vocational learning (Crompton & Sykora, 2021). The use of a manual book is also consistent with the operational emphasis of maritime regulation, which requires operating manuals and appropriate training for shipboard incinerators. Accordingly, the intervention is expected to contribute not only to environmental awareness but also to the pedagogical integration of applied technology into maritime education.

The objective of this study was to improve the understanding and readiness of AMSS Padang students to use the PF-SCWSCBR eco-friendly incinerator properly, safely, and in an environmentally responsible manner, while strengthening the use of the manual book as a supplementary learning resource. The working hypothesis was that structured education and manual-book dissemination would produce a high level of participant understanding and perceived readiness regarding the function, operating procedures, safety aspects, and appropriate use of the technology. The intervention variable was the educational dissemination of the PF-SCWSCBR eco-friendly incinerator combined with manual-book socialization, whereas the outcome dimensions included participants' understanding of the material, equipment functions, operating principles, equipment use, manual-book comprehension and usability, perceived benefits, relevance to maritime education, environmental awareness, and overall satisfaction. The activity was implemented as a community-service program involving lecturers and students of AMSS Padang through educational presentations, demonstrations, interactive discussions, question-and-answer sessions, and evaluation activities. A descriptive evaluation approach was used to assess the achievement of the targeted indicators among participating lecturers and students.

For clarity, Community Service Program refers to an applied higher-education activity intended to transfer knowledge, technology, and practical innovation to community or partner institutions, while AMSS refers to Akademi Maritim Sapta Samudra Padang. The term "eco-friendly incinerator" in this study refers specifically to the PF-SCWSCBR waste-processing technology disseminated by the Community Service team, and "manual book" refers to the instructional guide used to explain the equipment, operating procedures, and safety considerations. The study therefore positions the PF-SCWSCBR technology not simply as a waste-treatment device but as an applied learning resource that can connect environmental technology with maritime vocational education. This positioning is important because shipboard incineration requires proper equipment, controlled operation, operational guidance, and training, as recognized in IMO Regulation 16. By linking technological dissemination with structured learning support, the present

intervention provides a practical pathway for strengthening environmental competence among future maritime professionals while generating a foundation for subsequent technological refinement and further community-service implementation.

METHOD

The participants were lecturers and students of Akademi Maritim Sapta Samudra Padang (AMSS Padang), selected purposively because they were the direct beneficiaries of the program. The evaluation involved three lecturers and participating students who attended the community-service activity and completed the evaluation form (Jakob *et al*., 2026; Ebsen & Rieland, 2026). Data were collected using structured evaluation forms covering understanding of the material, equipment functions and operation, manual-book use, perceived benefits, relevance to maritime education, environmental awareness, and satisfaction. Observation and discussion records were also used to document participant questions, responses, and feedback during the activity.

Figure 1. Community Service Procedure



The activity was conducted on September 29, 2026, from 8am to 11am at Politeknik Pelayaran Sumatera Barat and consisted of preparation, implementation, and evaluation. The implementation included participant registration, an opening session, education and socialization of the PF-SCWSCBR eco-friendly incinerator, manual-book dissemination, discussion and question-and-answer sessions, and closing activities. The evaluation data were analyzed descriptively by calculating the percentage of positive responses for each indicator and the average achievement percentage for the student evaluation. The lecturer responses were also summarized using descriptive percentages, while no inferential statistical tests were applied because the activity focused on evaluating program implementation rather than testing causal effects.

RESULT AND DISCUSSION

The major finding of the community-service program was the high level of participant acceptance of the PF-SCWSCBR eco-friendly incinerator education and manual-book socialization. The three participating lecturers reported 100% agreement across all evaluation indicators, while the student evaluation reached an average achievement rate of 97.93%, with four indicators receiving 100% achievement: understanding of the material, understanding of the manual book, perceived benefits, and satisfaction with the program. The remaining student indicators, including understanding of equipment functions, operating procedures, manual-book usability, relevance to maritime education, and environmental awareness, reached 97%. These results are supported by the active participation of lecturers and students in the discussion and

question-and-answer sessions, particularly on the types of waste suitable for incineration, environmental effects, shipboard application, and liquid-smoke production.

Figure 2. Education and Socialization by the Team Leader



These findings indicate that the intervention was well aligned with the immediate learning needs of the participating maritime students and lecturers. The high evaluation scores suggest that the combination of technical explanation, interactive discussion, and manual-book socialization was acceptable as a learning support strategy for introducing applied environmental technology. However, the findings should be interpreted as evidence of perceived understanding and program acceptance rather than direct evidence of learning gain, because the activity did not employ a pretest-posttest design or an objective performance assessment. The active questions raised by participants nevertheless provide qualitative support that the material was considered relevant to practical maritime contexts rather than being perceived solely as theoretical information. This interpretation is important because previous community-service studies have similarly shown that technology dissemination is more meaningful when participants are engaged through education and practical interaction rather than through one-way information delivery alone (Hanafi et al., 2025; Muhtadin et al., 2026). Thus, the present results are consistent with the expectation that participatory education can facilitate the transfer of applied technology into a learning environment.

Figure 3. Question from AMSS Lecturer



The findings are also consistent with previous work on waste-management education and technology dissemination, although the present program differs in its target population and educational context. Hanafi et al. (2025) reported that community education combined with the introduction of small-scale incineration technology could

strengthen participants' knowledge and skills in waste management, while Muhtadin et al. (2026) emphasized the value of integrating appropriate technology with knowledge and skills transfer. Similarly, Mashartanto et al. (2024) and Riyanto et al. (2026) highlighted the importance of connecting environmental technology with users' practical needs rather than treating technology as an isolated technical product. The present activity extends this approach to maritime higher education by positioning the incinerator not only as a waste-treatment technology but also as an applied learning resource. This distinction is important because the educational value of the intervention depends on whether students can relate the technology to occupational situations, environmental responsibility, and future shipboard practice.

Figure 4. Discussion with AMSS Female Cadet



The maritime education context further explains why the intervention received a high level of acceptance. Previous studies have emphasized that environmental knowledge and sustainability should form part of the competency development of future maritime professionals (Yanti et al., 2025; Uddin & Siska, 2026). Purba & Simanjuntak (2024) reported that the integration of environmental science within maritime education has developed but may vary in terms of practical implementation and students' learning experiences, while Diahyleva et al. (2024) demonstrated the value of interactive learning media in connecting theoretical knowledge with practical sustainability-oriented learning. The present findings fit this literature because the PF-SCWSCBR technology provided a concrete object through which students could discuss waste classification, operational procedures, environmental risks, and potential shipboard applications (Kurniawan et al., 2025; Hasnur et al., 2026). The discussion questions also suggest that students did not view the technology solely from the perspective of equipment operation but considered its implications for marine ecosystems and waste management at sea. Therefore, the intervention has implications for strengthening the connection between technical competence, environmental awareness, and maritime professional preparation.

Figure 5. Evaluation Questionnaire Completion



From a technical perspective, the findings should not be interpreted as proof that the PF-SCWSCBR system itself reduces emissions or produces superior environmental performance, because those outcomes were not directly measured in the present activity. Existing research demonstrates that incineration performance and pollutant formation are influenced by waste characteristics, composition, moisture content, and operating conditions (Liao et al., 2023; Tian et al., 2024), while Asyari et al. (2026) emphasized that visual observation alone is insufficient for evaluating the safety and environmental performance of incineration processes. These studies provide an important context for interpreting the participants' questions concerning suitable waste types, environmental effects, and the application of the technology on ships. In particular, the discussion regarding food waste, leaves, plastics, and other materials highlights the need for waste classification and controlled operation rather than indiscriminate combustion (Díaz-secades & Bouz, 2025; Riyadi et al., 2026). For future technical development, PF-SCWSCBR therefore requires empirical testing of combustion efficiency, waste composition, operating temperature, residence time, energy consumption, residue characteristics, and emission performance before claims about environmental effectiveness can be generalized (Riyanto et al., 2026; Purwantini et al., 2026).

The manual book was another important component of the intervention because it transformed the technology from a demonstrated device into a structured learning resource (Siska et al., 2024; Siska et al., 2024). The strong participant response to the manual book is consistent with the operational emphasis of maritime practice, where standardized procedures, operator guidance, training, and equipment-specific instructions are important components of safe operation (Nazarwin et al., 2026; Fauzi et al., 2026). Phanphichit & Bartusevičienė (2025) likewise emphasized the importance of appropriate operating procedures, material selection, maintenance, and personnel understanding in maritime incinerator operation. In the present context, however, the manual book served an additional pedagogical function by supporting students' understanding before, during, and after the educational session. An alternative explanation for the very high evaluation scores is that participants may have been influenced by the novelty of the technology, the immediate interaction with the PkM team, or socially desirable responses in a partner-based educational activity (Alim et al., 2026; Baskoro et al., 2026). Future implementation should therefore examine whether the positive perceptions are sustained after repeated use and whether they translate into observable competence in operating procedures and safety practices.

The implications of the findings are both educational and developmental. For maritime education, the activity provides a model for integrating applied environmental technology with contextual learning, while for the technology itself, participant feedback identifies practical directions for refinement, including adaptation to different maritime programs and further development of the manual book. The lecturers' recommendations to extend similar activities to Port and Shipping Management and to strengthen institutional collaboration indicate opportunities to broaden the educational application of the technology and related learning materials. At the same time, the methodological limitations of the present activity should be acknowledged: the evaluation was conducted in a single community-service session, relied primarily on descriptive responses, involved purposively selected participants, and did not include a control group, pretest-posttest comparison, long-term follow-up, or direct technical measurements of incinerator performance. Consequently, the findings demonstrate strong immediate acceptance and perceived relevance but do not establish causal effects on students' competence or the environmental performance of the PF-SCWSCBR technology. Future research should employ larger samples, pretest-posttest or quasi-experimental designs, objective performance assessments, and laboratory or field measurements of emissions and combustion efficiency, followed by further community-service activities to translate validated research findings into sustainable maritime learning and practice.

CONCLUSION

The community engagement activity demonstrates that the introduction of the eco-friendly incinerator PF-SCWSCBR, supported by a structured manual book, can strengthen students' understanding and readiness to apply environmentally responsible waste-management practices in a maritime education context. The activity was meaningful not only because it introduced the functions and operating procedures of an environmental technology, but also because it connected waste classification, safe equipment operation, and environmental responsibility with the competencies expected in maritime education and future workplace settings. The manual book further supports systematic and independent learning by providing accessible guidance for understanding the operational stages and safety considerations of the technology. These outcomes highlight the practical relevance of integrating environmental technology into maritime education as part of efforts to develop environmentally aware and safety-oriented human resources. Accordingly, the PF-SCWSCBR and its accompanying learning materials have potential to support broader educational and community-based environmental initiatives, while continued improvement through practical demonstrations, user feedback, technological refinement, and wider institutional dissemination is important to strengthen their applicability in diverse maritime and educational settings.

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