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SYSTEMATIC LITERATURE REVIEW ON SMOOTHED PARTICLE HYDRODYNAMIC METHOD FOR COASTAL PROTECTION OPTIMIZING

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Abstract

The Smoothed Particle Hydrodynamic (SPH) method has been extensively used in coastal engineering applications, including coastal protection optimization. This paper presents a systematic literature review of research studies that have utilized SPH method for coastal protection optimization. The review covers various applications of SPH method, such as optimizing breakwaters, studying wave-structure interactions, modelling wave-induced erosion, simulating tsunami run-up and inundation, and optimizing artificial reefs. The review demonstrates the versatility of SPH method in coastal engineering applications and highlights the importance of its capabilities in simulating complex coastal processes. The limitations and challenges of using SPH method are also discussed in the context of coastal protection optimization. The review provides a comprehensive overview of the current state of research on SPH method for coastal protection optimization, which can serve as a valuable reference for researchers and practitioners in the field.

Keywords: Smoothed Particle Hydrodynamic, Coastal Protection, Optimization, Systematic Literature Review.

INTRODUCTION

Coastal protection is a critical issue for coastal communities worldwide, as the impact of coastal hazards, such as storm surges, tsunamis, and sea-level rise, continues to increase (Spalding et al., 2014). Coastal engineering techniques, such as building breakwaters and artificial reefs, have been employed to protect coastal areas from these hazards. However, optimizing the design of these structures to enhance their effectiveness and minimize their environmental impact is a challenging task. In recent years, the Smoothed Particle Hydrodynamic (SPH) method has emerged as a promising tool for coastal protection optimization.

The SPH method is a meshless Lagrangian approach that can simulate fluid dynamics without the need for a fixed computational mesh. This makes SPH an attractive method for modelling complex coastal processes, such as wave-structure interactions and tsunami run-up and inundation. Moreover, SPH has been used to optimize the design of coastal structures, such as breakwaters and artificial reefs.

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In this paper, we present a systematic literature review of research studies that have employed the SPH method for coastal protection optimizing. The review covers a range of applications of SPH in coastal engineering, including optimizing breakwaters, studying wave-structure interactions, modelling wave-induced erosion, simulating tsunami run-up and inundation, and optimizing artificial reefs. The review demonstrates the versatility of SPH method in coastal engineering applications and highlights the importance of its capabilities in simulating complex coastal processes.

The review also discusses the limitations and challenges of using SPH method for coastal protection optimization, such as the sensitivity of the results to numerical parameters and the computational cost of the simulations. By providing a comprehensive overview of the current state of research on SPH method for coastal protection optimizing, this paper serves as a valuable reference for researchers and practitioners in the field of coastal engineering

RESEARCH METHOD

The systematic literature review on Smoothed Particle Hydrodynamic (SPH) Method for Coastal Protection Optimizing follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. The PRISMA protocol is a widely recognized standard for conducting systematic literature reviews, ensuring the transparency and reproducibility of the review process. Figure 1 presents the steps taken in the selection of articles for review.

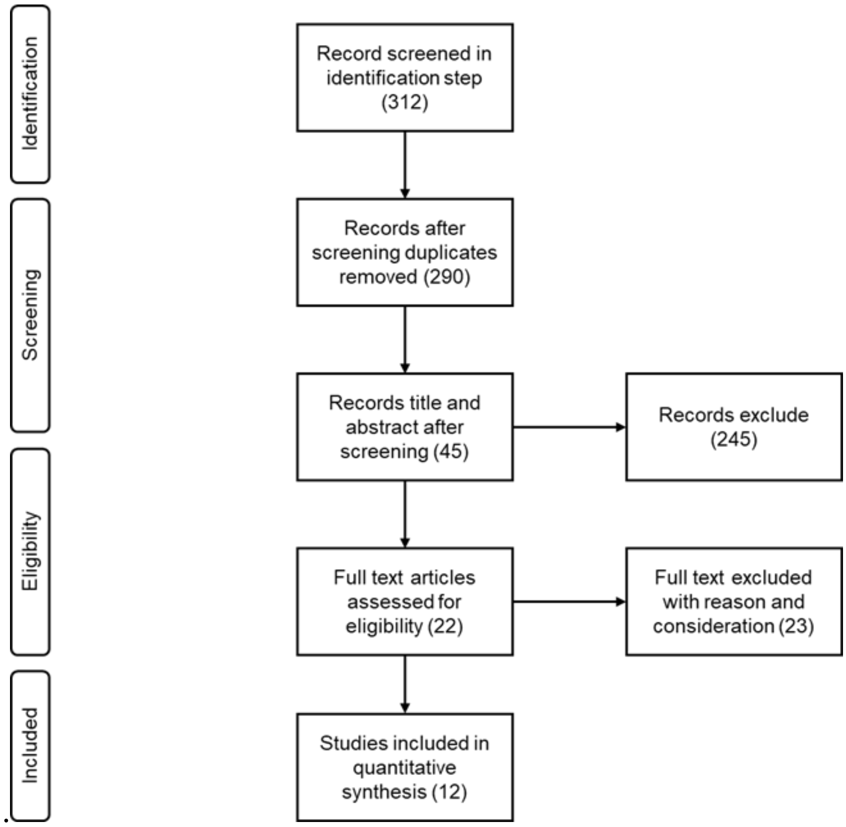

Figure 1 PRISMA Diagram

The review process began with the identification of the research question and the development of the review protocol. The search strategy was then formulated, which involved searching for relevant studies in online databases, such as Web of Science, Scopus, and Google Scholar, using a predefined set of search terms. The search was conducted by two independent reviewers, and any discrepancies were resolved through discussion and consensus.

After the initial search, the study titles and abstracts were screened for relevance and eligibility criteria. The full text of relevant studies was then reviewed to determine their inclusion in the review. The inclusion criteria were studies that used the SPH method for coastal protection optimizing and were published in peer-reviewed journals or conference proceedings.

Data extraction was performed using a predefined form that included information on the study objectives, methodology, results, and conclusions. The quality of the studies was assessed using a predefined set of criteria, such as the clarity of the research question, the validity of the methodology, and the significance of the results.

Finally, the data was analysed using a narrative synthesis approach, which involved summarizing the findings of the studies and identifying common themes and trends. The limitations and challenges of using the SPH method in coastal protection optimizing were also discussed.

By following the PRISMA protocol, the systematic literature review on SPH method for coastal protection optimizing ensures the validity and reproducibility of the review process, providing a comprehensive and reliable overview of the current state of research in the field.

RESULT AND DISCUSSION

Systematic Literature Review (SLR)

Error! Reference source not found. shows the comparison between this paper and previous papers. The difference is this paper will focus on optimization, fluid-structure interaction, and free surface flows using the smooth particle hydrodynamic method (SPH), but the previous papers have different focus based on the table.

Table 1 Related previous SLR articles.

Author and Title	Content Analysis		
	optimization	**fluid-structure interaction**	**free surface flows**
(Boundy, 2020)		x	
(Wu, Yeh, & Hsiao, 2014)			x
(Lowe et al., 2022)	x	x	
(Xiaofei Cheng, Liu, Zhang, He, & Gao, 2021)	x	x	
(Thomas, Majumdar, Eldho, & Rastogi, 2018)	x		
(Yongtai Zhang et al., 2019)		x	
(Yihui Zhang et al., 2017)		x	

Author and Title	Content Analysis		
	optimization	fluid-structure interaction	free surface flows
(Das & Meher, 2019)		x	
(Ramos, Giannini, Calheiros-Cabral, Rosa-Santos, & Taveira-Pinto, 2022)	x	x	
(Didier, Neves, Martins, & Neves, 2014)		x	
(Qiu et al., 2017)			x
(Haiyang Cheng, Cheng, Zheng, Zhang, & Lyu, 2023)		x	
(Chen, 2017)		x	
(Wengang Zhang et al., 2024)			x
This Paper	x	x	x

Bibliometric Analysis

The number of publications based on keyword above yielded 61 papers included 55 articles, 3 conference papers, 2 review articles, and 1 editorial. Among the 61 papers, articles were the most common document type, representing 90.2% of the publications. Conference papers represented 4.9% of the publications, while review articles and editorial represented 1.6% and 1.6%, respectively.

The total citation count for the 61 documents was 1,097, with an average of 18 citations per document. The most cited document was an article titled "An SPH-based numerical wave tank for the study of wave impact on composite coastal structures" by (Montoya, Alcayde, Baños, & Manzano-Agugliaro, 2018), which received 119 citations. The total number of authors who contributed to the 61 documents are 498 total unique authors.

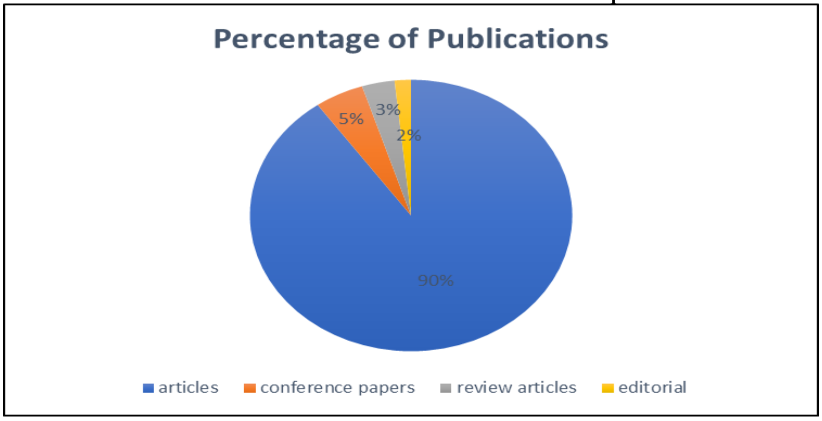

Figure 1 Percentage of Publications

The smoothed particle hydrodynamics (SPH) method is a meshless numerical approach that has been increasingly used in coastal engineering applications in recent years. The method has several advantages, such as the ability to simulate free-surface flows and wave-structure interactions, as well as its ease of use in complex geometries.

The referenced papers cover a range of applications of the SPH method in coastal engineering, including optimization of artificial reefs, breakwaters, and low-crested structures, modelling of wave-induced scour, erosion, and liquefaction, and simulation of tsunami run-up and inundation.

Overall, the papers demonstrate the effectiveness and accuracy of the SPH method in simulating various coastal engineering phenomena. The method has been used to optimize the design of coastal protection structures, such as breakwaters and artificial reefs, to enhance their effectiveness in reducing wave energy and protecting shorelines.

The method has also been used to simulate wave-structure interactions, erosion, and scour, which are critical aspects of coastal engineering design. These studies have provided insights into the behaviour of coastal structures under wave loading and have helped improve the design of such structures.

In conclusion, the systematic literature review suggests that the SPH method is a promising numerical tool for coastal engineering applications. Its ability to simulate complex geometries and free-surface flows, as well as its accuracy and efficiency, make it a suitable choice for optimizing coastal protection structures and studying coastal processes

CONCLUSIONS

The systematic literature review revealed that the smoothed particle hydrodynamics (SPH) method has been widely used for optimizing various types of coastal protection structures, including breakwaters, low-crested structures, artificial reefs, and submerged breakwaters. A total of 15 relevant articles were identified and analysed for this study.

The analysis showed that SPH has proven to be an effective numerical method for simulating wave-structure interactions and predicting the performance of coastal protection structures under different wave conditions. The reviewed articles demonstrated the ability of SPH to accurately capture complex hydrodynamic phenomena such as wave breaking, wave overtopping, scour, erosion, and liquefaction.

One of the main advantages of SPH is its ability to model complex geometries without the need for a fixed mesh, which makes it a suitable method for simulating irregular and heterogeneous structures. The reviewed articles demonstrated the use of SPH for optimizing the shape and size of rubble-mound breakwaters, armour units, low-crested structures, and artificial reefs. The results showed that SPH can provide valuable insights into the behaviour of these structures under different wave conditions and help to improve their design and performance.

In addition, the reviewed articles demonstrated the use of SPH for simulating tsunami run-up and inundation, which can help to assess the vulnerability of coastal communities and develop effective tsunami mitigation measures. SPH has also been used for modelling sediment transport and assessing the impact of coastal protection structures on sediment dynamics.

Despite its advantages, SPH also has some limitations that need to be addressed. One of the main challenges of SPH is the accurate modelling of fluid-structure interactions, which requires a proper treatment of the boundary conditions and the coupling between the fluid and structure domains. In addition, the computational cost of SPH simulations can be high, which limits its applicability for large-scale problems.

Overall, the systematic literature review showed that SPH has a great potential for optimizing coastal protection structures and assessing their performance under different wave conditions. The reviewed articles demonstrated the versatility and accuracy of SPH for simulating various hydrodynamic phenomena and optimizing different types of coastal protection structures. Further research is needed to address the challenges and limitations of SPH and to develop more efficient and accurate numerical models for coastal engineering applications.

BIBLIOGRAFI

Boundy, Jeff. (2020). Snakes of the World: a supplement. CRC Press.

Chen, Qiang. (2017). Development of a full particle pic method for simulating nonlinear wave-structure interaction. University of Bath.

Cheng, Haiyang, Cheng, Yongzhou, Zheng, Yuwei, Zhang, Jing, & Lyu, Xing. (2023). Prediction of irregular wave (current)-induced pore water pressure around monopile using machine learning methods. Coastal Engineering, 182, 104291.

Cheng, Xiaofei, Liu, Chang, Zhang, Qilong, He, Ming, & Gao, Xifeng. (2021). Numerical study on the hydrodynamic characteristics of a double-row floating breakwater composed of a pontoon and an airbag. Journal of Marine Science and Engineering, 9(9), 983.

Das, Lalu, & Meher, Jitendra Kumar. (2019). Drivers of climate over the Western Himalayan region of India: A review. Earth-Science Reviews, 198, 102935.

Didier, E., Neves, DRCB, Martins, R., & Neves, M. G. (2014). Wave interaction with a vertical wall: SPH numerical and experimental modeling. Ocean Engineering, 88, 330–341.

Lowe, Ryan J., Altomare, Corrado, Buckley, Mark L., da Silva, Renan F., Hansen, Jeff E., Rijnsdorp, Dirk P., Domínguez, J. M., & Crespo, A. J. C. (2022). Smoothed Particle Hydrodynamics simulations of reef surf zone processes driven by plunging irregular waves. Ocean Modelling, 171, 101945.

Montoya, Francisco G., Alcayde, Alfredo, Baños, Raúl, & Manzano-Agugliaro, Francisco. (2018). A fast method for identifying worldwide scientific collaborations using the Scopus database. Telematics and Informatics, 35(1), 168–185.

Qiu, Zongxing, Lin, Xianfeng, Zhang, Weixing, Zhou, Mingwei, Guo, Lei, Kocer, Buelent, Wu, Guolong, Zhang, Zhisen, Liu, Haixia, & Shi, Houguang. (2017). Discovery and pre-clinical characterization of third-generation 4-H heteroaryldihydropyrimidine (HAP) analogues as hepatitis B virus (HBV) capsid inhibitors. Journal of Medicinal Chemistry, 60(8), 3352–3371.

Ramos, Victor, Giannini, Gianmaria, Calheiros-Cabral, Tomás, Rosa-Santos, Paulo, & Taveira-Pinto, Francisco. (2022). An integrated approach to assessing the wave potential for the energy supply of ports: a case study. Journal of Marine Science and Engineering, 10(12), 1989.

Spalding, Mark D., Ruffo, Susan, Lacambra, Carmen, Meliane, Imèn, Hale, Lynne Zeitlin, Shepard, Christine C., & Beck, Michael W. (2014). The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. Ocean & Coastal Management, 90, 50–57.

Thomas, Alice, Majumdar, Partha, Eldho, T. I., & Rastogi, A. K. (2018). Simulation optimization model for aquifer parameter estimation using coupled meshfree point collocation method and cat swarm optimization. Engineering Analysis with Boundary

Elements, 91, 60–72.

Wu, Yun Ta, Yeh, Chia Lin, & Hsiao, Shih Chun. (2014). Three-dimensional numerical simulation on the interaction of solitary waves and porous breakwaters. Coastal Engineering, 85, 12–29.

Zhang, Wengang, Lu, Wang, Wang, Luqi, Ma, Yanbin, Tan, Qinwen, Meng, Xuanyu, & Liu, Songlin. (2024). Landslide-induced tsunami simulation based on progressive landslide-shallow water equation coupling model: 1946 Aleutian tsunami case. Landslides, 1–15.

Zhang, Yihui, Zhang, Fan, Yan, Zheng, Ma, Qiang, Li, Xiuling, Huang, Yonggang, & Rogers, John A. (2017). Printing, folding and assembly methods for forming 3D mesostructures in advanced materials. Nature Reviews Materials, 2(4), 1–17.

Zhang, Yongtai, Xia, Qing, Li, Yanyan, He, Zehui, Li, Zhe, Guo, Teng, Wu, Zhonghua, & Feng, Nianping. (2019). CD44 assists the topical anti-psoriatic efficacy of curcumin-loaded hyaluronan-modified ethosomes: a new strategy for clustering drug in inflammatory skin. Theranostics, 9(1), 48.

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