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Enhancing River Water Quality: A Collaborative Effort Between BrantaSae, RIVER, and Citizen Science for Sustainable River Cleaning

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Abstract

River water pollution is a significant environmental issue affecting aquatic ecosystems and human health. In this study, we explore the collaborative efforts between BrantaSae, RIVER, and citizen science initiatives to enhance river water quality through sustainable cleaning practices. The partnership aims to integrate technology, community participation, and scientific research to address river pollution effectively. BrantaSae's innovative monitoring tools, combined with RIVER's research framework, have enabled real-time data collection on water quality. Citizen science, as an inclusive approach, engages local communities in data collection, fostering awareness and encouraging direct involvement in river cleaning activities. The collaboration has demonstrated promising results in improving water quality, reducing pollutants, and enhancing community engagement in river conservation. The study emphasizes the importance of multi-stakeholder collaboration and the role of citizen science in promoting sustainable environmental practices. By combining scientific knowledge with community-driven efforts, this initiative serves as a model for future river management strategies aimed at preserving water quality and biodiversity for future generations.

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Introduction

River water quality degradation has become a global environmental concern due to rapid urbanization, industrial discharge, and agricultural runoff, which significantly impact aquatic ecosystems and human health (Smith et al., 1999; United Nations Environment Programme, 2021). Water bodies exposed to pollutants exhibit reduced biodiversity, declining ecosystem services, and heightened public health risks, demanding urgent mitigation efforts (Vörösmarty et al., 2010; United Nations Environment Programme, 2021). Rivers play a critical role as freshwater resources for drinking water supply, agriculture, industry, and ecosystem functions (UN-Water, 2021). However, anthropogenic pressures have intensified pollution levels, leading to eutrophication, decreased dissolved oxygen concentrations, and contamination

by heavy metals, nutrients, and pathogenic microorganisms (Carpenter et al., 1998; Dodds & Smith, 2016; United Nations Environment Programme, 2021). Therefore, sustainable strategies for river rehabilitation have become an urgent priority for scientists and policymakers alike.

Recent research underscores the importance of integrating multi-stakeholder approaches for addressing water pollution, highlighting the need for combined scientific monitoring and community participation (Ostrom, 2009). Scientific monitoring programs alone often fail to capture the spatial and temporal variability of water quality across extensive river systems because of financial and logistical limitations (Buytaert et al., 2014; Kosmala et al., 2016). Consequently, complementary monitoring approaches have gained increasing attention within environmental management frameworks.

Citizen science has emerged as an effective complementary approach, enabling extensive environmental data collection while fostering environmental stewardship among local communities (Conrad & Hilchey, 2011; Haklay, 2013). It bridges gaps between formal scientific research and public engagement by empowering non-experts to participate in scientific observations and environmental monitoring (Bonney et al., 2009). Community involvement contributes to broader spatial and temporal datasets while strengthening public awareness and support for conservation initiatives (Danielsen et al., 2014; Dickinson et al., 2012). Citizen-generated data have increasingly been incorporated into environmental planning and policy-making across numerous countries, demonstrating their value for both research and environmental governance (Kosmala et al., 2016; Fraisl et al., 2022).

The collaborative initiative between BrantaSae and RIVER, as outlined in this study, is predicated on harnessing technological innovation and public participation to improve river water quality sustainably. BrantaSae provides innovative water quality sensors and mobile applications for near real-time monitoring. RIVER, a research consortium focused on aquatic ecosystem management, contributes analytical frameworks and quality assurance protocols to ensure data reliability and scientific consistency. Such interdisciplinary collaboration reflects current recommendations for integrated water resource management that emphasize partnerships among academia, communities, and environmental organizations (UN-Water, 2021; Fraisl et al., 2022).

Sustainable river restoration requires robust monitoring frameworks capable of tracking environmental changes over extended periods. Conventional laboratory-based analyses, although highly accurate, are often expensive, labor-intensive, and spatially limited (Buytaert et al., 2014). Consequently, technological innovations such as low-cost water quality sensors, Internet of Things (IoT) devices, cloud computing, and mobile applications have emerged as promising alternatives for expanding monitoring coverage while reducing operational costs (Kumar et al., 2020). When integrated with citizen science networks, these technologies create scalable and resilient monitoring systems capable of supporting adaptive environmental management.

Citizen science initiatives have increasingly been applied in freshwater quality assessment worldwide, producing positive outcomes in environmental awareness, scientific literacy, and policy influence (Conrad & Hilchey, 2011; Haklay, 2013; Fraisl et al., 2022). This participatory approach effectively aligns public interests with scientific objectives while strengthening community capacity for environmental stewardship (Bonney et al., 2016). In Indonesia, however, river pollution remains a persistent environmental challenge. Many rivers continue to experience elevated concentrations of domestic wastewater, organic pollutants, agricultural runoff, and industrial effluents, resulting in ecosystem degradation and declining water quality (KLHK, 2023). Despite increasing environmental awareness, public participation in systematic water quality monitoring remains relatively limited.

Addressing river pollution in Indonesia therefore requires a multidimensional strategy that combines scientific expertise, technological innovation, institutional collaboration, and sustained community engagement (United Nations Environment Programme, 2021; Fraisl et al., 2022). The

BrantaSae-RIVER collaboration seeks to address this need by integrating low-cost monitoring technologies with citizen science practices. Previous studies have demonstrated that citizen science enhances monitoring frequency, expands spatial coverage, reduces monitoring costs, and strengthens environmental awareness among participating communities (Danielsen et al., 2014; Kosmala et al., 2016; Fraisl et al., 2022).

Furthermore, collaborative networks involving government agencies, universities, non-governmental organizations, and local communities have shown measurable improvements in environmental management when supported by transparent communication, standardized monitoring protocols, and real-time environmental data (Ostrom, 2009; Fraisl et al., 2022). Nevertheless, incorporating citizen-generated data into official environmental management systems requires rigorous quality assurance, standardized methodologies, and systematic validation procedures to ensure scientific credibility (Kosmala et al., 2016; Buytaert et al., 2014).

This study adopts internationally recognized water quality indicators and standardized monitoring protocols to ensure data comparability, reliability, and scientific validity. Key indicators, including dissolved oxygen, turbidity, pH, temperature, and nutrient concentrations, are measured through citizen-assisted sampling supported by portable monitoring technologies (United Nations Environment Programme, 2021; APHA, 2023). Active citizen participation in river cleaning and monitoring not only contributes valuable environmental data but also strengthens local ownership of natural resources, an essential factor for long-term sustainability and successful river restoration (Bonney et al., 2016; Danielsen et al., 2014).

Successful river rehabilitation ultimately requires sustained commitment from government agencies, research institutions, environmental organizations, and citizens working collaboratively toward shared environmental goals (Ostrom, 2009; UN-Water, 2021). Collaborative platforms facilitate knowledge exchange, resource mobilization, and evidence-based decision-making through continuous environmental monitoring. Accordingly, this study investigates how synergistic collaboration among BrantaSae, RIVER, and citizen scientists can improve river water quality monitoring, strengthen community engagement, and support adaptive river management strategies. By integrating technological innovation with participatory environmental monitoring, this research contributes to the growing body of knowledge on citizen science as an effective approach for sustainable river conservation and water resource management (Fraisl et al., 2022; Kosmala et al., 2016).

Methodology

This research employs a collaborative and participatory approach with an action research design to evaluate the effectiveness of the river water quality monitoring and cleaning program conducted by BrantaSae, RIVER, and local communities. The action research approach was selected because it integrates fieldwork implementation with continuous scientific reflection, ensuring that the results obtained are both descriptive and applicable for river water quality improvement (Reason & Bradbury, 2008). The research was carried out in three main phases: preparation and volunteer training, periodic water quality data collection, and evaluation with feedback on the monitoring results to all stakeholders.

The first phase involved community and volunteer capacity building in water sample collection, the use of BrantaSae sensor devices, and the application of the Standard Operating Procedures (SOP) set by RIVER. The training was conducted through a 3-day intensive workshop and field practice at selected river sites. This participatory training approach aligns with findings that community-based training improves the accuracy of data collection by non-experts and strengthens social ownership of the program (Shirk et al., 2012).

The second phase focused on water quality data collection, covering physical, chemical, and biological parameters such as pH, temperature, BOD, DO, turbidity, and specific microbial indicators. Data collection was conducted bi-weekly over 6 months at 10 standardized sampling points. The sensor devices

were connected to a cloud-based application, allowing real-time monitoring and temporal-spatial mapping of water quality. This method enhances long-term monitoring capabilities without the high costs of central laboratory analysis (Hussain et al., 2017).

The third phase involved data analysis and collaborative evaluation, where researchers from RIVER, BrantaSae's team, and community representatives validated results, interpreted findings, and recommended further cleaning and conservation actions. Descriptive and inferential statistical analysis was used to assess changes in water quality before and after community interventions. Feedback was provided through regular reports and community meetings to ensure transparency and sustained actions according to the principles of adaptive and reflective participatory research.

Results and Discussion

The collaborative water quality monitoring initiative involving BrantaSae, RIVER, and citizen scientists resulted in significant increases in the volume and spatial coverage of water quality data compared to baseline monitoring before the intervention. Routine bi-weekly sampling across 10 river sites produced a high-resolution dataset that captured temporal fluctuations in key indicators such as dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, and nutrient concentrations. This density of data allowed for trend analysis that would not have been feasible with traditional expert-only monitoring programs.

Data analyses demonstrated measurable improvements in several water quality parameters over the 6-month period. Specifically, mean DO levels showed an upward trend, indicating reduced organic pollution and improved aerobic conditions in sections of the river where community cleanup efforts were most active. Turbidity and BOD values also declined marginally, although the extent of reduction varied across sampling sites. These results align with documented benefits of community-based monitoring initiatives, where frequent engagement can track localized improvements and stimulate responsive actions (George et al., 2021). (Frontiers)

Citizen participation contributed to a greater volume of data points than pre-intervention professional sampling alone, enhancing the statistical power of trend analyses. Volunteer-collected data were consistently evaluated for quality using periodic cross-checks with professional measurements. Comparable research has shown that well-trained volunteers can produce reliable water quality measurements, particularly when supported by clear protocols and sensor technologies (Chaabane et al., 2024). (MDPI)

Spatial mapping of water quality trends revealed clear zones of improvement in sections proximal to community cleanup hubs, suggesting that engaged local action complements monitoring efforts. Upstream locations with less cleanup activity exhibited relatively stagnant improvements, highlighting the role of sustained local engagement in driving ecological change.

Social survey data collected alongside environmental measurements revealed heightened environmental awareness and stewardship among participating citizen scientists. Respondents reported improved understanding of pollution sources and expressed stronger motivation to maintain river cleanliness beyond the formal monitoring period. This corroborates findings that citizen monitoring can reinforce environmental literacy and behavior change (Frontiers review on citizen science for rivers, 2025). (Frontiers)

Engagement outcomes varied by demographic group, with youth volunteers showing particularly high retention and enthusiasm for digital data recording and app-based reporting. Community leaders became key coordinators of sampling schedules and cleanup events, illustrating how decentralized leadership can strengthen program continuity.

Qualitative interviews indicated that stakeholders perceived greater legitimacy in water quality data when community members were involved in collection and interpretation, compared to externally produced reports. Such co-ownership of environmental information can improve trust and incentivize community-driven solutions to pollution sources.

Feedback sessions with local government representatives highlighted the usefulness of dense monitoring data in informing local policy discussions on pollution control and habitat restoration. Officials indicated an increased willingness to integrate citizen-generated data into municipal water quality planning, marking a shift in institutional openness toward participatory science outcomes.

Some limitations were observed: data variability was higher in volunteer-collected datasets compared to professional analysis, particularly in complex parameters that require precise calibration. Nonetheless, correction protocols and quality assurance checks mitigated much of this variability, as also found in studies of citizen science data quality frameworks (conservational monitoring assessments). (Citizen Science: Theory and Practice)

Challenges remained in sustaining long-term volunteer engagement without ongoing support incentives. Seasonal fluctuations in participation suggested that volunteer fatigue could impact data continuity if not countered with motivational strategies and community rewards.

Overall, the hybrid monitoring model validated that participatory science enriched the river water quality assessment process, furnished actionable datasets, and intensified community capacity for environmental stewardship. These outcomes support broader literature advocating integrated citizen science as a cost-effective complement to traditional environmental monitoring programs that help address data gaps and resource constraints.

Conclusion

The collaborative initiative between BrantaSae, RIVER, and citizen scientists demonstrated meaningful enhancements in river water quality monitoring and community engagement. Through systematic bi-weekly sampling at multiple standardized sites, the project generated a rich dataset that captured temporal and spatial patterns in key water quality parameters. This citizen science-supported approach revealed measurable improvements particularly increased dissolved oxygen levels and reduced turbidity in areas where community cleanup actions were consistently implemented. The results underscore the value of merging advanced sensing technologies with community participation to achieve robust environmental data that would otherwise be difficult and costly to obtain through conventional professional monitoring alone.

Beyond empirical water quality outcomes, the program significantly strengthened environmental awareness and stewardship among local residents. Volunteers reported deeper understanding of pollution dynamics, greater sense of responsibility for river ecosystems, and heightened motivation to sustain cleanup efforts beyond the formal study period. These socio-behavioral outcomes align with broader research showing that participatory monitoring enhances ecological literacy and supports pro-environmental behaviors. Furthermore, the collaboration fostered stronger connections between citizens, researchers, and local authorities, resulting in increased recognition of citizen-generated data in regional water management discussions and planning processes.

Despite challenges related to volunteer retention and occasional data variability, the integrated model proved effective at generating high-frequency environmental data and cultivating a community committed to sustainable river conservation. This study suggests that embedding citizen science within collaborative water quality initiatives not only enriches scientific datasets but also reinforces long-term stewardship practices, contributing to more resilient and inclusive approaches to environmental management.

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