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ASSISTANCE OF BIOPORE TECHNOLOGY AS A RAINWATER INFILTRATION METHOD TO REDUCE SURFACE RUNOFF AND FLOODING

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Abstrak: Kegiatan pengabdian kepada masyarakat (PPM) berada di RT.10 Desa Sungai Duren Kabupaten Muaro Jambi. Daerah ini merupakan daerah langganan banjir dan kawasan padat penduduk, dimana apabila terjadi hujan dalam waktu lama sering terjadi genangan air bahkan banjir. Hal ini disebabkan resapan air hujan yang tidak maksimal karena area permukaan tanah sudah tertutupi bangunan permanen. Tujuan dari pengabdian ini adalah memberikan pendampingan dan sosialisasi mengenai penanggulangan bencana banjir dengan menerapkan prinsip konservasi lingkungan serta pembuatan lubang resapan biopori. Selain itu kegiatan ini juga bertujuan untuk mengetahui penyebab terjadinya banjir berdasarkan kondisi spasial serta perilaku sosial masyarakat. Tim Pengabdian ini terdiri dari 5 orang dosen UNJA dari multidisiplin bidang ilmu dan 5 orang mahasiswa, yang akan berkontribusi sesuai keahlian masing-masing. Metode yang dilakukan dalam proses pendampingan dan sosialisasi adalah Focus Group Disscussion (FGD) serta Participatory Rural Appraisal (PRA) untuk mengajak masyarakat berpartisipasi dalam proses penanggulangan banjir. Hasil kegiatan menunjukkan bahwa seluruh peserta mengikuti rangkaian program dengan optimal. Terjadi peningkatan pemahaman tentang teknologi biopori sebesar 93,8%, peningkatan kepedulian masyarakat tentang kebersihan lingkungan sebesar 100%, peningkatan keyakinan kinerja lubang resapan biopori sebesar 81,3%, dan aplikasi biopori pada lingkungan sendiri sebesar 93,8%. Berdasarkan analisis spasial area mitra bukan merupakan dataran banjir Sungai Batanghari. Secara topografi area mitra berada pada elevasi 25m-12,5m dengan morfologi berupa lembah sehingga air dari area tinggian akan berkumpul pada area mitra PPM dan sekitarnya. Selain itu saluran air limbah dan kanal yang ada pada area mitra tidak berfungsi dengan baik sehingga memicu terjadinya bencana banjir.

Kata Kunci: lubang resapan biopori, limpasan air, banjir

Abstract: The community service program (PPM) was implemented in RT.10, Sungai Duren Village, Muaro Jambi Regency, an area highly vulnerable to flooding due to its dense population and limited rainwater infiltration. The extensive presence of permanent buildings prevents effective water absorption, often leading to waterlogging and floods during heavy rainfall. This program aims to provide mentoring and outreach on flood mitigation by applying environmental conservation principles and promoting the construction of biopore infiltration holes. Additionally, it sought to analyze the causes of flooding based on spatial characteristics and community behavior. The service team comprised five multidisciplinary lecturers from Jambi University (UNJA) and five students. The participatory methods employed included Focus Group Discussion (FGD) and Participatory Rural Appraisal (PRA), designed to engage local communities in disaster mitigation planning. Monitoring and evaluation involved direct observation, interviews, and Google Form surveys to assess knowledge, awareness, and attitude changes. The results demonstrated significant impacts: community understanding of biopore technology increased by 93.8%, environmental awareness improved by 100%, confidence in the effectiveness of biopore infiltration holes rose by 81.3%, and actual application of the technology in households reached 93.8%. Spatial analysis confirmed that the partner site is not part of the Batanghari River floodplain, which lies at lower elevations (<12.5 m) and is about 3 km away. Instead, the site lies between 12.5–25 m above sea level with valley-like morphology, causing runoff from higher terrain to accumulate locally. Poorly functioning wastewater channels and canals further intensify flood hazards.

Keywords: biopore absorption holes, water runoff, flooding

Introduction

The population growth in Jambi City has increased very rapidly, which corresponds with the city's economic growth, marked by the proliferation of housing developments, hotels, shopping centers, and industrial activities. In 2012, the total population of Jambi City was 557,216 people, with a population growth rate of 2.98%. By 2018, the population had increased to 591,134 people (BPS, 2018). This population and economic activity rise has led to more green open spaces being converted into built-up areas. The construction of permanent buildings without considering conservation principles and exceeding the area's carrying capacity will result in increased surface runoff from rainwater. If the rainwater flowing on the surface is not absorbed into the ground effectively, it will cause waterlogging or flooding. In such conditions, infiltration rates can drop to less than 10% of their natural values, while surface runoff can increase by more than 50% compared to pre-urban conditions (Wheater & Evans, 2009). Flood disasters affecting parts of Jambi City are not only caused by insufficient water absorption into the soil but also by a lack of environmental awareness. For example, dumping waste into rivers blocks water flow, causing overflow and subsequent flooding (Permana et al., 2019).

The location of the PPM biopore assistance activity is in RT.10, Sungai Duren Village, Muaro Jambi Regency, as shown in Figure 1. Based on observations and discussions with the Head of the neighbourhood, several problems faced by the community were identified. First, when rain precipitation occurs, surface runoff leads to prolonged waterlogging. Heavy and prolonged rainfall can result in flooding. Second, the household drainage systems in RT.10, Sungai Duren Village, are not interconnected, causing water to flow directly onto the surface, exacerbating surface runoff. Third, many residents show a lack of concern for environmental cleanliness, such as littering, and there is also sedimentation in the main drainage system, which reduces the volume of water it can carry.

An effort to reduce surface rainwater runoff is the creation of biopore infiltration holes. According to Victorianto et al (2014), biopore infiltration holes are artificially created holes designed to reduce flooding by accelerating water absorption into the soil. They are called "biopores" because the cylindrical infiltration holes contain pores formed naturally by the activities of soil fauna organisms and plant roots (Brata, 2008). According to the Ministry of Environment Regulation No. 12 (2009), the recommended dimensions for biopore infiltration holes are vertical holes with a depth of approximately 100 cm, but they should not exceed the groundwater table depth, with a diameter of 10–25 cm.

To maintain good water absorption capacity and to ensure the biopores function effectively, organic waste is added to the biopore holes to attract the activity of organisms such as earthworms, termites, ants, microfauna, and decomposer bacteria (Setyaningsih & Endriastuti, 2018). Based on research by Sari et al. (2017), 11 types of microfauna and macrofauna are found in biopore holes. Microfauna include Isotomurus sp, Entomobrya clitellaria, Entomobrya socia, and Hypogastrura nivicola, while macrofauna include Dolichoderus sp, Oechophylla smaragdina, Pheretima sp, Oechophylla sargillina, Gryllus vocalis, Forficula auricularia, and Buffo sp. The activity of these organisms, plant roots, and organic waste in the

biopore infiltration holes leads to composting, resulting in compost soil that can also be used as a planting medium and fertilizer for plants (Arifin et al., 2020).

Although biopore technology has been scientifically proven to increase soil infiltration capacity and reduce surface water runoff (Brata, 2008; Victorianto et al., 2014), its application in RT.10, Sungai Duren Village, remains limited. To date, there has been no integration between implementing biopore technology and programs to improve household drainage systems and community organic waste management. Furthermore, community awareness regarding the importance of water conservation and environmental cleanliness remains low, creating barriers to successfully implementing this technology (Purwanto et al., 2022). Moreover, no local quantitative study has measured the effectiveness of biopore holes in reducing rainwater runoff volume and improving soil quality in this area. This condition creates a research gap and, at the same time, an opportunity for community service programs that focus not only on the physical installation of biopore holes but also on education, active citizen participation, and measurable outcome monitoring. This program aimed to provide mentoring and outreach on flood mitigation by applying environmental conservation principles and promoting the construction of biopore infiltration holes. Additionally, it sought to analyze the causes of flooding based on spatial characteristics and community behavior (Baguna, Tamnge, & Tamrin, 2021)

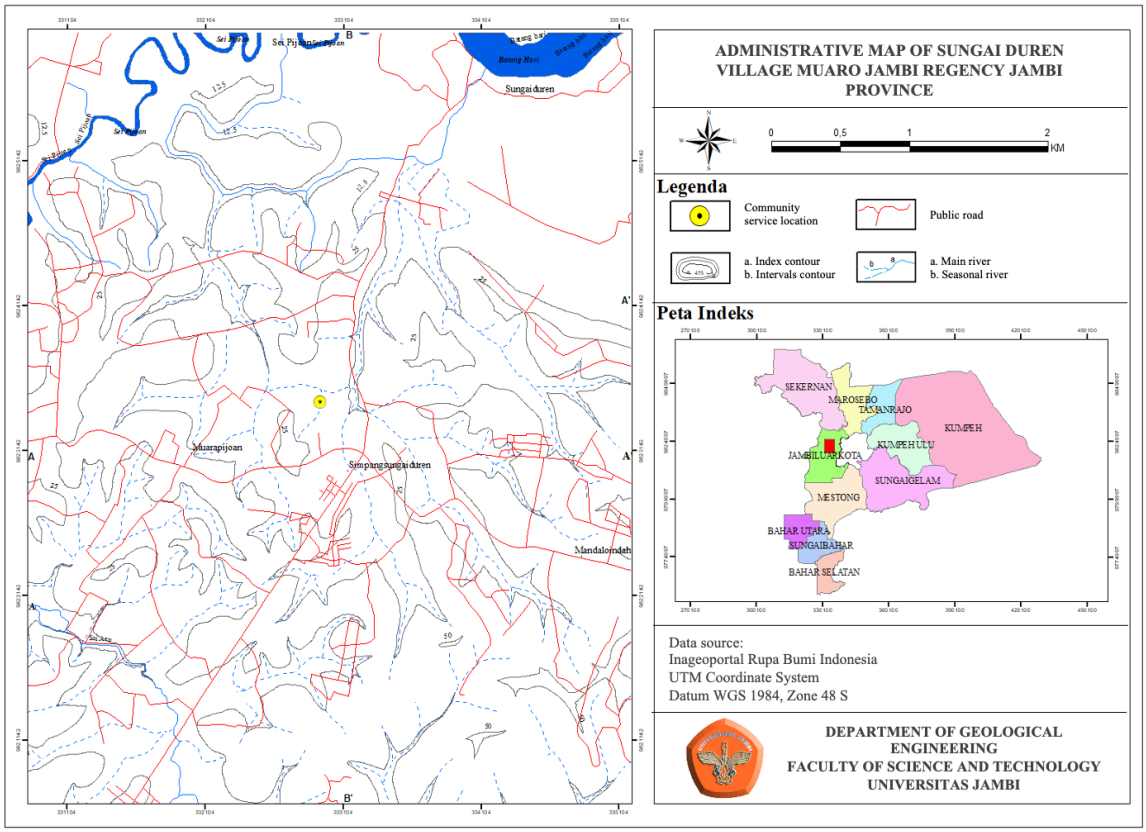


Figure 1. Administrative Map of Muaro Jambi Regency, Jambi Province, as the location of the Community Service activity, which takes place in RT.10, Sungai Duren Village (map content uses RBI Data of Jambi City area)

Methods

PPM activity was carried out in several stages to achieve its primary goal, which was to enable the community to decrease flooding disasters through assistance in creating biopores. The first stage is understanding the service target's environment and characteristics, which is conducted using the Participatory Rural Appraisal (PRA) approach. This method enables the PPM team to engage directly with the community, observe local conditions, and understand the community's character, habits, and challenges. The objective is to ensure that the team selects the most appropriate methods, timing, and communication strategies so that the service activities can be carried out effectively and provide substantial benefits (Subhan et al., 2025; McCracken & Parker, 1998; Rayyani et al., 2024).

While preliminary observations suggest that the area's low-lying location influences flooding, other contributing factors—such as inadequate drainage, canal silting, and seasonal river overflow—require confirmation. This stage will employ Focus Group Discussions (FGDs) with residents, community leaders, and relevant stakeholders to gather qualitative data, exchange perspectives, and reach consensus on the main factors contributing to the flooding problem (Lindarto et al., 2018; Azzahra et al., 2025)

The third stage is awareness-raising and technical training on collective flood prevention actions. The PPM team will conduct FGD-based awareness sessions to build community understanding, followed by hands-on training in biopore-making techniques. These practical sessions will enable the community to directly implement flood prevention measures, including expanding infiltration areas, applying geotechnical techniques, and constructing biopores. The final stage was monitoring and evaluation, which was carried out using a qualitative approach. The methods applied were in-depth interviews and direct field observations to obtain data regarding the sustainability of biopore technology implementation. Interviews were conducted with community members who participated in the program to explore their perceptions, experiences, and challenges in implementing biopore infiltration holes. In addition, direct observations were performed to assess the physical condition of the biopores, such as their functionality and utilization in flood reduction and organic waste management. Field documentation in photos and videos was also used to strengthen the observational findings.

An online survey instrument using Google Forms was employed to evaluate community understanding, containing questions about knowledge, attitudes, behaviors, and the steps involved in creating biopore technology. The survey results were analyzed descriptively to assess the improvement in community understanding before and after the mentoring activities. The combination of interviews, observations, and online surveys was considered adequate as it provided a more comprehensive picture of the technical, social, and environmental aspects of biopore technology implementation (Efriyeldi et al., 2023). Thus, monitoring and evaluation results served as the basis for determining follow-up actions, improving mentoring strategies, and ensuring the sustainability of biopore technology utilization as a long-term flood mitigation effort in the community service area. The detailed sequence of PPM activities is illustrated in Figure 2.

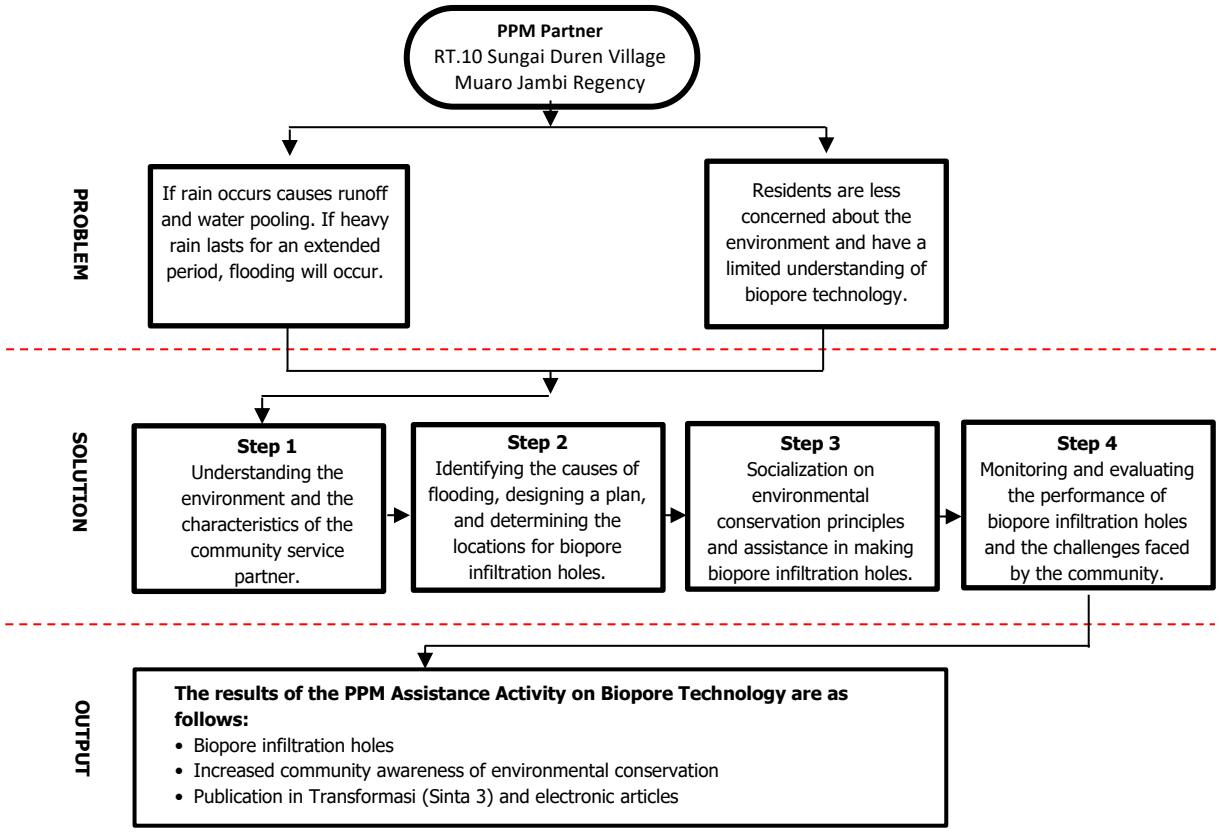


Figure 2. Series of PPM Activities Assisting Biopori Technology (Adhitya et al. 2021)

Results and Discussion

The main problem in the PPM partner location is flooding during the rainy season. Rainwater from precipitation remains on the surface for an extended time due to the soil's low absorption capacity, and prolonged rainfall with high intensity leads to flooding. This phenomenon is consistent with findings that urbanized and compacted soils have reduced infiltration capacity, leading to increased surface runoff during heavy precipitation events (Pataki et al., 2011). The solution offered and implemented in the Community Service (PPM) activities is generally structured into four stages, as follows:

Understanding the environment and the characteristics of the PPM partner

The drainage systems in the residential area are not interconnected, causing some household wastewater to flow directly onto the concrete-paved ground and streets. Additionally, although a canal in the PPM partner area functions as the main drainage channel, it has become silted due to a buildup of sediment and household waste carried in during floods. Sediment accumulation and debris blockages in drainage networks are well-documented factors that significantly reduce the hydraulic capacity of urban water channels, thereby undermining flood prevention measures (Shuster et al., 2005; Ferrans et al., 2022).

Community participation in maintaining environmental cleanliness is minimal, with no efforts to clean the canal or homeowner initiatives to repair their own drainage systems. The silting of the canal and the lack of maintenance have directly increased surface water runoff

rates. When rainfall intensity exceeds the drainage system's capacity, excess water quickly accumulates, leading to flash flooding. In Muaro Jambi and other similar low-lying areas in Indonesia, this issue is exacerbated by high seasonal rainfall, poor urban planning, and inadequate waste management (Handayani et al., 2020). The drainage systems and artificial canal can be seen in Figure 3.

Figure 3. A. Disconnected household drainage system that flows onto the ground and concrete-paved road; **B.** Artificial canal functioning as the main wastewater drainage channel, but has become silted

Identification of Flood Causes in the PPM Partner Area

In addition to the disconnected drainage systems and the silting of the canal, which serves as the main wastewater drainage channel, A geographic assessment was conducted to identify additional flood drivers in the PPM partner area. Groundwater measurements from local wells revealed the water table lies just around 62.5 cm below the surface—indicative of high groundwater flood susceptibility in valley settings.

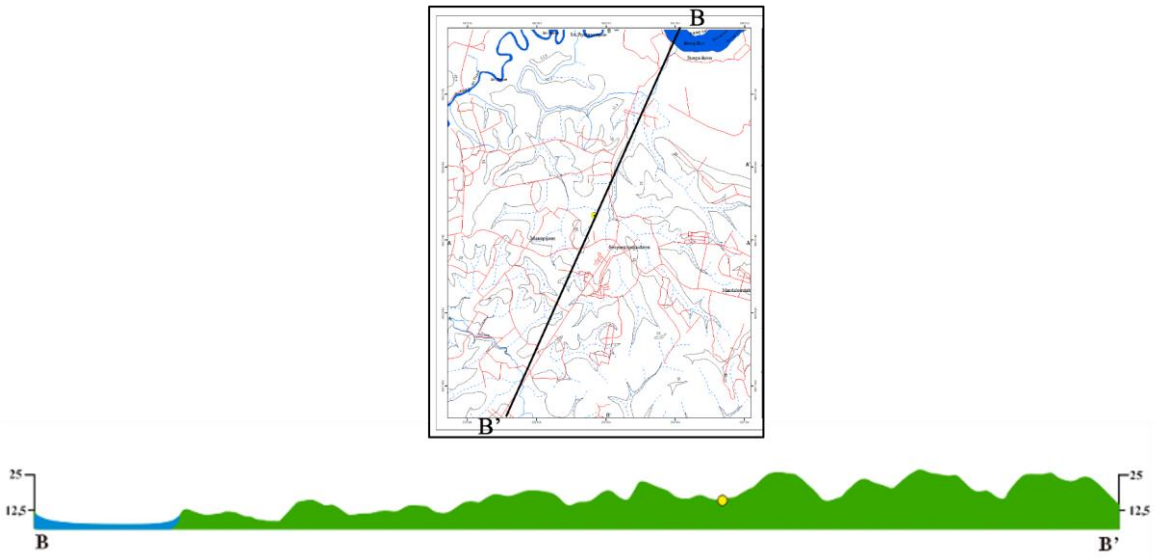


Figure 4. Topographic cross-section showing the PPM partner area in relation to the morphology and the Batang Hari River (the yellow point indicates the PPM partner area)

Topographic and elevation analysis showed that the community service area is situated at an altitude of 12.5 m to 25 m above sea level with valley-like morphology. According to (Clubb et al., 2017), areas with valley or depression morphology have the potential to channel greater surface runoff. Flood-prone areas can be objectively mapped by determining topographic thresholds such as groundwater level and relative elevation. In the service area, the floodplains influenced by the Batang Hari River are generally located at lower elevations, below 12.5 m, so it can be concluded that flooding in the service area is not directly caused by overflow from the Batang Hari River, which is relatively distant, approximately 3 km from the service site. The topographic cross-section can be seen in Figure 4.

Socialization about conservation principles and assistance in creating a Biopore Infiltration Hole

The series of awareness and assistance activities on biopore technology were conducted over two days, on July 20 to 21, 2024. The solution offered and implemented during the Community Service activities included: First, an awareness session on environmental conservation principles. Muhammad Ikrar Lagowa, S.T., M.T., a lecturer in the Mining Engineering program, presented the topic on environmental conservation. Understanding environmental conservation is essential to maintaining ecosystem balance and preventing environmental degradation. Conservation efforts can include maintaining, protecting, and restoring our environment. The biopore technology awareness activities of the PPM can be seen in Figure 5.

Figure 5. The first session consisted of outreach on environmental conservation principles, an introduction to biopore technology, and a discussion regarding the challenges faced by the community

The second session, still related to environmental conservation principles, was the awareness session on creating biopore infiltration holes, applied in the yard of the RT.10 Head's house in Sungai Duren Village, Muaro Jambi Regency. The biopore technology awareness aimed to address environmental issues caused by surface water runoff, flooding, and household organic waste. The presentation on biopore technology was delivered by Bagus Adhitya, S.T.,M.T., a lecturer from the Geological Engineering program and the Head of the PPM Team from the Department of Earth Engineering, University of Jambi. After the awareness session and discussion, the assistance activities for creating biopore infiltration holes were conducted, guided by the team of lecturers and students from the Department of Earth Engineering. The biopore technology assistance activities of the PPM can be seen in Figure 6.

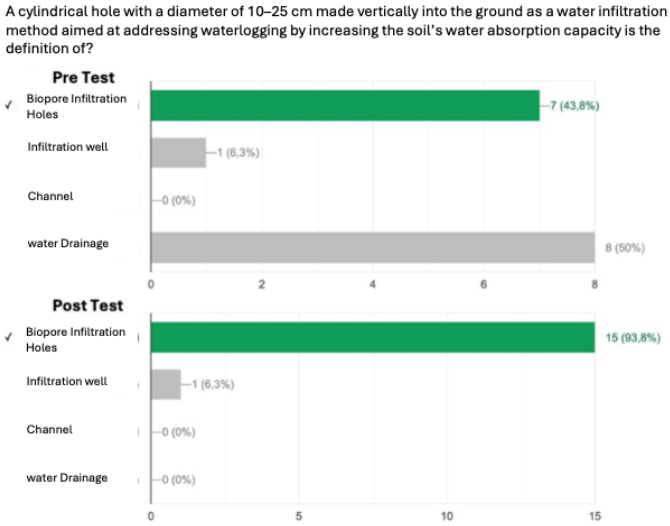
Figure 6. The second session of the assistance activity for creating biopore infiltration holes and measuring the groundwater table at the dug well conducted in the yard of the RT.10 Head's house in Sungai Duren Village, Muaro Jambi Regency

Monitoring and Evaluation of the Performance of Biopore Infiltration Holes and Challenges Faced by the Community

An essential aspect of this activity is the process of consistent monitoring and evaluation, which truly builds the community's capacity to face flood disasters. The community needs to be made aware that they can address the recurrent floods in the partner area of PPM. The monitoring and evaluation activities aim to assess the success level of the biopore assistance program. The parameters that determine the level of success include understanding environmental conservation principles, the cleanliness level of the partner area after the implementation of community service activities, improvements in drainage systems, and the performance of the biopore infiltration holes that have been created.

Understanding conservation principles is evaluated through a pre-test conducted before the socialization activity (43,8% correct) and a post-test after the socialization has been completed (93,8% correct). The post-test results indicate an increase in the community's understanding of environmental cleanliness and biopore technology. The pre-test and post-test results can be seen in Figure 7.

A



B

Questions	Pre Test (%)		Post Test (%)	
	True	False	True	False
Knowledge of Biopore Technology	43,8%	56,3%	93,8%	6,3%
Community awareness level regarding environmental cleanliness	63%	37,5%	100%	0%
Level of confidence in biopores and environmental conservation for flood mitigation	31,3%	68,8%	81,3%	18,8%
Interest in applying biopore technology in one's own environment	25%	75%	93,8%	6,3%

Figure 7. Image A shows a sample of the question from the pre-test and post-test. Image B shows an increase in understanding of environmental conservation principles and biopore infiltration holes

Based on direct observations made on September 9, 2024, approximately 50 days after the socialization activities were conducted, the overall cleanliness level of the environment has started to improve. The PPM partner has undertaken community service activities; however, due to heavy rainfall, a significant amount of plastic waste has been washed back into the area. Fortunately, this litter is only present in a few spots, and overall, the partner area has become much cleaner. This situation can be managed by maintaining cleanliness in each household's surroundings, rather than waiting for community cleanup efforts. An illustration of the change in community attitudes toward environmental cleanliness can be seen in Figure 8.

Figure 8. Changes in community attitudes toward the importance of environmental cleanliness. Image A shows the condition before the socialization on July 20, 2024, and Image B shows the condition during monitoring and evaluation on September 9, 2024

Improvements to the drainage system and normalization of the canals have not yet been implemented. Significant planning and funding are required for these improvements. Therefore, as of September 9, 2024 monitoring date, no changes have been made to the drainage system. The biopore infiltration holes were also evaluated to assess whether they are functioning

correctly and being properly maintained. Discussions with the RT.10 Head of Sungai Duren Village indicate that the infiltration holes are performing well in reducing surface water flow. Organic waste is routinely added to the biopore holes to support the survival of macro and microorganisms within the holes, thereby increasing the number of pores formed in the soil.

The monitoring and evaluation results show that several factors hinder effective flood management. A critical factor that must be addressed promptly is improving drainage systems and normalizing existing canals. Enhancing drainage systems is crucial to prevent surface runoff and ensure water is directly directed to the constructed canals. Deepening the canals will increase the volume of water that can be channeled, allowing water stored in rock pores to be retained in the canals, thereby lowering the groundwater table (GWT) and increasing the volume of water absorbed into the soil.

Another challenge is the lack of waste processing areas in the PPM partner area. Residents rely solely on waste management personnel who come twice a week. This can lead to the accumulation of both organic and inorganic waste over three days, making it likely that the collected waste will be washed away during heavy rainfall. To address this issue, collaboration has been established between the community service team, represented by the Faculty of Science and Technology at the University of Jambi, and RT.10 of Sungai Duren Village, Muaro Jambi Regency, Jambi Province. The output from this implementation arrangement will lead to further community service activities in 2025, focusing on independent waste management in the partner area. The condition of the biopore infiltration holes and the signing of the Implementation Arrangement can be seen in Figure 9.

Figure 9. Monitoring and evaluation of biopore infiltration hole performance and signing of the implementation arrangement

Conclusions

The biopore technology assistance program established a pilot biopore infiltration hole at the community service area. The monitoring and evaluation results showed that all participants carried out the community service activities optimally. There was a 93,8% increase in understanding of biopore technology, a 100% improvement in community awareness of environmental cleanliness, an 81,3% rise in confidence regarding the performance of biopore infiltration holes, and a 93,8% rate of application of biopores within their own environment. In addition, the community service team also conducted spatial analysis and direct observation to identify the causes of flooding in the service area. Geographic analysis and field observations confirmed that the partner area lies at an elevation of 12,5–25 m, outside the Batang Hari River floodplain and approximately 3 km from the river. Flooding in the area is mainly caused by seasonal rivers overflowing during heavy rain. Combined with disconnected drainage systems and a silted main canal, it accelerates surface runoff. To address these issues, it is recommended that the community collaboratively normalize the existing water channels to increase water flow capacity and actively implement biopori infiltration technology to enhance groundwater absorption. Sustainability of the program should be ensured through continuous community engagement, particularly in independent waste management, to support long-term flood mitigation efforts.

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