Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(4): 999 – 1011 (2025)
www.ejabf.journals.ekb.eg

Study on the Impact of Cafts (Communal Coastal Area Fecal Treatment System) Implementation on Environmental Sanitation in Batam

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ARTICLE INFO

Article History:
Received: May 28, 2025
Accepted: July 15, 2025
Online: July 18, 2025

Keywords:
Extension,
Open defecation,
Performance difference,
Septic tank,
Stinks

ABSTRACT

Open defecation is a problem faced by many regions, including Batam Municipality, while programs such as Communal CAFTS has been implemented to overcome the problem. This research aimed to evaluate the performance of different Communal CAFTS models applied and to formulate the best strategy to apply total sanitation in Batam Municipality. The research was carried out in Batam Municipality, including Kabil Village and Belakang Padang Village as pilot samples for the implementation of different Communal CAFTS models. The research was focused on the performance of Communal CAFTS, especially in the presence of leakages, stinks and clogging. Data collection was carried out through interviews with the local community in each village, while data analysis was carried out through cross tabulation and bivariate correlation. The result showed that the Communal CAFTS model with one septic tank for 3- 5 households lack performance compared to the model with one septic tank for one household. Leakages, stinks and clogging were reported by 46.67- 53.33% of the samples in the 1st model, compared to only 13.04-17.39% in the 2nd model which statistically have significant differences. The result showed the urgent need of extending the implementation of 2nd model Communal CAFTS to improve community's acceptance of open defecation free programs.

INTRODUCTION

Sanitation is a fundamental aspect supporting the community's quality of life **(Andersson *et al.*, 2016)**. According to **Vargová *et al.* (2020)**, sanitation is an act to reduce the exposure to infectious agents by limiting contact to waste or polluted media. Therefore, sanitation requires active participation of the subject itself. Unfortunately, in

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some communities, sanitation is often neglected, while some others simply have no access to proper sanitation. The estimated global number of people who lack access to basic sanitation service is approximately 2.4 billion **(Han & Hashemi, 2017)**.

Sanitation issues are mainly related to the garbage littering and open defecation practices **(Uddin *et al*., 2022)**. Both activities could cause environmental problems such as aesthetics degradation and health problems. In terms of aesthetics, the presence of litter and faeces causes visual disturbance and stinks, while from the health aspects these could promote the growth of pests. For example, solid waste could promote the development of various disease vectors, such as flies, cockroaches and mosquitoes **(De & Debnath, 2016)**, while open defecation could promote the spread of *Escherichia coli* and helminth **(Gizaw *et al*., 2022)**. Therefore, it could be a serious problem, especially in the urban areas.

Sanitation is an important factor that determines public health quality, especially in terms of disease and pest control **(Daley *et al*., 2015; Okaali *et al*., 2022)**. The Cambridge dictionary defines sanitation as "*the systems for taking dirty water and other waste products away from buildings in order to protect people's health*". Therefore, the final outcome of sanitation practice is public health. Sanitation plays an important role in preventing the community from being exposed to various diseases such as diarrhea, STH (Soil-Transmitted Helminth) infections, trachoma, schistosomiasis and nutritional status **(Freeman *et al*., 2017)**. According to **Depledge *et al*. (2017)**, coastal communitites are vulnerable to various source of diseases, including environmental threats and pollution. Diseases include infectious diseases caused by lack of sanitation, flooding, vector-borne and water-borne microbial and pharmaceutical pollution, pollutant toxicity, respiratory and cardiovascular diseases. Therefore, without proper sanitation, the community is vulnerable to such diseases. On the other hand, proper sanitation could hinder or at least suppress the development of pests.

Open defecation has become one major obstacle in the implementation of total sanitation practice **(Thys *et al*., 2015; Ntaro *et al*., 2022)**. To this day, open defecation practice is still found in many countries and practiced by over a billion people worldwide. Open defecation is defined as the activity of defecating in the open space, such as fields, bushes, water bodies, waterways, and trenches without proper disposal **(Njuguna, 2016; Saleem *et al*., 2019)**.

Open defecation practice has various risks, such as health, social and nutritional to the surrounding community **(Saleem *et al*., 2019; Rahman *et al*., 2020)**. From the subject's perspective, open defecation practice influences one's feeling of embarrassment and loss of dignity **(Sclar *et al*., 2018)**. In terms of health, open defecation alters the opportunity of the community to get exposed to disease vectors such as flies, cockroaches and dung beetles which carry zoonotic enteric parasites **(Patel *et al*., 2022)**. While the nutritional impact is caused by pathogens that lead to the loss of appetite, decreased immunity and disturbed nutrient absorption **(Rahman *et al*., 2020)**.

Open defecation is a global issue, practiced by millions of people in the world **(Mara, 2017)**. Many countries have put up a combat against open defecation practice, especially after the arrangement of Sustainable Development Goal 6 (SDG 6), which is to end open defecation practice by 2030 **(Ait-Kadi, 2016)**. Unfortunately, there are various factors preventing the achievement of open defecation free goals, including socio-cultural, economic and resource limitation **(Odagiri *et al*., 2017; Saleem *et al*., 2019)**. Therefore, open defecation practices are more frequently found in the rural areas, even though it can also be found in the urban areas.

The coastal community is one of the most frequently identified subjects practicing open defecation. Key factors to the behavior are the lack of environmental sanitation management and lack of attention **(Susilawati *et al*., 2022)**. However, some people still do open defecation practice simply out of habit. This refers to the finding of **Laksham *et al*. (2017)**, who elucidated that even for people who have latrine in their house, they still practice open defecation once in a while.

The attempt to deliver open defecation free to the coastal community requires serious effort from the stakeholders, especially the government. Coastal areas typically lack supporting resources, especially clean water that is needed to support total sanitation **(Welsh & Bowleg, 2022; Forde *et al*., 2024)**. On the other hand, coastal communities typically have low income, making them unable to afford the development of proper sanitation systems **(Mariwah *et al*., 2017; Ritonga & Susilawati, 2022)**. Another problem lies in the environmental condition, where coastal areas are vulnerable to environmental disturbance, such as tidal activities, soil/sand instability and high soil/sand porosity, which make the establishment of faecal treatment quite a hurdle **(Spirandelli, 2015; Beebe & Lowery, 2018)**.

According to the world bank data, Indonesia is ranked 72 among the countries with the highest percent of population practicing open defecation, with an approximate proportion of 4.19%. It suggests that open defecation is still applied by communities in many regions in Indonesia, including Batam Municipality which is the subject of this research. Batam Municipality is a city as well as the center of development of Riau Islands Province. Unfortunately, even though the development in Batam occurs rapidly, communities in some areas (districts) are identified unable to perform proper sanitation **(Ahmadi *et al*., 2021; Arindayu *et al*., 2021)**.

An attempt to accelerate sanitation and hygiene application has been conducted since 2012 by the Government of Indonesia supported by UNICEF **(Odagiri *et al*., 2020)**. Later, the Government of Indonesia also arranged sanitation policies at various levels. At the national level, the Minister of Health Affairs issued the Ministerial Decree No. 3/2014 on Community-Led Total Sanitation. Referred to article 4 paragraph 2 of the decree, the attemp to stop open defecation practice should be promoted by providing and maintaining defecation facilities. At regional level, the Governor of Riau Islands Province issued a Circular Letter No. 0768/106/SET on the Implementation of Universal Sanitation

Program of 2019, followed by the issuance Mayor's Regulation No. 9 of 2020 on the Effectuation of Healthy City in Batam Municipality, as well as the issuance of Circular Letter of Batam Mayor No. 55 of 2022 on the Acceleration of Urban Village for 5 CLTS Pillars which regulates the formation of working groups to accelerate the open defecation free program.

Therefore, intervention of the local government is needed to promote total sanitation in the society. The attempt to achieve open defecation free in Batam Municipality is carried out through the development of communal septic tanks **(Pakpahan & Savitri, 2022)**. Different types of communal septic tanks were identified in the preliminary study, including a single septic tank for 3-5 households and a single septic tank for each household. However, the performance of the built septic tank is currently unknown. This research aimed to evaluate the performance of different Communal CAFTS models applied and to formulate the best strategy to apply total sanitation in Batam Municipality.

MATERIALS AND METHODS

This study was conducted in Batam City, Province of Kepulauan Riau, Indonesia, encompassing Sekanak Raya Village and Kasu Village which are villages in small islands in the Belakang Padang District, and Kabil Village which is located in the coastal village of Nongsa District. These sites have been designated as pilot areas for the implementation of the Open Defecation Free (ODF) initiative through the Communal Coastal Area Fecal Treatment System (CAFTS). Geographically, Sekanak Raya Village and Kasu Village are located in the remote area from Batam Island while Kabil Village is located on the main island (Batam). Both locations implemented different models of Communal CAFTS, therefore considered as groups of samples. The Communal CAFTS model implemented in Sekanak Village and Kasu Village is a single septic tank for 3-5 households (Model 1), while in the Kabil Village is a single septic tank for one household (Model 2).

Data collection was carried out through interviews with the local community from each group. The interview was focused on the performance of the Communal CAFTS utilization with different application models. The indicators used in this research include the presence of leakage, stink and clogging. The samples include all of the households which have Communal CAFTS built. There samples include 60 units of Model 1 CAFTS and 46 units of Model 2 CAFTS.

Data analysis was carried out through cross tabulation and bivariate correlation. Cross tabulation analysis was performed to identify the difference of response between sample groups regarding the performance of Communal CAFTS models. Further, chi-square analysis was performed to analyse the significance of the differences in sample's responses. Chi-square analysis was done through the following formula:

$$X = \sum \frac{(E-O)^2}{E}$$

Where:

X^2 = the chi-square test statistic
O = the observed frequency
E = the expected frequency

Bivariate correlation was performed to analyze the correlation between leakages, stinks and clogging events.

RESULTS

The observation found that there were 60 people using the 1st model of Communal CAFTS distributed in Kabil Village, while the number of people using the 2nd model of Communal CAFTS in Sekanak Raya Village and Kasu Village was 46. Identification on the performance of Communal CAFTS showed that leakages, stinks and clogging were found in both samples. Leakages were found in 36 units or 33.96% of CAFTS, stinks were found in 39 units or 36.79% of CAFTS and clogging were found in 38 units or 35.85% of the CAFTS. Further analysis on the distribution of leakages, stinks and clogging in response of the Communal CAFTS models are shown in Table (1).

Table 1. The presence of leakage

	Presence of Leakage		
Application Model	**Leaked**	**Not Leaked**	**Total**
3-5 Households	28	32	60
	26.42%	30.19%	56.60%
1 Household	8	38	46
	7.55%	35.85%	43.40%
Total	36	70	106
	33.96%	66.04%	100.00%

Referring to Table (1), reports on the presence of leakages were primarily associated with the application of the first model of Communal CAFTS. Nearly half of the households using this model reported leakage issues. In contrast, only about one-fifth of the households using the second model of Communal CAFTS reported similar problems. Pearson's chi-square analysis revealed a significant difference in leakage reports between the two models. The chi-square value was 9.950, with a *P*-value of 0.002. This indicates that the second model of Communal CAFTS (one septic tank per household) is significantly more effective in reducing leakage incidents.

Table 2. The presence of stinks

	Presence of Stinks		
Application Model	**Stinky**	**Not Stinky**	**Total**
3-5 Households	32	28	60
	30.19%	26.42%	56.60%
1 Household	7	39	46
	6.60%	36.79%	43.40%
Total	39	67	106
	36.79%	63.21%	100.00%

An analysis of stink distribution, as presented in Table (2), reveals that unpleasant odors were most commonly reported in samples using the first model of Communal SPTDP. More than half of these households reported the presence of stinks. In contrast, only about one-sixth of the households using the second model of Communal CAFTS reported similar issues. Pearson's chi-square analysis indicated a significant difference in reported stink occurrences between the two models. The chi-square value was 16.266, with a *P*-value of 0.000. These findings suggest that the second model of Communal CAFTS (one septic tank per household) is significantly more effective in reducing odor-related issues.

Table 3. The presence of clogging

	Presence of Clogging		
Application Model	**Clogged**	**Not Clogged**	**Total**
3-5 Households	32	28	60
	30.19%	26.42%	56.60%
1 Household	6	40	46
	5.66%	37.74%	43.40%
Total	38	68	106
	35.85%	64.15%	100.00%

Table (3) shows that clogging events were reported most frequently in households using the first model of Communal CAFTS. More than half of the samples reported clogging during the use of this model. In contrast, only about one-seventh of the samples using the second model of Communal CAFTS reported clogging issues. Pearson's chi-square analysis revealed a significant difference in the frequency of clogging events between the two groups. The chi-square value was 18.379 with a *P*-value of 0.000. These results suggest that the second model of Communal CAFTS (one septic tank per household) is significantly more effective in reducing clogging incidents.

Correlation analysis further revealed a significant relationship between leakages, stinks, and clogging events in the application of Communal CAFTS. The strongest correlation was observed between leakages and stinks, indicating that unpleasant odors are most likely caused by the presence of leakages. However, leakages did not show a strong relationship with clogging, as indicated by a weak—though still statistically significant—correlation. A similar weak but significant correlation was observed between stinks and clogging. A detailed bivariate correlation analysis among leakages, stinks, and clogging is presented in Table (4).

Table 4. Bivariate correlation analysis result

Correlated Parameters	Pearson's Correlation Coefficient	Probability
Leakages ⇐⇒ Stinks	0.816	0.000
Leakages ⇐⇒ Clogging	0.585	0.000
Stinks ⇐⇒ Clogging	0.613	0.000

The findings of the research suggest that the implementation of the 2nd model of Communal CAFTS, which is one septic tank for one household is more advantageous than the 1st model. Referring to the performance analysis, the implementation of one septic tank for one household can significantly reduce leakages, stinks and clogging. Thus, the communities would feel less discomfort in using latrines and make the Communal CAFTS more acceptable.

DISCUSSION

Leakages, stinks, and clogging are common issues in the application of Communal CAFTS. These problems can arise from various causes, such as technical failures or operational mistakes **(Richards *et al.*, 2016; Lusk *et al.*, 2017)**. Technical failures may include inappropriate design relative to location or insufficient capacity compared to the number of users. Operational mistakes often involve inadequate flushing or the disposal of incompatible waste materials **(Yeasmin *et al.*, 2017)**.

The presence of such nuisances can be a determining factor in whether communities participate in open defecation-free (ODF) programs. A previous study by **Bhatt *et al.* (2019)** confirmed that unpleasant odors discourage communities from using latrines. The presence of leakages, stinks, and clogging represents a critical concern for the implementation of Communal CAFTS, particularly in urban areas, where community preferences strongly oppose nuisances such as odors from septic tanks. In response, some urban residents may choose to defecate in locations far from their homes **(Desai *et al.*, 2015; Das *et al.*, 2024)**.

Although leakages and clogging might seem minor in the context of septic tank usage, they can present significant obstacles—especially for urban communities lacking adequate support services. When such problems arise, households must perform maintenance tasks—an effort they typically avoid when practicing open defecation **(Thys *et al.*, 2015)**.

From a public health perspective, leakage problems pose serious risks. Septic tanks can become sources of environmental contamination, especially in aquatic systems such as drainage channels and basins **(Richards *et al.*, 2016; Brandão *et al.*, 2020)**. Since these tanks are often located near or within households, the risk of exposure to sanitation-related diseases is considerably heightened **(Verma *et al.*, 2023)**.

The findings of this study suggest that the first model of Communal CAFTS is less effective in terms of performance. Several factors may contribute to this inefficiency, including insufficient maintenance and excessive loading. In this model, maintenance responsibilities fall on the users; however, individuals who use communal or public toilets often show less willingness to engage in maintenance activities **(Prayitno & Widati, 2018)**. Consequently, the underperformance of the first model may be attributed to irresponsible usage and a lack of upkeep. Furthermore, because a single septic tank serves 3–5 households, the system bears a higher load and requires more frequent servicing.

On the other hand, the second model of Communal CAFTS (one septic tank per household) appears to be more effective. Users of this model tend to show greater awareness and responsibility in performing routine maintenance tasks such as cleaning and emptying **(Brownlie *et al.*, 2015; Odagiri *et al.*, 2021)**.

Based on the findings, improvements in the implementation of Communal CAFTS are necessary—particularly regarding system performance. The results suggest that the one-household-one-septic-tank model is more effective in reducing leakages, stinks, and clogging. A more efficient communal sanitation system is essential to encourage communities to abandon open defecation practices. Government intervention is critical in this regard. Many of these communities lack the interest or resources to build CAFTS independently, which sustains the practice of open defecation.

According to **Abubakar (2018)**, strategies to reduce open defecation should include promoting latrine ownership and implementing behavior change interventions. Providing adequate sanitation infrastructure can increase public awareness and reduce open defecation. However, behavioral change is unlikely without proper infrastructure. The lack of infrastructure is a key driver of open defecation, especially in coastal communities **(Susilawati *et al.*, 2022)**. Additionally, **Sari *et al.* (2022)** identified several factors that deter toilet use, such as the absence of private latrines, poor toilet conditions, and nuisances like foul odors.

Beyond infrastructure improvements, further assistance is necessary to enhance the effectiveness of Communal CAFTS in coastal communities. This includes both financial

and motivational support. Financial assistance is needed to ensure regular maintenance of infrastructure, as the lack of maintenance often leads communities to revert to open defecation **(Bhatt *et al.*, 2019)**. Motivational support is also vital for sustaining behavior change and encouraging continued use of latrines **(Mara, 2017)**.

CONCLUSION

The performance of Communal CAFTS is a critical factor in promoting an Open Defecation Free (ODF) status in Batam Municipality. However, the implementation of the Communal CAFTS model with one septic tank shared by 3–5 households appears to be less reliable in supporting this goal. This model has shown weaker performance in terms of leakages, unpleasant odors (stinks), and clogging—factors that can significantly discourage community participation in ODF initiatives. Incidents of leakages, stinks, and clogging were reported by approximately 46.67 to 53.33% of users in the shared-tank model, compared to only 13.04 to 17.39% in the model where each household has its own septic tank.

These findings underscore the need to expand the application of the one-septic-tank-per-household model of Communal CAFTS. However, infrastructure improvements alone are not sufficient. Continued support is also required—both technical and behavioral—to ensure sustained performance of the CAFTS and to reinforce community commitment to abandoning open defecation practices.

Acknowledgement

The authors would like to thank the Health Office of Batam City, Indonesia, Sriwijaya University, Indonesia for their support of this research and publication. The authors would also like to thank the reviewers for their constructive comments and suggestions.

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