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Research Article

Assessment of drainage capacity of a surface drain in Rajshahi, Bangladesh

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ABSTRACT

The drainage capacity of a community is essential for promoting environmental resilience, effective water management, and fostering a healthy urban lifestyle. The surface drains in Rajshahi City receive a mix of waste, including sanitary wastewater, stormwater runoff, and solid waste from roadsides and households. To improve the drainage facilities of Rajshahi, some new drains have been constructed. This study considered a recently constructed drain in the Rajshahi City Corporation (RCC), running from Talaimari to Chowddopai. The primary objective of this study is to assess the drainage capacity of this drain during both dry and monsoon seasons, ensuring its capability to contain the generated waste. Additionally, the investigation encompasses observing the sludge depth, and clear space of the drain. A field survey was conducted, employing a measuring rod and scale to precisely measure the depth, width, and sludge accumulation. The results show that the total volume of the drainage system is 117670 ft3, while the total volume of solid deposition is 6053.35 ft3. This study revealed that during typical rainfall intensity in Rajshahi City, the portions of drains from Talaimari to Octor Mor and from Rajshahi University main gate to Chowddopai have sufficient open space to prevent water overflow, but the capacity of the drains in the portion between Kajla and Rajshahi University main gate is inadequate.

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INTRODUCTION

Efficient drainage infrastructure is pivotal for mitigating the adverse impacts of heavy rainfall and preventing flooding, which can endanger lives, disrupt livelihoods, and cause extensive damage to property and infrastructure. Water, in any form – groundwater, surface water, or rain runoff – is a major contributor to road failure and damage [1]. So, a drainage system that includes the pavement and the water handling system must be properly designed, built, and maintained [2]. The purpose of drainage facilities is to ensure the timely removal of surface water runoff and sewage from large, impermeable areas [3].

Using the best drainage engineering principles, an effective drainage plan must be established to understand the drainage issues that Bangladeshi cities face [4]. Rajshahi, a prominent northern Bangladeshi city, established in 1876 as one of the first Municipalities, transitioned to Rajshahi Pourashava and finally to RCC in 1987 [5]. According to the Drainage Master Plan, Rajshahi City features primary, secondary, and tertiary drains, with 65% of tertiary, 14% of secondary, and 19% of primary drains in good structural condition. The city's management is organized into 30 wards, overseeing 132.27 km of various drain categories, originally designed to cater to the core area between the Railway line and the river Padma embankment, where the countryside elevations range from 16.75 to 18.25 m [6]. The

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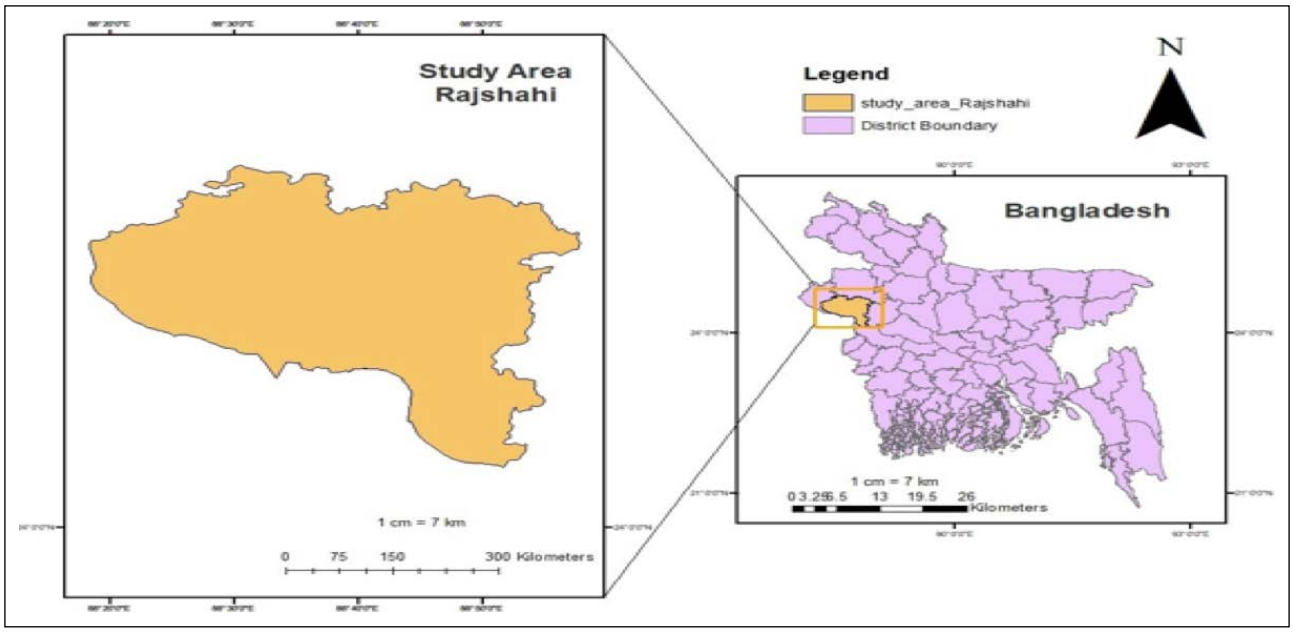

Figure 1. Study area.

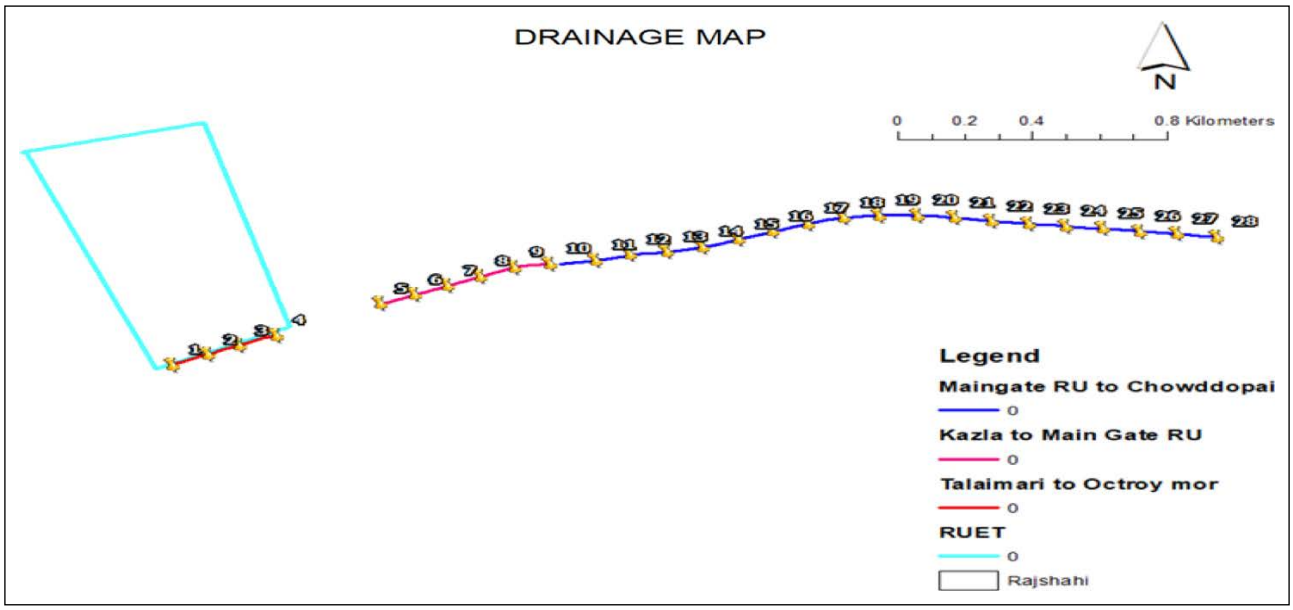

Figure 2. Drainage map.

drainage pattern of Rajshahi City is still filthy despite significant yearly budgets for development and reform; this is because insufficient planning led to a failure to meet demand [7].

A New drain has been constructed recently, in 2023, from Talaimari to Chowddopai. No work has been done about this drain, or how it is sustainable. So, our research focus is this new drain and its capacity along with some other factors about this drain.

MATERIALS AND METHODS

Study Area

Our study area is which is situated between latitudes 24°21' and 24°25' N and longitudes 88°32' and 88°40' E (Fig. 1). The municipal corporation in Rajshahi, the location of our study, has given careful consideration to the city's drainage system to maintain a clean city. There are a lot of outdated drains, a lot of recently constructed new drains, and additional drain construction is ongoing. Among them, a new drain that begins at Talaimari and finishes at the Chowddopai primary drain has been built in front of the Rajshahi University of Engineering & Technology.

Figure 2 shows the drain's path. We investigated this drain because it is a recently installed drain. We sought to determine its dimensions and capacity—that is, the amount of solid material that has already been deposited and the amount of space that may be used to convey trash to the principal drain. Figure 3 shows the study area from Google Earth Pro.

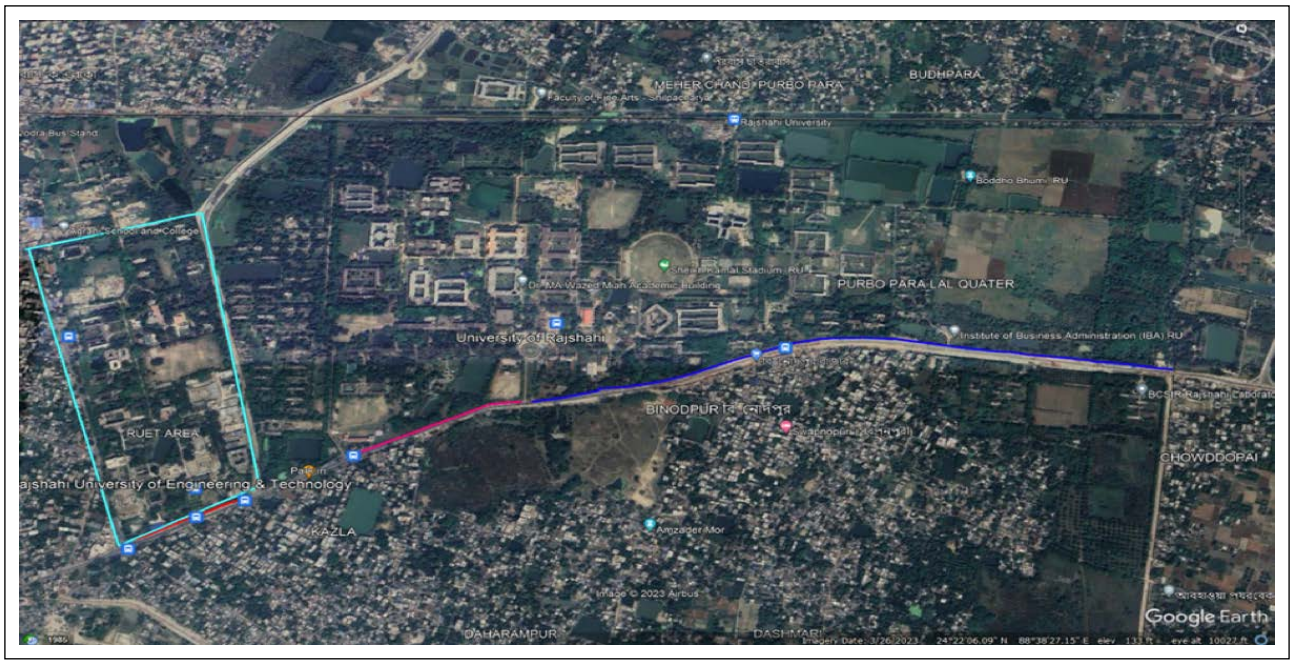

Figure 3. Picture of the study area (from Google Earth Pro).

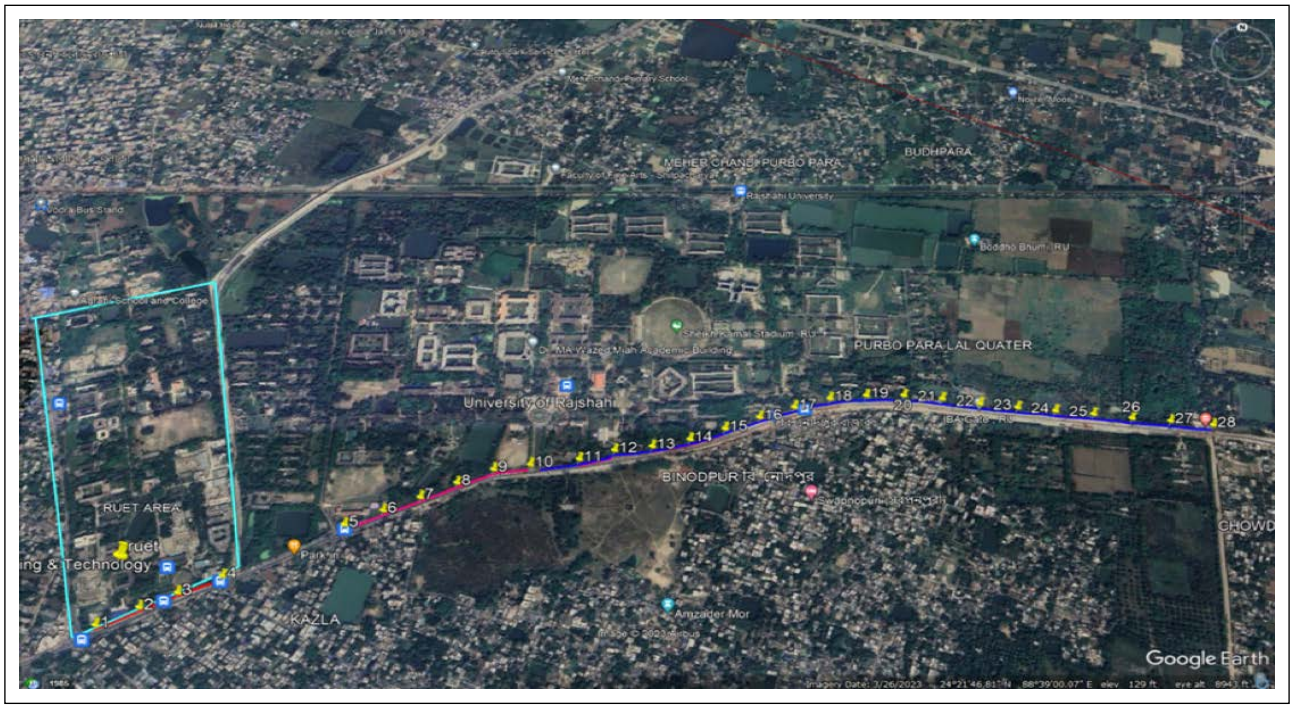

Figure 4. Data collection points.

Materials

i) Measuring tape

ii) Rod

iii Bamboo

iv) Software: Google Earth Pro, ArcGIS, Excel

Method

After selecting the study area and collecting materials, a map was made (Fig. 2). Then some points were selected from the starting point Talaimari, at intervals of 100 meters (Fig. 4). The distance was approximately 2.8 km, so 28 points were selected.

During the field survey, A rod was inserted down the drain. After that, the rod was pointed and measured, and the drain depth was ascertained. Proceed in the same manner, but this time, the rod was inserted into the drain at a depth where the solid deposit's surface was still visible. After that, the rod was pointed once more and was taken the measurement. Thus, the clear space of the drain was measured. Af-

Table 1. Drain data

Location	Actual width	Actual depth	Actual area(ft²)	Depth above solid	Area above solid waste (ft²)	Solid deposition (ft²)
Talaimari to octor mor	4'-0"	4'-7"	18.33	4'-5"	17.67	0.66
				4'-6"	18	0.33
				4'-7"	18.33	0
				4'-5"	17.67	0.66
Kazla gate to RU main gate	1'-9"	2'-3"	3.94	2'-2.5"	3.86	0.08
				2'-0"	3.5	0.44
				2'-2.7"	3.89	0.05
				2'-2.9"	3.92	0.02
				2'-3"	3.94	0
RU main gate to Chowddopai	4'-0"	4'-0"	16	4'-0"	16	0
				3'-9"	15	1
				3'-9"	15	1
				3'-9"	15	1
				3'-8"	14.67	1.33
				3'-11"	15.67	0.33
				3'-10"	15.33	0.67
				3'-7"	14.33	1.67
				3'-10"	15.33	0.67
				3'-10"	15.33	0.67
				3'-9"	15	1
				3'-11.5"	15.83	0.17
				3'-7"	14.33	1.67
				3'-8"	14.67	1.33
				3'-9.5"	15.17	1.17
				3'-8.75"	14.92	1.08
				3'-7"	14.33	1.67
				3'-8"	14.67	1.33
				3'-10"	15.33	0.67
Chowddopai primary drain	17'-0"			Actual depth 10'-0"		

ter that, with the measuring tape, the width of the drain was determined. After completion of the data collection, the data was plotted in Excel.

Equations

The actual cross-sectional area using the actual depth of the drain using the equation

A_1=b*D; here, b=Width of the drain, and D=depth of the drain

The clear cross-section of the drain,

A_2=b*d; here, d=depth of clear space.

The Solid Deposition area,

A=A1-A2

Solid Deposition depth, d=A/b

The total capacity of the drain,

V1=A1*L; here, L=Total length of drain =2.8 km (approx.)

The available capacity of the drain V2=A2*L

Rainfall Calculation:

Total Rainfall volume,

$V=h * L_a * b_a$; where, h=Rainfall depth, L_a= Length of catchment area and, b_a=Average width of the catchment area

If, Clear space volume > Total Rainfall volume: Adequate

If, Clear space volume < total Rainfall volume: Inadequate

FINDINGS AND DISCUSSIONS

Data Collection

A total of 28 points were selected as data points from the Talaimari to the Chowddopai. Four points were selected from the Talaimari to the Octor mor. No drain was found from the Octor mor to the Kajla. From the Kazla gate to the Rajshahi University (RU) main gate, five points were selected while from the RU main gate to the Chowddopai total of 19 points were selected. All the collected data are presented in Table 1. This drainage path is a new one constructed in the recent period.

Capacity of the Drain during Dry Season

Talaimari to Octor mor (Fig. 5):

Total length = 984 ft

Total volume = 18036.76 ft3

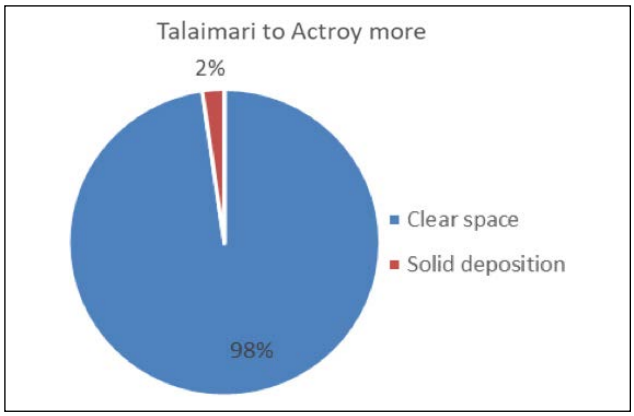

Figure 5. Clear space and solid deposition in Talaimari to Octor mor.

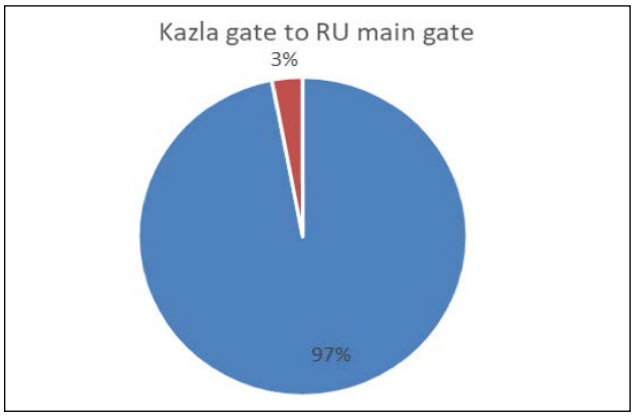

Figure 6. Clear space and solid deposition in Kazla gate to RU main gate.

Solid deposition in this zone = 0.4125 sq ft

The volume of deposition in this zone = 405.9 ft3

Volume of clear space = 17630.86 ft3

Kazla gate to RU main gate (Fig. 6):

Total length = 1312 ft

Total volume =5169.28 ft3

Solid deposition in this zone = 0.118 sq ft

The volume of solid deposition = 154.82 ft3

Volume of clear space = 5014.46 ft3

RU Main gate to Chowddopai (Fig. 7):

Total length = 5904 ft

Total volume =94464 ft3

Solid deposition in this zone = 0.97 sq ft

The volume of solid deposition in this zone =5726.88 ft3

Volume of clear space = 88737.12 ft3

Overall Analysis (Fig. 8):

The total volume of the drainage system = 117670 ft3

The total volume of Solid deposition in the entire drainage system = 6053.35 ft3

The total volume of clear space in this drainage system = 111616.643 ft3

Capacity of the Drain during Monsoon

According the to Bangladesh Metrological Department, Rajshahi's average rainfall = 3.74 inches = 0.31 ft

Talaimari to Octor mor:

Length = 984 ft

Average width = 66.2/2 =33.3 ft

Rainfall depth = 0.31 ft

Total rainfall volume =984*33.3*0.31 =10157 ft3

Volume of clear space of drain = 17630.86 ft3

Total rainfall volume < volume of clear space of drain. Therefore, the capacity of the drain is adequate.

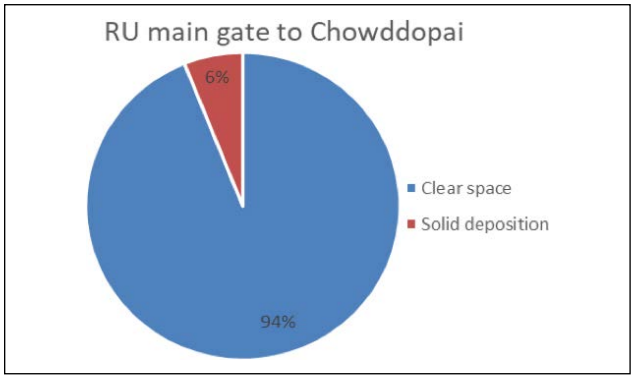

Figure 7. Clear space and solid deposition in RU main gate to Chowddopai.

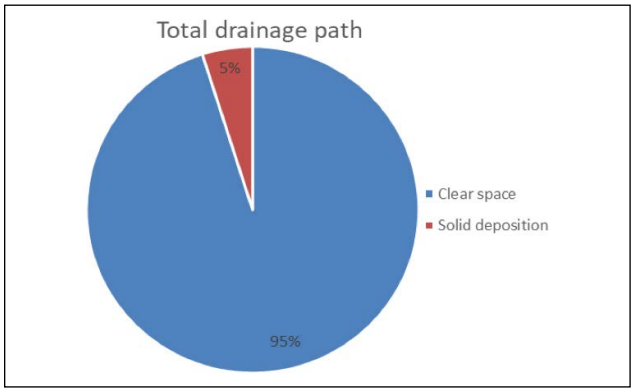

Figure 8. Clear space and solid deposition of the entire drainage path.

Kazla gate to RU main gate:

Length = 1312 ft

Average width = 33.3 ft

Rainfall depth = 0.31 ft

Total rainfall volume = 1312*33.3*0.31 = 13543.77 ft3

Volume of clear space of the drain = 5014.46 ft3 [From 4.2.2]

Total rainfall volume > volume of clear space of drain. Therefore, the capacity of the drain is inadequate.

RU main gate to Chowddopai:

Length = 5904 ft

Average width = 33.3 ft

Rainfall depth = 0.31 ft

Total rainfall volume = 5904*33.1*0.31 = 60947 ft3

Volume of clear space of the drain = 88731.12 ft3 [From 4.2.3]

Total rainfall volume < volume of clear space of drain. Therefore, the capacity of the drain is adequate.

RESULTS AND DISCUSSION

The area of solid deposition in the drain varies from 0 to 1.67 square feet. Maximum solid deposition was found between the RU main gate and Chowddopai while minimum solid deposition was found in the Kazla gate to the RU main gate. In Chowddopai, the primary drain is rooted in which has a 10 ft actual depth and 17 ft actual width. The drain portion from Talaimari to Octroy mor and the RU main gate to Chowddopai is adequate for the average rainfall of Rajshahi but From Kazla to RU main gate portion of the drain is inadequate. So, this portion of the drain should be reconstructed. A map was created in ArcGIS providing all the data collected from field surveys.

All reference items must This drainage path is very promising as it has adequate width and depth, as well as solid deposition rate, is also acceptable. It is capable enough to handle rainwater runoff, road safety, property protection, and urban planning. For typical rainfall intensity in Rajshahi City, the drain between Talaimari and Octor mor and between RU main gate and Chowddopai has enough open space to prevent the spilling of water, however, the drain between Kazla and Ru Main Gate does not.

CONCLUSION

Though the number of drains in RCC is sufficient, the condition of the drainage system is not satisfactory. In this paper, the depth of sludge deposition, clear space, and drainage capacity of the Talaimari to Chowddopai drain in RCC is calculated by conducting a field survey. Based on the study results, the following conclusions are drawn:

- As it is a new drain, the capacity of the drain is in satisfactory condition.
- The sludge accumulation is quite low as it has a low amount of solid deposition.
- To keep good performance of the drain, sludge should be kept minimum. For this reason, the drain should be cleaned at regular intervals, so sludge accumulation can be under control.
- Solid deposition is comparatively more in Ru's main gate to the Chowddopai area. Still, it is capable of flowing rainwater. But the dimension of the drain from Kazla to Ru main gate is less. So, it is inadequate for the average rainfall of Rajshahi.

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DATA AVAILABILITY STATEMENT

The author confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

USE OF AI FOR WRITING ASSISTANCE

Not declared.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] M. M. E. Zumrawi, "International Journal of Multidisciplinary and Scientific Emerging Research The Impacts of Poor Drainage on Road Performance in Khartoum," 2014. http://www.ijmser.com/ Accessed on Oct 15, 2024.

[2] G. Kebede Warati, "Assessment of the effect of urban road surface drainage: A case study at Ginjo Guduru Kebele of Jimma Town," International Journal of Science, Technology and Society, Vol. 3(4), Article 194, 2015. [CrossRef]

[3] C. O. Owuama, "Sustainable drainage system for road networking," International Journal of Innovation, Management and Technology, Vol. 5(2), pp. 83-86, 2014. [CrossRef]

[4] M. A. Ashraf, and M. S. A. Chowdhury, "Drainage planning in the cities of Bangladesh: Case study of drainage and water logging in Chaktai Commercial area, Chittagong," Journal of Bangladesh Institute of Planners, Vol. 2, pp. 49-60, 1970. [CrossRef]

[5] I. Faridatul, and S. Jahan, "People's Perception Regarding the Development of Community Facilities: A Case Study of Rajshahi City Corporation," 2014.

[6] M. S. Islam, S. M. Islam, and A. M. Islam, "Assessment of efficacy of drainage system in Rajshahi City Corporation, Bangladesh," Advances in Environmental Research, Vol. 10(2), pp. 105-116, 2021.

[7] M. M. M. N. Ullah, M. S. Hossain, M. Shahiduzaman, M. S. Islam, M. Z. Islam, and M. S. R. Choudhary, "A study on some aspects of drainage system in Rajshahi city, Bangladesh," Scientific Journal of Environmental Sciences, Vol. 2(6), pp. 118-124, 2013.