

Flushing Methods in Polder Drainage System to Obtain Better Environment Quality

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Abstract. The Banger Polder is a polder system which covers an area of around 670 hectares in Semarang city. There are about 90,000 inhabitants living in this area. The Polder area is vulnerable to flooding caused by high water levels during high tide and more during heavy rain. Climate change which may cause high sea level forms a serious threat for the coastal areas in Semarang as delta area. Objectives of the paper are to create cause relation flowchart, to analyse flushing zone, and to plan implementation and maintenance of flushing system. Regarding the research methods for implementing the case, there are seven parties interviewed and observed related to flushing program. The parties are described with their interests, influence and (optional) negative impacts of stakeholders. The Causal relation tree of flushing process is divided into 5 different steps: innovative, quality effect, operational effect, qualification effect, and monitor effect. According to the observation and interview result, flushing zone in Banger polder area can be divided into 5 zones which are implemented by some institutions; SIMA, PSDA, BBWS and Bappeda. A good implementation and maintenance is needed to maintain the flushing system.

1 Introduction

The Banger Polder is a polder system which covers an area of around 670 hectares. There are about 90,000 inhabitants living in this area. The Polder area is vulnerable to flooding caused by high water levels during high tide and more during heavy rain. Climate change which may cause high sea level forms a serious threat for the coastal areas of Semarang that are located at below sea level [1]. The business site is improving the hygiene and water quality in the Banger Area by flushing the canal drain during draught. This improvement will be the next priority after implementing the polder system. In dry season, the hygiene needs to be improved. In current situation, several toilets discharge land directly to secondary and tertiary gutters along the streets, which is known as an open sewer.

In dry season, flushing is a kind of difficult process since there is a scarcity of water. If the gutters cannot be flushed, the water quality and the hygiene will extremely reduce.

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Without flushing, the stationary water will cause diseases like Dengue and other mosquito diseases. [2]

The main role of flushing the gutters is to improve the social hygiene and decrease the diseases caused by poor water quality. During the current conditions in the Banger area, the plan of approach contains of three steps; cleaning, flushing and maintenance. Flushing and maintenance are long-term aspects. The cleaning is a one-time operation. There is lots of plastic waste and other solid garbage in the waterways and gutters. To improve the flush methods, the water needs to have latitude through the gutters for a right runoff. [3]

The flushing movement will be used frequently to pump water through the Banger area. It will flush the human excrements, the mosquito parasites and remaining solid waste. Dengue is currently a major health problem in Semarang “The Dengue mosquito eggs hatch into larva after a rain or flood. A larva changes into a pupa in about a week and become a mosquito in two days”. [4]. This fact shows clearly that it is necessary to flush the gutters every week to against the Dengue mosquitoes’ reproduction.

In dry seasons, the inlet of water will carry out by mobile pumps or pumps which are connected to the Banger River. After the implementation of the polder system, some pumps along Banger River are unnecessary and can be removed to be used for flushing program. Objectives of the paper are to create cause relation flowchart, to analyse flushing zone, and to plan of implementation and maintenance of flushing system.

2 Methods

Regarding the research for implementing a business, there are seven parties interviewed and observed related to flushing program in Banger Polder Area, Semarang. These parties showed their interests, influence and (optional) negative impacts of stakeholders, see table 1. [5]

Table1. Stakeholders’ interest and influence

Stakeholder	Interests	Influence	Negative Impacts
SIMA (Semarang Water board)	Responsible for Banger Polder operation and maintenance. The main goal is to reduce the flooding. The next goal is to improve solid waste management and sanitation.	High	Inhabitants need to pay tax for the polder system (the implementation and maintenance). Inhabitants have not paid the tax.
PSDA Kota (Water Resources Management Office of City)	The office manages Water in channels and waterways. The current responsibilities are operating and maintaining pump and polder channels, and improving the channels from solid waste.	High	When mobile pumps will be used for flushing, PSDA will be responsible for the maintenance and storage of these pumps.
Bappeda (Office of Planning and Development)	Having the responsibility for the allocation of projects for urban planning to corresponding all offices.	Low	
BBWS (Office of National River Area Management)	Having the authority of the Central Government in management of large rivers and river basins in Indonesia. In Semarang, the	High	In dry season, BBWS is not able to extract a large amount of water for flushing because of the lack of water in Rivers.

	authorisation of management of the east and west flood control.		
Province Cikataru (Province Office of Housing)	Giving support to develop Polder Kali Banger. Has the responsibility for 1 st dredging, the primary channel.	High	
Witteveen en Bos (Design Consultant)	Having the responsibility to design of the Banger Polder Project.	Low	
HHSK (Rotterdam Water board)	One of founders of the polder authority SIMA (Water board) and involved as advisor. The main goal is to transfer knowledge regarding the maintenance of the system.	Low	

Considering the diverse groups of stakeholders, which are involved in the flushing program, an influence versus interest grid is given to overview the regulations between the delegations in Semarang regarding the Banger polder. In the grid, Stakeholders are placed to show their interest and influence comparing to each other, based on formal and informal responsibilities. SIMA is the most interested and influenced stakeholder.

3 Description of Location

The Banger polder is located in East Semarang with a major population and high density throughout the north of the polder. The downstream area (north) has the biggest problem with its flooding and poor water quality. During the research, shown that the elevation level relative to sea level downstream of the polder was between -0,50 and 1,00 meter. Nowadays, with an annual subsidence of 7 cm, the area is progressively sunk under sea level. Climate change will further worsen the situation due to high sea level and increased rainfall in rainy season. The north side of Banger land area has nowadays a current elevation average between -0.72 m and 0,28 m to sea level. [6]

Flushing is required at the open drains in which untreated wastewater is discharged. [3] The downstream area of the Banger polder is divided in 5 flushing areas. The following areas have dense population and poor sanitation channels. They are East Kemijen, North-West Kemijen, South-West Kemijen, Rejomulyo, Progo channel, Mlatiharjo and Rejosari.

The **Banger polder** has one medium river, splitting the east and the west, the Banger River. The river appears in the northern of the area. In dry season, the only source for the river is wastewater from households. The quality of the Banger is therefore very worrying. Because of this bad quality, the condition of the social hygiene is getting critical. **East Flooding River** is located in the east of the banger area. The river appears from Penggaron River which is connected with Pucang Gading outlet, the drainage outlet of Kedung Mundu River, Candi River, Bajak River, drainage of Kartini pump and drainage of Sawah Besar/Sambirejo pump. The river downstream is located along many slums. The river is discharged into Java Sea. **Semarang River** is located in the west of the banger area. **Polder Tawang** is located in front of Tawang railway station. The polder was built to solve flood problems around Kota Lama. **West Flood River** is one of the largest rivers in Semarang. The water from **the culvert under Jl. Kartini** is originally from downtown and **West**

Flood River t which supply water to flush Semarang River. The description of important places is mentioned in Figure 1.

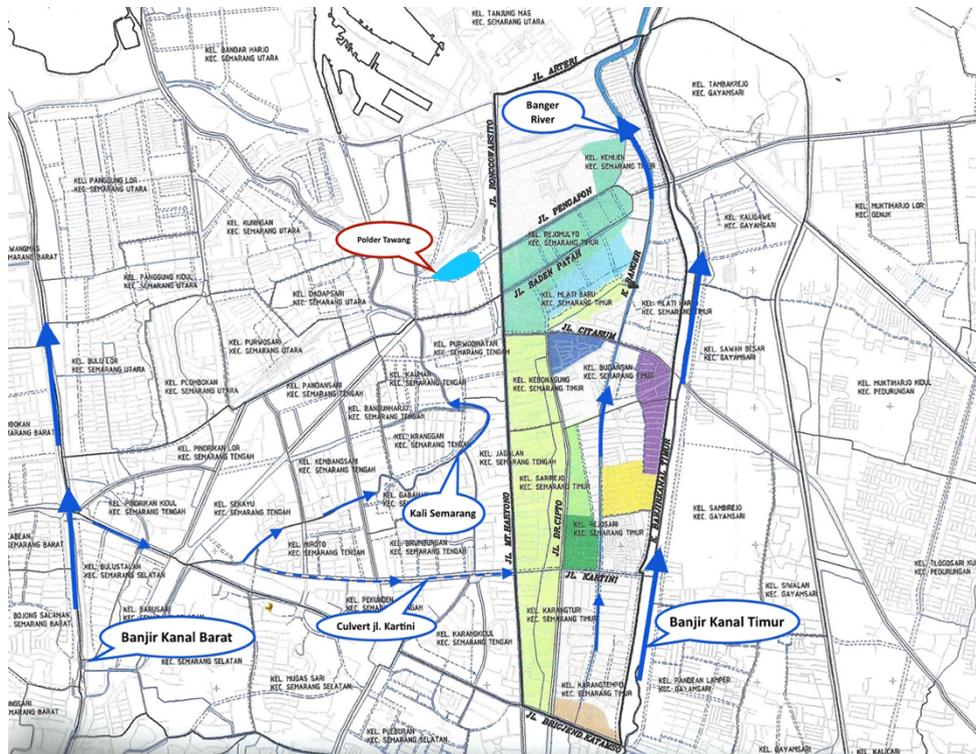


Fig. 1. Description of location and flushing alternative plan

4 Results and Discussion

The result can be elaborated in three paragraphs below. They are causal relation of flushing, more effective flushing zone, and implementing and maintenance.

4.1 Causal Relation of Flushing

According to reference [7], interview and investigation result, in the new flushing program, the writers suppose that there will be several positive impacts/ effects of polder water system. These impacts are represented in a causal relation tree.

A Causal relation tree shows specific interventions which will lead to quantified and qualified effects. The Causal relation tree is divided into 5 different steps, which are presented in shapes below (see figure 2). The last two steps, Qualification effect and monitor effect, are multiplied with each other. The result will express in a good overview about the benefits (€/ IDR). The key features in this causal relation tree are to improve the water quality and the liveability in the Banger Polder area.

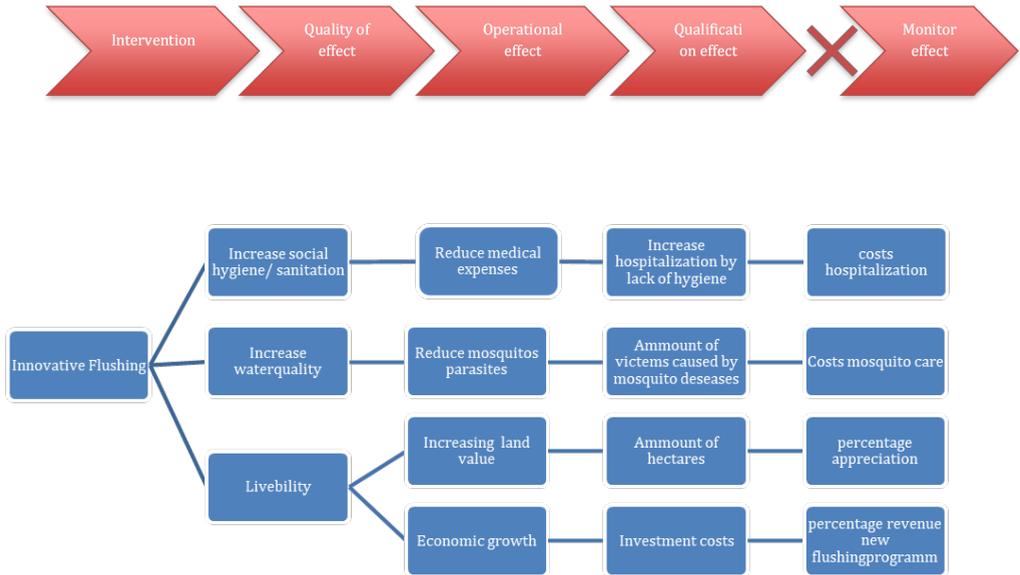


Fig. 2. Causal relation tree of environment impact

4.2 Flushing Zone

According to observation and interview result, for flushing the Banger Polder, the area can be divided in 5 subareas, Zone 1 to Zone 5. Zone 1 until 3 get the highest priority for flushing, since these areas are the most polluted and most densely populated of. Every zone has its own flushing program. In the following paragraphs, every zone will be explained comparing with the water system and the stakeholders who are involved. [8]

4.2.1 Flushing Zone 1

Zone 1 (East Kemijen) is located in the Northeast of the Banger polder, next to the pump station. The water source for flushing would be from East River by using mobile pumps. The flushing direction is towards Kali Banger. A capacity of 0,5 m³/s is required, by using 2 mobile pumps of 0,3 m³/s. The mobile pumps can be installed everywhere on the border of east River to flush the channels. The channel to flush can be regulated by blocking the other channels with e.g. sand bags. A volume of 4,769 m³ is required to flush this area and will take approximately 6 hours, including preparation. The stakeholders involved are BBWS as management of East River, PSDA as responsible party and it manages the mobile pumps replacement; SIMA handles the location for mobile pumps and regulations of blocking channels

4.2.2 Flushing Zone 2

Zone 2 (Kemijen North-West) is located in the Northwest of the Banger polder. The major part of the surface of the area contains the retention basin, which is used for fishery. Zone 2 can be flushed with water from Kali Banger. Nowadays, in the west of Kemijen Timur in Zone 1, there are pumps used to pump the water from the quarterly and tertiary channels in Zone 1 to Kali Banger. The pumps will be redundant because of the decrease of the water level in Kali Banger. According to this decrease, the flushing will be carried out by natural

gravitation of the water into Kali Banger. These pumps are no longer necessary for Zone 1 but can be used for flushing Zone 2. A volume of 912 m³ is required for flushing this area.

After flushing the quarterly and tertiary channels in Zone 2, the contaminated water will end up in the retention basin. For flushing the retention basin, the outlet to Kali Banger can be used. To give the flushing a boost from the North, seawater could be taken into the retention basin during high tide through the tidal gate at Jalan Arteri. Stakeholders involved are PSDA as placement and maintenance of the pumps and SIMA as management of water chain (pumps and gates of the area).

4.2.3 Flushing Zone 3

Zone 3 is located in the Midwest Banger Polder, which contains two areas for flushing. The water source for flushing would be from Tawang Polder, the pond in front of the railway station. Tawang Polder has sufficient capacity since it is flushed by water from Kali Semarang.

The water from Tawang can flush South-West zone, Kemijen. The water can flow from the pond via Jalan Pengapon channel. The channel has a width/ depth of 1m and water level difference of 1m. Therefore, it has a sufficient discharge capacity. A volume of 2.956 m³ is required to flush this area and will take approximately 6 hours, including preparation.

Zone of Rejomulyo can also be flushed by water from Tawang. The water can flow along Jalan Ronggowarsito towards Kemijen zone. Similar to the Zone, water can be pumped up by using one mobile pump of 0,3 m³/s to flush the quarterly and tertiary channels. The Stakeholders involved are PSDA and SIMA. PSDA prepares placement and maintenance of the pumps and cleaning channel. SIMA installs location for pumps and manages the water supply from Tawang in collaboration with PSDA.

4.2.4 Flushing Zone 4

Zone 4 is Progo River, which crosses the sub districts Sarirejo, Jagalan and Kebonagung. The river needs a continuous flushing, which could be supplied with water from the culvert under Jl. Kartini. The water can be pumped up from under the ground to Progo River. The water in this channel is originally from West Flood River (KBB) which supplies water to flush Kali Semarang. For flushing the Progo River, a permanent discharge of 31 l/s is required. According to BBWS, in dry season, KBB can supply a flow of 100 l/s for the flushing program in Banger Polder. Therefore, the source has a sufficient capacity. In dry season, when KBB cannot supply the requested capacity, there is an alternative in supplying more water to the culvert under Jl. Kartini for flushing. It means that all water will flow to the culvert under Jl. Kartini, which can be used for flushing. PSDA prepares placement and maintenance pump under Jl. Kartini and placement adaptive barrier, and SIMA handles the regulations about using adaptive barrier.

4.2.5 Flushing Zone 5

Zone 5 is located in the Mideast of Banger Polder which consists of Mlatiharjo and Rejosari sub district. Alongside Banjir Kanal Timur, this zone has 3 kilometres length which can be flushed by Banjir Timur with mobile pumps. Zone 5 will be flushed in three parts from south to north by using 2 mobile pumps from Zone 1.

There is a possibility to improve the retention basin and upstream of Banjir Kanal Timur (near Majapahit bridge). Upstream retention is preferred because it will reduce the required discharge capacity of channels and structures. In rainy season, it can be a buffer

for Banjir Kanal Timur. Even as the retention basin in Kemijen, it can be a fishery. The Stakeholders involved are BBWS as Banjir Kanal Timur management, PSDA as responsible party and it manages the mobile pumps replacement; SIMA handles the location for mobile pumps and regulations of blocking channels, Bappeda arranges regulations about potential retention basin.

4.3 Implementing and Maintaining Flushing System

4.3.1 Implementing

By implementing the polder system, the main pump is lower the water level in the Banger within 2 meters (by design Witteveen en Bos). [9] It means that all water from gutters and small channels can flow naturally by gravitation. So the small pumps along Banger River are not necessary. The small pumps can be used for flushing. To implement the small pumps in various locations in the slums, the flush capacity will increase. By increasing the flush capacity, the social hygiene and the water quality will be improved considerably.

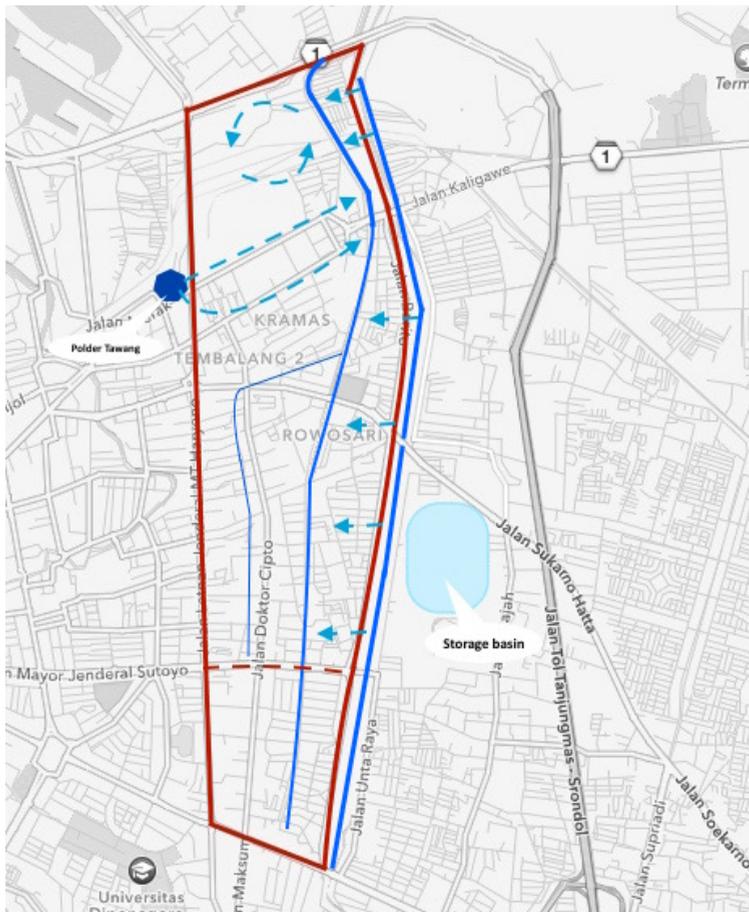


Fig. 3. Implementing plan of flushing zone

Implementing several small pumps in the areas of Kemijen (North and South-West) and Rejomulyo makes the mobile pumps redundant. These areas are connected with the

retention basin. Implementing small pumps in these areas will create a solid water system with the Banger and the retention basin.

The flushing program is based on a strict planning. SIMA and PSDA need to follow this structural planning because of the incubation time between birth and growth of mosquitoes and other parasites. The parasites take approximately a week for developing the flushing which has to happen every week. The flushing would not be reliable anymore for improving the water quality when the program is postponed.

4.3.2 Maintenance

Maintenance is important for an efficient flushing program. It is not a main priority in Indonesia. It really should be, because of the effectiveness of a running system. [10]

Mitigation channels in flushing system may be clogged by pollution and other solid waste. Mechanical complications for the pumps can also occur, which may be prevented with technical maintenance by engineers. All pumps have to work with the requested amount of water to improve the flushing system. PSDA is responsible for the maintenance of quarterly and tertiary channels, and the redundant and mobile pumps. They should be aware about the importance of maintaining and checking system to create an effective flushing program. In collaborating with SIMA, PSDA should improve a maintenance plan with strict regulations about planning, delegations, functions and agreements about the polder and flushing system.

5 Conclusion

The Causal relation of flushing process is divided into 5 different steps: innovative, quality effect, operational effect, qualification effect, and monitor effect. The quality impact can improve social quality, water quality and livability. According to observation and interview result, flushing zone in Banger polder area can be divided into 5 zones which are implemented by some parties, such as SIMA, PSDA, BBWS and Bappeda. Each Zone has its flushing methods, where water supply comes from and how to send water to the Polder drainage area. Sustaining the flushing system requires a good implementation and maintenance. A manual of flushing methods in polder area is definitely needed.

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