Evaluation of Home Sanitation System in Tidal Areas , A Case Study of Kemijen Village, Semarang, Indonesia

IM. Tri Hesti Mulyani[*], Etty Endang Listiati[*], B.Tyas Susanti[*], Djoko Suwarno[**]

[*]Faculty of Architecture and Design,
[**]Faculty of Engineering
Soegijapranata Catholic University, Semarang, Indonesia

***Abstract*-** The northern city of Semarang is experiencing severe flooding due to rising sea level. This is one effect of global warming as well as land subsidence because of groundwater exploitation. One of the areas affected by the flood is KelurahanKemijen Semarang wherethe house and the environment is always inundated.Efforts made by residents to overcome this problem is to elevate the neighborhood road. However, it poses a new problem for the poor because they cannot raise the floor of their houses so that the floor surface is below the road surface. The other problem is sanitation problem because in principle the area is designed for dry environment.

The residents who cannot raise the floor make an effort focusing on sanitation so the "biological activities" and bathing can still take place when the house is submerged in water. There are two kind of effort that they make: 1)increasing the position of septic tank without raising the floor of bathroom and closet holder. However, this does not work optimally. 2)Increasing the bathroom floor and closet holder and raising (and connecting) with septic tank. It seems the second effort is more optimal to face the sanitation problem temporarily.

In the research,it took six houses as the sample (10% of the population), which experience the worse condition of the tidal. The research used qualitative description analysis method. The result of the research shows some solutions to the sanitation problems of bathrooms/ toilets performed by the residents, both individual and collective solution, as the adaptation efforts to flood

Keywords: home sanitation, Kemijen, tidal flood,

I. INTRODUCTION

Climate change and global warming have led to rising sea levels. According to the International Panel On Climate Change (IPCC) report, the average global surface temperature increased from 0.3 to 0.6 0 C since the late 19th century, and up to 2100 the earth's temperature is predicted to rise around 1.4 -5.8^{0} C (Dahuri, 2002 and Bratasida, 2002 in Syah AF). Rising global surface temperature causes melting ice in the north and south poles of the earth so that there is a sea level rise. It is estimated that in 1999-2100, sea level rise was about 1.4 to 5.8 m (Dahuri, 2002 in Syah AF). On the other hand, exploitation of groundwater use has led to a land subsidence (Marsudi in Pryambodo DG, 2012). Both are the causes of tidal flood. Tidal flood is caused by sea water tides so that the water inundates the land (the center of Indonesian geography study). Tidal floods have hit several coastal areas in Indonesia, such as Sumatera, Kalimantan, Sulawesi, Bali, Papua, and Java. The coastal cities of Java with tidal floods are: Jakarta, Subang, Tasikmalaya, Pengandaran, Probolinggo, Pacitan, Banyuwangi, Jember, Trenggalek, Malang, Tulungagung, Lumajang, Gresik, Tuban, Pemekasan, Surabaya, Kulon Progo, Bantul, Pekalongan, Cilacap, and Semarang (Republika.co.id, June 7, 2016). Semarang city experiences land subsidence due to excessive groundwater exploitation resulting in tidal floods in some parts of the region as seen on the map of the Spatial Plan of Semarang in 2010-2030 below.

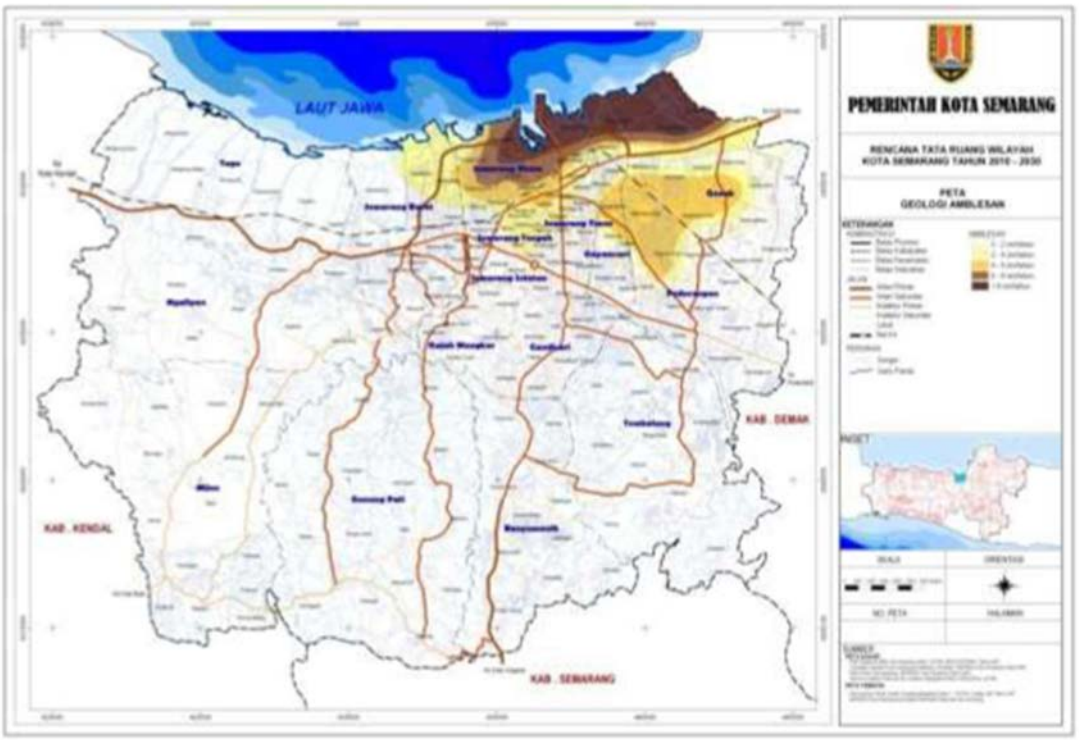


Figure-1: Geological Map of Subsidence in Semarang City
Source: Semarang City Government, 2010-2030

Some areas in North Semarang and East Semarang have the land subsidence of 4-8 cm per year (the part of map with the colors from yellow to dark brown). The other data from the results of land subsidence research in Semarang area by the Geodetic Scientific Group of the Earth Science and Technology in 2008, 2009, 2010, 2011, 2012 and 2016 using Global Positioning System (GPS) technology and Interferometric Syntetic Aperture RADAR (InSAR) obtained the data as follows (Andreas H, 2016):

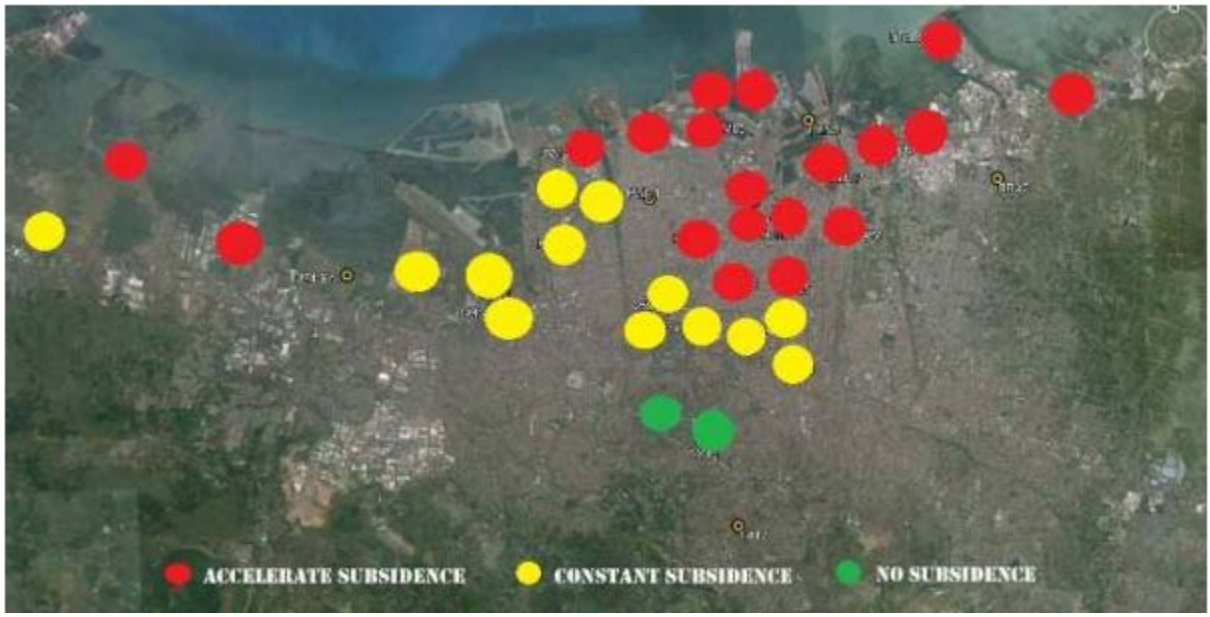


Figure-2: The research results of land subsidence in Semarang areas.
Source: the Geodetic Scientific Group of the Earth Science and Technology of ITB in 2008, 2009, 2010, 2011, 2012 and 2016

The red color in the figure shows the acceleration or the rapid land subsidence per year that occurred in the North and North East of Semarang City. The land subsidence in this section has reached about 1 m since 2008. Yellow color shows the subsidence with constant value per year. The land subsidence in this section was about 20 cm. Green color means no land subsidence.
According to Ismanto A et al (2009), the land subsidence in North Semarang and part of West Semarang was 4.1-12 cm/ year.
From both maps above, the Northern and Eastern areas of Semarang are included in the areas with a high rate of land subsidence and are vulnerable to tidal floods as seen on the map below.

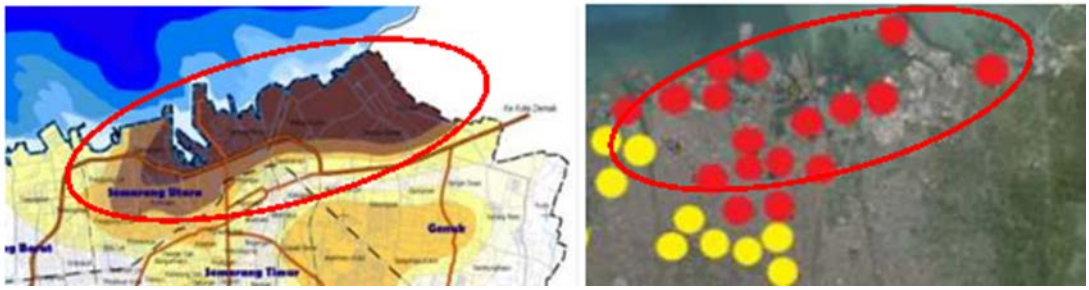


Figure-3: The comparison of the land subsiddence maps in North and East Semarang.
Source: Referring to the Government of Semarang City in 2010-2030 and the Geodetic Scientific Group of the Earth Science and Technology of ITB.

The areas of North and Eastos Semarang which are vulnerable to tide can be seeen in table below.

No	Lokasi Kecamatan	Luas (ha)	Sebaran (Kelurahan)
1.	Kecamatan Tugu	257,20	Mangunharjo, Mangkang Wetan, Randugarut, Karanganyar dan Tugurejo
2.	Kecamatan Semarang Barat	237,19	Tambakharjo, Tawangsari, dan Tawangmas
3.	Kecamatan Semarang Tengah	22,95	Kauman, Kranggan, dan Jagalan
4.	Kecamatan Semarang Utara	508,28	Panggung Lor, Bulu Lor, Bandarharjo, dan Tanjung Emas
5.	Kecamatan Semarang Timur	44,15	Kemijen
6.	Kecamatan Genuk	377,68	Terboyo Kulon, Trimulyo, dan Terboyo Wetan
7.	Kecamatan Gayamsari	73,23	Tambakrejo, Kaligawe, dan Sawah Besar
8.	Kecamatan Semarang Selatan	18,12	Pleburan, Bulustalan

Kemijen Village is one of residential areas routinely struck by tidal flood. The village consists of 11 RWs with the borders that can be seen in the figure below..

Figure-4: The Map of the Use and Spatial Plan of Kemijen Village, the Sub-District of East Semarang in 2011
Source : Jacobus S, PMLP Unika Soegijapranata Semarang, 2011

Community efforts

Environmental street elevation.

Street elevation is useful for people's access to daily activities. However, it caused a new problem for the poor/ low income people because they could not raise their houses so that the floor surface was lower than the street level.

Government Efforts

Semarang city government provides pumps to reduce puddles by dumping inundated water into nearby river (pumping system). The system is capable of reducing inundation in some areas of Kemijen. Tidal puddles cause sanitary problems which are principally designed for dry areas (not inundated). The purpose of the research was to evaluate home sanitation system in tidal areas.

II. COLLECT IDEA

This research completes some previous researches which have been done before. One of the studies related to Kemijen is a research on identification of sanitation system which is suitable to the sanitation problems in KelurahanKemijen Semarang (Tri HestiMulyani& BPR Gandhi, 2014). This study examined alternative sanitation systems that was suitable to be applied in areas which suffered from flooding.

In addition, research related to social factors in KelurahanKemijen has also been done by Andi Suriadi, et al (2018), and AnantoBangkit Pradana and Mussadun (2014). Both of these social researches concluded that, the slum environment conditions did not make the citizens of Kemijen wanted to move. They wanted to stay there, even if they realized that the environment was not good to be resided. This was due to the ease access to the workplace as well as, the level of security, the connection to the environmental organizations and relationships with the family and neighbors that has been closely intertwined so far.

The study relates to the type of house desired by the citizens of Kemijen has been investigated by Pribadi SB et al (Module vol 11, no 2, August 2011) which revealed that the percentage of residents related to the type of house that they wanted to build as follows: 1) 42.75% wanted a house on stilts, 2)20.75% wanted the house floating and 3)36.50% wanteda house which was elevated with the pile of soil

While the other research showed that efforts by the Kemijen residents in relation to deal with environmental conditions indicated that the majority of residents created dams as a barrier (52.94%) whereas people with sufficient economic capabilities would then bought pumps and people with higher economic capability raised the floor (35, 29%) (AdityoSetionurjaya et al, 2016; KenanaAufa D. And

Nanny Y, 2016). In relation to floor elevation, the main priority of elevation was the bedroom (29.4%) and the bathroom (11.76%), considering the bathroom always created problems when the water and dirt appeared on surface due to the rob.

III. RESULT AND DISCUSSION

Now it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

A. Method

The research method used was observation and interview. The observations were made in detail on the areas which were still inundated. The most heavily inundated areas were in RW-IV of Kemijen village. The interviews were conducted to the Village Head and the residents of the houses who were sampled. The number of homes in the study area was 55 houses, and the study took six houses as the samples. The sanitation solutions conducted in six cases were further assessed/ discussed using a reference of ideal sanitation system.

B. Result and discussion

Kemijen Village, Semarang, consists of 11 RWs, and six out of the eleven RWs had successfully overcome the problem of tide. The solutions undertaken to overcome it were by:
- Environmental street elevation
- House floor elevation performed by most houses, on average once in five years
- suctioning water using pump and discharged to Banger river.

The other five RWs have not been able to solve the tidal problem and one of the most severe was RW IV. RW-IV consists of 2 RTs inhabited by 72 families in 55 houses. The severe condition occurred because there were still many houses with the floor height which was the same as or lower than the street level. The condition did not change significantly although the effort to raise the floor of the houses had been performed. In addition, the non-functioning of environmental channels due to very high sedimentation rate also exacerbated the sanitary conditions in this area as shown in the figure below

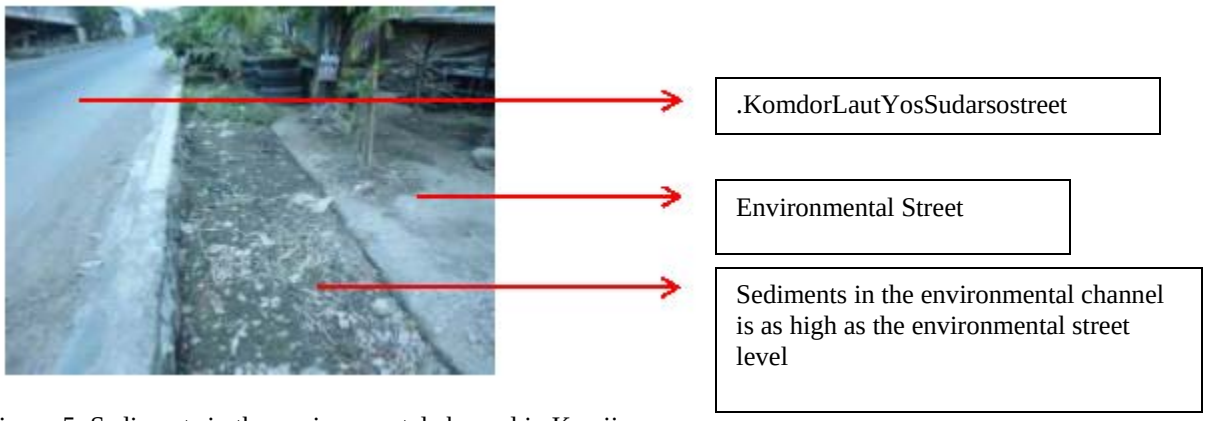


Figure-5: Sediments in the environmental channel in Kemijen
Source: Mulyani TH, Semarang 2017

This condition caused flood and sanitation problems that disrupted the health of the residents. The handling of tidal puddles and disposal of wastewater from bathrooms and washing activities were performed collectively by the residents. The effort made was by draining the liquid waste in the channel to the pond located in front of the houses of the residents using the electric pumps as shown in the figure below.

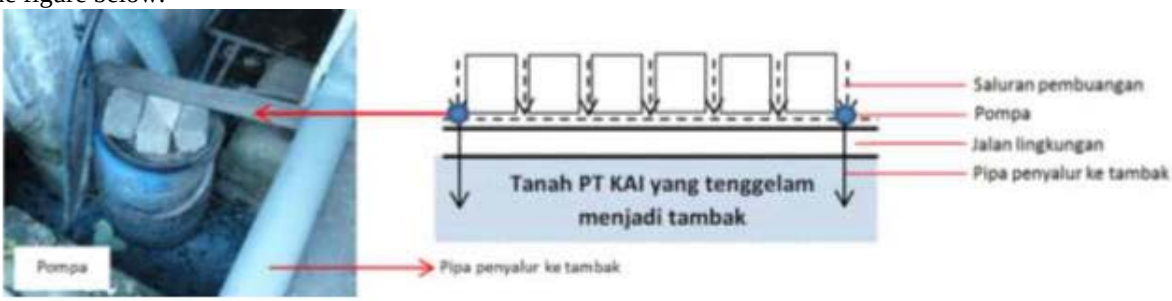


Figure-6: the picture of the pump and the sketch of pumping collective solution in RW-IV of Kemijen

Source: Mulyani TH, Semarang 2017

The effort was made because the position of the environmental channel is much lower than and pond waterfront. Without the pump, water cannot flow into the dump.

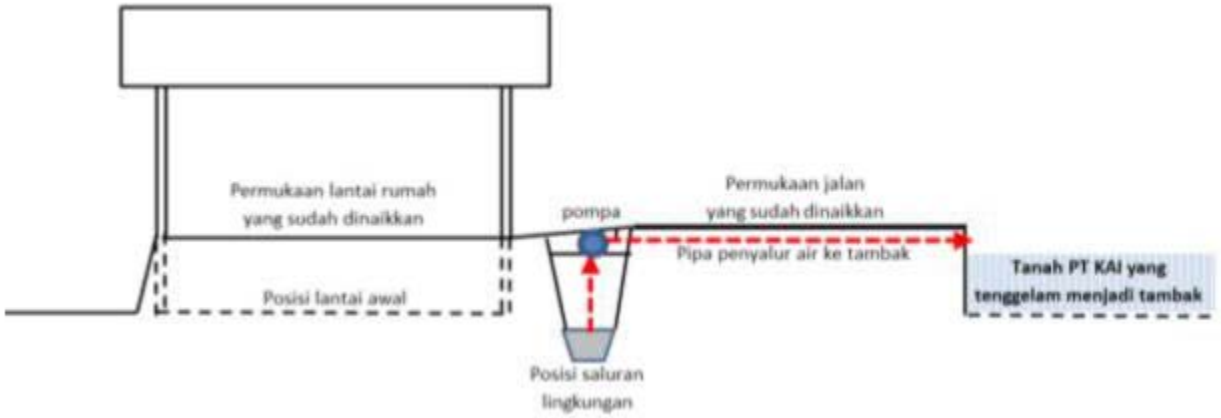


Figure-7: the scheme of the positions of environmental channel, pump, and retention pool in RW-IV of Kemijen
Source: Mulyani TH, Semarang 2017

In this study, the samples taken were 10% of home population (six houses). The samples consist of two categories:
- The houses that had been able to overcome tidal flooding (1 sample).
- The houses that had not been able to overcome tidal flooding (5 samples)

The number of the house samples that had not been able to overcome tidal flooding was taken more because most of the houses in the area were in this condition. The next discussion focused on the solution efforts made by the residents in the bathrooms and toilets in overcoming the problem of flood/ tide, while the problem of gray water was handled collectively using the pump as mentioned above.

The detailed condition of the six house samples and the adaptation effort on the sanitation system can be seen in the following descriptions:

1. Mr. Mahdi's house

The house is categorized as the one that had been able to overcome tidal flooding consisting of two units; one unit was used for residential house and one unit for boarding house. The house had been partially raised with a floor height of 1.5 m higher than the street level for the boarding house, while in the residential house, the floor height was still the same as the environmental street level.
The sanitation issues were resolved by:
Raising the bathroom floor surface and connecting septic tank to approximately 1.5 m higher than the environmental street level. The resident's solution scheme can be seen in the following figure.

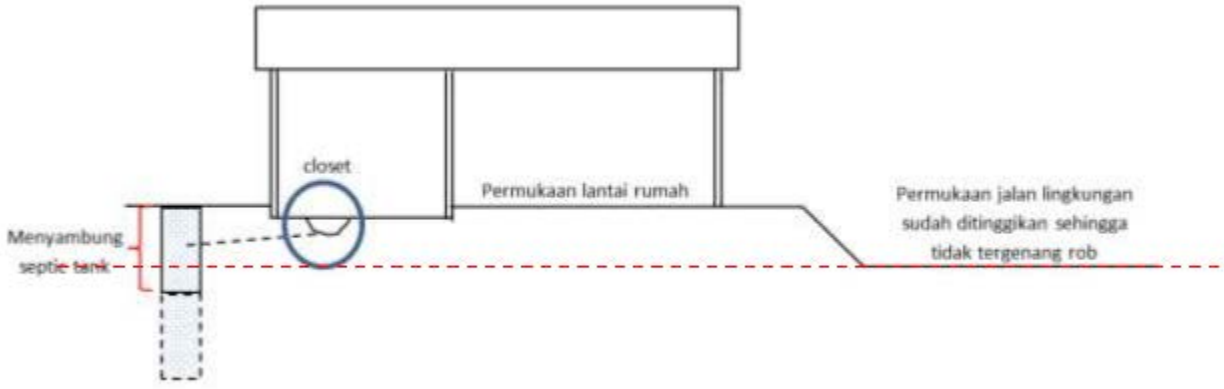


Figure-8: the sollution scheme of the floor raising for homes and teh sanitation for bathrooms and toilets
Source: Mulyani TH, Semarang, 2017

By doing this, when puddle of flood/ tide occurs, bathroom still can be used by the residents of boarding house and homeowners.

2. Mr. Timbul's House

The house belongs to the category of the house that had not been able to overcome flood/ tide because the floor of the house was 60 cm lower than the street level. The sanitation issues are solved by raising the bathroom floor level and connecting the septic tank to about 1.5 m high from the floor surface of the house. Therefore, when the house is flooded, the bathroom can still be used. The solution scheme can be seen in the following figure.

Figure-9: the solution scheme of raising the sanitation of bathroom/ toilet
Source: Mulyani TH, Semarang, 2017

3. Mr. Bambang Susilo's house
The house belongs to the category of house that had not able to adapt to flood/ tide. The height of the floor surface was 60 cm lower than the street level, and there was no change in the height of the bathroom and toilet. Therefore, it can not be used when the house is struck by flood/ tide. The solution made by the resident in the conditions was to evacuate to another place. The scheme of the sanitary condition is as follows:

Figure-10: the solution scheme of raising the septic tank
Source: Mulyani TH, Semarang, 2017

4. Mrs. Hanifah's House
Overall, the condition of this house was very apprehensive because most of the houses had been destroyed. One-third of the building that can still be occupied was optimized by elevating the rear floor for bedroom and bathroom so that when flooded it still can be used. The height of the floor surface of the front house (living room) was under the street level. The sanitation problems were solved by elevating the bathroom at the back to 1.50 m higher than the living room floor. The solution scheme performed on the bathroom part is as follows:

Figure-11: the solution scheme of raising the sanitation of bathroom/ toilet
Source: Mulyani TH, Semarang, 2017

5. Mrs. Kartupi's House

The condition of the house was very severe because the building was almost drowned. The buried part of the house was about 3 meters and the height of the inner space was left only about 160 cm. The floor surface of the house was 80 cm lower than the environmental street.

With the floor position of the house which was 80 cm lower than the street level, the house had the highest flood/ tide. To reduce the flood/ tide water, suction was performed by pumping individually and flowed to the environmental channel as shown in the following figure.

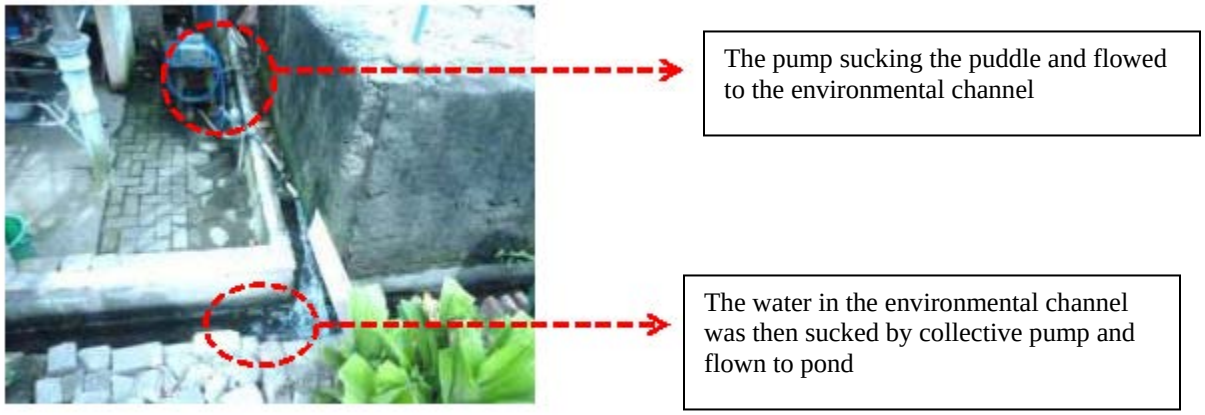


Figure-12: the pump sucking grey water
Source: Mulyani TH, Semarang, 2017

The sanitation problems in the bathroom and toilet had no solution because the height was still the same as the surface of the house floor (lower than the street level). Thus, when flooding, the bathroom and toilet could not be used. The scheme of the sanitary conditions can be seen in the following figure.

Figure-13: the scheme of the sanitation position of bathroom ad toilet with no solution effort.
Source: Mulyani TH, Semarang, 2017

6. Mr. Suyanto's House

Around the house, there was no sewerage, so the water was inundated in the yard of the house. The floor height of the house was slightly lower than the main street (Komodor Laut Yos Sudarso Street). The sanitation problems in the bathroom and toilet had no solution because the surface of the floor was slightly lower than the main street. Therefore, when flooding, the bathroom could not be used. The scheme of the sanitary conditions can be seen in the following figure.

Figure-14: the scheme of the sanitation position of bathroom ad toilet with no solution effort.
Source: Mulyani TH, Semarang, 2017

The sanitation system in the toilets in most homes in the study sites used the conventional wet systems using water for drainage (Hans Van Bruggen in Darwati S, 2007). The type of the closet used was squat closet as shown in the following picture.

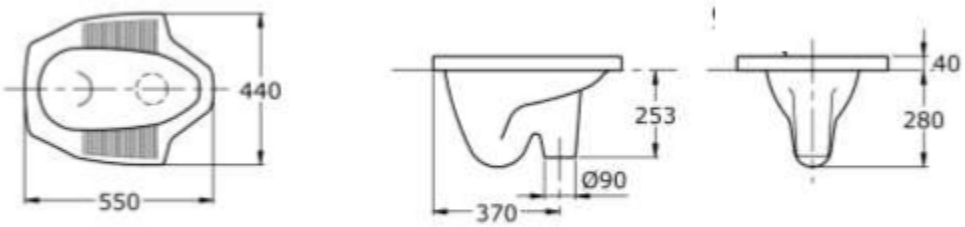
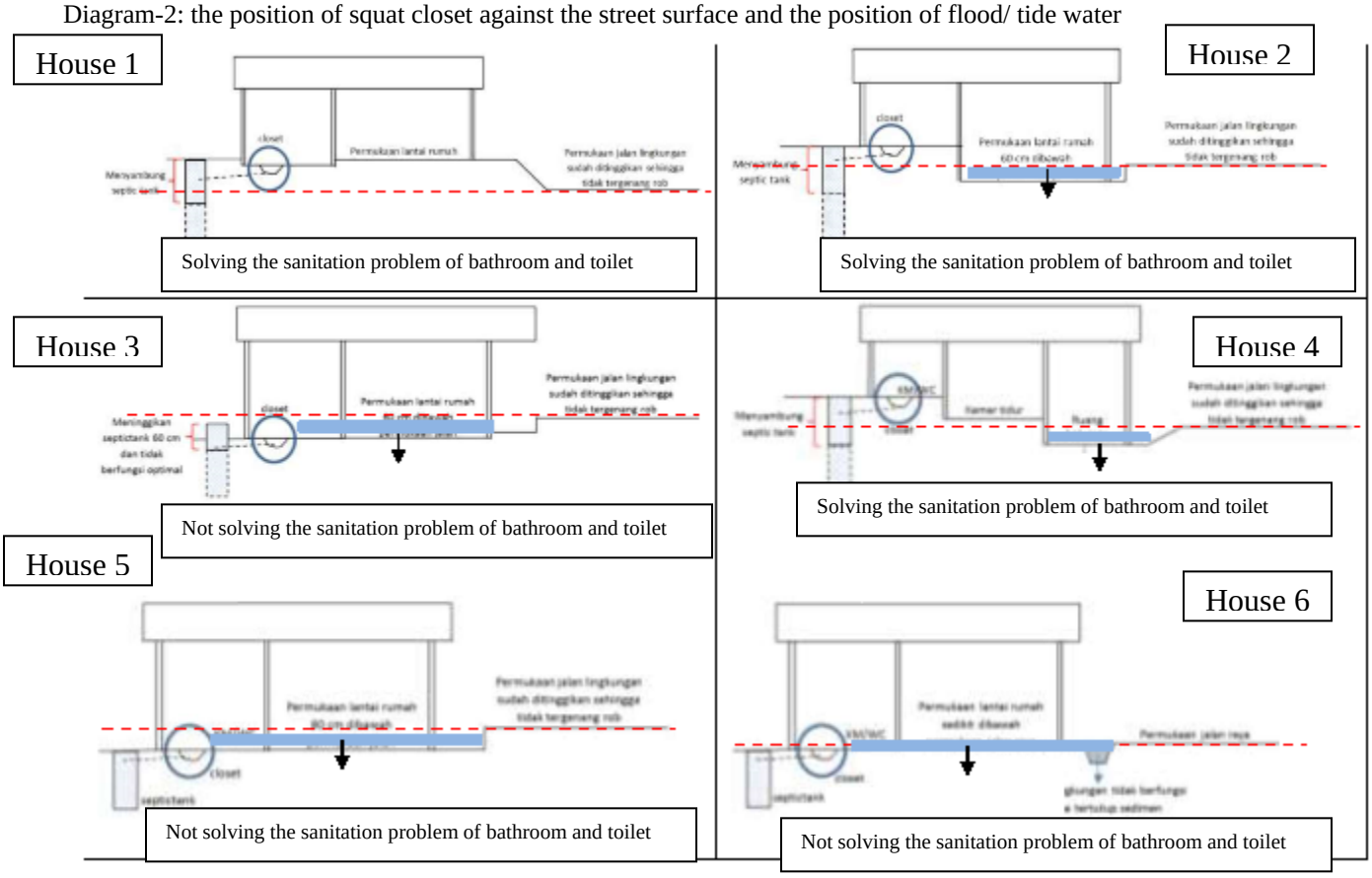


Figure-15: Squat Closet

With a wet system, it demands smooth flow of water for flushing. The system can work well when the closet is in a dry position (not inundated by flood/ tide).
The red lines in the Figs. 8-11 and 13-14 show the elevated street surface positions in order not to be inundated by flood/ tide. In the case of the houses number 3, 5, 6, the closet position was under the surface of the street (below the red line). It means that it will be inundated during the flood/ tide, so the closet could not be used because the flushing water could not flow.
In the case of the houses number 1,2,4, the position of the closets was raised and the septic tank hole was connected upward. It was intended that in flood/ tide the flushing water can still flow smoothly to the septic tank.

The comparison of squat closet position with street surface and flood/ tide water positions in the six cases of the houses can be seen in the following diagram:

Diagram-2: the position of squat closet against the street surface and the position of flood/ tide water



IV. CONCLUSION

The solutions to the sanitation problems of bathrooms/ toilets performed by the residents as the adaptation efforts to flood/ tide were:
- the collective solution in the scale of RT performed to dispose liquid waste *(grey water)* and the puddle of flood using pumps. The water was flown to the lands of PT. KAI which has been inundated into ponds..
- The individual solution performed by each house to solve the sanitation problems of bathrooms and toilets. The solution was by raising the floor surface of bathrooms and the position of the closets was higher than the street level. It was aimed to be able to use the occupied space although it was flooded.

ACKNOWLEDGMENT

The writers delivered a great gratitude to the Head of Village and the entire managers of Kemijen Village for the permit and assistance given to the researchers to collect the data in the research location. The writers also thanked Mr. Puji, Mr. Timbul, and Mr. Kusri as the public figures of Kemijen who had willingly been the informants of the research. The scheme of Penelitian Unggulan Perguruan Tinggi (the Superior Research of Higher Education) was funded by KEMENRISTEKDIKTI (the Ministry of Research, Technology, and Higher Education) in 2017.

REFERENCES

[1] Andreas H, 2016. “Penurunan Tanah di Semarang Kian Mengkhawatirkan”. Institut Teknologi Bandung

[2] Darwati S, 2007. “Tinjauan Penerapan Sanitasi Berwawasan Lingkungan Dengan Sistem Pemisahan Tinja Dan Urin**”,Jurnal Permukiman** Vol. 2 No. 3 Desember 2007

[3] Ismanto A dkk, 2009. **“Model Sebaran Penurunan Tanah di Wilayah Pesisir Semarang”.** ILMU KELAUTAN UNIVERSITAS DIPONEGORO. Desember 2009 Vol 14 (4): 189-196 ISSN 0853-7291

[4] Pryambodo DG, 2012.” Penurunan Muka Tanah Di Pesisir Semarang (Studi Kasus : Daerah Industri Kaligawe)”. Jurnal Ilmiah Geomatika Vol. 18, No. 2, Desember 2012

[5] Ramadhany AS dkk, 2012. **“Daerah Rawan Genangan Rob di Wilayah Semarang”**. Journal Of Marine Research. Volume 1, Nomor 2, Tahun 2012, Halaman 174-180, Program Studi Ilmu Kelautan, Fakultas Perikanan dan Ilmu Kelautan, Universitas Diponegoro.

AUTHORS

First Author – IM.Tri Hesti Mulyani, Lecturer on Ecological Architecture, Dept of Architecture, Faculty of Architecture and Design, Soegijapranata Catholic University, email: mulyani@unika.ac.id.
Second Author – Etty Endang Listiati, Lecturer on landscape Architecture and Behaviour Architecture, , Faculty of Architecture and Design, Soegijapranata Catholic University, email: etty@unika.ac.id.
Third Author – B.Tyas Susanti, Lecturer on Antropology, Faculty of Architecture and Design, Soegijapranata Catholic University, email: santi@unika.ac.id
Fourth Author- Djoko Suwarno, Lecturer on Civil Engineering, Faculty of Engineering, Soegijapranata Catholic University, email: dj.suwarno@unika.ac.id

Correspondence Author – B.Tyas Susanti, santi@unika.ac.id, contact number +62 813 262 79547