Development And Implementation of Infiltration Wells in 9 Districts of Sidoarjo Regency, Indonesia

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Abstract
The area of Sidoarjo Regency consists of 18 districts with a land area of around 714,245 km2 and a coastal area of around 201,687 km2. The topographical conditions in the Sidoarjo Regency are lowlands with altitudes ranging from 0 to +25 m above sea level, so that certain areas in Sidoarjo Regency show a condition that has the potential to experience flooding problems. Making infiltration wells is one of the most efficient solutions. Infiltration wells are wells or holes on the ground surface that are made to collect rainwater so that it can seep into the ground either through the roofs of buildings, roads and yards. There are 20 points spread across 9 sub-districts in Sidoarjo Regency which, based on field survey reviews, have the potential to experience flooding problems. In this area, infiltration wells will be built. Direct observation in the field is carried out to determine the condition of the area under review and to plan the design and recommendation points to be carried out. In addition to this, soil permeability conditions also need to be analyzed so that the coefficient is known. Primary data collection related to soil type classification was obtained from literacy data and soil type maps in Sidoarjo Regency. Based on direct observation and soil type literacy data, it is recommended that infiltration wells with a depth of 2 meter and a diameter of 1.1 meter be used are buis concrete and a filter system using palm fiber as a filter for sediment and waste so as not to interfere with the infiltration process in the infiltration well. 1 infiltration well can accommodate and absorb ± 1900 liters of water which can reduce flood discharge within 46 to 61 hours depending on the type of soil under review.

Keywords: Topography; Flood; Infiltration wells.

1. Introduction
The Sidoarjo Regency area consists of 18 districts, which include Sidoarjo, Balongbendo, Buduran, Candi, Gedangan, Jabon, Krembung, Krian, Prambon, Porong, Sedati, Sukodono, Taman, Tanggulangin, Tarik, Reinforcement, Waru and Wonoayu Districts. The administrative area of Sidoarjo Regency consists of land area and sea area. The land area is around 714.245 km2 while the sea area is around 201.687 km². Sidoarjo Regency is located between 112°5' and 112°9' East Longitude and between 7°3' and 7°5' South Latitude [1]. Sidoarjo Regency has regional boundaries as shown in Figure 1, which are as follows:

- The northern boundary: Surabaya City and Gresik Regency,
- Southern boundary: Pasuruan Regency and Mojokerto Regency
- Eastern boundary: Madura Strait, and
- West boundary: Mojokerto Regency.

The topography of Sidoarjo Regency is in the form of a delta plain with an altitude between 0-25 m, a height of 0-3 m with an area of 19,006 Ha, covering 29.99% which is an area of fishponds in the eastern region. The central region, which has fresh water with an altitude of 3-10 m above sea level, which covers 40.81%, is an area of settlement, trade and government. The western region with an altitude of 10-25 m above sea level is an agricultural area, covering an area of 29.20%. While the hydrology consists of groundwater, brackish, and salt water reaching area of 16,312.69 Ha. The average depth of groundwater is 0-5 m from the ground surface. Sidoarjo Regency is located between two

rivers, namely Surabaya River and Porong River which are branches of the Brantas River which originates in Malang Regency. The climate is tropical with two seasons, namely the dry season from June to October and the rainy season from November to May. The structure of the regency's soil is in the form of gray alluvial covering an area of 6,236.37 Ha; a mixture of gray alluvial and brown alluvial covering an area of 4,970.23 Ha; alluvial hydromart with an area of 29,346.95 Ha; and dark gray grumosol covering an area of 870.70 Ha [1].

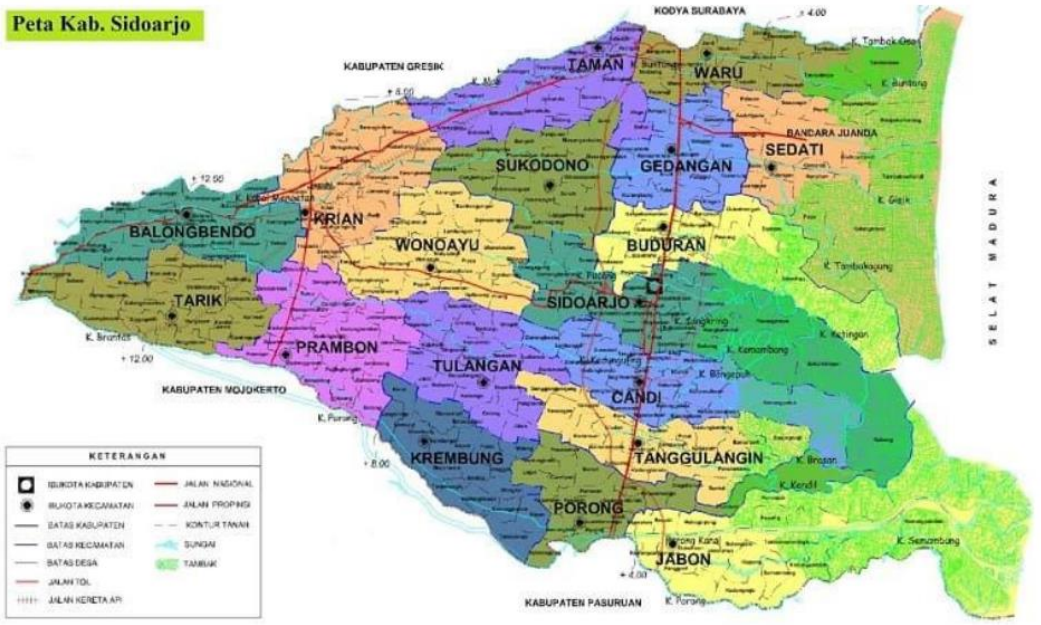

Fig. 1. Sidoarjo Administration Map
Source: BPS – Sidoarjo in Figures 2014

Topographic conditions in the Sidoarjo Regency area are lowlands with altitudes ranging from 0 to + 25 m above Sidoarjo Regency. In figures, the detailed division of the Sidoarjo Regency area based on height above sea level is shown in Table 1. And mapped as shown in Figure 2.

Table 1. Location of the Altitude of the Sidoarjo Region from Sea Level

Sea Level Altitude (m)	Information
0 - 3	Is a beach area and ponds, located in the East, covering 29.99%
3 - 10	Is an area of fresh water, located in the Middle part covers 40.81 %
10 - 25	Located in the West, covering 29.20%

Source: BPS – Sidoarjo in Figures 2014

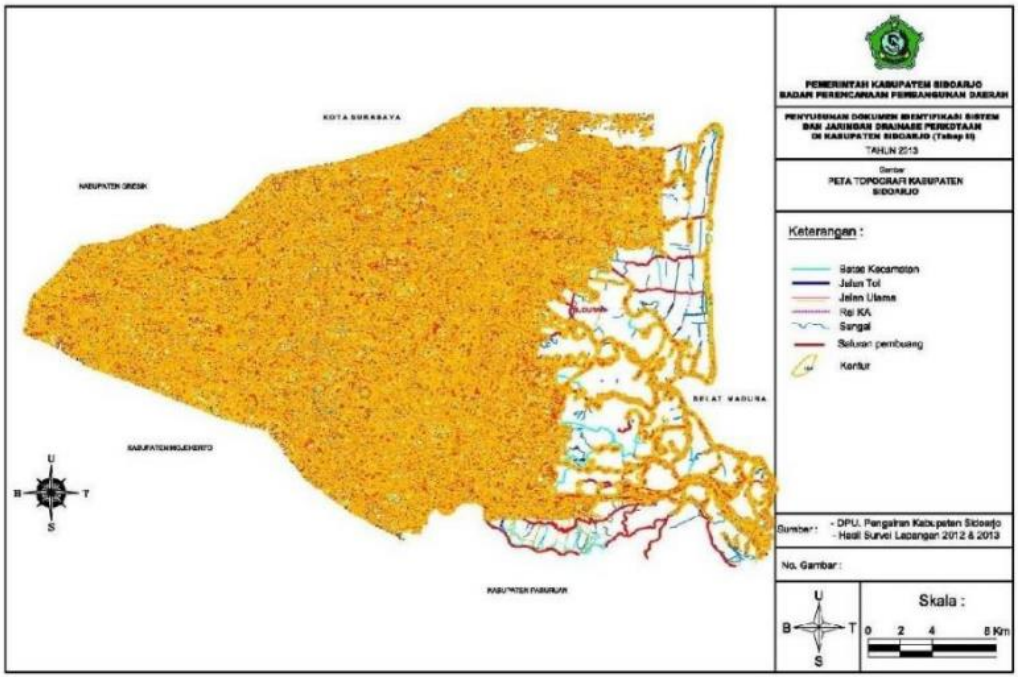

Fig. 2. Topographic Map of Sidoarjo

2. Literature review

2.1. Infiltration wells

Infiltration wells are wells or holes on the ground surface that are made to collect rainwater so it can seep into the ground. Overflow water from drainage canals and gutters is directed towards infiltration wells, to be impregnated. Infiltration wells function to collect and absorb rainwater that falls on the ground either through the roofs of buildings, roads and courtyards. [2]

2.2. Soil Permeability

Soil permeability is the ability of the soil to allow water to pass through. Soil permeability that can be used for infiltration wells is divided into three classes, namely:

1. Medium soil permeability (soil type in the form of loam/silt, has an absorption capacity of 2.0 – 6.5 cm/hour).
2. The permeability of the soil is rather fast (soil type in the form of fine sand, has an absorption capacity of 6.5 – 12.5 cm/hour).
3. Fast soil permeability (soil type in the form of coarse sand, has an absorption capacity of 12.5 cm/hour).

There are at least six main factors that affect soil permeability, namely:

1. The viscosity of the liquid, the higher the viscosity, the smaller the soil permeability coefficient.

2. The pore size distribution, the more even the pore size distribution, the smaller the permeability coefficient tends to be.
3. The grain size distribution, the more even the grain size distribution, the smaller the permeability coefficient tends to be.
4. Void ratio, the greater the void ratio, the higher the soil permeability coefficient.
5. The roughness of the mineral particles, the coarser the mineral particles, the higher the soil permeability coefficient.
6. Degree of soil saturation. The more saturated the soil, the higher the soil permeability coefficient.

Some prices of soil permeability coefficients are given in the following table.

Table 2. Soil Permeability Coefficient

Type of soil	K value (cm/s)
Sand containing clay	$1x10^{-1}$ - $1x10^{-2}$
Fine Sand	$1x10^{-2}$ - $1x10^{-3}$
Clay Sand	$1x10^{-3}$ - $1x10^{-4}$
Silt	$1x10^{-4}$ - $1x10^{-5}$
Clay	$1x10^{-5}$ - $1x10^{-9}$

Source: Author own work

2.3. Infiltration Well Material

1. Structure: The infiltration well structure is made of buis concrete with a length of 100 meters and a diameter of 110 cm. The concrete buis cover can be opened and closed for routine cleaning and control processes. The walls are also given holes to speed up the infiltration process into the ground.
2. Basic Structure: The bottom of the infiltration well is filled with stones measuring 15 – 25 cm to function as an additional filter and additional reinforcement structure.
3. Filtering System: The filtering system in the infiltration well is used to separate the sediment carried by the water from the inlet. This prevents clogging and maintains the proper function of the infiltration well. The filter is made of palm fiber which can be controlled when the sediment is full. The filter system support structure uses concrete anchors, then wire mesh is added for additional filtration.
4. Inlets/channels: Water from the drainage canal or from the house gutters is directed to an infiltration well with a 4” diameter pipe.
5. Dimensions: Planned well dimensions are made with an outer diameter of 110 cm and a minimum depth of 200 cm, this is adjusted to the size of a conventional buis concrete.

2.4. Soil Type Classification

1. Andosol soil: Andosol soils are upland soils that develop from volcanic ash as parent material. Usually, andosol soils are found at an altitude of more than a thousand meters or near a volcano. Andosol is very suitable for planting various types of plants. [3]
2. Alluvial Soil: Alluvial soil is a type of soil that is formed as a result of sediment. The sediment in question is sediment from rivers, lakes, or also from rainwater which usually stagnates a little because of the basin.

3. Method

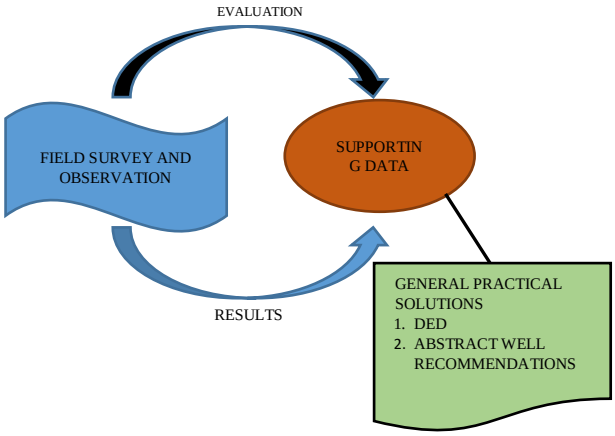

Fig. 3. Flow cart implementation method

4. Results and Discussion

Based on survey results and field observations, the following table describes in detail the condition of location points that have the potential to flood.

Table 3. Problems of each sub-district that experienced flooding

No	Subdistrict	Number of Points	Problems
1	Krian	6	- Lack of water catchment area - The water line is not functioning normally - The groundwater table tends to be low
2	Jabon	1	- Channels can not hold water with lots of debt - Depends on the intensity of rain
3	Prambon	3	- Depends on the intensity of rain - Lack of water catchment area - The water line is not working properly
4	Tulangan	3	- None and it doesn't work the drainage channel of the review area - Channels can not hold water with lots of debt
5	Wonoayu	1	- Sloping topography - Lack of adequate channels to drain the water
6	Sukodono	3	- Drainage channels often experience overflow due to large water discharge
7	Tarik	0	- Tidak ada masalah
8	Krembung	2	- There are some points that do not have drainage channel - Low ground water table
9	Balongbendo	1	- Water channels are not smooth due to garbage
TOTAL		20 POINT	

Source: Author own work

Classification of soil types is obtained from literacy data. The soil type map is made based on the classification of the level of water absorption in the average review area. In the 8 sub-districts, the types of soil are distributed as follows:

- Jabon : Alluvial land
- Krembung : Andosol land
- Prambon : Andosol land
- Balongbendo : Andosol land
- Reinforcement : Andosol soil
- Wonoayu : Andosol land
- Sukodono : Andosol land
- Krian : Andosol land

In the Jabon sub-district, which has andosol soil which has characteristics such as sandy loam soil, it has a permeability of 4.27 cm/hour, which includes a moderate permeability rate.

Recommendations for the construction of infiltration wells in Jabon sub-district which have andosol soil types with infiltration well dimensions of 110 cm in diameter and with a minimum depth of 200 cm. Obtained data as follows:
Infiltration well volume (tube)

: $\pi r^2 \cdot t$
: 22/7 x (55^2) x 200
:1901.428,57 cm3
: 1901, 42857 liter

With a volume of 1901.42857 liters and a permeability rate of 4.27 cm/hour. So one infiltration well can accommodate and absorb + 1900 liters of water which can reduce flood discharge in the area. So the andosol soil in Sidoarjo district is estimated to be able to absorb as much as + 1900 liters of water with + 46 hours.

In the seven districts reviewed, namely the sub-districts of Krembung, Prambon, Balongbendo, Reinforcement, Wonoayu, Sukodono and Krian, alluvial soil types are classified. With characteristics such as clay soil with a water saturation of 58%, it has a water absorption capacity (permeability) of 3.26 cm/hour [4] (Asep Mulyono, 2019) which includes a moderate permeability rate.

Recommendations for the construction of infiltration wells in these seven districts which have alluvial soil types with infiltration well dimensions of 110 cm in diameter and with a minimum depth of 200 cm. Obtained data as follows:
Infiltration well volume (tube)

: $\pi r^2 \cdot t$
: 22/7 x (55^2) x 200
: 1901.428,57 cm3
: 1901, 42857 liter

With a volume of 1901.42857 liters and a permeability rate of 3.26 cm/hour. So one infiltration well can accommodate and absorb + 1900 liters of water which can reduce flood discharge in the area. So the alluvial soil in Sidoarjo Regency is estimated to be able to absorb as much as + 1900 liters of water with + 61 hours.

5. Infiltration Well Design

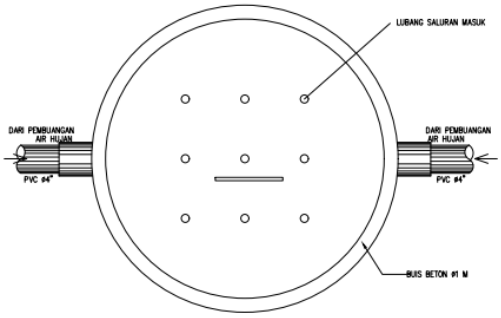

Fig. 4. Infiltration Well Plan

6. Conclusion

Sidoarjo Regency, which is a lowland area, has a land area of around 71,424.25 km², while the sea area is around 201,687 km². Sidoarjo Regency which has a topography with a height of between 0–25 meter. and with an average height of 3–10 meter covering 40.81% of the total area of Sidoarjo district.

Based on the results of observations in the field, there are 20 recommendation points for flood areas. It is recommended to provide infiltration wells at this point as an effort to reduce the impact of flooding. Infiltration wells are recommended with a depth of 2 meter and a diameter of 1.1 meter. The material used in making this infiltration well is buis concrete and the filtering system uses palm fiber as a filter for sediment and garbage so that it does not interfere with the infiltration process in the infiltration well. One infiltration well can accommodate and absorb + 1900 liters of water which can reduce flood discharge in the area within 46 to 61 hours. This depends on the type of soil under review.

To get maximum results to solve the problem of flooding in the review area. So it is necessary to conduct further studies regarding drainage channels in the review area, study the impact of flooding that occurred in 9 sub-districts in Sidoarjo Regency and planning flood prevention water pumps. Thus, the results of this study conclude that the use of infiltration wells in the sub-districts under review needs to be adjusted to the number of infiltration wells at each flood location in accordance with the existing floodwater discharge, in order to reduce flood discharge.

References

[1] BPS (2014), *Sidoarjo Regency In figures 2014*, No. 11020013515

[2] Bisri, M., Norman, A. (2009*), Imbuhan airtanah buatan untuk mer-eduksi genangan (Studi kasus di Kecamatan Batu Kota Batu) [Artificial groundwater recharge for reducing inundation (A case study at Batu district, Batu city)]*, Jurnal Rekayasa Sipil. Vol. 3. No. 67 p. 77–90.
[3] Putri, V. K. M. (2022), *Tanah Andosol: Pengertian dan Ciri-Cirinya*, https://www.kompas.com/skola/read/2022/07/01/073000069/tanah-andosol--pengertian-dan-ciri-cirinya.
[4] Mulyono, A., Lestiana, H., Rusdy, A. F., (2019), *Permeabilitas Tanah Berbagai Tipe Penggunaan Lahan Di Tanah Aluvial Pesisir Das Cimanuk*, Indramayu, Jurnal Ilmu Lingkungan, Volume 17.