

# Surface and Groundwater Interactions: Cikapundung Bandung, Kanal Banjir Timur Semarang and Cisadane Tangerang

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**Abstract.** In most Asia countries, the riverbank area is mostly inhabited by the low-income population, due to the shortage of formal housing. Most of the settlement areas are not equipped with proper sanitation system. Hence, the water quality gets lower over time with the increasing number of inhabitants around the riverbank. The water quality gets worse with the close hydrological connection between surface water and the shallow groundwater. We compare the state of water quality based on our three case studies: Cikapundung Bandung, Kanal Banjir Timur Semarang, and Cisadane Tangerang. In each location, we gathered the following data: water level measurements, water flow mapping, and water quality samples. Then we make maps to evaluate existing status. The comparison will be made based on the physical and chemical properties that we get from the field. On all locations, we find very close interactions between surface water and groundwater. The hydrological connections are different in direction from upstream to downstream: gaining stream, combined stream or perched stream, and losing stream. However different river gradient gives a slightly different length of hydrological zonations. All samples show a high bicarbonate from rain water, the dissolution of carbonate minerals from the rocks and soils, and also organic species from microbial activities, which induced by domestic wastes. However, we need to make a carbonate balance calculation to break down the components. All samples also have high nitrate and nitrite concentration which come from domestic waste along the river and fertilizer from the rice fields upstream (only in Cikapundung river). For further research, we suggest chemical modeling to break up the contamination components and possible sources.

## 1 Introduction

In most Asia countries, the riverbank area is mostly inhabited by the low-income population, due to the shortage of formal housing. Most of the settlement areas are not equipped with proper sanitation system. Hence, the water quality gets lower over time with the increasing number of inhabitants around the riverbank. The water quality gets worse with the close hydrological connection between surface water and the shallow groundwater.

Several studies on surface and groundwater interactions have been done in several Metropolitans in Asia (references) and SE Asia (references). Aside to that we also found several existing studies from Indonesia: Cikapundung, Ciliwung, Cisadane, and Bengawan Solo (references) (Figure 1). All studies identify that surface water and groundwater have close connections as most of the metropolitans are



located in lowlands, close to the coastal area, on top of a fluvial system. They also point out that water quality is closely controlled by anthropogenic contaminants, households waste, and agricultural waste.

In this paper, we compare the state of water quality based on our three case studies: Cikapundung Bandung, Kanal Banjir Timur Semarang, and Cisadane Tangerang. We need to get typical characteristics of river bank based on geological and water resources properties.



**Figure 1.** Insert location maps: (a) Cikapundung-Bandung, (b) Kanal Banjir Timur-Semarang, (c) Cisadane-Tangerang.

## 2 Materials and methods

In each location, we gathered the following data: water level measurements, water flow mapping, and water quality samples (Irawan, 2017). Then we make maps to evaluate existing status. The comparison will be made based on the physical and chemical properties that we get from the field (Table 1). All data will be made public after the submission of the full paper on OSF repository. For water level measurements, we used Solinst water level meter, and for TDS, temperature, and pH measurements we used Hanna Instruments portable equipment. All equipment was calibrated before field measurements.

**Table 1.** Data

Locations	Parameters	Sampling/ observation points
Cikapundung	Water level	50
	Water samples	20
Kanal Banjir Timur	Water level	10
	Water samples	11
Cisadane	Water level	50
	Water level	10

### 3 Results and discussions

The hydrological connections are different in direction from upstream to downstream: gaining stream, combined stream or perched stream, and losing stream. However different river gradient gives a slightly different length of hydrological zonations. All samples show a high bicarbonate from rain water, the dissolution of carbonate minerals from the rocks and soils, and also organic species from microbial activities, which induced by domestic wastes. However, we need to make a carbonate balance calculation to break down the components. All samples also have high nitrate, nitrite, and sulfate concentration which come from domestic waste along the river and fertilizer from the rice fields upstream (only in Cikapundung river and some part in Kanal Banjir Timur river). Another similarity is all three rivers serve as one of the sources for public water supply managed by local government water company (PDAM). The condition should give more reason for the government to endorse a more strict water conservation law in the areas. The comparison summary of the three rivers/channels is presented in Table 2.

#### 3.1 Cikapundung

Cikapundung is a good example showing the evolution of water quality from highlands to lowlands in a short distance, less than 100 km. The morphological features quickly change from sharply eroded mountainous terrain to a flat urban city landscape. The high gradient gives the advantage of self-natural flushing during the wet season. Looking at this feature, Cikapundung has a more favorable condition compared to the other two sites. However, it holds another risk. With poor drainage management, this rapid natural flushing system will quickly turn into flash floods in seconds. Several authors observed the connection between groundwater and river water in the river bank. It shows that the change of connection from upstream to downstream: no connection (zero flux), gaining stream, mixed stream, and then losing stream [1-3].

#### 3.2 Cisadane

Cisadane riverbank has the longest distance from the upstream compared to Cikapundung dan KBT. The water flows through several cities, Bogor, Depok, and Jakarta with heavy urban housing in the riverbank. This setting gives a severe contamination potential to this river. A set of 60 observations along the riverbank which shows that the TDS values are three or four times higher in the downstream than upstream [4], which is due to the active large and home-scale industries along its riverbank, including electro-plating home industries.

### 3.3 Kanal Banjir Timur (KBT) Channel

Kanal Banjir Timur has a length of 27.82 km which flows from the south of Semarang City to the Java Sea on the north of Semarang City. In the upper reaches, there are plantation areas and residential areas along the river, while on the downstream, there are residents and rice fields along the river. To know the relationship between river water and groundwater, then test water quality. There are 11 points of water sampling along KBT. 7 points are water from citizen well, and 4 points are water from river KBT. Water sampling is conducted in the downstream river area (data set is available at [5]). Here we also see a close similarity of groundwater with river water. Of which, we see an increase of TDS, nitrite, nitrate, and sulfate values three times from upstream and downstream. The KBT channel has a more reserved riverbank as no settlements are allowed to be developed in its river bank.

### 3.4 Regulations, references, data loggers

The water quality flowing on the three rivers and the groundwater flowing in the aquifer in the riverbank area doesn't getting better unless we make efforts to manage the water. Recently the only law concerning water management (UU No. 7/2004) was evaluated and withdrawn with no revised version up to now. The no revised version would a drawback for water regulators as no other national law (UU) that regulates water resources as such details as the withdrawn law [6]. However, the references written in this here are limited, due to the limited online availability of published scholarly works. More detail literature study should be done using text mining and reference manager to visualize all researches that have been done in all three areas [7]

Technically, we see that all water level observations were not done rapidly to make a good time series data. We propose more researchers in these areas should use data logger tools to record the water level and water temperature in the riverbank intensively to understand the interactions between groundwater and surface water.

**Table 2.** A summary of river comparison.

No	Rivers	Length (km)	Basins (km <sup>2</sup> )	Min elevation (mdpl)	Max elevation (mdpl)	Gradient
1	Cikapundung	28.5	0.4	600	1500	31.6
2	Cisadane	137.6	1367	0	3002	21.8
3	KBT	27.82	74.07	0	1300	46.7

No	Rivers	Water similarity*	TDS increase	Season when observed	Morphological setting
1	Cikapundung	Similar	2 times	Combined	Highlands
2	Cisadane	Similar	3 times	Combined	Coastal
3	KBT	Similar	3 times	Combined	Coastal

## 4 Conclusions

Water quality is highly controlled by land use and anthropogenic activities. Therefore the authorities must have a strong control on those aspects to conserve water quality, surface water as well as groundwater. The results of this paper show a strong control of anthropogenic activities to steer water quality. However, due to limited time series data, we still cannot determine the exact component in the

process. Hence for further research, we suggest chemical modeling to break up the contamination components and possible sources.

Moreover, we need to gradually, restore the role of river bank zone as a buffer zone, using more engineering efforts. The efforts are due to the vast development of unregistered settlements along the riverbank. We also suggest for the authorities to compose more integrated rules on the subject, to replace the withdrawn UU 7/2004.

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