Decreasing groundwater quality at Cisadane riverbanks: groundwater-surface water approach

Irawan, DE.[1], Puradimaja, DJ.[1], Yeni, D.[3], Kuntoro, AA.[2], and Julian, MM.[1]

1 Faculty of Earth Sciences and Technology, Institut Teknologi Bandung, Jalan Ganesa No. 10, Bandung-40132, West Java, Indonesia
2 Faculty of Civil and Environmental Engineering, Institut Teknologi Bandung, Jalan Ganesa No. 10, Bandung-40132, West Java, Indonesia
3 Agency for Environment of Tangerang Regency, Institut Teknologi Bandung, Jalan Ganesa No. 10, Bandung-40132, West Java, Indonesia

E-mail: `erwin@fitb.itb.ac.id`

Abstract.

The decreasing of groundwater quality has been the major issue in Tangerang area. One of the key process is the interaction between groundwater and Cisadane river water, which flows over volcanic deposits of Bojongmanik Fm, Genteng Fm, Tuf Banten, and Alluvial Fan. The objective of this study is to unravel such interactions based on the potentiometric mapping in the riverbank. We had 60 stop sites along the riverbank for groundwater and river water level observations, and chemical measurements (TDS, EC, temp, and pH). Three river water gauge were also analyzed to see the fluctuations.

We identified three types of hydrodynamic relationships with fairly low flow gradients: effluent flow at Segmen I (Kranggan - Batuceper) with 0.2-0.25 gradient, perched flow at Segmen II (Batuceper-Kalibaru) with gradient 0.2-0.25, and influent flow at Segmen III (Kalibaru-Tanjungburung) with gradient 0.15-0.20. Such low flow gradient is controlled by the moderate to low morphological slope in the area. The gaining and losing stream model were also supported by the river water fluctuation data. TDS and EC readings increased more than 40% from upstream to downstream. At some points the both measurements were two times higher than the permissible limits, along with the drops of pH values at those areas.

This study shows the very close interaction between Cisadane river water and groundwater in the riverbank. Therefore the authorities need to be managed the areas with a very strict regulations related to the small and large scale industries located near by the river.

Keywords: Cisadane, groundwater-river water interactiona, water quality

1. Introduction

In this area, groundwater has been used for domestic, industrial, agricultural and aquaculture purposes for more than 100 years. It has been highly exploited since 1990s due to the raise of urbanization and economy. The river flows through areas that has been developed as central of economy activities. It has to be supported by all means of water sources, including Cisadane (Figure 1) and Figure 2.

Major impact due to such condition is the decreasing of groundwater quality has been the major issue in Tangerang area as shown by organic and non-organic indicators[10, 12, 6, 13, 15, 4]. One of the key process is the interaction between groundwater and Cisadane river, as also shown by another case in Cikapundung river basin. The objective of this study is to unravel such decreasing as a function of water interactions between river water and groundwater in the riverbank. This information will be important for optimal use and sustainable management of the water resources in the area.

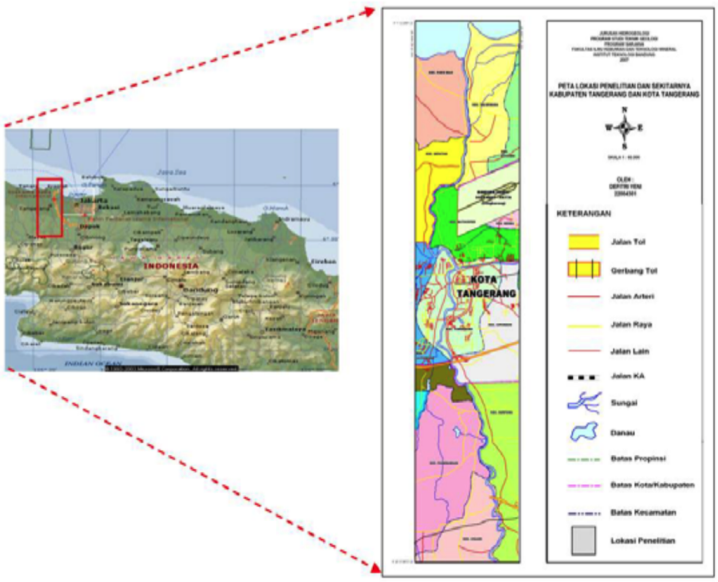

Figure 1. Map of the study location

2. Materials and methods

The field investigation and sampling of river, canal and groundwater were performed in the dry season of 2006. Totally, 30 water samples were stored in 100 ml plastic bottles, consist of: 10 river water samples and 20 groundwater samples from shallow private tube-wells, with well depth ranges from 10m to 30m below land surface. The sample dates are rather old but the results are still relevant with current situation. We propose newer research in 2011 by a team from Sam Ratulangi University [9] for comparison.

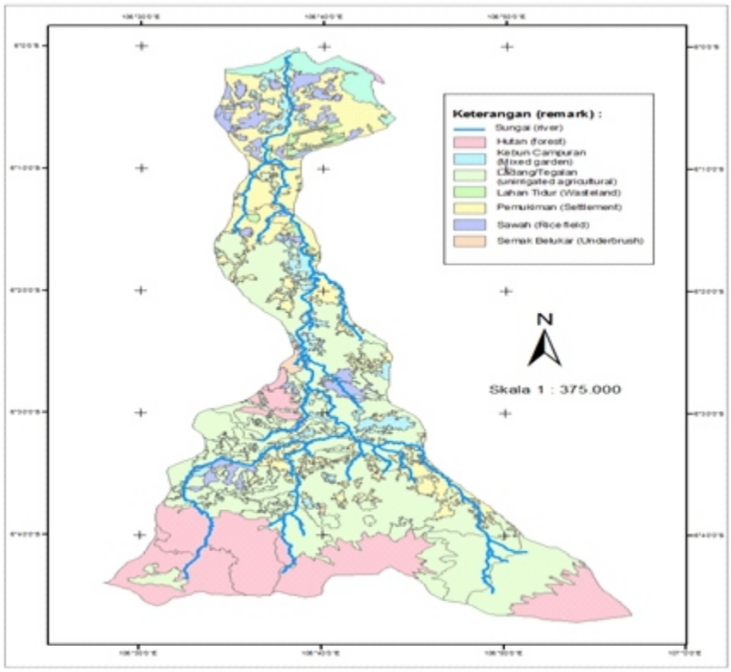

Figure 2. Profile showing the deteoriating water quality towards downstream

We conducted field measurements consist of groundwater levels, temperature, pH, Electrical Conductivity (EC), Total dissolved solids (TDS) using portable tools, Hanna Instruments. The samples collected were filtered and sent to the laboratory to be analysed to determine their Dissolved Oxygen (DO), major cations (sodium, potassium, calcium, magnesium) and major anions (chloride, sulfate, nitrate) by using inductively coupled plasma optical emission spectrometer (ICP-OES) and chromatography(IC). We also used Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) to obtain the organic setting in the environment.

Groundwater and river water level data were used to make potentiometric map. We plotted the data set and build a water flow model based on the contours using using GIS software. Subsequently, we intrepreted the interaction between groundwater and river water based on the following model (Figure 3), gathered from following sources [5, 16, 3].

3. Results and discussions

Potentiometric mapping has shown three major river water-groundwater interactions (Figure 4) at three segments as follows:

(i) Effluent interaction (Segment 1, Kranggan Batu Ceper) with characteristics:

- groundwater recharges to river,
- river water level elevation 10 -18.75 masl,
- groundwater level elevation 12.5- 30 masl,

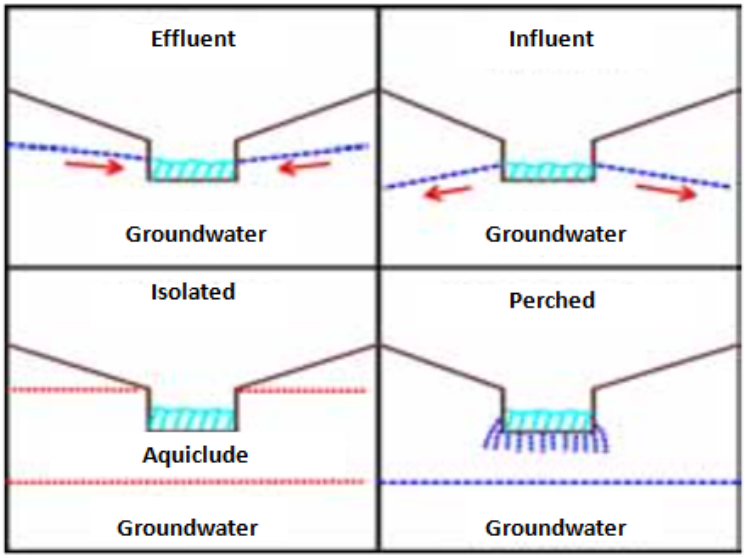

Figure 3. Profile showing the deteriorating water quality towards downstream

- hydraulic gradient from 0.2 to 0.25.

(ii) Perched interaction (Segment 2, Batuceper-Kalibaru) with characteristics:

- river water infiltrates to aquifer in river bed. The distance between river bed and groundwater level ranges 1.25 7.5 m,
- river water level elevation 6.25 12.5 masl,
- groundwater level elevation 1 - 4 masl,
- hydraulic gradient from 0.2 to 0.25.

(iii) Influent interaction (Segment 3, Kalibaru-Tanjungburung) with characteristics:

- river water infiltrates to aquifer,
- river water level elevation 0 - 5 masl,
- groundwater level elevation 0 2 masl,
- hydraulic gradient from 0,15 to 0,2.

At all three segments, groundwater flow is controlled by relatively flat ground level with slope gradient between 0.016 to 0.02). Following such condition, groundwater flow gradient is also very low, from 0.15 to 0.25 (see Figure 4). Two geological sections have been built to give a short illustration on the subsurface condition of the area (Figure 5). We can see variation of geometry of young alluvium deposit in all segments with fairly random in thickness.

The deterioration of river and groundwater quality is shown by the increasing concentrations of Iron, Copper, TSS, BOD, COD, and E. coli towards downstream (Figure 6). Such contamination is due to the increasing settlement and industrial activities along the river. Related publications [9, 7, 14] confirm such condition. Average TSS content 73.38 mg/l (higher than max limit of 50 mg/l) portrays high natural erosion, and also man-made sand digging sites in the Kranggan area. Solids from aerated Fe^{2+}

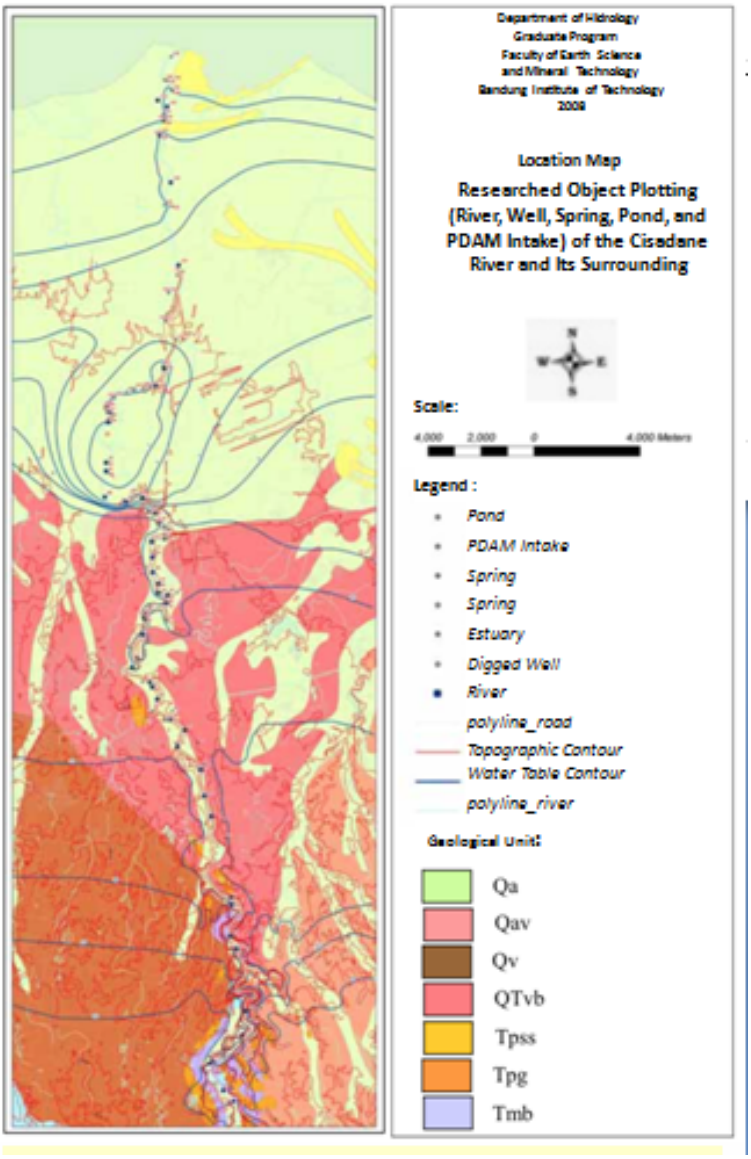

Figure 4. Profile showing the deteoriating water quality towards downstream

and Cu^{+} can also contribute to the TSS value. The samples also show averagely high iron content 0.61 mg/l (max limit: 0.30 mg/l) and Copper 0.13 mg/l (max limit: 0.02 mg/l) which possibly came from many electroplating industries in the riverbank, as one of the source. Organic condition is indicated by average BOD value 8.42 mg/l (limit: 2 mg/l), COD 25.75 mg/l (limit 10 mg/l), and E. coli 6275/100 liter (limit 1000/100 liter). All three indicators are higher than tolerable limits, which came from poor sanitation and domestic waste management. Similar situation is shown in Cikapundung river [1, 2, 8, 11, 6].

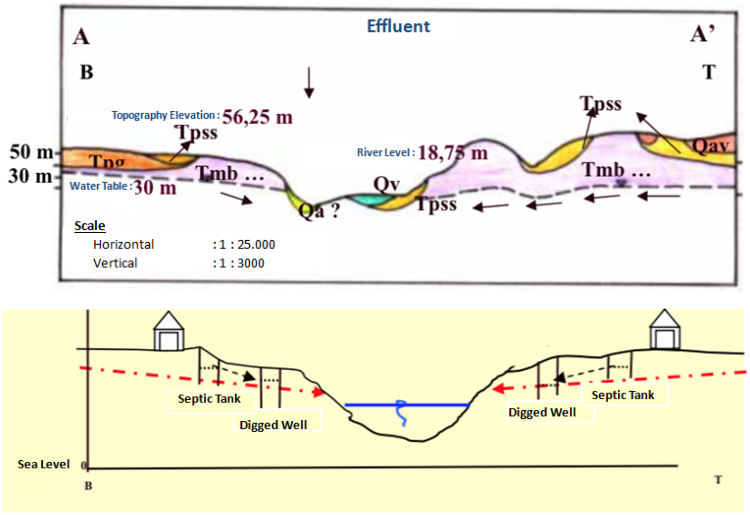

Figure 5. Example of subsurface profile in section 3

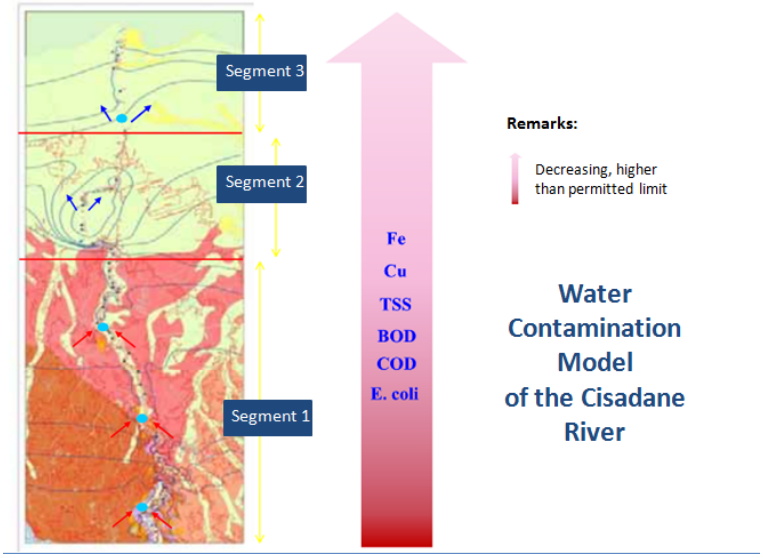

Figure 6. Profile showing the deteoriating water quality towards downstream

4. Conclusions

The results from this paper can be used to explain water quality deterioration along Cisadane riverbank. Three unique groundwater and river water interactions have been detected using relatively simple and cheap method. Major element concentrations were able to show the quality transition from upstream to downstream. However more samples should be added with more heavy or trace minerals measurements such as As and Pb for more detail water quality zones and involving processes.

The above-mentioned situation has been un-treated. Many efforts in years have been done to overcome the contamination, but the impact is still not significant. Our results in 2006 is still comparable with what another team had identified in 2011.

Therefore we need to strongly address the condition to be continuously treated by the local government and inter-governments collaboration.

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