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Developing groundwater conservation zone of unconfined aquifer in Semarang, Indonesia

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Abstract. The increasing exploitation of groundwater affects some environmental problems such as declining groundwater levels and its quality, land subsidence, seawater intrusion, and flooding in Semarang. Nowadays, groundwater protection and its management programs are crucial in Semarang due to raising several environmental problems. Semarang has two different morphologies i.e. lowlands, and coastal plains are in the north while hilly areas spread in the south. The main objective of this research is delineating groundwater conservation zone based on its current status of groundwater both in quantity and quality. The hydrogeology mapping was performed by measuring water table as well as physical parameters of groundwater samples from both dug wells and springs. Results conduct that the groundwater depth is approximately 0.03 m to 34 m below ground surface and flowing from the south to the north. The pH varies between 4.63 and 8.95. The Dissolved Oxygen is around 0.06-3.37 mg/L while salinity has yielded up to 3,600 mg/L in the north of Semarang. The EC value is in a range from 39-6,370 µS/cm. Based on lowering the water table, deterioration of groundwater quality, and land subsidence there are four groundwater conservation zones, i.e. secure, vulnerable, critical, and damaged zones.

1. Introduction

The issue of urban groundwater management is growing significance for groundwater-dependent cities due to its urbanisation has a major impact on aquifer beneath cities [1]. One of the consideration transformations in Indonesia is about urbanization. The proportion of people living in urban areas exceeds 50% by 2010 and will reach up to 60% by 2025. Badan Pusat Statistik (BPS-Statistics Indonesia) [2] stated that the increasing population is unevenly distributed in Indonesia. Java Island is the most populated with an annual population growth around 0.37-1.9% in the years 2000-2010. The highest percentage of urban growth in Java Island occurs in the coastal cities.

Semarang, as an urban coastal city and a capital city of the Central Java Province in Indonesia, is facing some enviromental problems (e.g. declining groundwater level and its quality, land subsidence, seawater intrusion, and flooding) related to the groundwater used which is in response to population growth [3] – [5]. Statistic Center Bureau of Semarang City [6] reported the rate of population growth in the last five years (2010-2015) increased around 0.85%. Recently, it is up to 1.59 million people live in Semarang. According to Ditjen Cipta Karya [7], the standard of fresh water in Semarang as a metropolitan city is around 150 L/person/day. Hence, it needs around 239x10^6 L/person/ day or up to 87.3 million cubic meters per year (MCM/yr). However, the local water board (PDAM) can only provide 44.5 MCM/yr or around 50% of water needs [6]. Thus, people employ groundwater to fullfil their fresh water need. Groundwater plays a major role in the total of the water supply of much of in Semarang. One of the main aquifer system in Semarang is the unconfined aquifer [8] – [10]. Groundwater is exploited by numerous dug wells, mainly for domestic water supply in the unconfined aquifer. However, overexploitation and poor groundwater management contribute to disreputable groundwater depletion problems and deterioration in groundwater quality.

Given the steadily expanding groundwater dynamics in the urban coastal city, it is thoughtful to take an adjusting concept to groundwater resource management guided by developing groundwater conservation zone. The conservation zone is advanced by monitoring of groundwater levels and its quality trends. This should authorize the assessment of future prognoses and precede to more robust and sustainable solutions to municipal water supply [11]. Moreover, there may be a need to examine the potential loss of water supply access of dug wells in areas of very shallow water table. Thus, this study aims at delineating groundwater conservation zone of the unconfined aquifer by considering such criteria as lowering the water table, deterioration of groundwater quality, and land subsidence.

2. Hydrogeologic Setting

Semarang has two different morphologies, namely coastal plains and lowlands in the north, and hilly area in the south. The northern part, where the economic and trade centre such as an airport, bus and train stations, and harbour are located, is relatively flat to gentle with slopes ranging between 0 and 5° and altitude up to 30 m sea level datum (masl). Meanwhile, in the southern part, slopes reach up to 45°, and altitudes reach up to 440 masl [12]. The land use in the north is mainly residence with higher density than in the south, industrial zones, ponds, and transportation areas. Open space areas (such as plantation, forest, moor) and residence are the main land use in the south of Semarang.

According to the regional hydrogeological map of Semarang [13], which the study area is located in Semarang (a capital of Central Java Province, Indonesia), the occurrence and productivity of aquifer can be divide into three as shown in Figure 1. In the northern part, the aquifer is mainly flowing in the intergranular system. It consists of the extensive aquifer with higly to the productive aquifer. The main litology in this aquifer system is alluvial deposits. Meanwhile, in the southern part, aquifer mainly flows both through fissures, and interstices which extensive spreading and moderately productive, but locally also available productive aquifer. It is located in the hilly area where volcanics and sedimentary rocks presence. There are areas with poor productivity as well as a region without exploitable groundwater due to the presence of sedimentary rocks such as claystone and marl appear.

3. Methods

The integrated approach of the hydrogeological mapping, physical parameters assessment, and spatial analysis were the basis methods to achieve the main objective of this research. Measuring water table of the dug wells and its geographical position, and investigating surface lithology were performed in the hydrogeological mapping. There were three hundred and eighteen (318) measurements of groundwater table and physical parameters of water sample (pH, Dissolved Oxygen/DO, salinity, and Electrical Conductivity/EC). The values were then interpolated to visualize the groundwater level and its quality maps. Lowering water table, deterioration of groundwater quality, and land subsidence rates were the parameters to delineate groundwater conservation zone [14]. All parameters were depicted into raster images and overlaid into a groundwater conservation zone map by using spatial analysis in ArcGIS. There were four (4) zones namely secure, vulnerable, critical, and damaged zone (Table 1). The secure zone was represented by low of EC value (<1,000 µS/cm) and groundwater level decline up to 40%. Meanwhile, the vulnerable zone was depicted by a scale of EC value between 1,000-1,500 µS/cm and lowering groundwater level in the range 40-60%. Areas where the EC value up to 5,000 µS/cm and above with lowering groundwater level more than 60% including the subsidence rates >8 cm/yr were in the critical zone and damaged zone. In the damaged zone, heavy metals were a presence to enhance unfavourable areas.

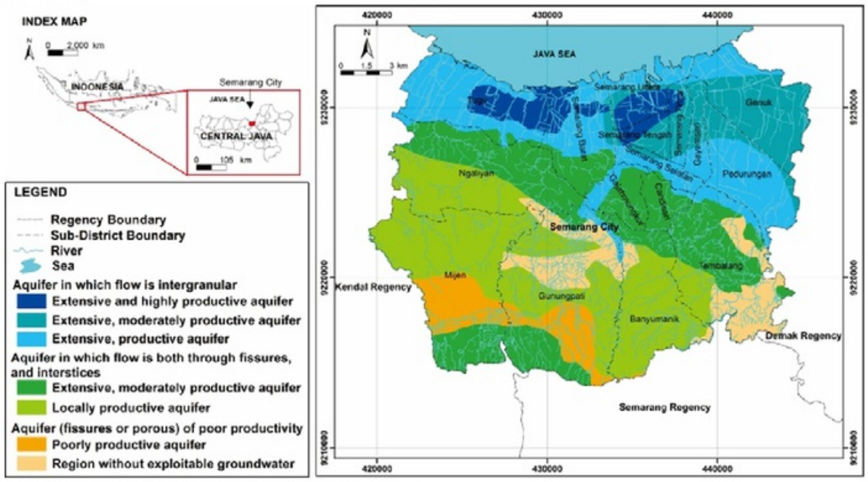

Figure 1. Hydrogeological map of Semarang.

Table 1. Matrix for delineating groundwater conservation zone

Groundwater Quality	Lowering groundwater level			
	< 40%	40%-60%	60%-80%	> 80%
EC< 1,000 µS/cm	secure			
EC 1,000-1,500 µS/cm		vulnerable		
EC 1,500-5,000 µS/cm and subsidence			critical	
EC>5,000 µS/cm and the toxic heavy metal presence				damaged

4. Results and discussion

4.1 Groundwater level

Groundwater from the unconfined aquifer is abstracted by numeourus dug wells in Semarang. According to the hydrogelogical mapping, the groundwater depth is approximately 0.03 m to 34 m below ground surface and flows from the south to the north. The minimum depth is found in the north to the east of Semarang i.e. Genuk Sub-District, Semarang Utara Sub-District, and Semarang Timur Sub-District. Water table depth is below 2 m. Meanwhile, the water table depth in the centre to the south (Semarang Tengah Sub-District to Gunungpati Sub-District) varies between 2 and 34 m. The maximum depth is found in Kembangarum (Semarang Barat Sub-District). Groundwater levels in Semarang are around below 1 meter to 376 masl. To assess declining the groundwater level, the groundwater level in 2016 compare to the report of Direktorat Tata Lingkungan Geologi dan Kawasan Pertambangan [15] that provides water table measurement in 2003 (Figure 3). The declining groundwater level in the north and the east of Semarang is up to 15 m (80-85% of the lowering water table). Meanwhile, In the centre and the west, it is around 5-10 m drop of the water table. There is insignificance water table diffence in the south of Semarang. It means the groundwater used of the unconfined aquifer in these areas less than in

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the north and the east. Furthermore, it shows in the spreading of dug wells location which is very dense in the north and the east of Semarang (Figure 2).

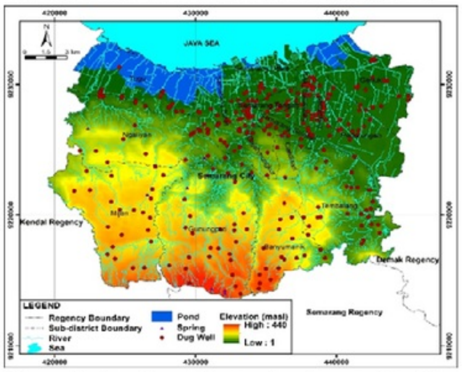

Figure 2. Location of groundwater samples. The elevation is retrieved from Digital Elevation Model [18].

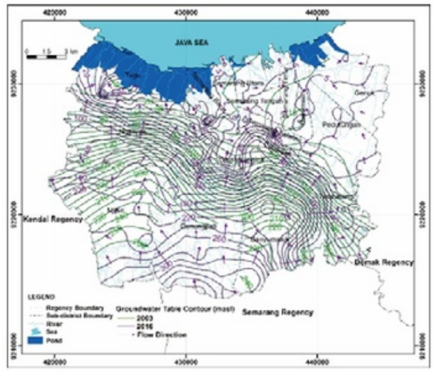

Figure 3. Groundwater level and its direction. Equipotensial lines in 2003 and 2016 are represented by green and purple respectively.

4.2 Groundwater quality

pH on groundwater samples provides a range from 4.88 to 8.9 (Figure 4). The minimum and maximum pH values are found in Mijen Sub-District and Gunungpati Sub-District respectively. Both areas are located in the highlands. Meanwhile, the pH values of the water in coastal plains and lowlands of Semarang are neutral around 6.5-8.2. As stated by WHO [16], the pH values are in desirable range for pH in water-drinking quality. Although pH usually has no direct impact on water consumers, it is one of the most fundamental operational water-quality parameters.

EC is a measure of water capacity to conduct electrical current. The EC value is varying from 39 to 6,370 µS/cm with an average of 855 µS/cm (Figure 5). The acceptable limit of EC in drinking water is recommended as 1,500 µS/cm [16]. The minimum and maximum of EC values are 39 and 1,313 µS/cm respectively. The EC value in the highlands of Semarang shows in an average of 406 µS/cm. Thus, groundwater in this region is permissible for drinking water. Meanwhile, the EC has a range 274-6,370 µS/cm with the average of 1,154 µS/cm in the coastal plains and lowlands. The highest of EC is found in the northeast of Semarang. High EC value in that area indicates the enrichment in groundwater. The EC value also represents the index of the total content of dissolved solids in water. It can be classified as type I, if the EC<1,500 µS/cm indicates the enrichments of salts are low; type II if EC 1,500-3,000 µS/cm represent the enrichments of salts are medium, and type III if EC above 3,000 µS/cm expresses the enrichments of salts are high [17]. According to with EC classification above, 84% of samples in the coastal plains and lowlands are in type I (low enrichments of salts), 13% of type II, and around 3% samples are type III. The latest is mainly located in the north (Genuk Sub-District), and the east (Semarang Timur Sub-District). The effect of seawater intrusion leads the medium to high level of the enrichments of salts in those regions.

Accordance with EC, groundwater samples in coastal plains and lowlands indicates high salinity from 1,500 mg/L up to 3,600 mg/L in the north and the east of Semarang (Figure 6). It is obviously that sea water coming in those areas. Meanwhile, in the center and the west, salinity ranges between 400 and 800 mg/L. Low salinity appears in the south of Semarang which is varying 0-200 mg/L. It illustrates fresh water predominant in the highlands.

DO is a major indicator of groundwater quality which often controls the fate of dissolved organic contaminants by constraining the types and numbers of microorganisms present within an aquifer [19]. Dissolved oxygen is available into the water by diffusion from the atmosphere, aeration of the water, and as a waste product of photosynthesis. The DO level ranges from 0.06-3.37 mg/L in the study area

(Figure 7). The low DO is found in the lowlands and coastal plains in the north and the east of Semarang which is below 1 mg/L. Several factors affect the low DO level such as the water is too warm, many bacteria and an excess amount of Biological Oxygen Demand (BOD). It means in these regions no supporting for aquatic life organisms due to the DO level below 3 mg/L.

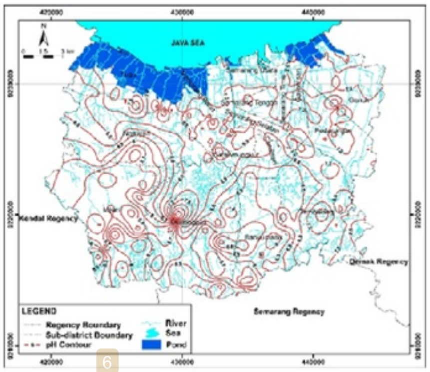

Figure 4. pH map of the study area.

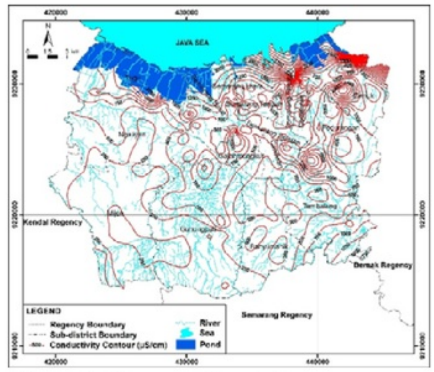

Figure 5. EC map of the study area.

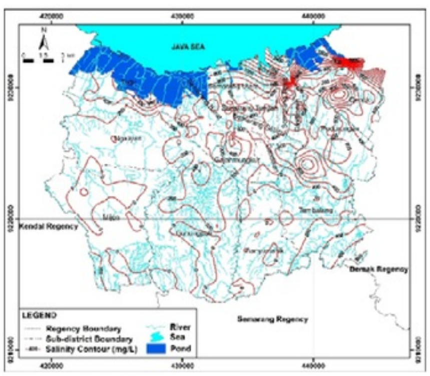

Figure 6. Salinity map of the study area.

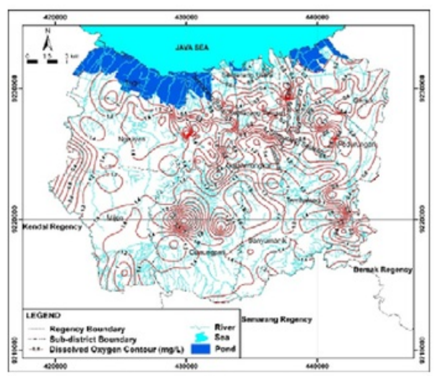

Figure 7. DO map of the study area.

4.3 Land subsidence

Several researchers [3],[12],[20] investigated land subsidence in Semarang using several geodetic monitoring methods such as levelling surveys, Persistent Scatterer Interferometry (PSI) technique, GPS surveys, and microgravity surveys.

The land subsidence in Semarang is supposed to be resulting mainly from natural compaction in alluvial sediments, excessive of groundwater abstraction and load of construction (i.e. settlement on high compressibility soil). The lowlands and coastal plains of Semarang consist of unconsolidated alluvium with alternating layers of medium grained sands with gravel and clayey sands and clayey materials. They are the aquifer composition in these regions which groundwater is excessive abstracted. The consolidation occurs as a consequence the water pressure in the aquifer declines and compression occurs within the sand layers. The number of registered deep wells in Semarang-Demak groundwater basin increase sharply in the 1980s. In 1900, the total number of deep wells was 16, become 260 in the 1990s and the first decade of the new millennium it goes to 1,127 wells with total abstraction more than 30 million cubic meters per year [21].

Based on the results of Kuehn et al. [20] investigation of land use using Persistent Scatterer Interferometry (PSI) as shown in Figure 8, the annual land subsidence rates detected vary from a millimeter to above 8 cm per year. Distribution and visualization of the ground motion data evidently shows the boundary between preferably stable ground in the south and the increasingly land-subsidence affected land towards the harbor area (Semarang Utara Sub-district) in the north.

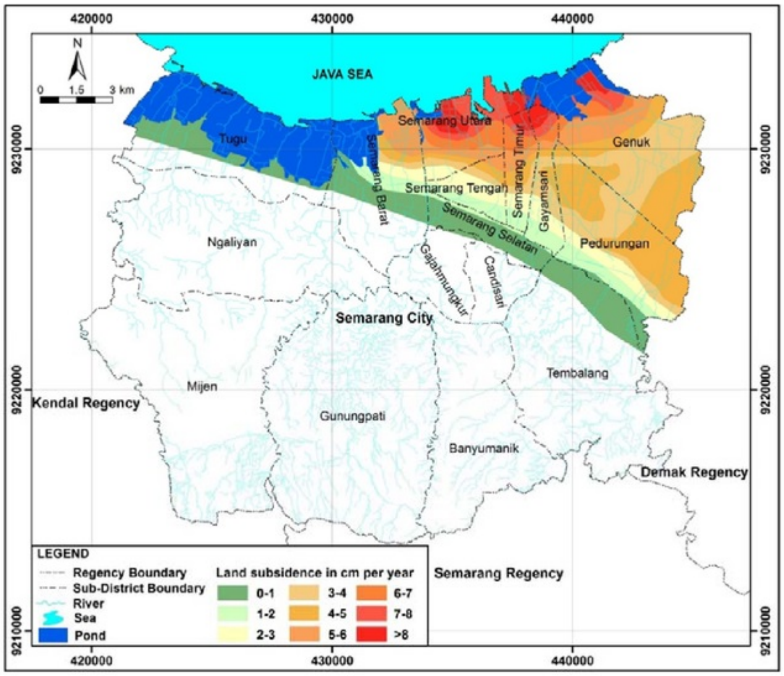

Figure 8. Land subsidence in Semarang (adapted from Kuehn et al. [20]).

4.4 Groundwater conservation zone

Three parameters which are groundwater quality, lowering groundwater level, and land subsidence rates must be concerned to develop groundwater conservation zone of an unconfined aquifer. Groundwater quality is represented by the classification of water quality based on EC value while lowering groundwater level depicts groundwater used in some periods. Furthermore, land subsidence interprets a geological hazard as an impact of natural and human activities is a major constraint to the city development.

All parameters to develop groundwater conservation zone are explained clearly above, a spatial analysis in ArcGIS is then applied to overlay those parameters become a groundwater conservation zone map (Figure 9). There are four zones which are secure, vulnerable, critical, and damaged. The characteristics of each zone is shown in Table 2.

The secure zone is mainly located in the center to the south of Semarang (gentle slope to highlands), groundwater is favorable for water drinking with low of EC value (<1,000 µS/cm), insignificant of lowering water table (<10%), and land subsidence rate maximum 2 cm/year in the center of Semarang. The vulnerable zone widespread in the city center to the east and the west, and locally in the middle slope due to the EC value reaches up to 1,500 µS/cm, but it is acceptable for water drinking. The water table in this zone is around 30-40% decline in the land subsidence rate up to 4 cm/yr. Lowlands in the north to the east of Semarang are classified into the critical zone due to EC value up to 5,000 µS/cm. It means groundwater quality in these regions permissible to unsuitable for water drinking. Moreover, in the area which is the EC value above 2,000 µS/cm, it is classified as medium to high salinity water. Thus, groundwater in this area has no recommendation for water drinking. Furthermore, this critical zone has the impact of land subsidence with the rate up to 7 cm/yr, and water table drops up to 60%. The damaged zone spreads in the coastal plains which is located in the north of Semarang. Groundwater in this region is unsuitable for water drinking due to sea water intrusion occurs in this region. It is reflected by the EC value above 5,000 mg/L. Water table declines more than 80%, and land subsidence rate more than 7 cm/yr. Indeed, Suryono et al. [22] reported that toxic heavy metals detected in shallow groundwater of Semarang coastal region. Toxic heavy metals levels (mg/L) in the water were Cr^{2+} 5.083±1.59, and Pb^{2+} 5.52±1.34. Those levels were exceeded the maximum permissible limit for drinking water by WHO [16].

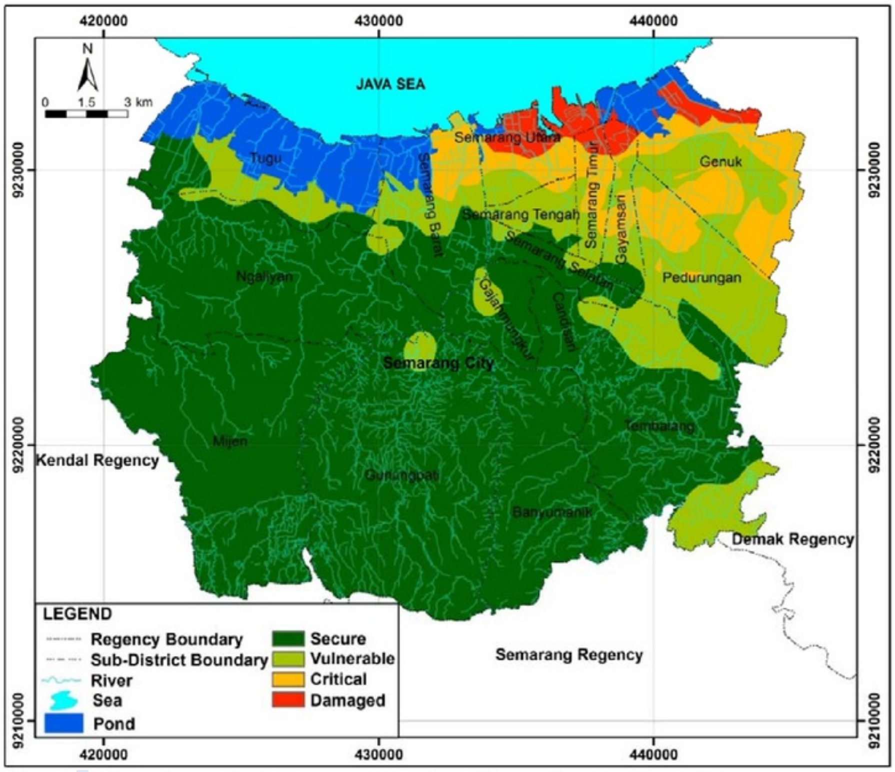

Figure 9. Map of groundwater conservation zone of unconfined aquifer in Semarang

Table 1. Parameter for defining groundwater conservation zone of unconfined aquifer in Semarang

Parameter	Groundwater conservation zone			
	Secure	Vulnerable	Critical	Damaged
Groundwater quality (EC µS/cm)	<1,000	1,000-1,500	1,500-5,000	>5,000
Lowering groundwater level (%)	5-10	30-40	50-60	80-85
Land subsidence rate (cm/yr)	0-2	2-4	4-7	>7

5 Conclusion

Groundwater quality, lowering of water table, and land subsidence rates are the main parameters to develop groundwater conservation zone of unconfined aquifer in Semarang, Indonesia. There are four conservation zones which are secure, vulnerable, critical, and damaged. In the secure zone, groundwater is pleasant for drinking water in the south of Semarang. Human activity needs to be a concern in the vulnerable zone (the center of Semarang) to preserve groundwater quality. Groundwater in this zone is permissible for drinking water. Meanwhile in the critical zone which widespread in the north to the east of Semarang, groundwater is moderate to high salinity water. Groundwater is classified as doubtful to unsuitable for drinking water related to its quality, and sea water occurs in this region. Furthermore, the damaged zone strictly has no recommendation for water drinking. The presence of toxic heavy metals and sea water intrusion predominant affect that groundwater is unsuitable for water drinking in the north of Semarang.

Acknowledgments

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References

[1] B Morris 1999 Earthwise Sustainability *Urban Groundwater: Monitoring the contamination of aquifers below cities* ed J. Thomas (Nottingham: British Geological Survey) p 23

[2] Badan Pusat Statistik (BPS-Statistics Indonesia) *Population Growth by Province*, Retrieved from http://www.bps.go.id/tab_sub/view.php?kat=1&tabel=1&daftar=1&id_subyek=12&notab=2 (Citation date: January 12th, 2014)

[3] M A Marfai and L King 2007 Monitoring Land Subsidence in Semarang, Indonesia *Environmental Geology*. **53(3)** 651 – 659

[4] N Rahmawati and M A Marfai 2013 Salinity pattern in Semarang Semarang Coastal City *Indonesian Journal on Geoscience*. **8(2)** 111-120

[5] E Suhartono, P Purwanto, and S Suripin 2015 Seawater Intrusion Modeling on Groundwater Confined Aquifer in Semarang *Procedia Environmental Sciences*. **23(2015)** 110 – 15

[6] Statistic Center Bureau of Semarang City 2015 *Semarang City in Figures* (Semarang: Badan Pusat Statistik Kota Semarang)

[7] Ditjen Cipta Karya 1996 *Standar Kebutuhan Air Bersih Untuk Keperluan Rumah Tangga* (Jakarta: Departemen Pekerjaan Umum)

[8] Spitz K and Moreno J 1996 *A practical guide to groundwater and solute transport modeling* (Canada: John willey & sons Inc.)

[9] Arifin M B and Wahyudin 2000. *Penyelidikan potensi cekungan air tanah Semarang, Jawa Tengah; data dan analisis* (Bandung: Direktorat Geologi Tata Lingkungan)

[10] T T Putranto and T R Rüde Hydrogeological model of an urban city in a coastal area, case study: Semarang, Indonesia. *Indonesian Journal on Geoscience*. **3(1)** 17-27

[11] S D Foster, R Hirata and K W F Howard 2010 Groundwater use in developing cities: policy issues arising from current trends. *Hydrogeology Journal*. **19** 271-274

[12] H Z Abidin, H Andreas, I Gumilar, T P Sidiq, M Gamal, D Murdohardono, Supriyadi, and Y Fukuda 2010 Studying Land Subsidence in Semarang (Indonesia) Using Geodetic Methods *FIG Congress Facing the Challenges – Building the Capacity (Sydney, Australia, 11-16 April 2010)*

[13] H D Said and Sukrisno 1988 *Hydrogeological Map of Indonesia Scale 1:250.000 Sheet VII Semarang (Jawa)* (Bandung: Directorate of Environmental Geology)

[14] Danaryanto, Djaendi, Harnadi D, Mudiana W and Budiyanto 2007 *Kumpulan panduan teknis pengelolaan airtanah* (Bandung: Pusat Lingkungan Geologi)

[15] Direktorat Tata Lingkungan Geologi dan Kawasan Pertambangan 2003 *Laporan akhir kajianzonasi konfigurasi dan tata guna air bawah tanah pada Cekungan Semarang-Demak, Subah, dan Karanganyar-Boyolali* (Bandung: Direktorat Tata Lingkungan Geologi dan Kawasan Pertambangan)

[16] WHO/World Health Organization 2011 *Guidelines for drinking-water quality 4th Ed.* (Geneva, Switzerland)

[17] S V S Prasanth, N S Magesh, K V Jitheshlal, N Chandrasekar, and K Gangadhar 2012 Evaluation of groundwater quality and its suitability for drinking and agricultural use in the coastal stretch of Alappuzha

District, Kerala India. *Appl Water Sci*. **2**(165-175)

[18] Jarvis A, Reuter H I, Nelson A, Guevara E 2008 *Hole-filled SRTM for the globe Version 4*, available from the CGIAR-CSI SRTM 90m Database. Retrieved from http://srtm.csi.cgiar.org. (citation date: June 26th, 2010)

[19] S Rose and A Long 1988 Monitoring dissolved oxygen in groundwater: some basic consideration *Ground Water Monitoring & Remediation*. **8(1)** 93-97

[20] F Kuehn, D Albiol, G Cooksley, J Duro, J Granda, S Haas, A Hoffman-Rothe, and D Murdohardono 2010 Detection of land subsidence in Semarang, Indonesia, using stable points network (SPN) technique. *Environmental Earth Scince*. **60(5)** 909-921

[21] Putranto T T 2013 *Hydrogeological and numerical groundwater flow model in Semarang/Indonesia* (Aachen: Dissertation RWTH Aachen University Germany)

[22] C A Suryono, B Rochaddi, A Sabdono, and B T Susanti, 2007 Physico-chemical characteristics and heavy metal contents in shallow groundwater of Semarang coastal region, *Journal Ilmu Kelautan*. **12(4)** 227-232

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GENERAL COMMENTS

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