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Daftar Isi

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ANALYSIS OF SUBSIDENCE SOURCE IN JAKARTA USING TIME-LAPSE MICROGRAVITY

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Abstract

Jakarta as capital city of Indonesia has some environmental and energy sustainability problems. Some environmental problems at Jakarta are highly populated city and highly potential for natural disaster and energy resources due to geology condition of Jakarta area as an active island arc Indonesia. These matter cause the natural disaster, such as subsidence and groundwater level lowering. In this research, we improved geophysical methods, time-lapse microgravity to analyze and to make a model of subsidence source in Jakarta. Using striping filter we can extract anomaly caused by subsidence and combined it with groundwater level changes data we got subsidence value based on it's sources such as groundwater withdrawal and other sources except ones. Based on time-lapse microgravity data and groundwater level changes data, we can analysize source of subsidence at all part of Jakarta.

Keywords: subsidence, groundwater level lowering, time-lapse microgravity, striping filter

Introduction

Jakarta as a capital of Indonesia has some environmental and energy sustainability problems. Some environmental problems at Jakarta are highly populated city and highly potential for natural disaster and energy resources due to geology condition of Jakarta area as an active island arc Indonesia. Increasing population and industry at Jakarta have impacted on the excessive extracting groundwater and energy. These matter cause the natural disaster, such as subsidence and groundwater level lowering.

Hutasoit and Pindratno (2004) said that Jakarta as geologically laid on Quarter and tertiary rock unit with active structure. Relative young age of the rock, occurred of high compressibility clay and active structure caused that area have high risk on subsidence. Human activity such as groundwater withdrawal, load of building and construction, dewatering, decreasing of absorber due to infrastructure, subsurface development, increasing risk of subsidence. Natural geology and hydrogeology condition, and human activity caused this area have high risk on subsidence.

According to Abidin et. al. (2009), land subsidence in Jakarta can be caused by four factors, namely: excessive groundwater extraction, load of buildings and constructions, natural consolidation of alluvium soil, and tectonic activities. Up to now, there is no information yet about the contribution of each factor on the subsidence at each location and their spatial (contribution) variation. In case of Jakarta, tectonic activities seem to be the least dominant factor, while excessive groundwater extraction is considered to be one of dominant factor. The first three factors will have close relation with urban development activities in Jakarta and its surrounding areas. By simulation method, at the 1950 – 1999 period groundwater withdrawal only influenced ± 17% of total subsidence in the most intens subsidence area (North Western area) Jakarta Mining Agency and LPPM-ITB (1999).

To handle these situations, it is important to conduct improvement/development methods for solving Jakarta environmental and energy problems. In this research, we have improved geophysical method by analysis the **time-lapse microgravity** methods to identify subsidence and groundwater level lowering at Jakarta and its surrounding areas. This method was chosen because Jakarta is mostly located in/close to the country area, so we need the method which using handy equipment (moveable), easy in station to station movement, no environmental damage, minimum in 'electricity support', small team and nearly no social conflict.

Methods

Subsidence And Groundwater Level Changes In Jakarta

Land subsidence in several places in Jakarta has been measured since the early 1980's using several techniques. Rate of land subsidence which measured using several techniques given in Table 1 (Abidin et. Al.,2009).

Table 1. Land subsidence rate of several places in Jakarta which measured using many techniques (Abidin et. Al. (2009)

Technique	Period	Rate (cm/year)
Leveling Survey	1982 – 1991	0 – 9
	1991 – 1997	0 – 25
GPS Survey	1997 – 2008	0 – 25
INSAR	2006 – 2007	0 – 12

In order to control extraction of groundwater from the reservoir, Jakarta Mining Agency an BPLHD has been measured groundwater level at several places in Jakarta. Result of measurement shows that groundwater level in Jakarta was decreased at several places and increased at other places, but decreasing of groundwater level in dominant.

Many researcher have carried out investigation on the causes of subsidence in Jakarta. Rismianto and Mak (1993), Murdohardono dan Tirtomihardjo (1993), concluded that main source of subsidence in Jakarta is groundwater withdrawal. Abidin et.al (2001) has comparated subsidence and hydrogeology data, and concluded that subsidence have strong relation and caused by groundwater withdrawal. Maathuis, et.al (1996) found inconsistency in groundwater level lowering and changes of benchmark elevation patern, and concluded that settlement caused by natural compaction and infrastructure loading is a source of subsidene also. Purnomo et.al. (1999) interpreted subsidence and groundwater level maps, and found that groundwater withdrawal was significant source of subsidence in many area but at other area it's not significant.

Time-Lapse Microgravity Anomaly

To understand sources of subsidence in Jakarta especially which caused by groundwater withdrawal, microgravity measurements have conducted in two years, 2007 and 2008. Measurements have done in same season to minimize effect of rain fall.

The main cause of gravity changes at the same observation point between surveys are vertical ground movement and subsurface change (Allis and Hunt, 1986). Subsurface change factors that affect gravity differences are change in ground water level, changes in saturation (soil moisture content) in the vadose zone, change in rainfall (seasons), and other fluid change in subsurface. Local topographic changes, horizontal ground movement and changes in gravity at the base station are other factor causing gravity change.

The gravity effects of groundwater movements and changes in subsurface density are obtained by correcting the measured gravity anomalies for the gravitational effect of vertical ground movement

(subsidence) and change in base value if any. For convention, a decrease in gravity is referred to as a negative change (groundwater level lowering) and an increase (groundwater level upheaval) a positive value. Negative value implies groundwater withdrawal (discharge) and positive change imply groundwater increased (recharge).

One meter of water level change at reservoir with 30% porosity can cause gravity change of about 12,579 µgal. Result of gravity measurements in Jakarta at 2007 and 2008 were given in Figure 1.

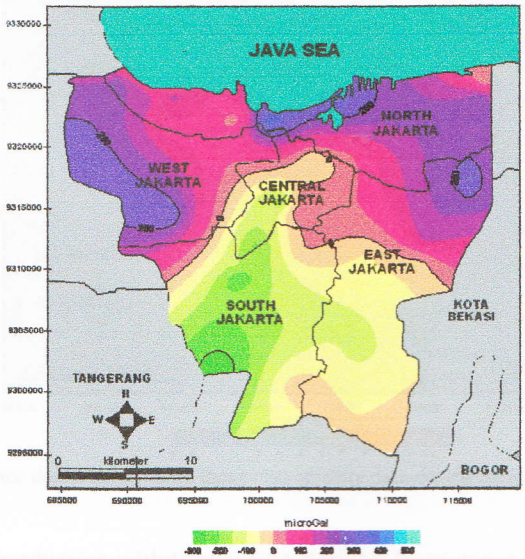

Figure 1. Time-lapse microgravity anomaly Sept. 2007 – July 2008 period.

Result And Discussion

The main sources of time-lapse microgravity are ground movement and sub-surface change, such as groundwater level change. Based on this statement, we can separate both of time-lapse main sources using a filter. In this research we used striping filter (Aina, 1994; Cordell, 1985; Zaenudin, 2009) to separate both of them.

Result of filtering process are time-lapse microgravity anomaly caused by subsidence and change of subsurface mass. Subsidence which derived from time-lapse microgravity data is total subsidence, caused by several sources of subsidence. Total subsidence as a result of filtering given in Figure 2.

Filtering result used striping filter shows that subsidence has occurred at all part of Jakarta with value about 0 to 12 cm.

The high value of subsidence, about 9 to 12 centimeters, was happened at North Jakarta, triple junction boundary of Central Jakarta, South Jakarta, and East Jakarta, and part of South Jakarta.

Medium subsidence, about 5 to 8 centimeters happened at eastern part of North Jakarta, southern part of West Jakarta, south western part of South Jakarta, and eastern part of East Jakarta.

Low value of subsidence, 0 to 4 centimeters, happened at northwestern part of West Jakarta and North Jakarta, southern part of South Jakarta, northeastern part of East Jakarta, and eastern part of North Jakarta.

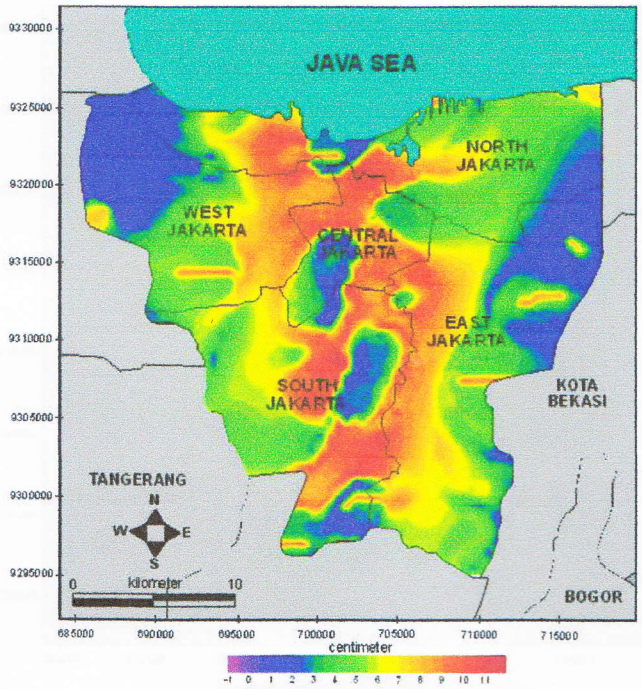

Figure 2. Subsidence derived from time-lapse microgravity data during period of 2007 to 2008

Subsidence caused by groundwater withdrawal was derived from groundwater level changes data which direct measured from groundwater monitoring well.
Result of subsidence sources modeling are given at **Figure 3** for groundwater level lowering and **Figure 4** for other sources.

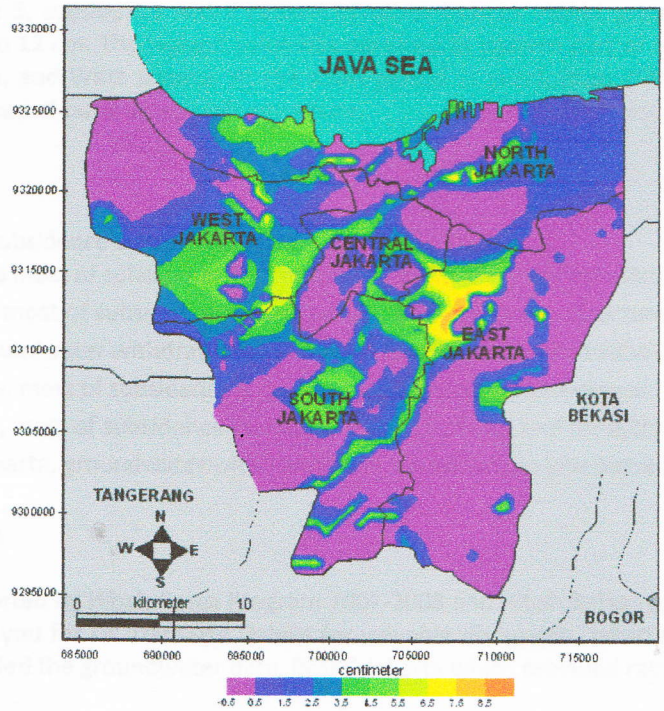

Figure 3. Subsidence caused by groundwater level lowering during period of 2007 to 2008

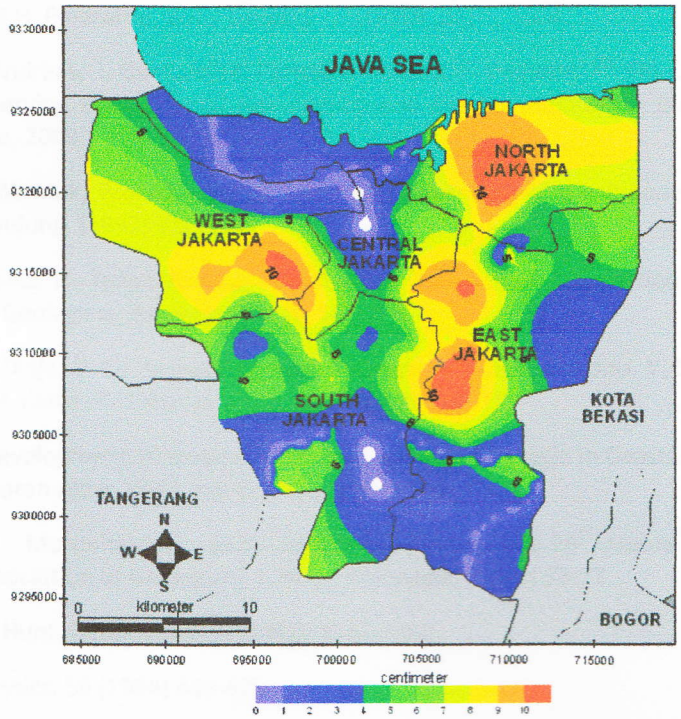

Figure 4. Subsidence caused by sources except groundwater level lowering during period of 2007 to 2008

Groundwater level lowering as impact of groundwater withdrawal, given in Figure 4 has caused subsidence in Jakarta about 0 to 9 centimeters. The highest impact of groundwater withdrawal on subsidence was happen in northwestern part of East Jakarta.

According to Figure 5, subsidence which caused by other sources except groundwater withdrawal has value about 0 to 12 cm. The highest value has occurred at eastern part of North Jakarta, a large part of East Jakarta, and West Jakarta. At the short period (1 year), from 2007 to 2008, the most possible source is load of building and infrastructure.

Conclusion

Based on result of subsidence source analysis we concluded that :

1. At North Jakarta most of subsidence caused by load of building and infrastructure.
2. At East Jakarta, most of subsidence caused by load of building and structure but at a few part of East Jakarta groundwater withdrawal give significant influence for the subsidence.
3. At South Jakarta, most of subsidence is caused by groundwater withdrawal.
4. At West Jakarta, most of subsidence caused by load of building and infrastructure.
5. At Central of Jakarta, groundwater withdrawal and infrastructure give same influence.

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References

[1] L.M. Hutasoit, M.H. Pindratno, Buku Longsor - P3TPSLK, BPPT, 2004.

[2] H.Z. Abidin, H. Andreas, I. Gumilar, M. Gamal, Y. Fukuda, T. Deguchi, 7th FIG Regional Conference Spatial Data Serving People: Land Governance and the Environment – Building the Capacity Hanoi, Vietnam, 2009

[3] D. Rismianto, W. Mak, Proceedings 22nd Annual Convention of the Indonesian Association of Geologists, Bandung, (1993) 327-345.

[4] D. Murdohardono, H. Tirtomihardjo, Proceedings 22nd Annual Convention of the Indonesian Association of Geologists, Bandung, (1993) 346-354.

[5] H.Z. Abidin, R. Djaja, D. Darmawan, S. Hadi, A. Akbar, H. Rajiyowiryono, Y. Sudibyo, I. Meilano, M.A. Kasuma, J. Kahar, C. Subarya, Natural Hazard 23 (2001).

[6] H. Maathuis, Development of Groundwater Management Strategic in Coastal Region of Jakarta, Indonesia, Laporan Akhir, BPPT dan IDRC, Jakarta, 1996.

[7] H. Purnomo, D. Murdohardono, M.H. Pindratmo, Proceedings 28th Annual Convention of the Indonesian Association of Geologists, Jakarta, Indonesia, (1999) 53-72.

[8] R.G. Allis, T.M. Hunt, Geophysics. 51 (1986) 1647-1660.

[9] A. Aina, Geophysics. 59 (1994) 488-490.

[10] L. Cordell, 55th Annual International Meeting, SEG, Expanded Abstracts, (1985) 217-218.

[11] A. Zaenudin, Dissertation, Study Program Applied Geophysics, Bandung Institute of Technology, Indonesia, 2009.