Prediction of time-lapse microgravity value based on groundwater change map in 2003 - 2010 at Dayeuhkolot industrial area, Bandung

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Abstract. Changes in groundwater levels in the industrial area were seen on ground air maps from the Directorate of Environmental Geology in 2003 and 2010. Digitization of groundwater level maps was carried out and then the changes were analyzed for getting the volume of water used. Time-lapse microgravity is sensitive to density changes. To get the value of density changes of groundwater, we need information such as rock porosity and water density. In this case we assumed that the porosity value is 30% and the water density value is 1 gr/cc, so the value of water density changes is 0.3 gr/cc. The value of density changes is distributed across the entire volume of groundwater changes during 2003 to 2010. The volume of groundwater changes in interval 2003 to 2010 was around 33,971,200 m3. From calculation of time-lapse microgravity for geometry the reduction of groundwater in the Dayeuhkolot industrial area shows the highest value about -125 microGal. The time-lapse microgravity of the Dayeuhkolot industrial area during 2003 to 2010 shows a value -125 microGal which is very detectable with a gravimeter like Scintrex CG-5 which has accuracy up to 1 microGal.

1. Introduction
Gravity can be considered an optimal geophysical method for cave detection, given the high density contrast between an empty cavity and the surrounding materials [1]. microgravity survey could be an adequate and relatively cheap monitoring tool for the identification [2]. In gravity surveys, many unwanted effects are produced by geological or non-geological sources [3]. The gravity anomaly to the position of station can be calculated instead of the gravity anomaly relative to the datum [4]. The interpretation of the Bouguer gravity anomalies ranged from visual inspection of figures to more complex methods that involved modelling of the subsurface layers [5].

This study is planned to find out the dominant regions experiencing land subsidence and decreasing groundwater level in the South Bandung area. Some researchers have conducted research related to phenomena of ambiguity, decreased water level and sea water intrusion. Abidin et al. stated that subsidence was caused by several factors, namely: groundwater extraction, natural compaction, loading on the surface due to buildings and infrastructure and tectonic activity [6]. Hutasoit and Pindratno stated that groundwater extraction is not the only cause of ambiguity and besides that geologically and hydrogeologically and human activities result in vulnerability to phenomena of ambiguity [7]. Marsudi, states that a decrease in groundwater level causes an increase in the effective stress on the soil and if the amount of effective stress exceeds the voltage received by the previous soil, the soil will experience...
consolidation resulting in land subsidence. Rapid population growth will put great pressure on Natural Resources (SDA) in South Bandung [8].

2. Method

2.1. Research area geology
According to van Bemmelen as in figure 1, physiographically the area of West Java is divided into five major parts, namely the North West Alluvial Plain of Java, the Bogor Anticlinorium, the Dome and Mountains of the Middle Depression Zone, the Middle Depression Zone of West Java, and the Southern Mountains of West Java. The research area is located in the Bandung Zone, precisely in the Dome and Mountains of the Middle Depression Zone. The Bandung zone is a volcanic area that is relatively depressed compared to the flanking zone, the Bogor Zone and the Southern Mountain Zone. Most of them are filled with young alluvial and volcanic deposits (Quaternary) from volcanic products located in the lowlands in the border area and form a line. Although the Bandung Zone forms depression, its height is still quite large, such as the Bandung depression with an altitude of 700-750 masl (meters above sea level). In some places in this zone is a mixture of Quaternary and Tertiary sediments, the Tertiary mountains are the Bayah Mountains (Eocene), hills in the Cimandiri Valley (continuation of the Bayah Mountains), Bukit Rajamandala (Oligocene) and the Rongga plateau including the Jampang plains (Pliocene), and Kabanaran Hill [9].

![Figure 1. Division of physiographic zones in West Java](image_url)

2.2. Acquisition microgravity
At the measurement stage in the field using the gravity method, before making measurements or data acquisition in the field the first step we have to do is to look at the geological map and topographic map, the purpose is to determine the measurement path and base station. In determining the base station, it is usually chosen at a location that is stable enough, easily recognizable and accessible. Base stations can number more than one depending on the state of the field. Each base station should be explained carefully and in detail including the position and place name. This base is used as a daily closing point and also as a reference value for other gravity stations. In determining the base station for microgravity measurements, several parameters are needed, namely:
The measurement point must be in a place that is clearly visible and easily recognizable.

The measurement point must be read on the map.

The measurement location must be easily accessible and free from motor vehicle interference and other disturbances.

The location of the measurement point must be open so that it is easy to find GPS signals.

Then the location of the reference point is determined or the base station must be a point or place that is stable and easy to reach. This reference point is very important because field data retrieval is done in a loop, i.e. starting at a predetermined point, and ending at that point too. The Loop system is expected to eliminate errors caused by shifting gravimeter readings. This method arises because the device used during the measurement will experience a shock, thus causing the zero point reading to shift on the tool. If possible or if there is a reference point this needs to be tied to the binding point that has been measured previously. In the data acquisition, the looping system is used so that it can obtain a tool floating rate correction (drift) caused by device shocks during the journey so that there is a change in the reading of gravity meter values. In the gravity method in the data acquisition process there are several data that must be recorded, namely the reading time (days, dates and hours), the gravity meter reading value, the coordinates of the measurement points, and the height at the measuring point. Actually, if we use the latest tools at this time, all the data above has been automatically saved when taking measurements, but it is also good that we manually record it as a backup if there is an error or damage to the equipment we use when making measurements. Data retrieval is carried out at predetermined points with certain measurement distance intervals.

2.3. Processing data

The reading value of the data from gravity measurements shows the magnitude of the gravitational pull due to the earth's time and the effects of the Earth's rotation. So that in the processing of gravity data, there are several corrections that must be done before the power can be interpreted. All effects of gravitational pull force which are not related to the effect of changes in subsurface density must be removed (corrected). These effects are variations in latitude, elevation changes, topography and tides. Here are some steps that can be done in processing gravity observation data:

- Calculation of drift correction (float correction);
- Calculation of earth tide correction (tidal correction);
- Calculation of observed gravity anomaly (anomaly gravity observation);
- Calculation of latitude (correction of latitude) correction;
- Calculation of terrain correction (field correction);
- Calculation of free water correction (free air correction);
- Calculation of correction for bouguer;
- Calculation of gravity bouger anomaly;

3. Results

The Bouger anomaly map is shown in figure 2, which is a collection of various anomalous values from the source anomaly below it. The price of Bouger anomalies at each measurement point is the combined price of a relatively shallow subsurface geological structure with deep geological structural elements. Anomalous sources are generally divided into regional and residuals. Regional anomalies have a low frequency, while residual anomalies have a high frequency. The Bouger anomaly pattern shown in figure 2 describes the shape of the Bandung Groundwater Basin, which has a low and high anomaly so it is patterned.
In this initial research we tried to use the Gravity Vertical Gravity method, which means that the gravity measurement is carried out at least twice in the same point, with different heights. In general, we use heights between 0 m and 60 cm from the ground. This is done to get a negative anomaly that is strengthened so that the Groundwater Face is lost due to Industrial usage and the community can be detected properly. Vertical Gradient Gravity results can be shown in figure 3.

To determine changes in groundwater level (MAT) that occurred, then added data analysis of groundwater in 2010 which can be seen in figure 4.
Figure 4. Map of groundwater in 2010.

In the figure, it can be seen that the measurement concentration is in the negative zone of the form of groundwater in 2010, then overlaid the two maps to get the changes in the form of groundwater that occurs at this time. Then the results obtained in figure 5.

Figure 5. Map of the 2010 vertical gradient gravity overlay and groundwater advance.

In the figure, it can be explained that in 2010 the negative toilet pattern was only 1 large pattern, whereas in fact there were three patterns of anomalies. The first pattern is Boguer anomaly which is -0.32 to -0.6
which indicates that the change in groundwater level is very large. The second pattern is Bouger anomaly valued at -0.32, and the third pattern is an anomaly valued at -0.1 which indicates that the change in groundwater level is not so significant. This happened because Bouger's anomaly area which was valued at -0.32 to -0.6 turned out to be an industrial-dense area.

From the change in the value of the Bouger anomaly, according to the change in groundwater level issued by ground air maps from the Directorate of Environmental Geology. So that the prediction of using this microgravity is relevant to changes in groundwater levels that occur in the industrial area of Bandung, Bandung.

4. Conclusion

The results obtained from research on the prediction of microgravity values obtained from changes in groundwater level with microgravity values are changes in groundwater level with changes in microgravity values. By predicting the microgravity value that occurs due to a decrease in the groundwater level, the value of microgravity is around -0.32 to -0.6. This calculation is done using vertical gradient gravity, which is used as a change in rock mass. The results of vertical gradient gravity analysis indicate that there is a very negative value in the industrial area that is solid which indicates a change in the groundwater level in the area. The rock characteristics seen from this gravity response are that the flow of water flows from north to south and from west to south.

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