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On the Influence of DC Railway Noise on Variation Data from Tangerang Geomagnetic Observatories

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***Abstract*—Geomagnetic variation data from the observatories in Tangerang (TNG, Indonesia) significantly suffer from disturbances caused by DC electric railways. The aim of this study is to quantify the impact of these disturbances on quantities derived from such data, as the K index of magnetic activity. Therefore, undisturbed data have been reconstructed by means of a moving average filter. The comparison of the K index derived from original and reconstructed data shows an decrease of quiet time segments by 25.92% for TNG. Furthermore, the distribution of the corrected K indices agrees well with the one from the Tuntungan observatory in Medan Indonesia.**

Keywords*— *Geomagnetic observations; DC railway noise; Moving Average; K index.

I. INTRODUCTION

Geomagnetic observatory must provide variation data that free from interference or noise, because the resulting data reflect only the expected natural conditions without mixed noise originating from man-made. Because of this, the magnetic observatory should be and should remain far enough from man-made disturbances (Jankowski, and Sucksdorff, IAGA 1996). Especially electric rail system running with direct current (DC) should be avoided or placed a safe distance (Nezka et al, 2013). Geomagnetic observatory at least should have distance to the observation building 300 meters from other buildings and at least within 1 km from the railway, if the railroad is electric, the distance has to be several kilometers, and in case of DC trains tens of kilometers, depending on the conductivity of the ground. (Jankowski , and Sucksdorff, IAGA 1996).

In fact, some of the magnetic observatories in Indonesia are located close to several sources of interference and man-made disturbance. This is evident from the variation data were recorded on variometer instrument and have the impact on the natural values of inaccuracies in the determination of the magnetic field around the area. This is what happens on Tangerang geomagnetic observatories (TNG), as can be seen at figure 1, where in 1997 an electric railway line became fully operational. Coupled with the operation of the wholesale market Tangerang in 2001 and residential population are growing rapidly.

From the above issues in the same case in several countries have found some answers. One of the most extreme solutions is to move the magnetic observation station. This is has been done in the magnetic observation station Niemegk in Germany, Uppsala in Sweden and Belsk in Poland (Nezka et al, 2013). The solution to the same problem has been found in Japan. Electric railway system located near the Earth's magnetic observation station Kakioka has changed from DC to AC (Tokumoto and Tsunomura, 1984). The latter emits disturbances only in a limited frequency range and is harmless compared to the first. It is enforced by law in Japan that the rail way company takes into account the needs of geophysical observatories (Y. Minamoto, personal communication in nezka's paper). This is certainly laudable, but unfortunately, unrealistic for most other countries

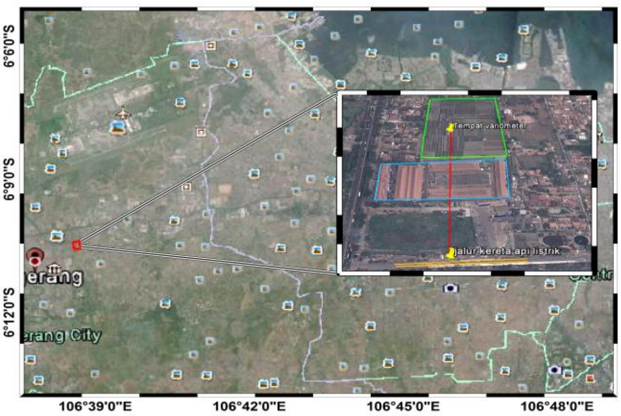


Fig 1. Overview map with positions of Tangerang (TNG). The zoomed-in areas around the observatories demonstrate their proximity to DC railways. TNG observatories with green lines, electrical railroad tracks with a yellow striped, and a wholesale market with blue striped.

Previous research in the same case has been made by (Georgescu et al, 2002), (Pirjola et al, 2007), (Lowes, 2009), and (Neska, 2010), they focused on the mechanism of propagation of disturbances that applying an electric train DC. In this study we have the same intention, but we use a different method. First of all we will show the data of magnetic field variations in the time series, and then determine the k-index for Tangerang data and contrasting with the data k-index of the reference observation stations for which data is not compromised. After that, we will introduce simple methods of filters to eliminate interference in the data.

II. DATA CONTAMINATION

Electric Trains (Commuter)

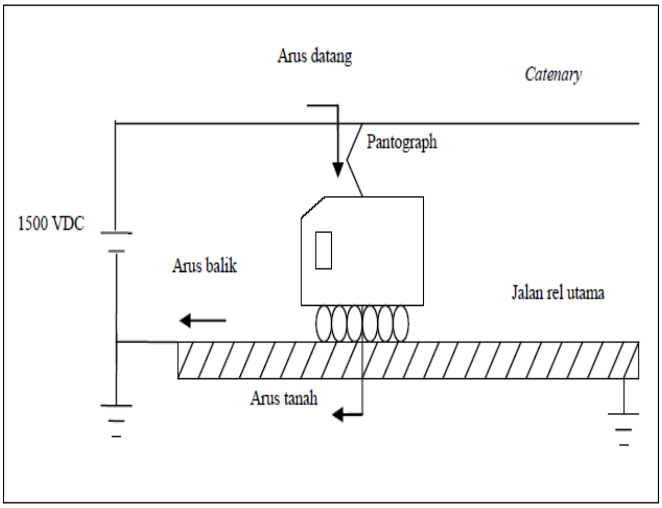
Electric trains or Mass Rapid Transit is a public transportation service with local coverage available to anyone who pays the cost of which has been determined and is designed to move a large number of passengers at the same time. Ones kinds of mass rapid transit are Kereta API (KA) commuter. The term relates to the operation of the commuter train only at the beginning and end of the working day, devoted to transport consumers who want to go to and or leave the city center. However, the term is also commonly used for all types of freight trains which are not included in the category

Fig 2. Kinds of commuter line that through tangerang city.

Types of Electric Railway (commuter) is a non - AC KRL Economy, Economic KRL AC look Fig 2, KRL Pakuan Ekspress. KRL Economy is a non - AC unit electric train fleet which society is aimed for lower-middle economic class. This class uses the old electric train fleet that did not use the air conditioning (AC). A number of series made by Nippon Sharyo, Hitachi, and BN - Holec. KRL AC Economic same function as the non - AC , a significant difference only lies in the more adequate facilities (air conditioning , new units) and the ticket prices are more expensive . KRL fleet of Ekspress Pakuan Using the same unit with KRL Express. KRL Express is the highest grade in the network Commuter Jabodetabek. Using the same unit with the AC KRL economy, differing only in a more limited station stops, and the ticket prices are more expensive. Maintaining the Integrity of the Specifications.

Electrical system of electric trains

Resources are used as the main power supply to the rail system in Indonesia is obtained from the grid which is then rectified by the rectifier (rectifier) at the substation (sub-station) to be a direct current power with nominal voltage of 1500 VDC great channeled through the upper channel (catenary) and transmitted to the train by using a pantograph (Bien et al, 2006). Pantograph is located on the roof of the carriage. Each pantograph distributes power to electrical installations. Feedback on the installation of high voltage rail is channeled to go back in through the wheels on the wagon. Under conditions of employment, such as conductive channel in Fig. 3, several thousand amperes energized, so that the top of the channel network are voltage losses must be considered.



. Fig 3. A simple form of electrical systems KRL and Upper channel network (Catenary) (Biek et al, 2006)

To overcome the voltage loss, then at certain distances (typically every 5 km) mounted substation circuit (sub - station) of the PLN. In addition to the above channel network should remain on track even though exposed to strong winds, hot weather and cold, as well as to other adverse weather conditions

Data Contamination.

At this time we will show about the influence of the electric train to magnetic field variations at tangerang observation. It can be seen that the interference on all components, i.e., components x, y and z-component parts. This disorder can be seen as a noise spike in some components.

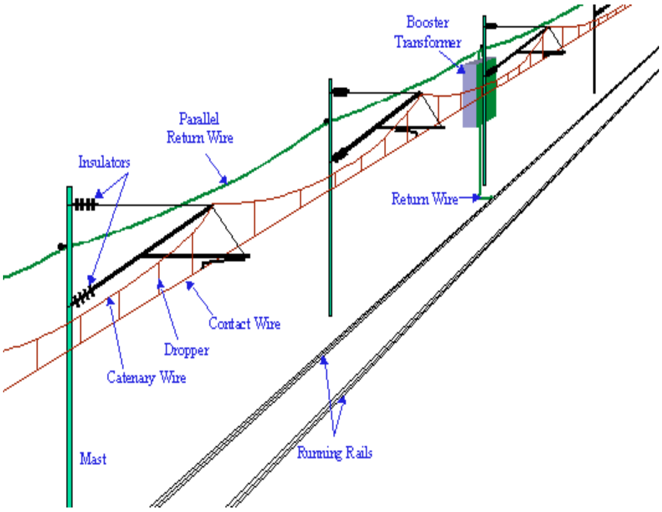


Fig 3. A simple form of electrical systems KRL and Upper channel network (Catenary) (Biek et al, 2006).

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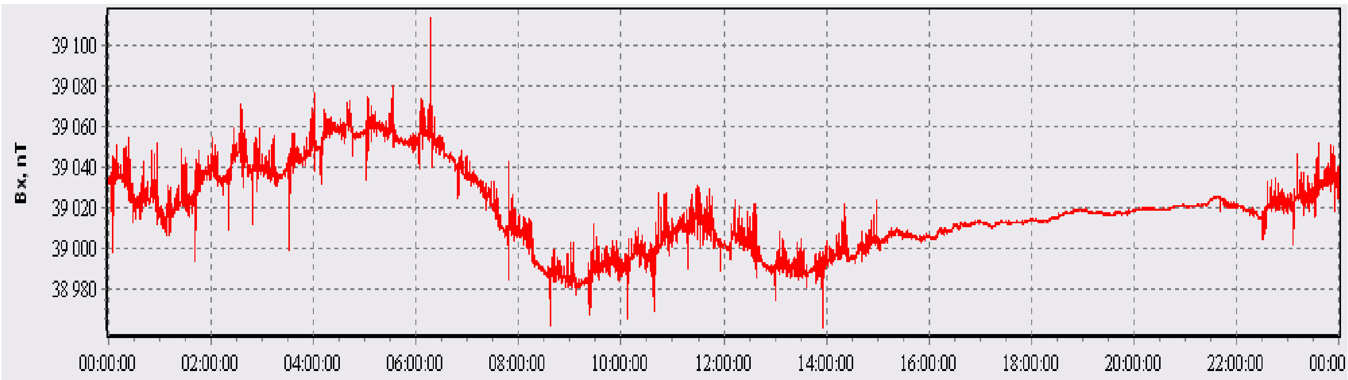
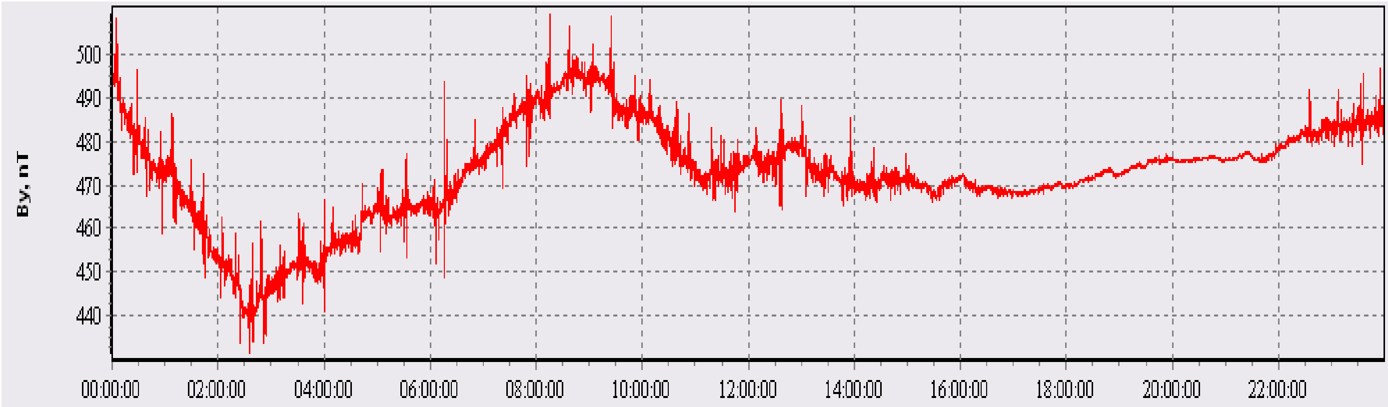
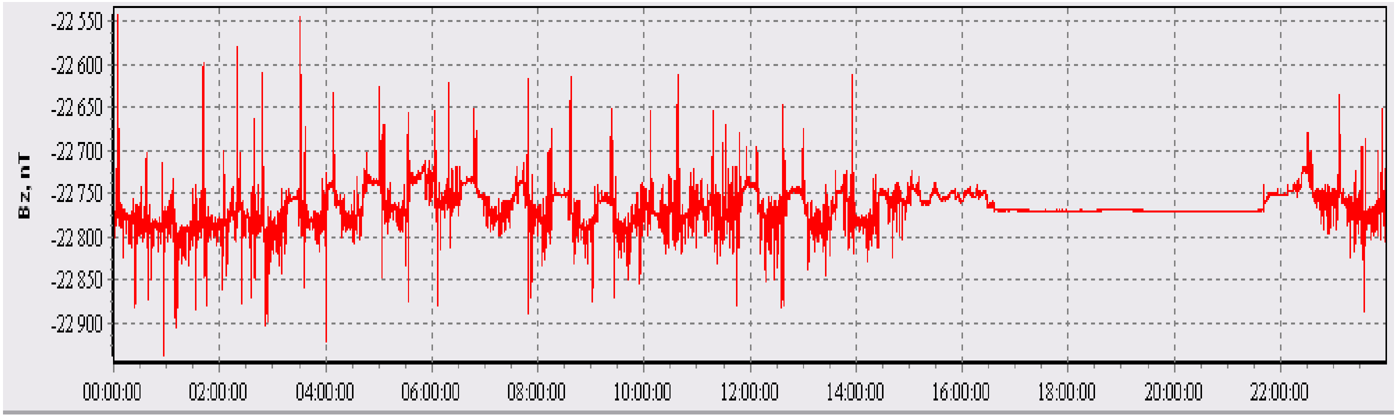


X component 31-08-2013 00:00:00 – 23:59:59



Y component 31-08-2013 00:00:00 – 23:59:59



Z component 31-08-2013 00:00:00 – 23:59:59

Fig 4. Magnetic variation signal at tangerang observatory. All of component x, y, z have noise in any time

Disruption caused by electric trains also has an impact on the determination of the K-index. K-index tangerang (TNG) is very difficult to quantify because the noise almost evenly in several components. Compared to the K-index generated by the observation station Tuntungan (TUN), the obtained K-index differences are very large in any time

III. METHOD

In this section a method will be outlined allowing for reconstruction of undisturbed time series data and, thereby, of corrected K indices. We use moving average filter, The moving average is the most common filter in DSP, mainly because it is the easiest digital filter to understand and use. In spite of its simplicity, the moving average filter is *optimal* for a common task: reducing random noise while retaining a sharp step response. This makes it the premier filter for time domain encoded signals. As the name implies, the moving average filter operates by averaging a number of points from the input signal to produce each point in the output signal.

$$y[i] = \frac{1}{M} \sum_{j=0}^{M-1} x[i+j]$$

Equation of the moving average filter. In this equation, x is the input signal, y is the output signal, and M is the number of points used in the moving average. This equation only uses points on *one side* of the output sample being calculated. In this method, we have to try some window width used. If the result is less satisfying then the window can be widened to get maximum results.

IV. RESULT AND DISCUSSION

Reconstructed time series are shown in Fig. 6. It is evident that their noisy character has vanished, but natural features have been preserved. As visible from difference time series between original and corrected data, the order of magnitude of the disturbance amplitudes is 0.01-49 nT for TNG in x component and 0.01-28 nT for TNG in y component and 0.37-190 nT for TNG in z component.

Data reconstruction was performed magnetic field variations of data components x, y and z are impaired. Disturbance data contained in all the components identified as spike noise contained in a certain time frame. In figure 5 can be seen that the interference was in the period 22:30 UTC to 15:00 UTC. In a span of 15:00 UTC until 22:30 UTC identified as the quiet period of the disturbance.

The time of the disturbs occurrence disorder in comparison with the electric train schedule that pass in Tangerang is perfect. We can see in Table 1, the departure of the electric railway in the city of Tangerang start at 22:30 UTC or 05:30 local time. Once observed, the data variation of the magnetic field also began to experience disturbances on that time. Electric railway was completed at 15:00 UTC operates and disorders also completed at the same hour.

Compatibility of the value of the magnetic field disturbance variation with respect to time the operation of an electric railway reinforced by the magnetic field variation of data prior to the change of the electric train schedule . When looking at the data value variations before 1 April 2013 as the attachment to the first, electric trains stop operating at 14:30 UTC, and the value of disturbance also end at the same time.

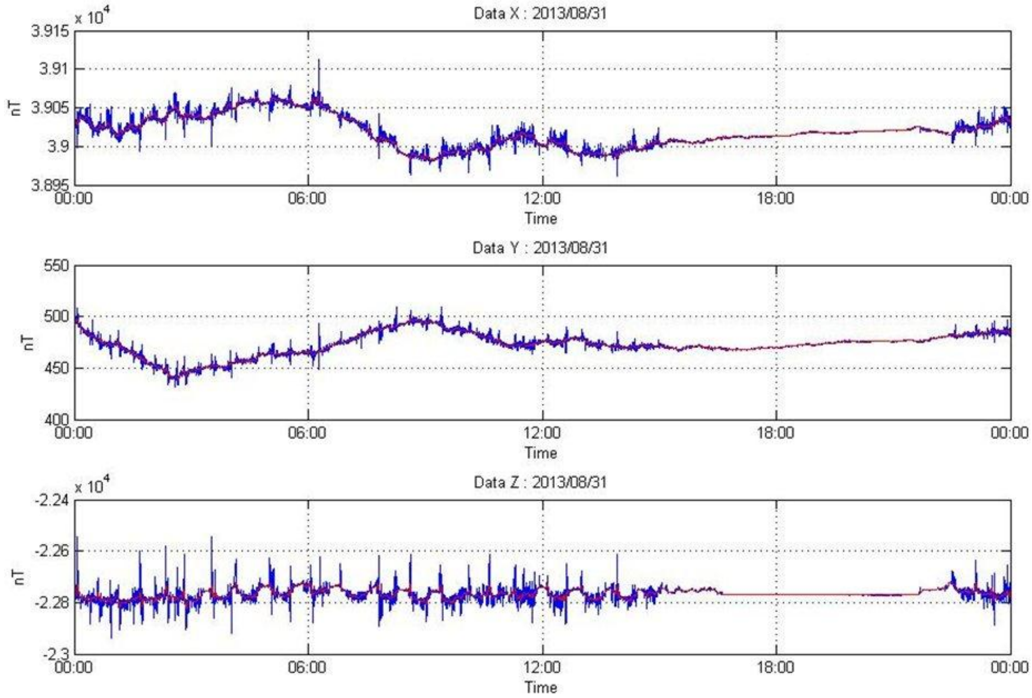


Fig 6. Reconstructed time series of TNG. For comparison, every panel contains the correspondent original time series in blue color and reconstructed data in red color.

From the results of the moving average filter is generated as shown in figure 6 shows that the interference data on the value of the magnetic field variations can be reduced. The result of the reduction depends on the moving average filter window width used. The width of the window used for data reduction is 180 seconds. This is because the window is too wide can cut the authenticity of the data and the window is too narrow can slip off the noise. In the x and y components of the reduction results showed very satisfactory results, but the results of the z component of the reduction is still not optimal. This is because the interference z component very large and require maximum width of the window.

The results of the analysis of the K - index after reduction experienced some significant differences. From Figure 7 it can be seen that the value of the K - index of changes before reaching a few percent reduction. On 26 August 2013 acquired k - index reduction results are close to the k - index reference station. Reference stations used is Tuntungan observation station, because it is a place that away from distractions than Tangerang . It can be seen from the analysis of the k- index , maximum index occurs in 1-3 hours to 13-15 , then the index decreased in 16-18 hours to 19-21, while the index began to rise in the index 22-24 . The decrease and increase in the index is in accordance with the disturbance. Index of 22-24 to 13-15 are the index when operating electric railway. While the minimum index at 16-18 to 19-21 have a minimum value because the electric trains are not operating.

K - Index reconstruction results decreased an average of 21.52 percent before reconstruction. After reconstructing the data taken at the impaired only obtained an average decline of 25.92 percent. The results of k - index correlated with the data reconstruction Tuntungan generate a positive correlation, This shows a strong relationship between the results of reconstruction with the reference value.

V. CONCLUSSION

The conclusions of this study can be summarized as follows: (1) moving average method can reconstruct the variation data disturbance due to electric trains with well; (2). K-index reconstruction results of data has a value that is closer to the reference stations that did not happen due to the disturbance of electric trains.

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APPENDIX

TABLE 1. THE ELECTRIC TRAIN SCHEDULE THAT PASS IN TANGERANG

Duri	Tangerang	Tangerang	Duri
6:15	6:49	5:30	6:00

6:47	7:21	6:00	6:32
7:20	7:54	6:30	7:04
7:52	8:26	7:02	7:37
8:25	8:59	7:35	8:09
8:56	9:31	8:05	8:42
9:30	10:11	8:40	9:14
10:20	10:56	9:10	9:47
11:10	11:41	9:40	10:11
12:00	12:33	10:25	10:56
12:50	13:21	11:05	11:39
14:00	14:33	12:00	12:33
14:40	15:16	13:00	13:35
15:30	16:06	13:45	14:17
16:18	16:51	14:45	15:16
16:45	17:20	15:35	16:06
17:20	17:54	16:20	16:58
17:52	18:30	17:00	17:37
18:20	18:51	17:35	18:09
19:10	19:41	18:15	18:49
20:00	20:31	19:05	19:39
20:45	21:21	19:55	20:29
21:35	22:05	20:50	21:21

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