IDENTIFICATION OF SEDIMENTATION AND EROSION SOLO RIVER BOARD USING GROUND PENETRATING RADAR (GPR) IN VILLAGE KANOR, BOJONEGORO

Moh Hasan Basri , Yono Hadi Pramono, Dwa Desa Warnana
Laboratorium Geofisika, Jurusan Fisika-FMIPA,
Institut Teknologi Sepuluh Nopember
Kampus ITS Sukolilo, Surabaya 61111

Intisari

Ground Penetrating Radar method has been used in this study to identify *sedimentation* and erosion on the body of the Solo River in the village of Kanor, Bojonegoro. GPR antenna used is the frequency of 90 MHz. The advantage of using this antenna is penetration into the surface deep enough (10-20 meters). Pattern reflection of electromagnetic waves obtained will describe the system bedding sedimentation and *scouring* Solo River. Results of interpretation on the condition of subsurface structures and erosion on the river Bengawan Solo and compared with the results of the drill data generally shows that track 1 at a depth of 2.5-7.5 meters are visible reflector regularly with sharp horizon, interpreted as sand. Then the track 2 at a depth of 1 to 7.5 meters are argillaceous and sand at a depth of 7.5 to 20 meters of a sand berlanau. In addition it also obtained phenomena that demonstrate alternating sand with clay at a depth of 1 to 7.5 meters on the track 3. While the identification result reveals that the Solo River *fluvial sedimentation* patterns dominated by clay, sand and silt. There is a path that has a history *scouring* which led to the erosion, precipitation and *sedimentation* unbalanced look at radagram on Kanor.

Keyword : sedimentation, scouring, GPR, Rivers Agency

I. INTRODUCTION

The development of electronic devices and technology in recent years, has given rise to a relatively new method of geophysical exploration in the world, namely the *Ground Penetrating Radar* (GPR). The development of electronic devices also influenced the development of radar devices used in exploration.

Some types of reinforcement has been implemented on a river embankment solo, but many have failed. The failure is expected due to the subgrade embankment of the river is soft soils that can not withstand the heavy load, thus strengthening-reinforcement implemented can not function properly. Damage to the river embankment solo also occurred in the village of Kanor, Bojonegoro [1]. At this area embankments that have been made decreased land (landslide). Here's a (figure 1.1) of the areas that experienced landslide.

The impact of erosion is the depletion of the surface layer of topsoil, which will lead to the fall in the ability of land (land degradation). Another consequence of the erosion is the declining ability of the soil to absorb water (*infiltration*), [2].

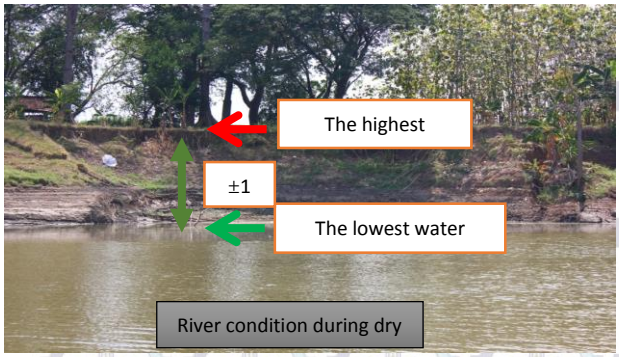
In the study, GPR antenna used with a frequency of 90 MHz. The advantage of using this antenna is penetration into the subsurface fairly deep (10-20 meters). These electromagnetic signals are radiated into the water to detect some of the anomalies in the dielectric properties of geological material. Pattern reflection of electromagnetic waves obtained will describe the system perlapisan river sedimentation and *scouring* rivers solo.

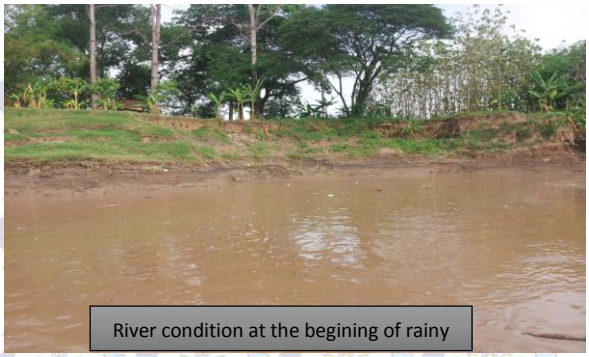
II. BASIC THEORY

A. *Sedimentation*

Sediment general meaning of the word can be interpreted as a precipitate. However, in the specific sediment can be interpreted as a collection of material that can be moved by the flow of the fluid in which the material will be collected (stored) into a solidified coating material. While the meaning of sedimentation is a collection of material because of the buildup that occurs due to flow-containing material be interrupted or stalled. Of course, if the material in question in terms of geology is rock or soil layer [3].

Sedimentation is not only due to the fluid flow, but can also be caused by wind or permafrost melt. Sea, lake, river sediment is a gathering place from time to time. Each layer of sediment that is shaped to have different characteristics, for example porous rock, granules, volume, density and shape. This is due to the difference in settling speed at the time of the formation of sedimentary layers.





2.1. Ground began to landslides

B. *Erosion*

Erosion is the displacement events or her transported land or section - section of land from one place to another by natural media [4]. Factors - factors influencing soil erosion are rainfall, soil, slope, vegetation and humans [2].

C. *Basic Principles GPR*

GPR method for the identification of the riverbed (*subbottom profiling*) bias using smaller tools frequency below 100 MHz. Selection of the actual frequency depends on the needs of the field, but to get the riverbed is greater than 10 meters is better to use a frequency <100MHz. besides when we make measurements over the water then there is energy absorption of electromagnetic waves emitted by the *transmitter* to the *receiver*. Thus it is very important in choosing the type of frequency to be used. In taking these data we use frequency of 90 MHz of Geoscan. This frequency is more specific to the needs of the deeper skin depth so that when there is a barrier layer (absorption), at least half of the maximum depth bias is used to do the interpretation. [5,6].

Electromagnetic properties that are commonly measured using GPR the data is the relative dielectric constant (Er), for the frequency and field surveys are affected by groundwater. *Travel time* (or speed electromagnetic) and the amplitude of the signal GPR can also be used to estimate the relative dielectric constants. Travel time measurement is the most effective measure to estimate the relative dielectric constant when the subsurface geometry is known or when the offset variable data obtained.

Tabel 2.1. Data Bor Kanor (Lab. Mekanika Tanah dan Batuan Teknik Sipil, FTSP,ITS, 2005) [6].

Kedalaman	Jenis tanah dan batuan
0 – 4.5 meter	Lempung
4.5 – 8.5 meter	Lempung, berpasir
8.5 – 14.5 meter	Pasir berlanau
14.5 – 19.5 meter	Lempung
19.5 – 22.5 meter	Lempung berlanau

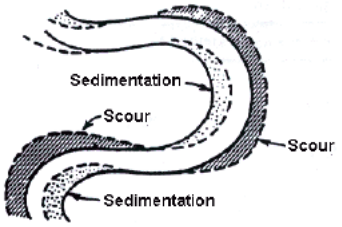


Figure 2.2. *Scouring* the river sedimentation

III. METHODOLOGY

A. Location Data Collection

Solo River chosen as the location for our thesis study because previous research based on the evaluation of the Department of Public Works Irrigation East Java and input from the community that most of the Solo River dike is prone to collapse, including the one of which is in the village of Kanor, Bojonegoro on 30 May 2015.

Figure 3.1. Position Tracks In Satellite Photos

Selection of antenna frequency is determined by the purpose of the survey is to determine the depth of the required resolution. On the river sedimentation study. Bengawan Solo in the area Kanor, used frequency 90 MHz antenna. By using these frequencies. it will get the penetration depth of up to 10-20 meters [7].

MATGPR *trigging* can be done differently at the time of the survey. The process of data collection is done on the surface of the river by boat. Due to the presence of unstable stream, then *trigging* method used is the reading *time interval* (time) while maintaining a constant amount of boat speed course.

A. Data Processing

GPR measurement results are then processed by using software tools MATGPR Version 3.5 [9] so that the profiling / picture image of the subsurface can be imaged with a high resolution. GPR data processing workflow can be seen in (Figure 4.1).

IV. DATA INTERPRETATION

When viewed from the condition of geological and drill data Bengawan Solo area, especially the village of Kanor composed of fluvial sediment. Fluvial is lithologies have the youngest age that quarter (Holocene) composed of sand, clay, silt, gravel result of the activities of the river. Fluvial sediment caused by activities of the Bengawan Solo river, and is currently depositional process is still ongoing.

In addition to determining the characteristics reflector GPR data generated will also be compared with the determination of the type of sedimentation table below the surface that has been done by Bares and Haeni [8] in previous studies.

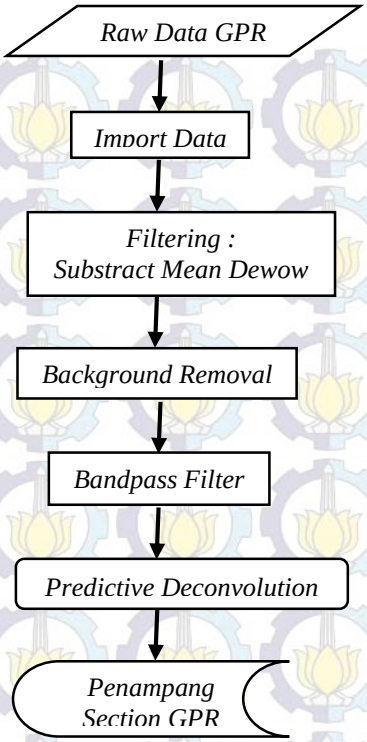


Figure 4.1: Flow diagram of the data processing work

1. Track 1.

   On the data Kanor 1, there is a layer of soil structure which has an amplitude of electromagnetic waves were very high. At a depth of 2.5-7.5 meters, it seems clear sand deposits along the track Kanor 1. The precipitate was also visible at a depth of 15 m, from the point of 0-20m. This is consistent with the drill data around the site (Table 2.1).
   From the results of the drill data mentioned that the area Research consists of sand, clay and silt where silt is included in the clay rock types. While sand beaches including sludge and sediment ground. The drill data can also be concluded that precipitated his special Solo River in the study area is dominated by clay, silt and sand (Figure 4.2).

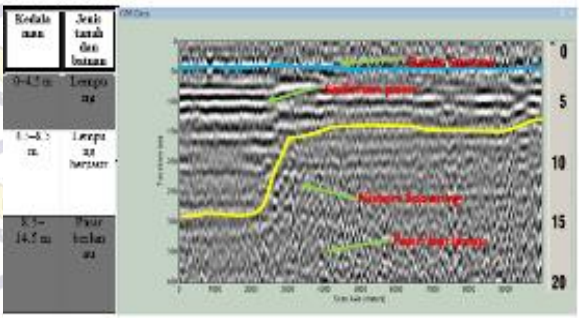


Figure 4.2: Interpretation of track 1

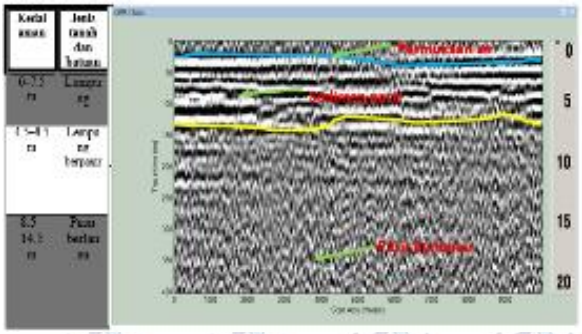


Figure 4.3: Interpretation of track 2

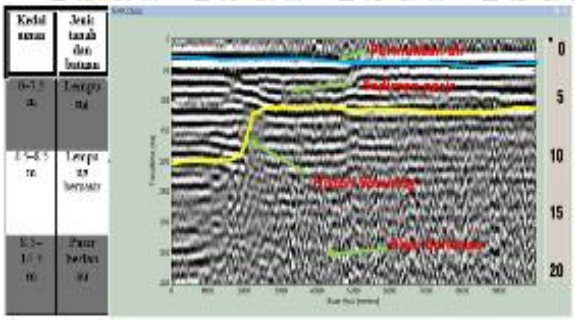


Figure 4.4: Interpretation of track 3

2. Tracks 2.

From the results of data processing in Figure 4.2, we can see clearly the shape of the riverbed on track to two. But on top of the river bottom horizon as sharp as a reflector, this happens because of the noise caused by the presence of water. Where water is a medium that is highly conductive and have a very high dielectric constant. Thus greatly affecting the radar response. From the picture above we can also see the process of sedimentation and erosion of river body section is uneven. This can result in one of the milling bodies occurs silting in rivers and other water bodies, so that eventually can disrupt the flow of water in the river (Figure 4.3).

After calibration is seen that the results of the drill data is relatively the same as the results of georadar data interpretation that is at a depth of 1 to 7.5 meters are argillaceous and sand at a depth of 7.5 to 20 meters of a sand berlanau. So that the results of the drill data we can conclude that the river stream sediment solo dominated by clay, silt and sand.

3. Tracks 3.

Pattern on track 3, similar to the trajectory 1. Only the sand layer can already observed at a depth of <2.5 meters to 12.5 meters. The thickness of the sand layer thicker than the first track, presumably because track position 3 are located in the southern part or the downstream side of the track 1. Which of the current through this path submerged by layer at the same depth in the path of one (Figure 4.4).

As the track 1 and 2 to get a more accurate interpretation of the results of the drill data used as comparative data. Based on drill data obtained at a depth of 2.5 to 20 meters is dominated by sand, silt and clay. But broadly on track 3 is the sedimentation consists of sand, clay and silt.

4. Tracks 4.

From ha sil data processing on track 4, the model of the river bottom is clearly visible and distinct trajectories 2 and 3. From these images there is also a part of the river that could potentially be scouring hole. This can occur because of erosion that are too large without offset deposition. It also indicates the section that has the potential to be scouring flows relatively greater than in other parts. In the figure 4.4 we can also see the noise caused by the presence of water in the presence of models such as the reflector above the riverbed (Figure 4.5).

So on this fourth track, a lot of sand mining is done because of the location of its sand deposits are not too deep. Can be seen on the position of the river mouth up to 15 meters are not visible straight line which is sand. This is apparently due to the passage of the mining activities carried out. Sand deposits also no longer appear in the middle of the river is deeper because the river flows more rapidly in that section.

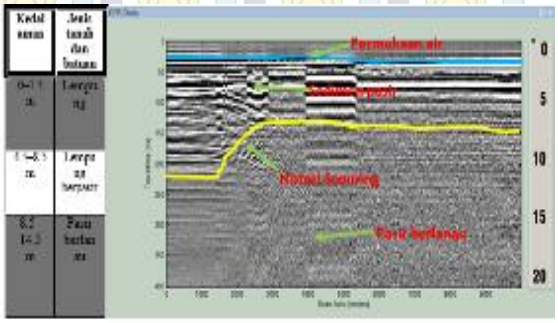


Figure 4.5: Interpretation of track 4

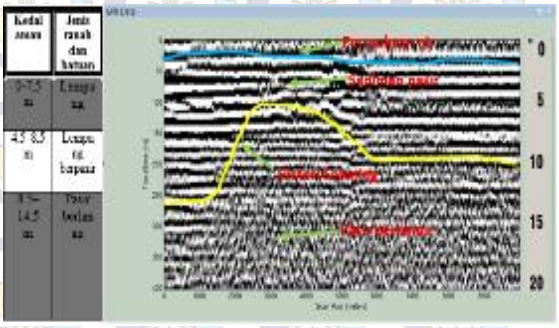


Figure 4.6: Interpretation of track 5

5. Tracks 5.

From the data processing can be seen in the form of regular reflector with a model (Wavy) this can be interpreted as sand, as seen there on the track

surface 5 is in addition to containing sand also contains clay and silt. It is estimated that the depth of this layer reaches 4.8 meters as seen from the regular reflector models reach a depth of almost 5 meters. On the surface also looks younger sediment. Besides differences in the speed of deposition also occurs in this trajectory at a depth of 0.5 meters (Figure 4.6).

Then the trajectory 5 is a mining sites and also appears that the layers of sand upstream from the river mouth was not observed up to 5 meters into. The depth of the sand layer only observed to a depth of 10 meters.

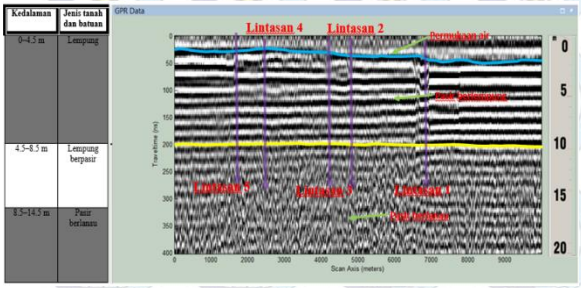


Figure 4.5: Interpretation of track 6

6. Tracks 6.

Tracks 6 taken on the west side of the river because it avoids the mining activity. Looked at this track (from north to south) the thickness of the lower layer of sand at the end of the track. This corresponds to the cross section of the track 1-5 is also hypothesized that the upstream section of the river (West) cross-section of more sand layer near the surface of the river eroded in the appeal at the downstream (east) river. (Figure 4.7).

From the data processing on different trajectories of the river show that the morphology or shape of the riverbed is relatively healthy even though there are parts that could potentially be *scouring*. Potential areas as scouring lies in the trajectory of 1,3,4 and 5, it is because the track is located on a bend position. At position here river flow will be pressed and gets outside and gets the riverbed, causing scour continuously in the long term this erosion can cause *scouring*.

While the results of GPR radagram correlation with the drill data from all the data, the overall show a correlation also with electromagnet wave amplitude. On bedding river sedimentation shows alternating high amplitude values and weak. This is made possible because of the type of soil there is the content of sand. Where the sand has a porosity large enough, so that the rock pores easily filled by fluid. Then the fluid that enters the pores of rocks resulting dielectric constant value becomes greater, because the speed of propagation of the wave gets smaller and it can be shown by the amplitude of the weak. Then a layer of sand is piled with other rock types are clay so that the value of the amplitude is varied, which indicates that in this region there is a process of continuous erosion [8].

V. CONCLUSION

Based on the above results of the study can be summarized as follows:

1. Based on the interpretation of the subsurface structural conditions and the erosion of the river Bengawan and compared with the results of the drill data generally shows that track 1 at a depth of 2.5-7.5 meters are visible reflector regularly with sharp horizon, interpreted as sand. Then the track 2 at a depth of 1 to 7.5 meters are argillaceous and sand at a depth of 7.5 to 20 meters of a sand berlanau. In addition it also obtained phenomena that demonstrate alternating sand with clay at a depth of 1 to 7.5 meters in track 3. As for the pattern layer radagram GPR results Kanor addressed each layer pattern layer different trajectories, it is generally caused by erosion, difference in energy loss by radar and human activities, one of which in the form of sand mining.
2. The identification results reveals that the Solo River fluvial sedimentation patterns dominated by clay, sand and silt. There is a path that has a history of scouring which causes the erosion, sedimentation and sedimentation unbalanced look at radagram on Kanor. Overall of 6 data have been interpreted to have different sedimentation bedding system caused differences in the pattern of erosion and sedimentation.

[1] Warnana. D.D dan Ian R., "*Penerapan Metode Geolistrik dan analisa keandalan tanggul sungai: studi /kasus Sungai Bengawan Solo*", Proc Seminar Fisika dan Aplikasinya. Surabaya. 2007.

[2] Utomo, Wani Hadi. 1994. Erosi dan Konservasi Tanah. Malang: Penerbit IKIP Malang

[3] Pamela J. W. Gore, (2004), *"Depositional Sedimentary Environments"*, Departement of Geology, Georgia Perimeter College.

[4] Arsyad, Sitanala. 1989. Konservasi Tanah dan Air. Bogor : IPB

[5] Reynolds, John M., An Introduction to Applied and Environmental Geophysics (John Wiley & Sons. New York, 1997).

[6] Annan, A.P., Ground Penetrating Radar Workshop Notes (Sensors & Software Inc, Canada, 1992).

[7] GeoScan32. 2009. "*Georadar 'OKO' Program of Control and Visualization of the Obtained Data"*. Rusia.
[8] Bares, M and Haeni, F.P., Ground Water, 29(3), 375-386 (1991).
[9] Tzanis, Andreas. 2013. "*MATGPR Release 3 Manual and Technical Reference"*. Department of Geophysics, University of Athens. Athens.