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Mapping Flood Prone Areas in Ekpoma, Edo State, Nigeria Using Electromagnetic Profiling and Electrical Resistivity Soundings

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Abstract

This study exploits the integrated approach of using the electromagnetic profiling and electrical resistivity soundings in flood management with the goal of mapping areas vulnerable to flood in Ekpoma- Edo State- Nigeria. Profiles length of 900m, 200m, 140m and 500m were covered using the Abem Wadi (West-East Orientation) at a measuring interval of 20m. The electromagnetic data were plotted against the station position, and the plots were found to exhibit positive peak and negative trough. The Schlumberger vertical electrical sounding was conducted in the conductive zones prone to flooding. Resistivity values were obtained by taking readings using the Ohmaga resistivity meter. The readings were further processed accordingly using Resist software meter. The study reveals that subsurface geophysical method is very useful for flood control.

Keywords

Flooding, Clay/Shale, VLF- Electromagnetic, Conductive, Sandstone

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1. Introduction

In Nigeria, floods occur in three main forms: coastal flooding, river flooding and urban flooding (Oriola, 1994; Okoduwa, 1999; Folorunsho, 2004 and Awosika 2001; Ologunorisa, 2004). Coastal flooding occurs in the lowly belt of mangrove and fresh water swamps along the coast. River flooding occurs in the flood plains of the larger rivers, while sudden, short-lived flash floods are associated with rivers in the inland areas where sudden heavy rains can change them into destructive torrents within a short period. Urban flooding on the other hand occurs in towns, on flat or low-lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with municipal waste, refuse and eroded soil sediments (Adeoye, 2009; Adejuwon, 2011; Festus, 2014).

Flooding is the most common of all environmental hazards and it regularly claims over 20,000 lives per year and adversely affects around 75 million people world-wide (Smith, 1996). Across the globe, floods have posed tremendous danger to people's lives and properties. Floods cause about one third of all deaths, one third of all injuries and one third of all damage from natural disasters (Askew, 1999). In Nigeria, the pattern is similar with the rest of word. Flooding in various parts of Nigeria have forced millions of people from their homes, destroyed businesses, polluted water resources and increased the risk of diseases (Baiye, 1988; Akinyemi, 1990; Nwaubani, 1991; Edward, 1997). Though not leading in terms of claiming lives, flood affects and displaces more people than any other disaster; it also causes more damage to properties. At least 20 percent of the population may be at risk from one form of flooding or another. Flood disaster has been perilous to people, communities and institutions.

Flood disaster management just as other disasters management can be grouped into (i) the preparedness phase where activities such as prediction and risk zone

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identification or vulnerable mapping are taken up long before the event occurs; (ii) the prevention phase where activities such as forecasting, early warning, monitoring and preparation of contingency plans are taken up just before or during the event and (ii) the response and mitigation phase where activities are undertaken just after the disaster and its includes damage assessment and relief management (Van Wester,1993; Ishaya, 2009).

Mitigation of flood disaster can be successful only when detailed knowledge is obtained about the expected frequency, character, and magnitude of hazardous events in an area as well as the vulnerability of the people, buildings, infrastructures and economic activities in a potential dangerous area (Van Western and Hosfstee, 2000). Unfortunately, Ifatimehin (2009), Ishaya (2008), and Ifatimehin and Ufuah (2006) reported that this detailed knowledge is always lacking in most urban centres of the developing world especially Nigeria. One way to mitigate the effect of flooding is to ensure that all area that are vulnerable are identified and adequate precautionary measures taken to either or all of adequate preparedness, effective response, quick recovery and effective prevention. Before these could be done, information is required on important indices of flood risk identification which are elevation, slope orientation, proximity of built-up areas to drainage, network of drains, presence of buffers, extent of inundation, cultural practices as well as attitudes and perceptions.

To get information on most of these, and identify areas that are vulnerable to flooding, reliable geophysical techniques of collecting and analysing the data information are required. In this regard, an integrated approach of VLF-Electromagnetic and electrical methods has proved to be the most effective and perhaps the only option to flood hazard preparedness and to reduce potential risk. This will be part of a larger, long term effort to gain a better understanding of community vulnerability on the floodplains and low elevated areas to flood hazard.

2. Materials and Methods

The materials used in this study are the Global Positioning System (GPS), Compass clinometers, the Abem Wadi VLF-electromagnetic equipment and its accessories and the omega Resistivity meter.

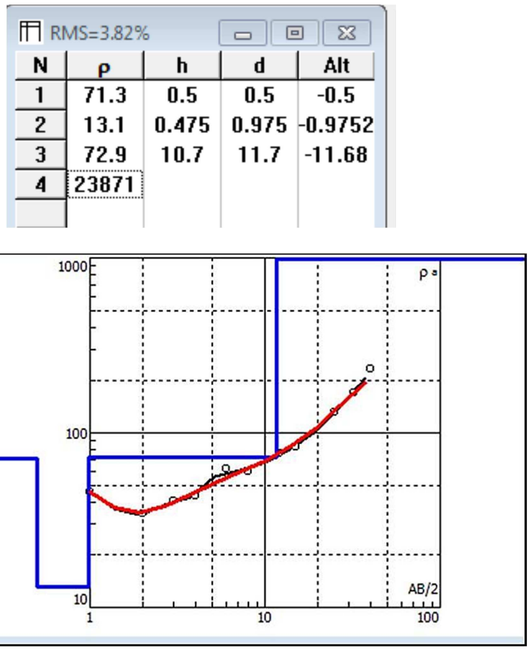

Figure 1. Typical VES curve from Ujoelen-Ekpoma

The GPS was used to acquire data on the point of distinguishing land use and points of elevation. Profiles length of 900m, 200m, 140m and 500m were covered using the Abem Wadi (West-East Orientation) at a measuring interval of 20m. The electromagnetic data were plotted against the station position, and the plots were found to exhibit positive peak and negative trough. Geologically, the positive peak represents the conductive / weak zone. These identified zones May contain plastic clay / shale. The negative trough is indicative of resistive/competent zone. This may represent sandstone materials.

Table 1. Ujoelen Road VES 1 PROFILE 1 100m

Electrode Position	Electrode Separation (m) AB/2	Potential Electrode MN	Geometric Factor (k) K	Resistance (Ω) R	Apparent Resistivity *pa = (kR)*
1	1	0.5	6.28	7.554	47
2	2	0.5	25.13	1.270	32
3	3	0.5	56.55	0.6361	36
4	4	0.5	100.53	0.4393	44
5	6	0.5	226.19	0.2764	63
6	6	1.0	113.10	0.5905	67
7	8	1.0	201.06	0.2724	55
8	12	1.0	452.39	0.1534	69
9	15	1.0	706.86	0.1148	81
10	15	2.0	353.43	0.2358	83
11	25	2.0	981.75	0.1321	130
12	32	2.0	1608.50	0.1010	167
13	40	2.0	2513.27	0.0925	232
14	40	5.0	1005.31	0.2317	233

The Schlumberger vertical electrical sounding was conducted in the conductive zones prone to flooding. Resistivity values were obtained by taking readings using the Ohmaga resistivity meter. The readings were further processed accordingly using Resist software. The very low frequency electromagnetic data were processed by downloading the raw real and filtered real components from the Abem Wadi VLF-Electromagnetic equipment and using the Karuff Jet filter software. The data are presented as profiles below.

Table 2. VES 2 PROFILE 1 320m

Electrode Position	Electrode Separation (m) AB/2	Potential Electrode MN	Geometric Factor (k) K	Resistance (Ω) R	Apparent Resistivity *pa = (kR)*
1	1	0.5	6.28	9.343	59
2	2	0.5	25.13	1.616	41
3	3	0.5	56.55	0.8518	48
4	4	0.5	100.53	0.5295	53
5	6	0.5	226.19	0.2673	60
6	6	1.0	113.10	0.8784	99
7	8	1.0	201.06	0.5591	112
8	12	1.0	452.39	0.3385	153
9	15	1.0	706.86	0.2490	176
10	15	2.0	353.43	0.4839	171
11	25	2.0	981.75	0.2551	250
12	32	2.0	1608.50	0.1840	296
13	40	2.0	2513.27	0.1565	393
14	40	5.0	1005.31	0.3132	315

Table 3. VES 3 PROFILE 1 560m

Electrode Position	Electrode Separation (m) AB/2	Potential Electrode MN	Geometric Factor (k) K	Resistance (Ω) R	Apparent Resistivity *pa = (kR)*
1	1	0.5	6.28	10.47	66
2	2	0.5	25.13	2.043	51
3	3	0.5	56.55	1.118	63
4	4	0.5	100.53	0.7288	73
5	6	0.5	226.19	0.3588	81
6	6	1.0	113.10	0.6769	76
7	8	1.0	201.06	0.3954	79
8	12	1.0	452.39	0.2144	96
9	15	1.0	706.86	0.1514	107
10	15	2.0	353.43	0.2937	103
11	25	2.0	981.75	0.1575	154
12	32	2.0	1608.50	0.1250	201
13	40	2.0	2513.27	0.1087	273
14	40	5.0	1005.31	0.2174	218

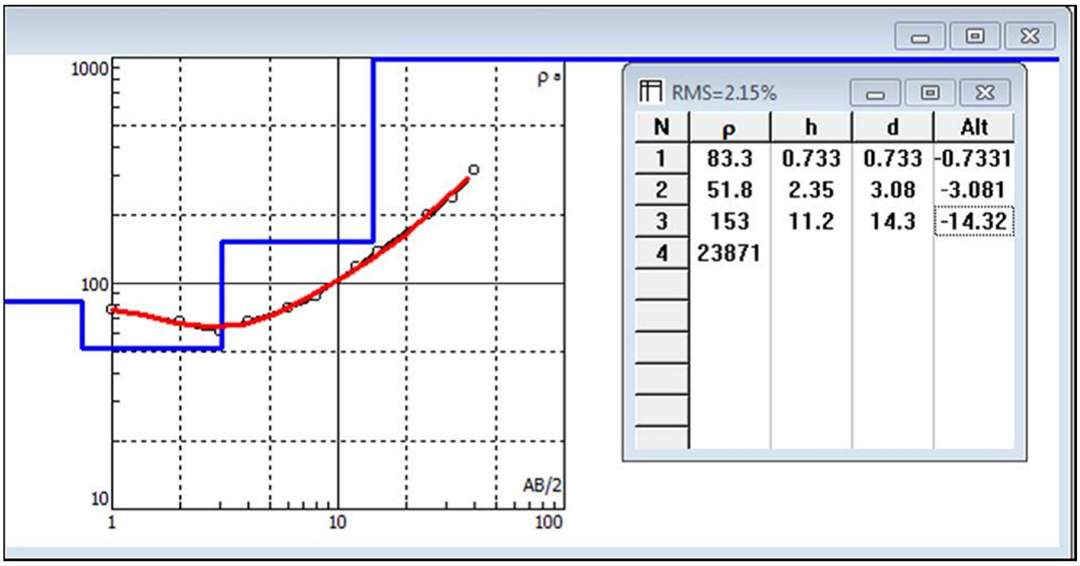

Figure 2. Typical VES curve from Mousco-Ukpenu road 1

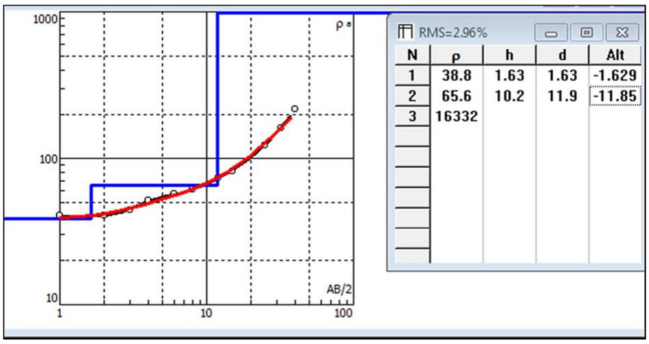

Figure 3. Typical VES curve from Mousco-Ukpenu road 2

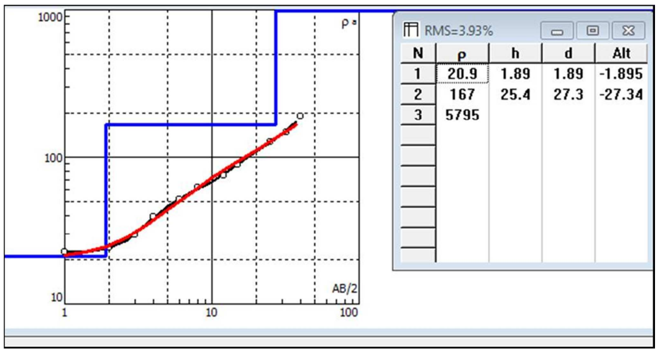

Figure 4. Typical VES curve from Mousco-Extension

Table 4. VES 4 PROFILE 1 780m

Electrode Position	Electrode Separation (m) AB/2	Potential Electrode MN	Geometric Factor (k) K	Resistance (Ω) R	Apparent Resistivity *pa = (kR)*
1	1	0.5	6.28	4.503	28
2	2	0.5	25.13	1.199	30
3	3	0.5	56.55	0.6556	37
4	4	0.5	100.53	0.4899	49
5	6	0.5	226.19	0.2876	65
6	6	1.0	113.10	0.6109	69
7	8	1.0	201.06	0.4177	83
8	12	1.0	452.39	0.2205	99
9	15	1.0	706.86	0.1697	119
10	15	2.0	353.43	0.3191	112
11	25	2.0	981.75	0.1616	158
12	32	2.0	1608.50	0.1158	186
13	40	2.0	2513.27	0.0951	239
14	40	5.0	1005.31	0.1903	191

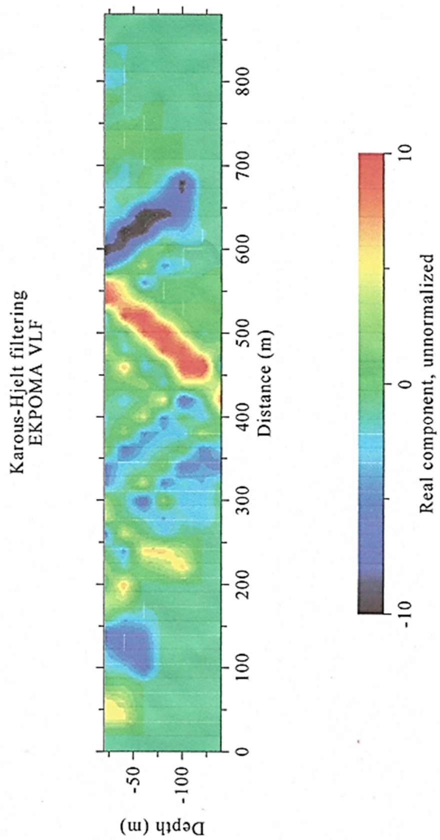

Figure 5. VLF Profile and KH Section along Traverse 1

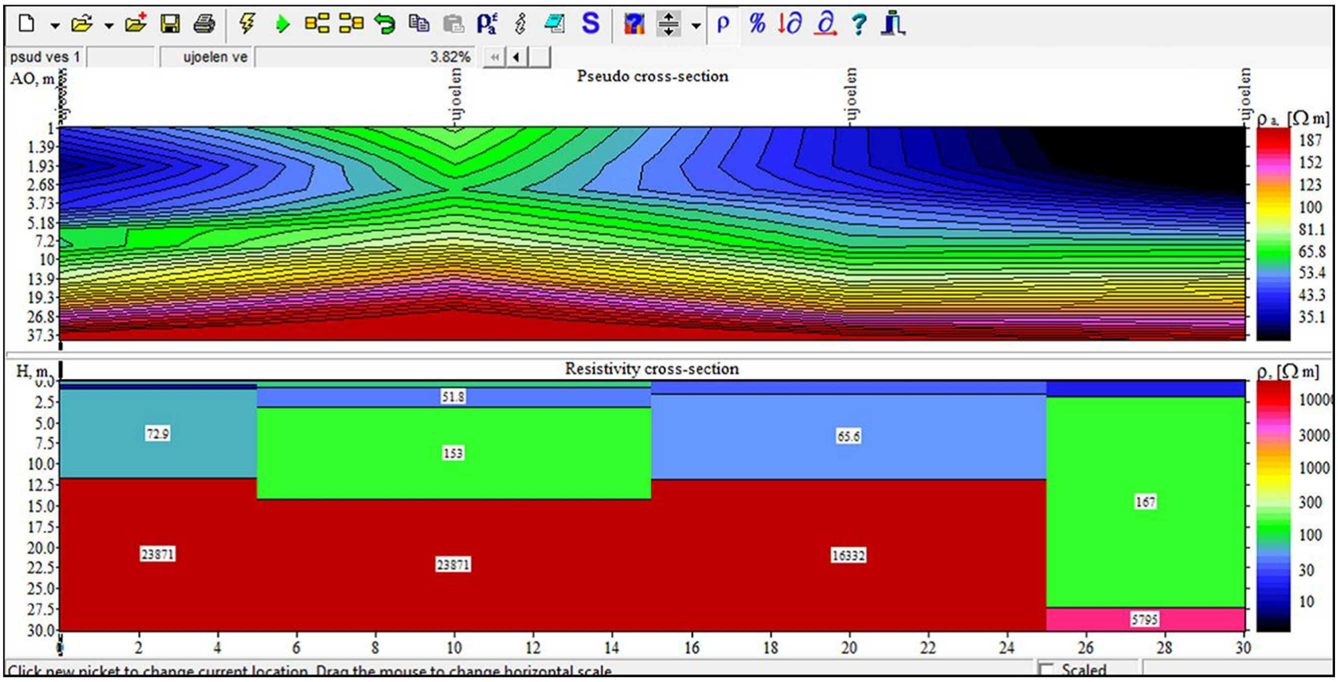

Figure 6. PSEUDO CROSS- SECTION

3. Discussion of Results/Conclusion

On Traverse 1, the VLF-EM profile identified peak positive filtered values which correspond to probable fracture zones at distance 20, 80, 220, 300, 480, 540, 560, 580 and 600m, along the Ujoelen road. These observations agree with the conductive zones delineated by the KH section from the EM-VLF results and the resistivity sounding curves.

Along the Mousco-Ukpenu road 1, the VLF-EM profile identified peak positive filtered values which correspond to probable fracture zones at distance 40 and 160m. While Mousco 3 road VLF-EM profile identified peak positive filtered values which correspond to probable zones at distance 100, 120, 160, 200, 220, 420, 440 and 480m.

The VES curves at each of the studied location are shown in the figures 1 – 4 above at each of the studied locations. The number of the layers varies between 3 and 5.

The 2-D Pseudo Sections were produced from the Schlumberger data. It delineated top soil withered/top layer. The results obtained revealed that the geophysical method used for these study are complementary. The positive peak represents the conductive / weak zone. These identified zones may contain plastic clay / shale and such area are prone to flooding.

We conclude that the integrated method used was an excellent approach toward mapping flood prone area in Ekpoma- Edo State. There is therefore, the need for continuous monitoring of flood areas and mapping of potential flood plains in order to identify flood prone areas for prediction and development planning areas. The study also reveals that subsurface geophysical method is very useful for flood control.

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