TIME-LAPSE AGRICULTURAL POLLUTION STUDY AT A TRANCHE OF 4 KM^2 SURVEY AT THE GIDAN KWANO CAMPUS DEVELOPMENT PHASE II, MINNA, NIGERIA

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Abstract
The result of interpretation of the data-field of a 4 km^2 dual vertical electrical sounding (VES)-induced polarisation (IP) survey at the planned Gidan Kwano Campus Development Phase II, Federal University of Technology (FUT), Minna, northcentral Nigeria, indicated groundwater prospect locations predominantly along the southernmost cross-profiles. It is instructive to investigate whether the applications of pesticides and inorganic fertilisers have had any deleterious effects on the properties of the near-surface soil of the region of a groundwater location or locations along particular cross-profiles. Three passes of VES in-line and cross-line survey [traditional three-dimensional (3-D) layout] over two-weekly interval were conducted in the local farming season for both the in-line and cross-line grids. For the agricultural pollutants leaching regime aspect of this study, the "correlation threshold" parameter was set at 70%. For P4-1: the suite of correlations is 70%:51%:72% for the three time sequences (thus, the groundwater prospect location is not at risk from agrochemical pollution). For P6-2: the suite of correlations is 60%:-55%:41% (thus, the groundwater prospect location is at risk from agrochemical pollution). For P15-3: the suite of correlations is -103%:-107%:-109% (thus, the groundwater prospect location is at risk from agrochemical pollution). For P20-4: the suite of correlations is 96%:80%:89% (thus, the groundwater prospect location is not at risk from agrochemical pollution). For P1-5: the suite of correlations is 76%:82%:84% (thus, the groundwater prospect location is not at risk from agrochemical pollution). Ultimately, a novel "Agricultural Pollutants Leaching Regime" was created from the tandem surveys conducted at the five southernmost cross-profiles of the area of study, and it is recommended that a broader "Threat Indicator" for the larger 4km^2 tranche of the Gidan Kwano Campus Development Phase II be produced in subsequent studies; this "Threat Indicator" document should be produced yearly, especially to keep tab on the prospect locations that have not yet been drilled for boreholes. The result of such an audit mechanism process would then be a public enlightenment advocacy geared towards the reduction of indiscriminate use of agrochemicals.

Keywords: Groundwater; agrochemicals; leaching; pollution; correlation; threat-indicator

Introduction
A 4 km^2 dual vertical electrical sounding (VES)-induced polarisation (IP) survey has been completed at the planned Gidan Kwano Campus (GKC) Development Phase II, Federal University of Technology, Minna, Nigeria (Jonah and Olasehinde, 2017). This 4 km^2 areal extent is, in reality, a 2 km x 2 km grid, and at 100 m station-spacing, 21 in-profiles and 21 cross-profiles could be easily defined. The result of the interpretation of the data-field of this 4 km^2 dual survey indicates groundwater prospect locations predominantly along the southernmost cross-profiles, with five definite prospects along the first cross-profile, two along the second cross-profile, four along the third cross-profile, three along the fourth cross-profile, two along the fifth cross-profile, and so on; over this 4 km^2 areal extent are tracts of tillage where subsistence agricultural activities are widespread and this means that the utilisation of

pesticides and inorganic fertilisers is commonplace, too. Now that the locations of groundwater have been established, it is instructive to investigate whether the applications of pesticides and inorganic fertilisers have had any deleterious effects on the properties of the near-surface soil of the region of a groundwater location or locations along particular cross-profiles; this investigation is aided by the time-lapse agricultural pollution model scheme and the investigation was conducted along the five southernmost cross-profiles. In-line VES and cross-line VES were conducted at tracts of tillage over specified time intervals [this is classic representation of four-dimensional (4-D) field layout] so as to model the resistivity profile of the tracts of tillage where agrochemicals have been used. A product of such a model would be an "agricultural pollutants leaching regime" for the area of study. Such a leaching regime would be a "threat indicator" with respect to the eventual condition of soil and groundwater at the area of study.

In ordinary comprehension, the term "pollution" would come across as one that denotes the process or activity of "making dirty" or "making impure" what was once pure. This line of perception has, without a doubt, been ingrained into the consciousness of the average Nigerian child. Pollution is the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form. The major kinds of pollution are (classified by environment) air pollution, water pollution, and land pollution. Modern society is also concerned about specific types of pollutants, such as noise pollution, light pollution, and even plastic pollution (Encyclopaedia Britannica, 2012).

Pollution (with environmental underpinning) is also defined as the contamination of the earth's environment with materials that interface with human health, the quality of life, or the natural functioning of the ecosystem (living organisms and their physical surroundings). Whilst some environmental pollution in a result of natural causes (such as volcanic eruptions), most are caused by human activities. This kind of pollution has been classified into different categories that include air pollution, water pollution, solid pollution, hazardous pollution, and noise pollution. Pollution, is in its different forms, degrades the environment and affects the quality of life of the organisms that depends on this environment for survival; this especially holds true for the interaction of man and his environmental. As humans become more skillful and adept at exploiting their environment, it becomes obvious that certain practices are quite detrimental to the health of the environment (Encarta, 2007). A time-lapse 3-D survey is actually a 4-D survey. A 4-D survey is any 3-D survey repeated over a particular time sequence. The 4 km^2 tranche of new development under consideration here, which is actually subsumed in the wider Phase II, is identified by the following georeferenced co-ordinates: $09^0$30′57.8′′N, $006^0$25′39.0′′E; $09^0$30′57.8′′N, $006^0$26′43.8′′E; $09^0$32′02.6′′N, $006^0$26′43.8′′E; $09^0$32′02.6′′N, $006^0$25′39.0′′E, see Figure 1. This 4km^2 areal extent is further subsumed in the wider 8km^2 Development Phase II, see Figure 2.

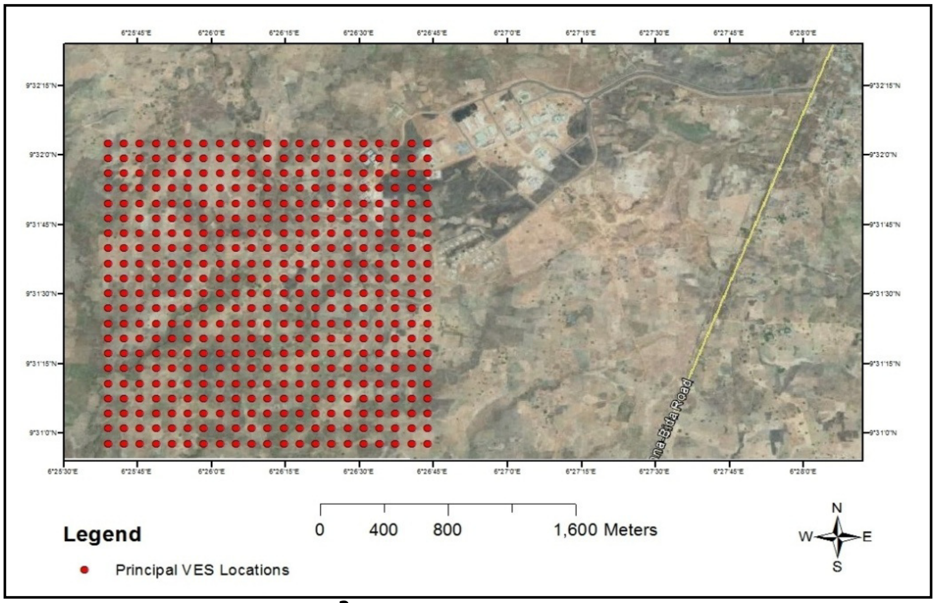

Fig.1. Grid of the 4km^2 tranche of New Development at the GKC at 100m station-spacing

(The tadpole-shaped feature is Phase I, the present developed portion of the GKC, seen to the northeast of the red-dotted grid of the 4km^2 areal extent; the Minna-Kateregi-Bida Road is seen as the linear slope to the far east of the grid).

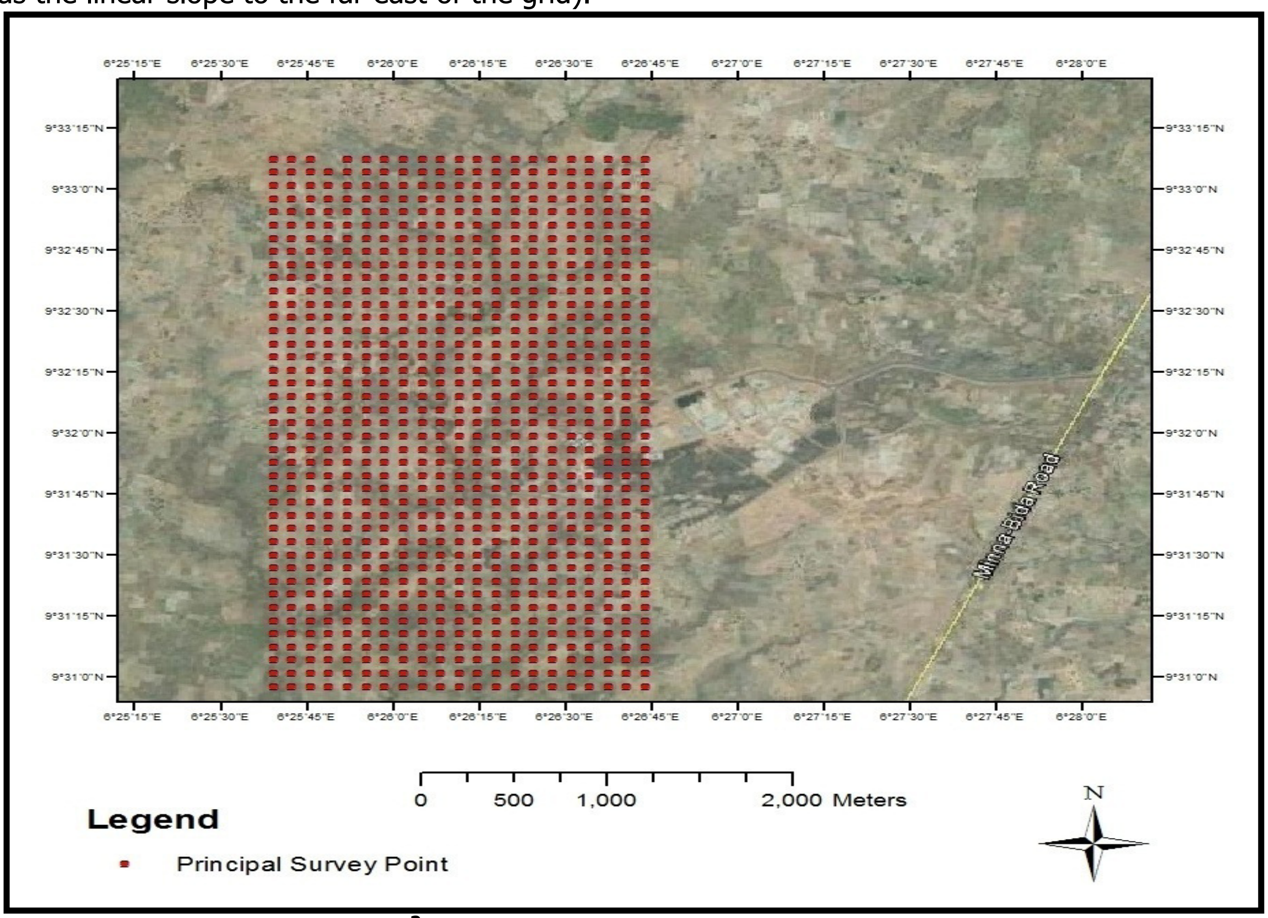

Fig.2. Grid of the wider 8km^2 Development Phase II at 100m station-spacing

(Now, the tadpole-shaped feature is seen to the east of the red-dotted grid of the 8km^2 areal extent; the Minna-Kateregi-Bida Road is still seen as the linear slope to the far east of the grid).

Spike in subsistence and research agricultural activities at the area of the planned Gidan Kwano Campus Development Phase II correlates strongly with widespread pesticide and herbicide applications at the tracts of farmlands of this Phase II. If the identified groundwater locations are drilled in a series of connecting sequences to form the proposed "water farm" scheme at Phase II, then it imperative that an agricultural pollution regime index around the locations of groundwater prospects be specifically created for the Phase II Development. At the moment there exists no such agricultural pollution regime index database for the Phase II Development, and this study would be partly devoted to creating such a database. Also, there exists no predictive modeling scheme by means of which longer sequences of VES surveying routes may be shortened so as to save on time and costs; this study would also be partly devoted to creating such a database.

The aim of this study is to build a valid agricultural pollution model for the location of the planned Gidan Kwano Campus Development Phase II, Federal University of Technology, Minna. The objective of this study is the following: the use of acquired VES data-set in the in-line and cross-line mode of a three-dimensional format over time-lapse to test for possible pollution profiles of the soil of the immediate vicinities where groundwater prospects have been identified.

An agricultural pollution model scheme for the Gidan Kwano Campus Development Phase II, Federal University of Technology, Minna, would be veritable geological/geophysical reference material akin to the "standard tables of values" that are usually encountered in most engineering processes.

With respect to published and unpublished geoelectrical studies that have been carried out at the local Basement Complex of which the location of this study is a part, the following works are cited: Jonah *et al.* (2013); Jonah *et al.* (2014A); Jonah *et al.* (2014B); Jonah *et al.* (2014C); Jonah *et al.* (2015A); Jonah *et al.* (2015B); Jonah *et al.* (2015C); Jonah *et al.* (2015D); Jonah and Olasehinde, (2015E); Jonah *et al.* (2015F); Jonah and Olasehinde (2016A); Jonah and Olasehinde (2016B); Jonah (2016C); Jonah (2016D); Jonah (2016E); Jonah (2016F); Jonah (2016G); Jonah and Olasehinde, (2017).

The fault-trace of water-bearing fracture signatures inferred from a combination of the geoelectric cross-sections and the induced polarisation tables on the conventional grid matrix of the layout of survey stations for the 4km^2 dual VES-IP survey is represented in Figure 3. The "2 km x 2 km grid, and at 100 m station-spacing…" mentioned earlier can easily be made out in Figure 3 as well as the "five definite prospects along the first cross-profile, two along the second cross-profile, four along the third cross-profile, three along the fourth cross-profile, two along the fifth cross-profile…" specification. What is also obvious in this figure is the statement-of-fact also pointed earlier, viz: "the result of the interpretation of the data-field of this 4 km^2 dual survey indicates groundwater prospect locations predominantly along the southernmost cross-profiles…" and the fact that there are "21 in-profiles and 21 cross-profiles."

The "five definite prospects along the first cross-profile" are the following: P2-1 (09^{0}30′57.80′′; 006^{0}25′42.24′′), P3-1 (09^{0}30′57.80′′; 006^{0}25′45.48′′), P4-1 (09^{0}30′57.80′′; 006^{0}25′48.72′′), P8-1 (09^{0}30′57.80′′; 006^{0}26′01.68′′), and P9-1 (09^{0}30′57.80′′; 006^{0}26′04.92′′).

The "two definite prospects along the second cross-profile" are the following: P5-2 (09^{0}31′01.04′′; 006^{0}25′51.96′′) and P6-2 (09^{0}31′01.04′′; 006^{0}25′55.20′′).

The "four definite prospects along the third cross-profile" are the following: P3-3 (09^{0}31′04.28′′; 006^{0}25′45.48′′), P6-3 (09^{0}31′04.28′′; 006^{0}25′55.20′′), P9-3 (09^{0}31′04.28′′; 006^{0}26′04.92′′), and P15-3 (09^{0}31′04.28′′; 006^{0}26′24.36′′).

The "three definite prospects along the fourth cross-profile" are the following: P15-4 (09^{0}31′07.52′′; 006^{0}26′24.36′′), P20-4 (09^{0}31′07.52′′; 006^{0}26′40.56′′), and P21-4 (09^{0}31′07.52′′; 006^{0}26′43.80′′).

The "two definite prospects along the first cross-profile" are the following: P1-5 (09^{0}31′10.76′′; 006^{0}25′39.00′′) and P4-5 (09^{0}31′10.76′′; 006^{0}25′48.72′′).

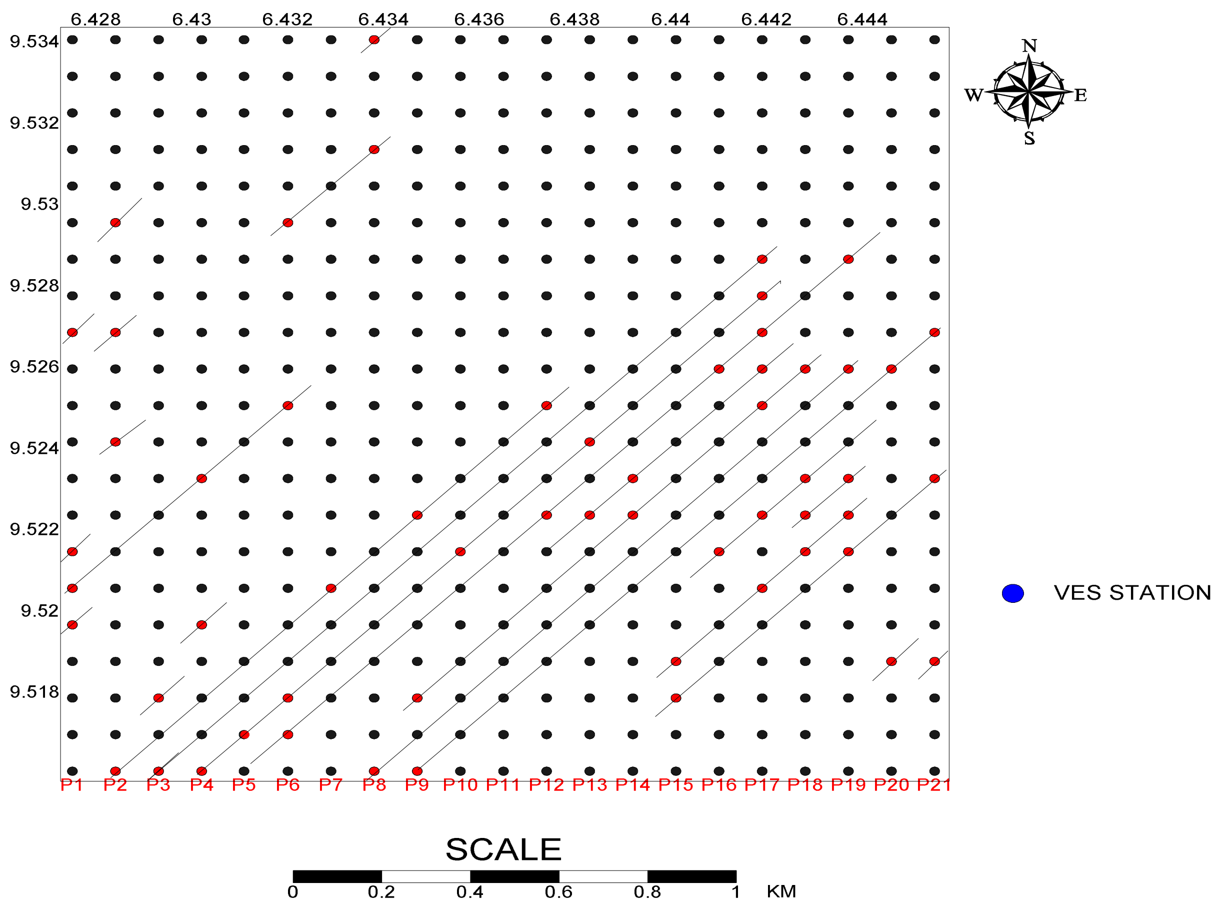

Fig.3. Fault-trace of fracture signatures inferred from a combination of the geoelectric cross-sections and the induced polarisation tables on the conventional grid matrix of the layout of survey stations for the 4km^2 dual VES-IP survey completed at the planned Gidan Kwano Campus Development Phase II, Federal University of Technology, Minna. (The red dots are definite groundwater prospect locations.)

Methodology
Several passes, over two-weekly interval, conducted in the conveniently local farming season was completed for the VES in-line and cross-line gridded survey. By this means, then, a time-lapse survey was defined. The schematic for the survey had a quartet of adjunct grids centred on a principal grid; such a format is shown in Figure 4.

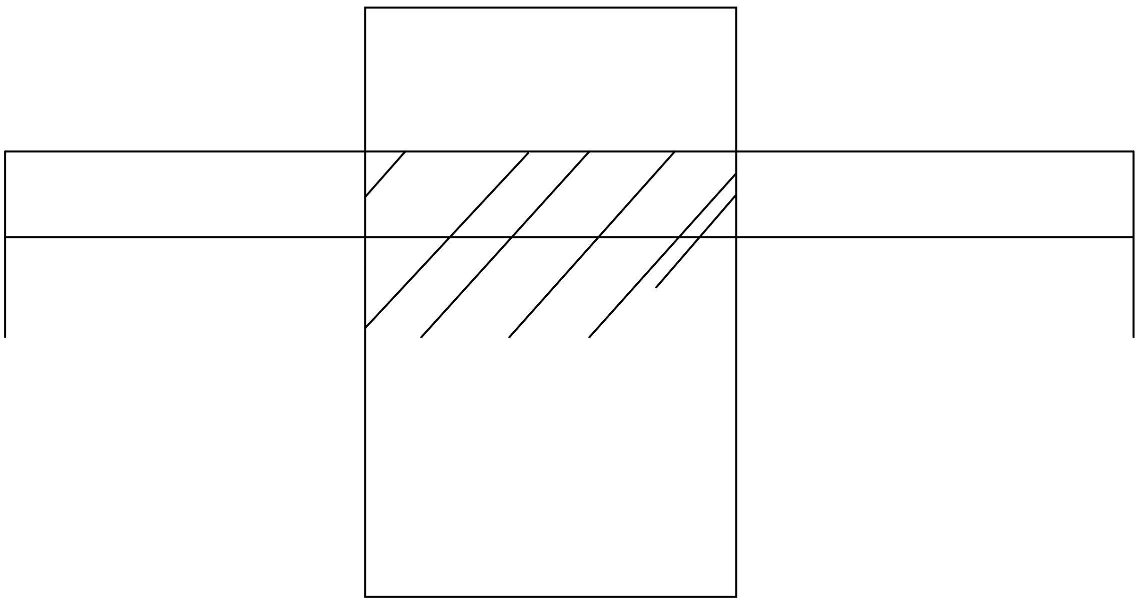

Fig.4. Schematic for survey showing layout of principal grid, represented by the shaded square, and its controls (the adjunct grids), represented by the quartet of plain squares

Whereas it is desired to conduct the investigation at the five definite prospects along the first cross-profile, two along the second cross-profile, four along the third cross-profile, three along the fourth cross-profile, and two along the fifth cross-profile that agricultural activities have occurred, cost consideration constraint imposed a limitation: the investigation was now restricted to just one definite groundwater prospect location along each of the five cross-profiles. Furthermore, instead of investigating four adjunct grids as controls for each single principal groundwater prospect location along a cross-profile, only one adjunct grid control was completed.

Results and Discussion
Analysis of the Time-lapse In-Line and Cross-Line Data-Field: The analysis of the time-lapse in-line and cross-line data-field is presented hence.

The First Time Sequence: For the P4-1 location, which is the selected principal groundwater prospect location along the first cross-profile, the resistivity values for the principal grid survey in the in-line and cross-line modes for the first time sequence are as shown in Table 1 and the resistivity values for the adjunct grid survey in the in-line and cross-line modes for the first time sequence are as shown in Table 2. Table 3 is the resultant table of correlation for the mean in-line and cross-line resistivity values of the principal grid and the mean in-line and cross-line resistivity values of the adjunct grid for the first time sequence derived from a consideration of

Tables 1 and 2; in this table are columns for "Difference," "% Conformance," "% Conformance Range," and "% Conformance Median." The "Difference" column indicates the difference in absolute resistivity values for the principal grid survey and the adjunct grid survey for coincident points of measurements. The "% Conformance" column indicates by what percentage is there agreement in absolute resistivity values for the principal grid survey and the adjunct grid survey for coincident points of measurements. The "% Conformance Range" and "% Conformance Median" are typical statistical routes by which final deduction could be made.

Table 1: Resistivity values for the principal grid survey in the in-line and cross-line modes for the first time sequence

AB/2 (half-current spacing), m	Mean in-line resistivity values (Ωm)	Mean cross-line resistivity values (Ωm)	Mean in-line and cross-line resistivity values (Ωm)
1	101.100	106.580	103.840
2	73.320	82.630	77.970
3	63.790	72.910	68.350
5	51.050	53.700	52.370
6	81.640	56.490	69.060
6	52.580	52.150	52.370
8	55.820	56.270	56.040
10	64.550	65.780	55.170
10	59.280	50.470	54.870

Table 2: Resistivity values for the adjunct grid survey in the in-line and cross-line modes for the first time sequence

AB/2 (half-current spacing), m	Mean in-line resistivity values (Ωm)	Mean cross-line resistivity values (Ωm)	Mean in-line cross-line resistivity values (Ωm)
1	205.740	183.720	194.730
2	57.990	77.160	67.570
3	32.880	43.380	38.130
5	23.330	23.790	23.560
6	20.310	18.300	19.310
6	30.810	24.850	27.830
8	18.180	14.900	16.540
10	18.050	15.970	17.010
10	25.530	26.540	26.030

Table 3: Table of correlation for the first time sequence

AB/2 (m)	Mean in-line and cross-line principal resistivity values (Ωm)	Mean in-line and cross-line adjunct resistivity values (Ωm)	Difference	% Conformance	% Conformance range	% Conformance median
1	103.840	194.730	140.730	40.730	40.730	
2	77.970	67.570	10.400	89.600	50.250	
3	68.350	38.130	30.220	69.780	60.500	
5	52.370	23.560	28.810	71.190	61.480	
6	69.060	19.310	49.750	50.250	69.780	**69.780**

6	52.370	27.830	24.540	75.460	71.160
8	56.040	16.540	39.500	60.500	71.190
10	55.170	17.010	38.160	61.840	75.460
10	54.870	26.030	28.840	71.160	89.600

The Second Time Sequence: Still, for the P4-1 location, Tables 4, 5, and 6 are results of the resistivity values for the principal grid survey in the in-line and cross-line modes for the second time sequence, the resistivity values for the adjunct grid survey in the in-line and cross-line modes for the second time sequence, and the resultant table of correlation for the mean 3-D resistivity values of the principal grid and the mean 3-D resistivity values of the adjunct grid for the second time sequence.

Table 4: Resistivity values for the principal grid survey in the in-line and cross-line modes for the second time sequence

AB/2 (half-current spacing), m	Mean in-line resistivity values (Ωm)	Mean cross-line resistivity values (Ωm)	Mean in-line and cross-line resistivity values (Ωm)
1	52.620	52.140	52.380
2	50.680	64.540	57.610
3	135.890	75.250	105.570
5	37.710	29.690	33.700
6	34.140	35.090	34.620
6	159.910	35.910	97.910
8	164.890	46.460	105.670
10	69.230	62.520	65.870
10	36.840	48.080	42.460

Table 5: Resistivity values for the adjunct grid survey in the in-line and cross-line modes for the second time sequence

AB/2 (half-current spacing), m	Mean in-line resistivity values (Ωm)	Mean cross-line resistivity values (Ωm)	Mean in-line and cross-line resistivity values (Ωm)
1	205.740	183.720	194.730
2	57.990	77.160	67.570
3	32.880	43.380	38.130
5	23.330	23.790	23.560
6	20.310	18.300	19.310
6	30.810	24.850	27.830
8	18.180	14.900	16.540
10	18.050	15.970	17.010
10	25.530	26.540	26.030

Table 6: Table of correlation for the second time sequence

AB/2 (m)	Mean 3-D principal resistivity values (Ωm)	Mean 3-D adjunct resistivity values (Ωm)	Difference	% Conformance	% Conformance range	% Conformance median
1	52.380	194.730	142.350	42.350	10.870	
2	57.610	67.570	9.960	90.040	29.920	
3	105.570	38.130	67.440	32.560	32.560	
5	33.700	23.560	10.140	89.860	42.350	
6	34.620	19.310	15.310	84.690	51.140	**51.140**
6	97.910	27.830	70.080	29.920	83.570	
8	105.670	16.540	89.130	10.870	84.690	
10	65.870	17.010	48.860	51.140	89.860	
10	42.460	26.030	16.430	83.570	90.040	

The Third Time Sequence: Still, for the P4-1 location, Tables 7, 8, and 9 are results of the resistivity values for the principal grid survey in the in-line and cross-line modes for the third time sequence, the resistivity values for the adjunct grid survey in the in-line and cross-line modes for the third time sequence, and the resultant table of correlation for the mean 3-D resistivity values of the principal grid and the mean 3-D resistivity values of the adjunct grid for the third time sequence.

Table 7: Resistivity values for the principal grid survey in the in-line and cross-line modes for the third time sequence

AB/2 (half-current spacing), m	Mean in-line resistivity values (Ωm)	Mean cross-line resistivity values (Ωm)	Mean in-line and cross-line resistivity values (Ωm)
1	65.570	51.070	58.320
2	44.350	61.800	53.080
3	49.650	50.320	49.980
5	88.830	42.740	65.780
6	90.890	43.800	67.340
6	42.880	48.700	45.790
8	36.060	48.140	42.100
10	38.940	51.390	45.160
10	58.900	51.600	55.250

Table 8: Resistivity values for the adjunct grid survey in the in-line and cross-line modes for the third time sequence

AB/2 (half-current spacing), m	Mean in-line resistivity values (Ωm)	Mean cross-line resistivity values (Ωm)	Mean in-line and cross-line resistivity values (Ωm)
1	205.740	183.720	194.730
2	57.990	77.160	67.570
3	32.880	43.380	38.130
5	23.330	23.790	23.560
6	20.310	18.300	19.310
6	30.810	24.850	27.830

8	18.180	14.900	16.540
10	18.050	15.970	17.010
10	25.530	26.540	26.030

Table 9: Table of correlation for the third time sequence

AB/2 (m)	Mean 3-D principal resistivity values (Ωm)	Mean 3-D adjunct resistivity values (Ωm)	Difference	% Conformance	% Conformance range	% Conformance median
1	58.320	194.730	136.410	36.410	36.410	
2	53.080	67.570	14.490	85.510	51.970	
3	49.980	38.130	11.850	88.150	57.780	
5	65.780	23.560	42.220	57.780	70.780	
6	67.340	19.310	48.030	51.970	71.850	**71.850**
6	45.790	27.830	17.960	82.040	74.440	
8	42.100	16.540	25.560	74.440	82.040	
10	45.160	17.010	28.150	71.850	85.510	
10	55.250	26.030	29.220	70.780	88.150	

Summary Table of Percentage Conformance Medians: Table 10 is the summary table of percentage conformance medians for the three time-lapse survey sequences.

Table 10: Summary table of percentage conformance medians for the three time-lapse survey sequences

Survey Time Sequences	% Conformance median
First Time Sequence	69.780
Second Time Sequence	51.140
Third Time Sequence	71.850

The format of the preceding analysis was carried through for the P6-2 location (which is the single principal groundwater prospect location along the second cross-profile), the P15-3 location (which is the single principal groundwater prospect location along the third cross-profile), the P20-4 location (which is the single principal groundwater prospect location along the fourth cross-profile), and the P1-5 location (which is the single principal groundwater prospect location along the fifth cross-profile).

Discussion

Three passes of VES in-line and cross-line survey over two-weekly interval were conducted in the local farming season for both the in-line and cross-line grids for this survey. Evidence abounds about the application of agrochemicals at the area of study during this local farming season. Each of the three passes of VES in-line and cross-line survey was a time sequence, and for each time sequence, resistivity values for the principal grid survey in the in-line and cross-line modes and resistivity values for the adjunct grid survey in the in-line and cross-line modes, were determined down to the 10m depth of investigation for this study. Then the mean 2-D-format in-line and cross-line resistivity values plus the overall mean 3-D-format resistivity values of the principal grid and the mean 2-D-format in-line and cross-line resistivity values plus the overall mean 3-D-format resistivity values of the adjunct grid at the different depth intervals (that is 1m, 2m, 3m, 5m, 6m, 6m, 8m, 10m, 10m) for the three time sequences were computed; subsequently, tables of correlation for the overall mean 3-D-format resistivity values of the principal grid and the overall mean 3-D-format resistivity values of the adjunct grid for the three time sequences were generated.

Discussion of Result of the First Time Sequence Survey for the P4-1 Location: The overall mean 3-D-format resistivity values for the first time sequence survey indicate an approximate progressive decrease of resistivity values from the 1 m depth-mark through to the 10 m depth-mark; a resistivity high of 103.840 Ωm is associated with the 1 m depth-mark and a resistivity low of 52.370 Ωm is associated with the 5 m depth-mark.

Discussion of Result of the Second Time Sequence Survey for the P4-1 Location: The overall mean 3-D-format resistivity values for the second time sequence survey indicate a low-high-low-high-low sequence of resistivity values from the 1 m depth-mark through to the 10m depth-mark; a resistivity low of 33.700 Ωm is associated with the 5 m depth-mark and a resistivity high of 105.670 Ωm is associated with the 8 m depth-mark.

Discussion of Result of the Third Time Sequence Survey for the P4-1 Location: The overall mean 3-D-format resistivity values for the third time sequence survey indicate an almost evenly-spread of resistivity values from the 1 m depth-mark through to the 10 m depth-mark; a resistivity high of 67.340 Ωm is associated with the first leg measurement 6 m depth-mark and a resistivity low of 42.100 Ωm is associated with the 8 m depth-mark.

Discussion of Result of the Three Time-Sequence Control for the P4-1 Location: The overall mean 3-D-format resistivity values of the adjunct grid for the three time sequences indicate a progressive drop in resistivity values down to the 8 m depth-mark and then a slight jump in value to the 10 m depth-mark; a resistivity high of 194.730 Ωm is associated with the 1 m depth-mark and a resistivity low of 16.540 Ωm is associated with the 8m depth-mark.

The Statistical Correlations for the P4-1 Location: The percentage conformance medians of the first time, second, and third time sequences are 70%, 51%, and 72%.

The Statistical Correlations for the P6-2, P15-3, P20-4, and P1-5 Locations: For P6-2, the percentage conformance medians of the first time, second, and third time sequences are 60%, -55%, and 41%.

For P15-3, the percentage conformance medians of the first time, second, and third time sequences are -103%, -107%, and -109%.

For P20-4, the percentage conformance medians of the first time, second, and third time sequences are 96%, 80%, and 89%.

For P1-5, the percentage conformance medians of the first time, second, and third time sequences are 76%, 82%, and 84%.

The Statistical Weight of the Correlations for the P4-1, P6-2, P15-3, P20-4, and P1-5 Locations: For this study, a threshold correlation value of 70% is taken as the acceptable boundary point for a first-pass positive correlation; this threshold bar is set so high because of the need to make a definite conclusion about the observations derivable from the results of the survey completed out there in the field. Overall, a second-pass positive correlation between the resistivity values for the principal grid survey and the resistivity values for the adjunct grid survey is achieved, if and only if, there are more threshold correlation values greater than 70% than there are those less than 70%. Thus, for P4-1, the statistical weight of the correlations of 70%:51%:72% is two-third second-pass positive correlation (approximately 67% positive correlation). For P6-2, the statistical weight of the correlations of 60%:-55%:41% is 100% second-pass negative correlation (or 0% positive correlation). For P15-3, the statistical weight of the correlations of -103%:-107%:-109% is 100% second-pass negative correlation (or 0% positive correlation). For P20-4, the statistical weight of the correlations of 96%:80%:89% is 100% second-pass positive correlation. For P1-5, the statistical weight of the correlations of 76%:82%:84% is 100% second-pass positive correlation.

Conclusion

For P4-1: A two-third second-pass positive correlation arising from the correlations of 70%:51%:72% is thus herein regarded as indicating that the groundwater prospect location of P4-1 is not at risk from agrochemical pollution.

For P6-2: A 100% second-pass negative correlation arising from the correlations of 60%:-55%:41% is thus herein regarded as indicating that the groundwater prospect location of P6-2 is at risk from agrochemical pollution. This fact is further corroborated by the fidelity of the correlation statistical weight with field observations.

For P15-3: A 100% second-pass negative correlation arising from the correlations of -103%:-107%:-109% is thus herein regarded as indicating that the groundwater prospect location of P15-3 is at risk from agrochemical pollution. This fact is further corroborated by the fidelity of the correlation statistical weight with field observations.

For P20-4: A 100% second-pass positive correlation arising from the correlations of 96%:80%:89% is thus herein regarded as indicating that the groundwater prospect location of P20-4 is not at risk from agrochemical pollution.

For P1-5: A 100% second-pass positive correlation arising from the correlations of 76%:82%:84% is thus herein regarded as indicating that the groundwater prospect location of P1-5 is not at risk from agrochemical pollution.

"Agricultural Pollutants Leaching Regime" for the Area of Study: Examination of the results of the tandem surveys of the five southernmost cross-profiles of TT1, TT2, TT3, TT4, and TT5, with their designated principal grids at P4-1, P6-2, P15-3, P20-4, and P1-5 would lead to the clarification of the term "Agricultural Pollutants Leaching Regime" for the five southernmost cross-profiles of the area of study; thus, the "Agricultural Pollutants Leaching Regime" herein is designated in the format specially developed for this study and shown as Table 11.

This "Agricultural Pollutants Leaching Regime" as a "Threat Indicator" for the Area of Study: The format of Table 11, produced herein on a standalone basis, would be a component of a veritable threat indicator suite of documents if several such agricultural pollution regimes are compiled for a large contiguous suite of a farming district. Such threat indicator documents would be useful as a tool of information dissemination in the hands of agricultural extension officers and geologists. Now that an "Agricultural Pollutants Leaching Regime" for the area of study herein has been defined, it is recommended that a broader "Threat Indicator" for the larger 4 km^2 tranche of the Gidan Kwano Campus Development Phase II be produced in subsequent studies; this "Threat Indicator" document should be produced yearly, especially to keep tab on the prospect locations that have not yet been drilled for boreholes. The result of such an audit mechanism process would then be a public enlightenment advocacy geared towards the reduction of indiscriminate use of agrochemicals.

Table 11: Agricultural Pollutants Leaching Regime for the five southernmost cross-profiles of the area of study

Cross-Profile	Particular Station Designation	First-Pass Correlation	Second-Pass Correlation	Threat Indicator Advisory for Particular Station of Cross-Profile Area of Study	Prevalence of Positive Correlation for Area of Study (AOS)	Threat Indicator Advisory for AOS	Remark
TT1	P4-1	70%≡ + Corr. 51%≡ - Corr. 72%≡ + Corr.	2/3 positive correlation ≡ 67%	No risk	3/5 ≡ 60%	No risk overall but vigilance advised	Reduce indiscriminate use of agrochemicals
TT2	P6-2	60%≡ - Corr. -55%≡- Corr. 41%≡ - Corr.	0% positive correlation	Risk present	3/5 ≡ 60%	No risk overall but vigilance advised	Reduce indiscriminate use of agrochemicals
TT3	P15-3	-103%≡-Corr. -107%≡-Corr. -109%≡-Corr.	0% positive correlation	Risk present	3/5 ≡ 60%	No risk overall but vigilance advised	Reduce indiscriminate use of agrochemicals
TT4	P20-4	96% ≡ + Corr. 80% ≡ + Corr. 89% ≡ + Corr.	100% positive correlation	No risk	3/5 ≡ 60%	No risk overall but vigilance advised	Reduce indiscriminate use of agrochemicals
TT5	P1-5	76% ≡ + Corr. 82% ≡ + Corr. 84% ≡ + Corr.	100% positive correlation	No risk	3/5 ≡ 60%	No risk overall but vigilance advised	Reduce indiscriminate use of agrochemicals

n.b.: + Corr. ≡ Positive Correlation - Corr. ≡ Negative Correlation

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