Investigation of soil and groundwater pollution using geophysical methods in West Bank, Palestine.

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Keywords: Electrical resistivity tomography, pollution, geophysics, waste water and Palestine.

1. Introduction:

Several geophysical surveys were conducted in different sites located in the West Bank, Palestine. Due to the dangerous effect of the pollution on underground water and geological formations, the electrical method has been employed to investigate the extent of waste water intrusion of the septic tanks found everywhere in the villages and marginalized areas within the geological formations This method aim essentially to:

(1) Characterize the geological structures which allow the infiltration. (Inhomogeneity).
(2) Detect the pollution and to localize of potential infiltration of pollutant.
(3) Localize the infiltration zone of pollution (facies changes/lithology).

2. Method:

Geophysical methods are widely employed in numerous domains related to environment and engineering (Auken *et al.,* 2006). DC resistivity measurement have been continuously developed for several decades and used with good results. The electrical resistivity tomography (ERT) is one of the geophysical techniques used for the earth's exploration. ERT is based on the measurements of one of the physical properties of the earth's subsurface; electrical resistivity. These electrical resistivity measurements in soil and rocks provide an image representing subsurface conditions and characterize the contents of the structures. Owning this valuable value allow acquiring more details about the geological structures and the lithology of the underground. In order to have an estimation of the apparent electrical resistivity (rho a) of the underground feature), a known value of an electrical current must be injected and the measurement of the potential distribution is needed. ERT technique has the ability to present the changes in electrical resistivity values of the compounds during a period of time, thus it is applicable in the environmental pollution (Kaya *et al,* 2007). Images of the spatial electrical resistivity variations will be clearly viewed using the latter techniques, thus locating contaminated zones and illustrating rapid changes caused during a period of time are well shown.

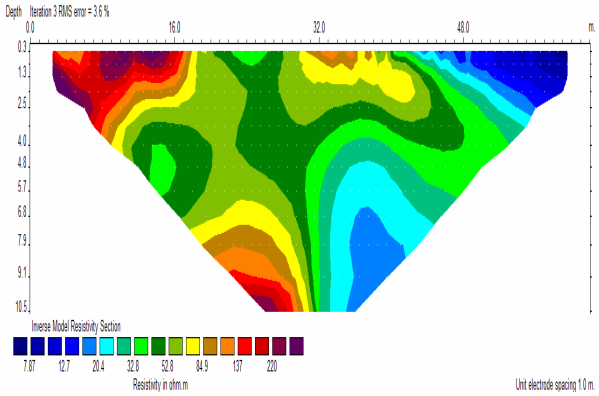
3. Experimental results:

A Syscal Junior device (Iris Instruments) has been used to acquire the field measurements. The data have been processed using the following software programs: Prosys, X2ipi (Robain and Bobachev, 2002) and Res2DInv (Loke, 2006). These programs have been employed to perform the acquisition, the filter process and the inversion of a 2D pseudo-sections resistivity models.

3.1 Site AbuDeis:

Figure 1 demonstrate the first results of the electrical tomography pseudo-sections; in the present case, the electrical profile represents two different electrode array configurations, Wenner α and Dipole-dipole configurations. This profile was carried out in Abu Deis

Abu Deis: Wenner α EW32 E 2M



Abu Deis : Dipole-dipole EW 32 E 2M

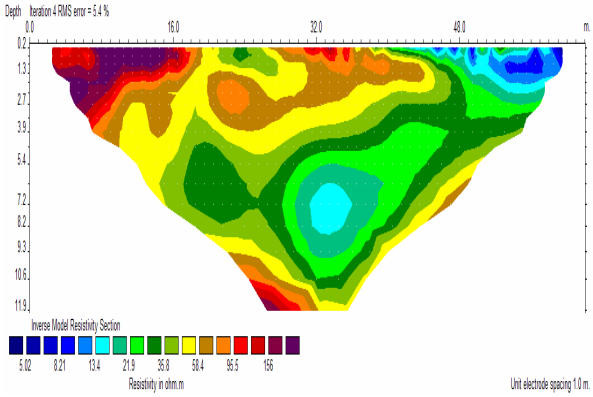


Figure 1: Wenner α and Dipole-dipole configurations pseudosections.

The geophysical survey campaign at Abu Deis and its environment aims to establish a geo-electrical log for the chalky geological formation of the west bank which is called Abu Deis formation. The obtained geo-electrical values by comparing three electrode array configurations are as follows:

- Massif chalky formations. (90-110 ohm.m).
- Chalky stone formations. (110-200 ohm.m).
- Chalky limestone formations (150-300 ohm.m).

The following study is chosen to present the influence of pollution of waste water on the above geological formations. For that reason, two electrode array configurations are applied in a large field between four houses near, very close to five evacuation dugs; two of them are closed and three are in function. The model of Abu Deis, 11.9m of depth shows from left to right as follows:

- At the surface, we observe an alternating of four different zone:
  - A medium resistant >220 ohm.m. (Chalky stone).
  - A conductive zone ~40 ohm.m (chalk).
  - A medium conductive ~ 100ohm .m(chalk)
  - A very conductive < 20 ohm.m(clay).
- At the basis of the model, we observe a conductive zone (40ohm.m) and a very conductive zone <40 ohm.m.

3.2 Site EinAsal Nablus - North of West bank:

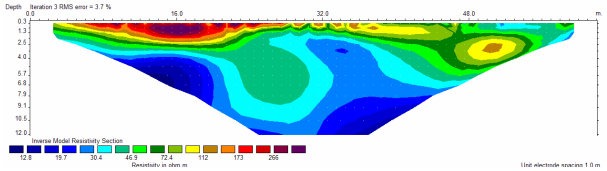
Two geoelectrical profiles separated by five meters between each other were carried out in this site. Figure 2 presents a 2D pseudo section:

Figure 2: Schlumberger, Wenner α and Dipole-dipole configurations pseudosections.

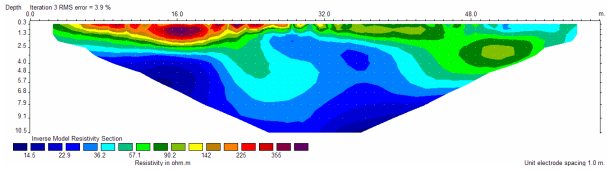
- Profile No.1: the obtained model of about 11 meters of depth shown in figure 2. presents the followings:

Nablus Ein Asal (Profile No.1)

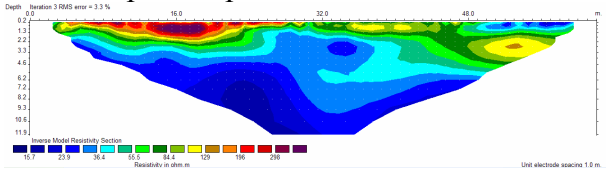
P1 NS Schlumberger 32 E 2M



P1 NS Wenner 32 E 2M

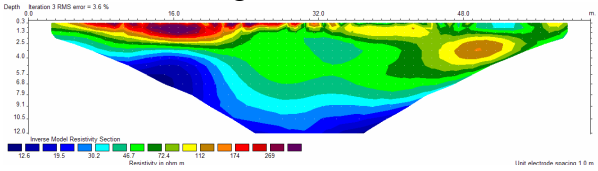


P1 NS Dipole -dipole 32 E 2M

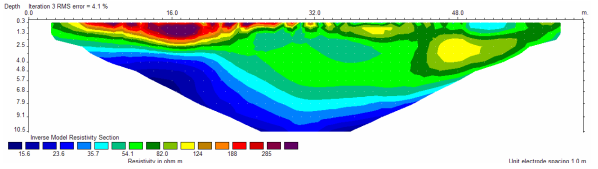


Nablus Ein Asal (Profile No.2)

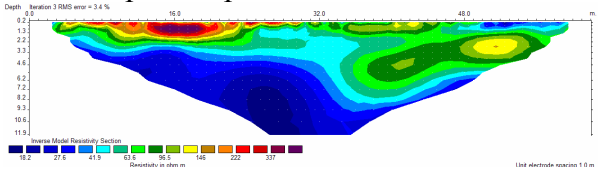
P2 NS Schlumberger 32 E 2M



P2 NS Wenner 32 E 2M



P2 NS Dipole -dipole 32 E 2M



- A conductive basement zone owning an apparent electrical resistivity of (12 - 30 ohm.m) with two branches. The first is situated in the middle of the profile, and the second is situated at the left part of the pseudo section at 5 m.of depth (Fig.2).
- On the surface, there exists three different zones starting from the left to the right, they are shown as:

- High electrical resistant zone with an apparent resistivity value ranged from 112 to 400 ohm.m. This zone represents a limestone and chalky limestone geological formation.
- An electrical resistant zone with an apparent resistivity values of (46-112 ohm.m). This geological formation can be considered as a chalky limestone and chalky stone. This zone is situated in the middle of the profile.
- A third zone is consisted of chalky stone and chalk to the right part of the profile.

- ProfileNo.2: Concerning the second profile where was applied at 5 meters from the first profile towards the east direction, it was clearly shown that the surface zone and the basement are quiet the same as the previous profile, but at the middle of the profile, it can be noticed that there is a zone with an apparent electrical resistivity from 50-80 ohm.m.(Chalky).

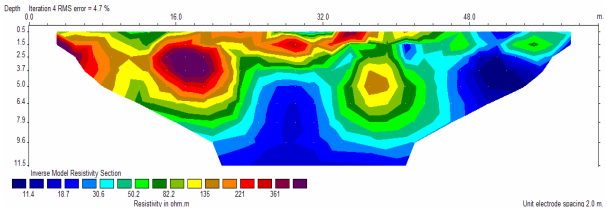
3.3 Site Jenin- Balama: Extreme north of west bank.

This study is realized with the cooperation of the Palestinian archeological direction in order to obvious the influence of a group of houses built on a hill which contains an historical tunnel; this site could be considered as an historical tourist site. Figure 3 demonstrates the geoelectrical pseudo section. The schlumberger model of 11.5 m depth shown from left to right as follow:

- At the left, an electrical resistance zone with an apparent electrical resistivity from 120 to >500 ohm.m. (Limestone and chalky limestone).

- At the middle, a conductive zone with an apparent electrical resistivity (11 -120) ohm.m at the basis of the model and the electrical resistant zone on the surface.
- At the right, two conductive zone having an apparent electrical resistivity (11-30 ohm.m).

Jenin: Schlumberger 32 E 2M PSN



Jenin: Wenner α 32 E 2M PSN

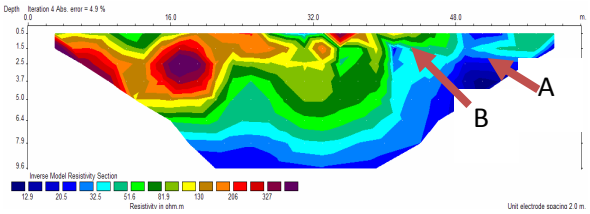


Figure 3: Schlumberger and Wenner α configurations pseudosections.
We mention here that the two results obtained by two different electrode array configurations are correlated.

4. Discussion:

Geo-electrical pseudo-sections for the three investigated sites reveal essentially the lithology changes at each site. In this exploration, the results obtained illustrate the inhomogeneities of the geological formation (Chalky limestone) in general where the pollution zones are well detected.

4.1Site Abu Deis-Jerusalem:

The localization of the five waste water tanks explains the decrease of apparent resistivity value of chalky formation from more than 100ohm.m to below 40ohm.m. We can distinguish clearly between the very conductive zone in the extremity right section (clay) presented at the surface and the conductive zone down the model which is chalky with apparent resistivity <40 ohm.m. The Dipole dipole model confirms also the above obtained results:

4.2 Site EinAsal-Nablus:

If we take the middle of the model, we will see that it presents multi surface fractures. This hypothesis can explain the infiltration zone from the surface till the basement of the pseudo section .These results are consistent in the three pseudo sections using three different electrode array configurations (Schlum, Wenner and Dipole dipole).

On the other hand, the second profile (5 m far away from the first profile) shows that the concentration of the pollution and the infiltration of the pollutant substances are less towards the spring and the east direction, but still very high at the basis of the investigated area.

4.3 Site Balama-Jenin:

The chalky limestone in the left shows horizontal and vertical variations in the apparent electrical resistivity which becomes very conductive at the basis and in the center of the model. In the right, it becomes very conductive also from the surface to the basis. Regarding the right zone, we can see clearly the effect of the existence of two septic tanks at the right of the profile.

- A: a big septic tank which works till now (Fig 3).
- B: a small closed septic tank (Fig 3).

The two other arrays; wenner and DD present the same results.

5. Synthesis and general conclusion:

The success of the tomography experimentation as an electrical method and the good results obtained at different sites in Palestine show that the geoelectrical method is a very adapted tool to realize a systematic surveys to characterize different geological and climatic context. The geophysical electrical method has shown that the geological structures are non homogeneous at the three sites, this inhomogeneity can be considered as the main reason of infiltration which leads to a suitable environment for pollution distribution of pollutants. The obtained results verified the resolution and low cost of the surveys of the electrical method, in order to delineate some of the environmental aspect; waste water intrusion. In particular, the technique was suitable for detecting zones of pollution and pollutants cause by waste water intrusion in the fractured shallow geological structures, with good reliability.

6. Acknowledgment:

The authors would like to express their appreciation to all people who helped in any part of this work. We would like to thank director and the team of the water department at Nablus Municipality and the Palestinian archeological direction for their help.

7. References:

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