CONTRIBUTION OF GEOPHYSICS TO THE STUDY OF SOIL SPATIAL VARIABILITY AND OF DETAILED PHYSICO – CHEMICAL ANALYSES TO ASSESS LAND MANAGEMENT IMPACT IN AN EXPERIMENTAL PLANTATION OF RUBBER TREES

Gaghik Hovhannissian[1], Rungsun Im-Erb[2], Ratchapol Siriboon[3], Sylvain Pasquet [4], Siwaporn Siltetcho[5], Wanpen Wiriyakitnateekul[6], Pascal Podwojewski[7]

[1] Research Engineer, UMR 211 BIOEMCO, Institut de Recherche pour le Developpement (IRD), Bondy, France. E-mail: gaghik.hovhannissian@ird.fr

[2] Advisor, Land Development Department (LDD), Bangkok, Thailand. Email: rungsuni@hotmail.com

[3] Master degree student, Graduate School, Khon Kaen University, Khon Kaen, Thailand.
E-mail: tape_siriboon@hotmail.com

[4] Ph.D. degree student, UMR 7619 SISYPHE, Pierre et Marie Curie University, Paris, France.
E-mail: sylvain.pasquet@upmc.fr

[5] Researcher, LDD – Region 5, Khon Kaen, Thailand. E-mail: aom_siwaporn@yahoo.com

[6] Researcher, Office of Science for Land Development, LDD, Bangkok, Thailand. E-mail: wpenldd@gmail.com

[7] Researcher, UMR 211 BIOEMCO, IRD, Bondy, France. E-mail: pascal.podwojewski@ird.fr

Abstract: Economical pressure on production and export of natural rubber leads to continuous expansion of rubber tree plantations in Thailand, even in areas, where climatic and environmental conditions are not optimal. In North-East Thailand the sandy textured soils are widespread. They are characterized by their weak structure and low cohesion between grains, making them vulnerable against erosion and degradation.

The land preparation and its adaptation for implementation of rubber tree plantations usually require major land management works (levelling, tree skidding, soil displacement, embankment, *etc.*). The use of powerful and heavy vehicles during these works deteriorates the already weak structure of soils and increases their vulnerability to erosion.

The experimental site of "Ban Non Tun" is located about 20-25 km southwest from Khon Kaen city and covers an area of 3.75 ha having a shape of irregular pentagon. This site is a trial of rubber tree plantation, which occupies a portion on one side of a small watershed with a variable main slope (between 2% and 5%) oriented approximately North-South along a distance of 250-300 m. The difference in altitude between southern (upstream) and northern (downstream) parts of the site is slightly more than 10 m (Fig. 1a). The land surface is convex with the upper central part (0.4 m to 0.9 m) relative to the lateral zones. In the "Ban Non Tun" experimental plantation, further works were undertaken to create elevation differences between "ranks" and "inter-ranks" of trees making the altitudes of "ranks" slightly higher (0.25 to 0.5 m) than the "inter-rank" areas.

[1] Corresponding author: gaghik.hovhannissian@ird.fr

These topographic structures were created in order to protect the tree roots from water excess during the rainy season.

In this experimental plantation, the soil spatial variability was studied by electrical apparent resistivity mapping, a non-destructive method well suited for the rapid and detailed characterization of large areas. Soil forming solid materials are usually characterised by very high values of electrical resistivity. The electric current conduction in soil occurs by displacement of ions, contained in water or in solutions present within the porous medium. This feature of electric current conduction explains the relationship between electrical resistivity values and different physicochemical soil properties such-as: textural and structural characteristics of soil (size and shape of solid particles and pores, their arrangements and aggregation), water and clay content, hydraulic and chemical properties (connectivity between pores, hydraulic conductivity, or ionic concentration in the pore space water).

Geophysical and topographical mapping results, characterizing the soil spatial variability and relief peculiarities of this site, showed a strong coherence between electrical resistivity anomalies and topographic structures created during the land management (Fig. 1a & 1b).

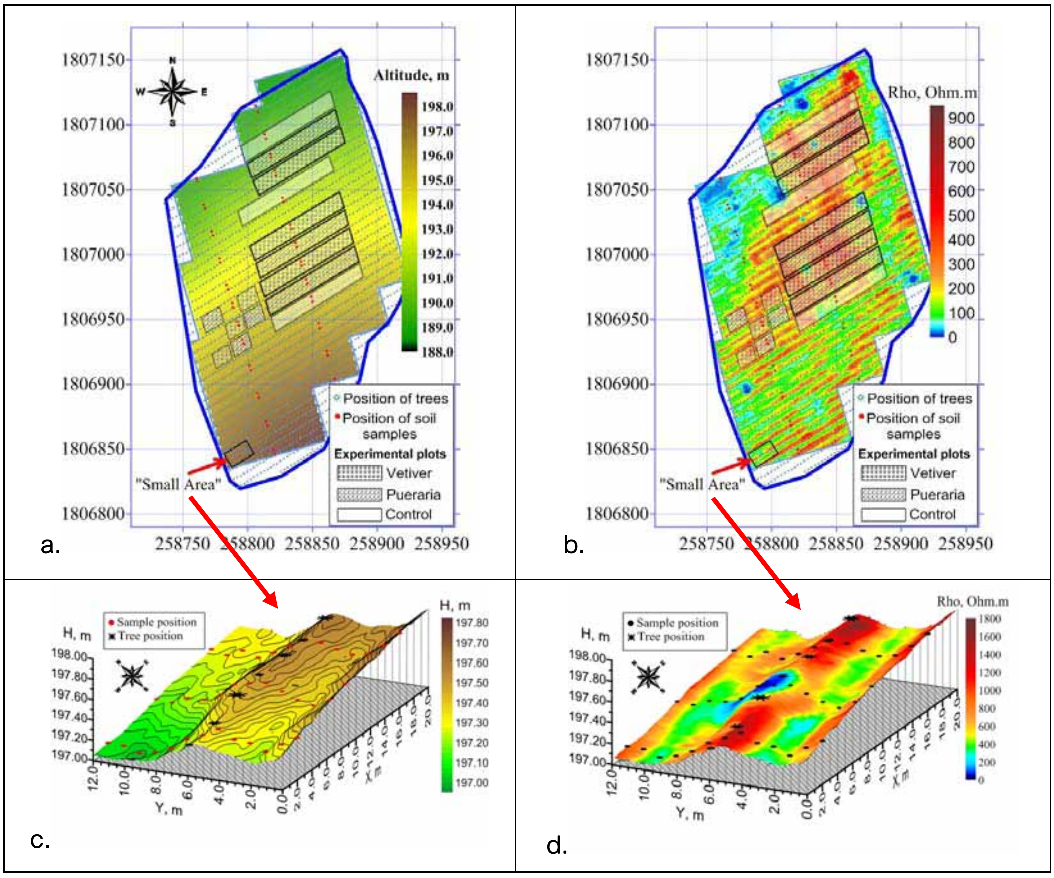

Figure 1 Topographic (a.) and apparent electrical resistivity (b.) maps of Ban Non Tun experimental site (in UTM geographic coordinates) and very detailed topographic (c.) and apparent electrical resistivity (d.) maps of the "Small Area" (in local coordinates)

To understand the origin and nature of these extended geophysical anomalies corresponding to the ranks of rubber trees, we selected a relatively "small area" (with dimensions of 20 m x 12 m) in the south-west part of the site, where we have performed more detailed studies (Fig. 1). This "small area" is centered on a "rank" of trees. It spreads on two "inter-rank" areas until the halves of the two adjacent "ranks". The elevation differences between "rank" and "inter-rank" areas vary from 0.2 m to 0.25 m. This area has two main slopes: one is oriented South-North with a slope varying from 0.8° to 1.3°; the other has East-West direction with a slope range between 0.6° to 1.2° (Fig. 1c).

For electrical apparent resistivity mapping in the "small area", we used a device integrating variations of the soil electrical characteristics down to 4 different depths: from 0 to about 0.25 m; from 0 to about 0.50 m; from 0 to about 1.0 m; from 0 to about 2.0 m. The map corresponding to the shallow part of soil (0 to 0.25 m deep), revealed different features: very resistive anomalies on the tree "ranks", relatively lower electrical resistivity values on the "inter-rank" areas and a conductive anomaly (about 3 – 4 m of diameter) on the central part of the "rank" of trees. Results of electrical resistivity tomography (ERT) obtained with electrode lines crossing this conductive anomaly indicate that it corresponds to the location of an uprooted tree pit, backfilled afterward.

Analysis of the geophysical prospecting and numerical modeling results has indicated the existence of a very thin and very resistive layer at the top part of each tree "rank", most probably related to the practice of soil management works.

Studies of physical and textural characteristics on soil samples were continued to understand the origins of geophysical anomalies and to assess the land management impact on the soil evolution.

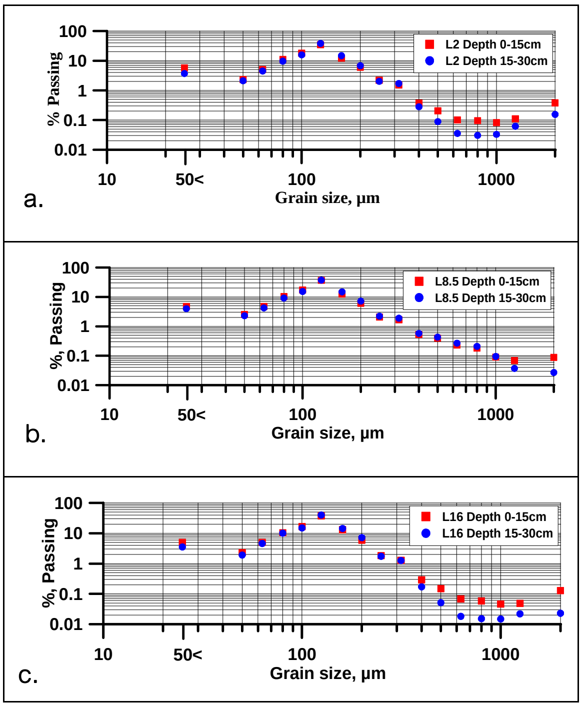

Figure 4 Particle size distributions of soil samples, taken on 3 lines in the "Small area":

a. for Line X = 2m, b. for Line X = 8.5m and c. for Line X = 16m

Soil samples were taken every 1 m along 3 lines, perpendicular to the "rank" of trees (Fig. 1c & 1d). At each sampling point, two undisturbed samples were collected from depths of 0 to 15 cm and 15 cm to 30 cm. The samples were used to define the bulk density and the particle size distribution (PSD). For PSD analysis, the weight fractions of solids were determined by dry sieving, using square mesh sieves of 16 different opening dimensions.

PSD analysis of the samples showed that more than 80-85% of the solid components have sizes between 80 μm and 200 μm for both depths, corresponding to shallow part (0-15 cm deep) and at the depth of 15 cm to 30 cm (Fig. 2). Comparison of PSD at different depths reveals higher amounts of coarse particles (0.4 – 2.0 mm diameter) near surface, versus at depth, indicating significant runoff erosion leading to the transfer of fine particles (Fig. 2a & 2c). Detailed analyses of each normalized weight fraction, relative to the sample position, indicate obvious links between the relief peculiarities and particle distributions, for both, at the surface and at depth. Relatively large amount of coarse particles at depth relative to the shallow part in the "inter-rank" areas, exhibits an important indicator of the water infiltration rate modification, resulting an increase in the leaching of fine particles. Bulk density values of the soil samples at different depths show also clear links with the relief peculiarities. Analysis of results exhibits noticeable differences between the characteristics of samples, taken along of different lines, and especially, for the samples corresponding to the uprooted tree location.

These results prove the impact of land management works on different characteristics of soil and show importance of the soil spatial variability studies before undertaking any change of land use in sensitive areas.

Geophysics combined with detailed analyses of soil physical properties appears to be proper tools for preliminary investigations in order to define adapted land management works and preserve soil resources.

The 5th National Conference on Water Resources Engineering
การประชุมวิชาการวิศวกรรมแหล่งน้ำแห่งชาติ ครั้งที่ 5

The 2nd EIT International Conference on Water Resources
การประชุมวิชาการนานาชาติวิศวกรรมแหล่งน้ำ ครั้งที่ 2

The 2nd WASWAC World Conference
การประชุมวิชาการอนุรักษ์ดินและน้ำโลก ครั้งที่ 2

องค์ความรู้แบบสหวิทยาการสำหรับการจัดการภัยพิบัติน้ำ
Multi-disciplinary Knowledge for Water Disaster Management

ระหว่างวันที่ 4-7 กันยายน 2556
ณ โรงแรม เลอเมอริเดียน เชียงราย รีสอร์ท จังหวัดเชียงราย

จัดโดย คณะอนุกรรมการสาขาวิศวกรรมแหล่งน้ำ วิศวกรรมสถานแห่งประเทศไทย ในพระบรมราชูปถัมภ์
ภาควิชาวิศวกรรมโยธา คณะวิศวกรรมศาสตร์ มหาวิทยาลัยธรรมศาสตร์
สมาคมอนุรักษ์ดินและน้ำโลก
ร่วมกับ

การประปานครหลวง
METROPOLITAN WATERWORKS AUTHORITY