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# Measurement of the electrokinetic properties of peats treated with chemical solutions



Hossein Moayedi<sup>a,\*</sup>, Ramli Nazir<sup>a</sup>, Khairul Anuar Kassim<sup>a</sup>, Bujang Kim Huat<sup>b</sup>

<sup>a</sup> Department of Geotechnics & Transportation, Faculty of Civil Engineering, Universiti Teknologi Malaysia, Johor, Malaysia

<sup>b</sup> Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

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## ABSTRACT

In this study the relations between different chemical stabiliser solutions on the electrokinetic (EK) properties of tropical peat such as surface charge, diffuse double layer (DDL), current density, electroosmosis flow (EOF) and energy consumption are measured. The EK injection tests (with different chemical solutions) were performed with several electrolytes, namely, sodium silicate ( $\text{Na}_2\text{SiO}_3$ ), calcium oxide (CaO), aluminium hydroxide ( $\text{Al}(\text{OH})_3$ ) and calcium chloride ( $\text{CaCl}_2$ ) as chemical reagents. As a result, the suspensions with the high molarities of  $\text{CaCl}_2$ ,  $\text{Al}(\text{OH})_3$  and CaO caused colloidal charge reversal in the surface of the colloidal from the negative to the positive. Furthermore, for the injection of NS-DW solution through the peat, electrokinetically, the total required energy was higher, about 693%, 373% and 234% for the EK injection of Al-DW, CaO-DW and Ca-DW, respectively. The same trend was also measured for the current density. After three days of EK tests, the current density for Al-DW, CaO-DW, Ca-DW and NS-DW was 0.267, 0.401, 0.668 and 1.872  $\text{mA}/\text{cm}^2$ , respectively. The results of this research can be used to evaluate an initial estimation for required energy to inject electrically and changing the flow net in a real electrokinetic treatment.

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## 1. Introduction

The physical and chemical characteristics of soils are connected to the surface charge properties of the colloidal particles that mobilised the soil. The surface of colloidal particles carries electric charges, and these surface charges are the basic cause for soil particles to possess a series of surface properties. Soil surface charges affect the chemical properties of the soil through varying the quantity of electric charge and the surface charge density [1]. Surface charge in turn is a function of pH and dissolved salts concentration, which normally measure by the zeta ( $\zeta$ ) potential [2,3]. The  $\zeta$  potential is defined as the work necessary to take a unit positive charge from the bulk liquid phase up to the strongly adsorbed rigid layer, and is generally less than  $\pm 0.1$  V. It is dependent upon the dielectric constant,

viscosity, ionic strength, pH, etc. of the liquid phase [4]. The  $\zeta$  potential also determines the strength of the repulsive forces between soil colloidal particles and controls the stability of a colloidal system [5]. The colloidal interaction of particles, including repulsion and attraction, changes with their inherent surface properties and the interfacial layer composition around them, resulting in chemical and physical equilibria between solid and aqueous phases [6]. In other words, order of magnitude of the  $\zeta$  potential gives an indication of the colloidal system stability. If all the particles in a suspension have high negative or positive  $\zeta$  potentials, then they will tend to repel each other, with no tendency of particles to come together and forming aggregates. However, if the particles show a low  $\zeta$  potential, there is no force to prevent them from coming together and flocculating. The dividing line between stable and unstable suspensions is usually taken to be either +30 mV or –30 mV. Particles with  $\zeta$  potentials either

\* Corresponding author. Tel.: +989177113193.

E-mail address: [hossein.moayedi@gmail.com](mailto:hossein.moayedi@gmail.com) (H. Moayedi).

more positive than +30 mV or more negative than –30 mV are considered stable [7,8].

The  $\zeta$  potential is one of the important electrokinetic properties of soil colloidal particles [9]. Fig. 1 schematically illustrates the  $\zeta$  potential on a charged particle that is presented by Kaya and Yukselen [10]. It is indeed well established that for many applications, the magnitude and the sign of the  $\zeta$  potential must be known. For soils such as clay and peat, it is usually negative, but it is mainly dependent on the chemistry of the pore-fluid.

It is well known that  $\zeta$  potential of pH dependent soils is highly influenced by the chemical solutions type and concentration. There is a large body of research on electrokinetic properties of clayey soils, electroosmosis improvement, such as the  $\zeta$  potential of clay minerals, clayey soil decontamination that can be found in journals such as Applied Clay Science, Journal of Hazardous Materials and Journal of Colloid and Interface Sciences. However, there is no comprehensive study on the electrokinetic properties of peat soil with accompanying cations, along with their influence on electrokinetic stabilisation.

The electroosmosis technique has been used by geotechnical engineers for many years to extract water from fine grained soils, thereby consolidating and improving the shear strength parameters [10,12]. Acar and Alshawabkeh [13] and Kim et al. [14] investigated whether this method could be used to remove subsurface contaminants. Page and Page [15] compiled a comprehensive review of the literature on electro-remediation of soils and discussed some of the problems that occur during this electrokinetic process. The most commonly tested artificial soil is kaolinite, but many experiments have also been performed using other clay minerals, peat, sand and artificial clay mixtures [15–18]. During an electrokinetic experiment, conductivity and pH of the pore solution, moisture

content of the soil, electroosmosis flow net, shear strength and/or contaminant distribution throughout the soil are often measured at the end of the experiment by analysing slices of the material. Experiments are run for times varying from maximum of several months to minimum of a few hours. For various researchers, the normal test period of EK test is between 7 and 15 days [16,19–22]. The main objective of the current research is to investigate the effect of various types of chemical solutions on the electrokinetic (EK) properties of treated soil such as surface charge, current density, electroosmosis flow (EOF) and energy consumption.

## 2. Materials and methods

### 2.1. Soil sample

Peat samples were collected and sealed to maintain soil moisture in accordance with the British Standard Institution (BS) methods of test for soils (BS 1377-1:1990) from Selangor, Malaysia. Although the collected soils were disturbed, the containers for the disturbed soil could be sealed to prevent any loss or gain of moisture. Precautions were also taken to avoid any kind of jolting during the transportation of the soil. The physicochemical properties of the used peat in this study are presented in Table 1.

### 2.2. Zeta potential measurements

The  $\zeta$  potential experiments were carried out at 25 °C at 0.1 g/L (solid-to-liquid ratios); of the suspended particles the  $\zeta$  potential of freshly prepared dispersions was determined using laser Doppler electrophoresis, namely, Malvern Zetasizer IIc instrument made in Worcestershire,

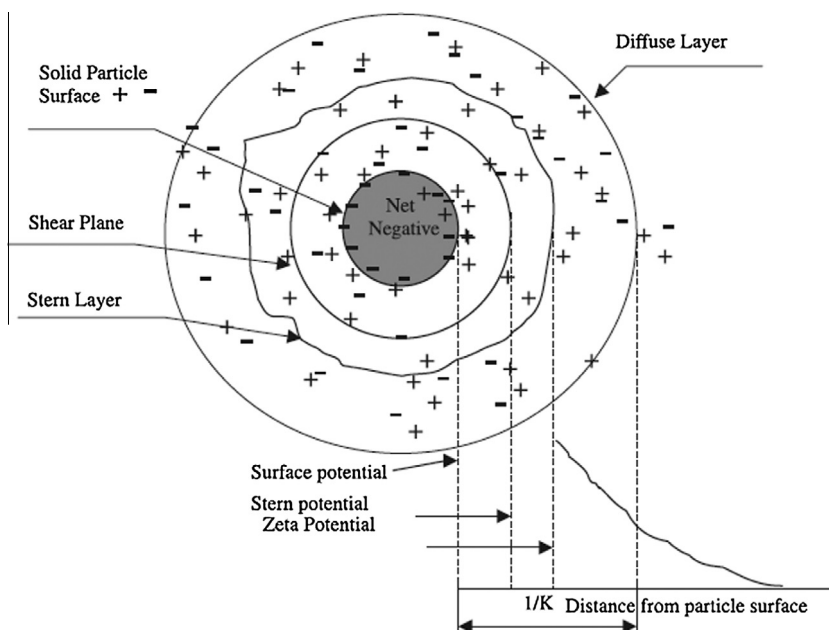


Fig. 1. Schematic illustration of  $\zeta$  potential on a charged particle [10,11].

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