APPLICATION OF ELECTROKINETIC REMEDIATION ON CONTAMINATED ALLUVIAL SOILS IN SRI GADING, BATU PAHAT, JOHOR

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Ilmu adalah panduan

Harta adalah alat

Kedua-duanya adalah untuk menegakkan kebenaran

Bukan untuk mencari kepentingan

Dan jauh sekali untuk tujuan kesombongan dan kebanggaan

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ABSTRACT

The research described in this thesis is a comprehensive account to remove excessive heavy metals and radionuclides contained in the most radiation-contaminated soil by using the most optimised electrokinetic remediation technique. This novel study that saved time and costs based on electrokinetic optimisation was the ultimate vision to be discovered on this thesis. In addition, reduction in terrestrial gamma radiation doserate (TGRD) by reducing soil pH level during electrokinetic processes was somewhat new and exciting in this study. The TGRD and soil pH of various soil type within Batu Pahat and Kluang districts were measured. Soil with the highest TGRD was selected to be remediated by various types of electrokinetics setup, to list out the best electrokinetic parameters. Results obtained from these setup led to the development of the most optimised electrokinetic setup, especially in remediating radionuclides. Data analysis showed that Holyrood-Lunas soil species taken from Sri Gading recorded the highest TGRD of 476.8±41.9 nGy h^{-1}. The pre-electrokinetic examination by X-ray fluorescence (XRF) indicated that 10 heavy metals contained in the sample were significantly higher than the Environmental Protection Agency (EPA) contamination indices limit, in decreasing order, were Th>As>Sb>Sn>U>Cr>Pb>Ni> V>Zr. The post-electrokinetic analysis suggested the most optimised parameters for Th and U removals were 3.0 hours remediation time, 30 volts electrode voltage, 22 cm electrode spacing, plate-shaped electrodes by 8×8 cm and in 1-D electrodes configuration. Applications of these optimised parameters by high-pure germanium (HPGe) analysis gave a very low ^{232}Th and ^{238}U removals at 2.74±23.78 and 0.23±2.64 ppms, respectively, while for the pilot scale electrokinetic setup shows average removals at 1.47±93.09 and 0.21±4.11 ppms, respectively. The relationships between ^{232}Th and ^{238}U concentrations with soil pH changes supported the initial hypotheses that reducing TGRD can be obtained by reducing soil pH level during the electrokinetic remediation process. Thus it can be concluded that the findings of this research can contribute towards the best soil decontamination.

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ABSTRAK

Penyelidikan dalam tesis ini adalah satu kajian menyeluruh untuk menyingkirkan lebihan logam berat dan radionuklid dalam tanah paling tercemar secara radiasi menggunakan teknik pemulihan elektrokinetik paling optimum. Kajian terbaru ini yang menjimatkan masa dan kos berdasarkan pengoptimuman elektrokinetik adalah visi muktamad di dalam tesis ini. Tambahan pula pengurangan kadar dos sinar gamma terrestrial (TGRD) dengan cara mengurangkan pH tanah semasa elektrokinetik adalah agak baru dan menarik dalam kajian ini. Pelbagai jenis tanah sekitar Batu Pahat dan Kluang telah diukur TGRD dan pH tanah. Tanah dengan TGRD tertinggi telah dipilih untuk dirawat melalui pelbagai jenis persediaan elektrokinetik, bagi menyenaraikan parameter elektrokinetik terbaik. Keputusan persediaan elektrokinetik ini menjurus kepada pembangunan persediaan elektrokinetik yang paling optimum, terutamanya dalam memulihkan radionuklid. Analisa data mendapati spesies tanah Holyrood-Lunas yang diambil dari Sri Gading mencatatkan TGRD tertinggi iaitu 476.8±41.9 nGy jam^{-1}. Pemeriksaan pra-elektrokinetik melalui analisa X-ray pendarflouran (XRF) mendapati 10 logam berat dalam sampel tersebut melampaui had indeks pencemaran Agensi Perlindungan Alam Sekitar (EPA), dalam susunan menurun: Th>As>Sb>Sn>U>Cr>Pb>Ni>V>Zr. Analisa pasca-elektrokinetik mencadangkan parameter paling optimum bagi nyah-singkir Th dan U adalah 3.0 jam masa rawatan, 30 volt beza keupayaan elektrod, 22 cm jarak elektrod, elektrod berbentuk plat bersaiz 8×8 cm dan konfigurasi elektrod 1-D. Aplikasi parameter optimum menerusi analisa germanium berketulenan tinggi (HPGe) memberikan nyah-singkir ^{232}Th dan ^{238}U yang sangat rendah iaitu 2.74±23.78 dan 0.23±2.64 ppm, masing-masingnya, sedangkan elektrokinetik pada skala perintis menunjukkan purata nyah-singkir 1.47±93.09 dan 0.21±4.11 ppm, masing-masingnya. Hubungan di antara kepekatan ^{232}Th dan ^{238}U dengan perubahan pH tanah menyokong hipotesis awal iaitu pengurangan TGRD boleh dilakukan dengan cara mengurangkan aras pH tanah semasa proses pemulihan elektrokinetik. Oleh itu adalah dirumuskan dapatan-dapatan di dalam penyelidikan ini boleh menyumbang kepada nyah-kontaminasi tanah yang terbaik.

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LIST OF SYMBOLS

^{40}K (or K-40)	-	Naturally occurring potassium isotope with A = 40
^{226}Ra (or Ra-226)	-	Naturally occurring radium isotope with A = 226
^{220}Rn (or Rn-220)	-	Naturally occurring radium isotope with A = 220
^{222}Ra (or Ra-222)	-	Naturally occurring radium isotope with A = 222
^{232}Th (or Th-232)	-	Naturally occurring thorium isotope with A = 232
^{238}U (or U-238)	-	Naturally occurring uranium isotope with A = 238
α	-	Alpha particle
β	-	Beta particle
Δ_m	-	The absolute difference between c_m and c_{CRM}
γ	-	Gamma radiation
η	-	Fluid viscosity
τ	-	Tortuosity
ζ	-	Zeta potential
A_K	-	Activity mass concentration of ^{40}K (in $Bq\cdot kg^{-1}$)
A_{Ra}	-	Activity mass concentration of ^{226}Ra (in $Bq\cdot kg^{-1}$)
A_S	-	Activity mass concentration (in $Bq\cdot kg^{-1}$)
A_{Th}	-	Activity mass concentration of ^{232}Th (in $Bq\cdot kg^{-1}$)
Al	-	Aluminium
As	-	Arsenic
At%	-	Soil element concentration in atomic percentage
Ba	-	Barium
Bq kg^{-1}	-	Becquerel per kilogram
c_m	-	The average of measured heavy metal concentrations
c_{CRM}	-	Certified values

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C	-	Coulomb
C_D	-	Post-electrokinetic deposition concentration
C_F	-	Dose conversion factor (absorbed dose rate in air per unit of activity concentration in soil)
C_R	-	Post-electrokinetic residual concentration
C_M background	-	The basic value of heavy metals (in ppm).
C_M sample	-	The concentration of heavy metals in contaminated soils (in ppm)
C_{smp}	-	The concentrations of the soil sample.
C_{std}	-	The concentrations of the standard sample
CF	-	Pollution factors
Ca	-	Calcium
Cd	-	Cadmium
Ce	-	Cerium
Co	-	Cobalt
Cu	-	Copper
Cr	-	Chromium
Cs	-	Cesium
d	-	Day
D	-	Dielectric constant
e^-	-	Electron
E	-	Electrical field strength (in V/m)
E_z	-	Applied voltage gradient
E_{eff}	-	Annual effective dose (in $mSv \cdot y^{-1}$)
EF	-	Enrichment Factor
F	-	Faraday constant (96.487 C/mol electrons)
F	-	Absorbed-to-effective dose conversion factor (in mSv per nGy)
Fe	-	Iron
Ga	-	Gallium
h	-	Hour
H_2	-	Chemical form of hydrogen gas
H_2O	-	Chemical form of water

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H^+	-	Hydrogen ion
H_{ext}	-	External hazard index
H_{int}	-	Internal hazard index
Hg	-	Mercury
I_{geo}	-	Index of Geo-accumulation
k	-	coverage factor
K	-	Potassium
La	-	Lanthanium
mass%	-	Soil element concentration in mass percentage
$mSv \cdot y^{-1}$	-	Millisievert per year
mGy	-	Milligray
Mg	-	Magnesium
Mn	-	Manganese
Mo	-	Molybdenum
n	-	Number of measurement data
N_{smp-bg}	-	The net counts of the photopeak area (after the background subtraction) of the soil sample
N_{std-bg},	-	The net counts of the photopeak area (after the background subtraction) of the standard sample
Na	-	Sodium
$nGy \cdot h^{-1}$	-	Nanogray per hour
Nb	-	Niobium
N	-	Soil porosity
Ni	-	Nickel
O_2	-	Chemical form of oxygen gas
OH^-	-	Hydroxide ion
Pb	-	Lead
pH	-	Hydrogen ion concentration
PLI	-	Pollution Load Index
Ra_{eq}	-	Radium equivalent activity
Rb	-	Rubidium
RSD	-	Relative standard deviation
s	-	Standard deviation

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