SEDIMENTATION RATE IN BERA LAKE AND SOIL REDISTRIBUTION AT ITS CATCHMENT USING RADIOISOTOPES

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ABSTRAK

Tasik Bera adalah bersistem lakustrin dan merupakan tasik semulajadi yang terbesar di Malaysia. Penilaian literasi jelas menunjukkan jurang evaluasi kesan persekitaran akibat aktiviti antropogen ke atas tanih dan sumber air dan regim sedimen di kawasan kajian. Sehubungan itu, penentuan taburan semula tanih dan nutrien di kawasan lembangan, kadar proses persedimenan, penilaian perubahan nutrien dan kualiti sedimen di Tasik Bera dengan menggunakan jatuhan radioisotop ^{210}Pb and ^{137}Cs dan garis panduan kualiti sedimen telah ditakrifkan sebagai objektif kajian ini.

Metodologi yang komprehensif telah di rangka untuk melaksanakan kajian literasi, inovasi alatan persampelan teras sedimen, survei lapangan, pengukuran eksperimen yang terperinci, pemetaan dan permodelan yang terkini. Kepelbagaian data set daripada model dan geo rujukan "GIS-tersedia" telah menyokong reka bentuk metodologi.

Aplikasi jatuhan inventori ^{137}Cs dan perkadaran model telah menrumuskan kadar purata hakisan tanih 915±345, 117±36 dan 70±35, t h^{-1} th^{-1} masing-masing bagi kawasan yang telah dibersihkan, kawasan perladangan baru dan lama. Kawasan kajian menunjukkan korelasi negatif di antara kandungan nutrien dan perluasan pembangunan tanah.

Pentarikhan statigrafi berdasarkan rekod-rekod jumlah jatuhan ^{137}Cs and ^{210}Pb yang diperolehi daripada kolum sedimen di Tasik Bera walau bagaimanapun secara relatifnya kekal malar. Keadaan ini membolehkan model CRS diaplikasikan untuk geokronologi sedimen di Tasik Bera. Kadar maksimum ^{210}Pb dan sedimentasi yang di kira dianggarkan masing-masing adalah 159±2 Bq cm^{-2} y^{-1} and 2.56 cm y^{-1} bagi kawasan

separuh tertutup di utara Tasik Bera. Kadar purata sedimentasi pra 1950 ialah sebanyak 0.08±0.02 g cm^{-2} y^{-1} (0.1±0.1cm y^{-1}) dan jelas menunjukkan akumulasi yang seragam sebelum adanya kesan aktiviti-aktiviti antropogen. Kadar sedimentasi meningkat secara drastik iaitu sebanyak 10 kali ganda sejak 1972 kesan permulaan fasa- fasa pembasmian hutan. Sehubungan itu, satu lapisan lumpur berpasir putih terenap secara drastik di antara 1972 dan 1993 di bahagian selatan, tengah dan utara Tasik Bera dengan kadar purata sebanyak 0.48±0.48, 0.54±1.2 and 0.17±0.12 g cm^{-2} y^{-1}.

Kewujudan ladang sawit matang telah meningkatkan produktiviti biojisim sebanyak 1.5 mil y-1 menyebabkan aliran air permukaan didominasi oleh bahan organik dengan kadar purata akumulasi sebanyak 0.2±0.1 g cm^{-2} y^{-1} (1.3 cm y^{-1}) di bahagian teratas jujukan lapisan sedimen di Tasik Bera semenjak 1994. Secara keseluruhannya, kadar sedimentasi menggunakan pentarikhan ^{210}Pb dan CRS model, jatuhan ^{137}Cs dan model perkadaran dengan nilai kecekapan penjerapan dan luahan sedimen yang diperolehi masing-masing adalah sebanyak 0.99, 1.025, and 1.11 cm y^{-1}.

Berdasarkan garis panduan kualiti sedimen menunjukkan pencemaran ketara bahan enapan di Tasik Bera oleh logam As dan di bahagian utara oleh logam Fe. Selain itu, profil sedimen Tasik Bera menunjukkan pencemaran sederhana oleh logam Cu, Cr dan Ni. Eutrofikasi sangat jelas berlaku di Tasik Bera kesan akibat fasa-fasa pembasmian hutan di kawasan lembangan.

Sebagai rumusan, keberhasilan kajian ini membolehkan keyakinan terhadap kaedah terpilih yang digunakan untuk mencapai objektif kajian ini. Kajian ini secara jelas telah menyumbang kepada ilmu pengetathuan berkenaan kaedah yang sesuai untuk menentukan kadar hakisan tanih di kawasan perladangan kelapa sawit di Malaysia dan

kadar sedimentasi dan penjanana semula sejarah tasik semulajadi, penilaian kualiti sedimen yang terenap dan pelan pengurusan bersepadu untuk penggunaan tanah, air dan pemuliharaan tanih yang mapan.

ABSTRACT

The Bera Lake is a lacustrine system and the largest natural lake in Malaysia. Assessment of literature review has highlighted a clear gap in the evaluation of environmental impacts of anthropogenic activities on the soil and water resources and sedimentary regime. Accordingly, determination of soil and nutrient redistribution in the catchment area, and sedimentation rates, nutrients fate and sediment quality assessment at Bera Lake using fallout ^{210}Pb and ^{137}Cs radioisotopes and sediment quality guidelines have been defined as aims of the present research.

A comprehensive methodology was formulated to perform an effective literature review, innovation of core sampler, field surveying, detailed experimental measurements, mapping, and an advanced modeling. A wide range of models and a geo-referenced "GIS-ready" data set have supported the designed methodology.

Application of fallout ^{137}Cs inventories and proportional model provide the mean of soil erosion of 914±345, 117±36, and 70±35, t h^{-1} y^{-1} in cleared lands, immature and mature oil palm plantations. A negative correlation between nutrient contents and the extent of land development was established in the study area

Stratigraphic dates based on records of fallout ^{137}Cs and ^{210}Pb supply rates to Bera Lake sediment columns have remained relatively constant. As a result, the CRS model is applied for geochronology of Bera Lake sediments. The estimated maximum ^{210}Pb flux and sedimentation rate were 159±2 Bq cm^{-2} y^{-1} and 2.56 cm y^{-1}, respectively in the semi-closed area at the north of Bera Lake. The mean pre-1950 sedimentation rate was 0.08±0.02 g cm^{-2} y^{-1} (0.1±0.1cm y^{-1}), which indicate a uniform accumulation trend prior to anthropogenic activities. Sedimentation rates raised were by 10 times since 1972

following deforestation. Accordingly, a white sandy mud layer was deposited between 1972 and 1993 at the south, middle, and the north of Bera Lake at mean rates of 0.48±0.48, 0.54±1.2 and 0.17±0.12 g cm^{-2} y^{-1}.

Establishment of mature oil palm plantations are promoting biomass productivity to 1.5 mil y^{-1}, dominates organic matters in run-off and accumulation of organic-rich deposits at mean rate of 0.2±0.1 g cm^{-2} y^{-1} (1.3 cm y^{-1}) at the uppermost layer of Bera Lake sediment sequence since 1994. Overall sedimentation rates in Bera Lake basin using ^{210}Pb date and CRS model, fallout ^{137}Cs and proportional model, and trap efficiency and sediment discharge values were 0.99, 1.025, and 1.11 cm y^{-1}, respectively.

Sediment quality guidelines have shown that lake deposits severely polluted by As and the north part polluted by Fe. Besides, Bera Lake sediment profiles are moderately polluted by Cu, Cr, and Ni. A clear eutrophication in Bera Lake has occurred due to deforestation phases in the catchment area.

To sum up, achievements have confidently approved capability of selected methods to achieve the research objective. Present study has remarkably contributed in knowledge due to formulation of the suitable method to estimate soil erosion in oil palm plantations in Malaysia, and sedimentation rates and reconstruction history of a natural lake, assessment of sediment quality and an integrated management plan for a sustainable land use and conservation of water and soil.

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Mohammadreza Gharibreza

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LIST OF ABBREVIATION

AWB	:	Asian Wetland Bureau
BLC	:	Bera Lake Catchment
BP	:	Before Present
Bq m^{-2}	:	Becquerel per square Meter
Bq m^{-2} y^{-1}	:	Becquerel per square Meter per Year
CBSQG	:	Consensus-Based Sediment Quality Guidelines of Wisconsin
cm y^{-1}	:	Centimeter per Year
CF:CS	:	Constant Flux: Constant Supply
C_f	:	Contamination Factor
CIC	:	Constant initial concentration model
Cl^-	:	Chloride
CRS	:	Constant rate of supply model
CV	:	Coefficient of Variation
^{137}Cs	:	Fallout Caesium-137 Radionuclide
DEM	:	Digital Elevation Model
DWNP	:	Department of Wildlife and National Parks
D_f	:	Degree of Contamination
DO	:	Dissolved Oxygen
EC	:	Electric conductivity
EF	:	Enrichment Factor
EFB	:	Empty Fruit Bunches
EIA	:	Environmental Impact Assessment

E_r	:	Potential Ecological Risk Factor for Individual Metal
FELDA	:	Federal Land Development Authority
FWHM	:	Full Width at Half Maximum
GC	:	Gas Chromatographic
GIS	:	Geographical Information System
g cm^{-3}	:	Gram per cubic Centimeter
H_3BO_4	:	Boric Acid
HCA	:	Hieratical cluster analysis
HCl	:	Chloride Acid
HF	:	Fluoride Acid
HNO_3^{1-}	:	Nitrate Acid
LDO	:	Lowest Dissolved Oxygen
LEL	:	Lowest Effect Level
LGM	:	Last Glacial Maximum
ICP-MS	:	Inductively Coupled Plasma Mass Spectrometry
ICP-OES	:	Inductively Coupled Plasma Optic Emission Spectrometry
IAEA	:	International Atomic Energy Agency
Igeo	:	Index of Geoaccumulation
IRBM	:	Integrated River Basin Management
ISQG	:	Interim Fresh Water Sediment Quality
IWRM	:	Integrated Water Resource Management
MACRES	:	Malaysian Centre for Remote Sensing
MPOB	:	Malaysian Oil Palm Board

$mg\ l^{-1}$	:	Milligram per Liter
$mg\ kg^{-1}$	:	Milligram per Kilogram
$MnCO_3$	:	Manganese Carbonate
NH_4^{+1}	:	Ammonia
NE-SW	:	North East- South West
NO_3^{2-}	:	Nitrate
NO_2^{-1}	:	Nitrate
NW-NE	:	North West-North East
NWQS	:	National Water Quality Standards for Malaysia
^{210}Pb	:	Fallout Lead-210 Radionuclide
PEL	:	Probable Effect Level
PFE	:	Permanent Forest Estate
pH	:	Acidity
POC	:	Particular Organic Carbon
PO_4	:	Phosphate
PPM	:	Per Part Million
RI	:	Potential Ecological Risk Factor for Basin
QAQC	:	Quality Assurance and Quality Control
SQG	:	Sediment Quality Guidelines
SEL	:	Severe Effect Level
SRM	:	Standard Reference Material
SW	:	South West
$t\ h^{-1}\ y^{-1}$	:	ton per hectare per year

TCD	:	Thermal Conductivity Detection
TDS	:	Total Dissolved Solid
TOC	:	Total Organic Carbon
TN	:	Total Nitrogen
USLE	:	Universal Soil Loss Equation
WGS	:	World Geographic Coordinate System