



**Faculty of Resource Science and Technology**

**Heavy Metals and Hydrocarbon Distribution Characteristics of  
Sediments from Batang Sadong of Samarahan Division, Sarawak,  
Malaysia**

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Heavy Metals and Hydrocarbon Distribution Characteristics of Sediments  
from Batang Sadong of Samarahan Division, Sarawak, Malaysia

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## DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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## **DEDICATION**

To God Almighty for his mercies and love. To my loving husband and wonderful children.

I would also like to dedicate this thesis to my parents and siblings for their love and encouragement.

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## ABSTRACT

Sediments are useful tools in understanding the environmental processes. The physical and chemical characteristics of sediments are dependent on geology, hydrological factors, geochemical influences, human activities and others. Sadong River is a major river catchment in Sarawak and the characteristics of the river sediments can be influenced by natural and anthropogenic factors. The aim of this study was to describe the sedimentological features of the river, and also determine the spatial and vertical distribution of heavy metals as well as the hydrocarbons. The degree of contamination by heavy metals and hydrocarbon compounds in the sediments were assessed. The surface sediments and core sediments with depths between 25 – 45 cm from seven sampling locations along Batang Sadong of Samarahan Division, Sarawak have been studied. The surface and core sediments were subjected to sedimentological analysis to determine the grain size distribution, moisture content, total organic matter (TOM) and ash content. Geochemical analyses were also conducted to determine the heavy metal and hydrocarbon contents in sediments. Heavy metals were extracted by wet digestion using a mixture of HNO<sub>3</sub>:HCl (3:1; v/v) and then analysed using atomic absorption spectrophotometer (AAS). Concentration of the eight (8) heavy metals and three (3) major metals in surface sediments were determined. The concentration of heavy metals in surface sediments were ranged 19.2 to 46.61 mg/kg (Zn), 3.45 to 12.30 mg/kg (Cu), 219.59 to 464.75 mg/kg (Mn), 1801.85 to 3447.62 mg/kg (Fe); 3.71 to 18.63 mg/kg (As) and 4.61 to 69.73 mg/kg (Pb). The geoaccumulation index ( $I_{geo}$ ), contamination factor (CF) and enrichment factor (EF) showed that the surface sediments of Sadong River is unpolluted. Both principal component analysis (PCA) and cluster analysis (CA) showed the heavy metals were mainly derived from lithogenic sources with minimal

input from anthropogenic sources. The concentration of Fe in core sediments was consistent from the upper layer to lower layer for all cores. The concentration of Cu in core sediments was consistent for all samples except for Sungai Buloh (BS3). Distribution pattern of Ni, Zn and Mn varied from the upper to the lower layers of core with a fluctuated pattern. Both aliphatic and aromatic hydrocarbons in the surface and core sediments were analysed using Gas Chromatography-Mass Spectrometry (GC-MS). Domination of *n*-alkanes originated from vascular plants were observed with significance high molecular weight (HMW) *n*-alkanes with odd carbon numbers in the sediments. Data of average chain length (ACL) and carbon preference index (CPI) supported this finding as observed in Sadong Jaya (BS2) and Serian (BS7). Terrigenous aquatic ratio (TAR) showed the importance of terrestrial plant over biogenic *n*-alkanes in the sediments. The LMW/HMW (value <1) showed domination of HMW *n*-alkanes in all sediment samples except for Sadong Jaya (BS2) sediment with a value 1.07. The presence of *n*-alkanes in the sediments of Sadong River may be associated with minimal petroleum input through direct deposition into the sediments or indirect ways by land runoff. Assessment of *n*-alkanes in the core sediment showed the hydrocarbons originated from terrestrial vascular plants, phytoplankton, algae and petroleum. Sixteen (16) targeted PAHs have been detected in Sadong River sediments with the occurrence of pyrene and fluoranthene which indicated pyrolytic input. The distribution and environmental indices of heavy metals and hydrocarbons showed sediments of Sadong River are unpolluted with heavy metals and hydrocarbons which are derived mainly from natural and minimal input of anthropogenic sources.

**Keywords:** Batang Sadong, heavy metals, Gas Chromatography-Mass Spectrometry (GC-MS), hydrocarbons, principal component analysis (PCA)

***Ciri-ciri Taburan Logam Berat dan Hidrokarbon dalam Enapan dari  
Batang Sadong di Bahagian Samarahan, Sarawak, Malaysia***

**ABSTRAK**

*Enapan merupakan petunjuk yang berguna untuk memahami proses yang berlaku di sekitaran. Ciri-ciri fizikal dan kimia enapan bergantung kepada geologi, hidrologi, pengaruh geokimia, aktiviti manusia dan sebagainya. Batang Sadong adalah salah satu tadahan sungai utama di Sarawak dan ciri-ciri enapan sungai boleh dipengaruhi oleh faktor semulajadi dan antropogenik. Kajian ini bertujuan untuk menerangkan ciri-ciri sedimentologi sungai dan juga menentukan taburan spatial dan vertikal logam berat dan hidrokarbon dalam enapan. Tahap pencemaran logam berat dan hidrokarbon dalam enapan telah dinilai. Enapan permukaan dan enapan teras dengan kedalaman antara 25-45 cm dari tujuh lokasi pensampelan di sepanjang Batang Sadong di Bahagian Samarahan, Sarawak telah dikaji. Analisis terhadap enapan dilakukan bagi menentukan taburan saiz bijian, kandungan kelembapan, jumlah bahan organik dan kandungan abu. Analisis geokimia dilakukan untuk menentukan kandungan logam berat dalam enapan serta analisis hidrokarbon. Logam berat diekstrak secara pencernaan basah menggunakan campuran asid  $\text{HNO}_3:\text{HCl}$  (3:1; isipadu/isipadu) dan seterusnya dianalisis menggunakan spektrofotometer serapan atom. Kepekatan lapan logam berat dan tiga logam utama dalam enapan permukaan telah ditentukan. Kepekatan logam berat dalam enapan permukaan adalah dalam julat 19.2- 46.61 mg/kg (Zn), 3.45-12.30 mg/kg (Cu), 219.59- 464.75 mg/kg (Mn), 1801.85- 3447.62 mg/kg (Fe); 3.71- 18.63 mg/kg (As) dan 4.61- 69.73 mg/kg (Pb). Indeks penumpukan geo ( $I_{geo}$ ), faktor pencemaran dan faktor perkayaan menunjukkan bahawa enapan permukaan Sungai Sadong tidak tercemar. Analisis komponen prinsipal dan analisis gugusan menunjukkan sebahagian besar logam berat adalah dari sumber litogenik dengan input minima dari sumber antropogenik. Kepekatan Fe dalam enapan teras adalah konsisten*



dari lapisan permukaan atas ke lapisan bawah untuk semua enapan teras. Kepekatan Cu dalam enapan teras adalah konsisten pada semua enapan teras kecuali dari sampel Sungai Buluh (BS3). Taburan untuk Ni, Zn dan Mn adalah turun naik secara rawak dari lapisan atas ke lapisan bawah teras. Kepekatan Pb dalam enapan teras adalah konsisten dari lapisan atas ke bawah untuk semua enapan teras kecuali sampel Sadong Jaya (BS2). Hidrokarbon alifatik dan aromatik dalam enapan permukaan dan teras telah dianalisis menggunakan Kromatografi Gas-Spektrometri Jisim (KG-SJ). Sebatian n-alkana dari tumbuhan vaskular adalah dominan dengan n-alkana berat molekul tinggi serta nombor karbon ganjil dicerapi dengan ketara dalam enapan. Data purata panjang rantai) dan indeks pilihan karbon menunjukkan n-alkana dari tumbuhan vaskular adalah dominan terutama sampel Sadong Jaya (BS2) dan Serian (BS7). Nisbah akuatik daratan menunjukkan kepentingan n-alkana dari tumbuhan darat berbanding yang berasal secara biogenik. Nisbah LMW/HMW (nilai <1) menunjukkan n-alkana HMW adalah dominan dalam semua sampel kecuali Sadong Jaya (BS2) dengan nilai 1.07. Kehadiran n-alkana dalam enapan Sungai Sadong menerima input minimum petroleum melalui pengendapan langsung atau secara tidak langsung melalui aliran dari daratan. Penilaian terhadap n-alkana dalam enapan teras menunjukkan hidrokarbon berasal dari tumbuhan vaskular, fitoplankton, rumpai dan petroleum. Enam belas (16) PAHs sasaran dikesan dalam enapan dari Sungai Sadong dengan kehadiran pirena dan fluorantena menunjukkan input pirolitik. Taburan dan indeks sekitaran menunjukkan Sungai Sadong tidak tercemar dengan logam berat dan hidrokarbon yang berasal terutamanya dari sumber semulajadi dengan input antropogenik yang minimum.

**Kata kunci:** Batang Sadong, logam berat, Kromatografi Gas-Spektrometri Jisim (KG-SJ), hidrokarbon, analisis komponen prinsipal (PCA)

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## LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
ACL	Average chain length
CA	Cluster analysis
CEFAS	Centre for Environment, Fisheries and Aquatic Science
CF	Contamination factor
CPI	Carbon preference index
DOSM	Department of Statistics Malaysia
EF	Enrichment factor
FRST	Faculty of Resource Science and Technology
GC-MS	Gas Chromatography-Mass spectrometry
GPS	Global positioning system
HMW	High molecular weight
$I_{geo}$	Geoaccumulation index
LOD	Limit of detection
LOL	Limit of linearity
LOQ	Limit of quantification
LMW	Low molecular weight
MH	Major hydrocarbon
OSPAR	Oslo/Paris convention for the protection of the marine environment of the North-East Atlantic
PAHs	Polycyclic aromatic hydrocarbons
PCA	Principal component analysis

RF	Response factor
TAR	Terrigenous aquatic ratio
TNA	Total normal alkanes
TOM	Total organic matter
UCM	Unresolved Complex Mixture
UNIMAS	Universiti Malaysia Sarawak
USEPA	United States Environmental Protection Agency