



Contamination of Heavy Metals and Polycyclic Aromatic Hydrocarbons (PAHs) in the Thai/Laos Mekong River

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Introduction

PAHs and heavy metals in the atmosphere can be polluted in many kinds of environmental sample such as soil, rain, river etc., which many are known to be carcinogenic agents.

The toxicity of the PAHs and heavy metals in environment depends on the types and quantity of each PAHs and heavy metals.

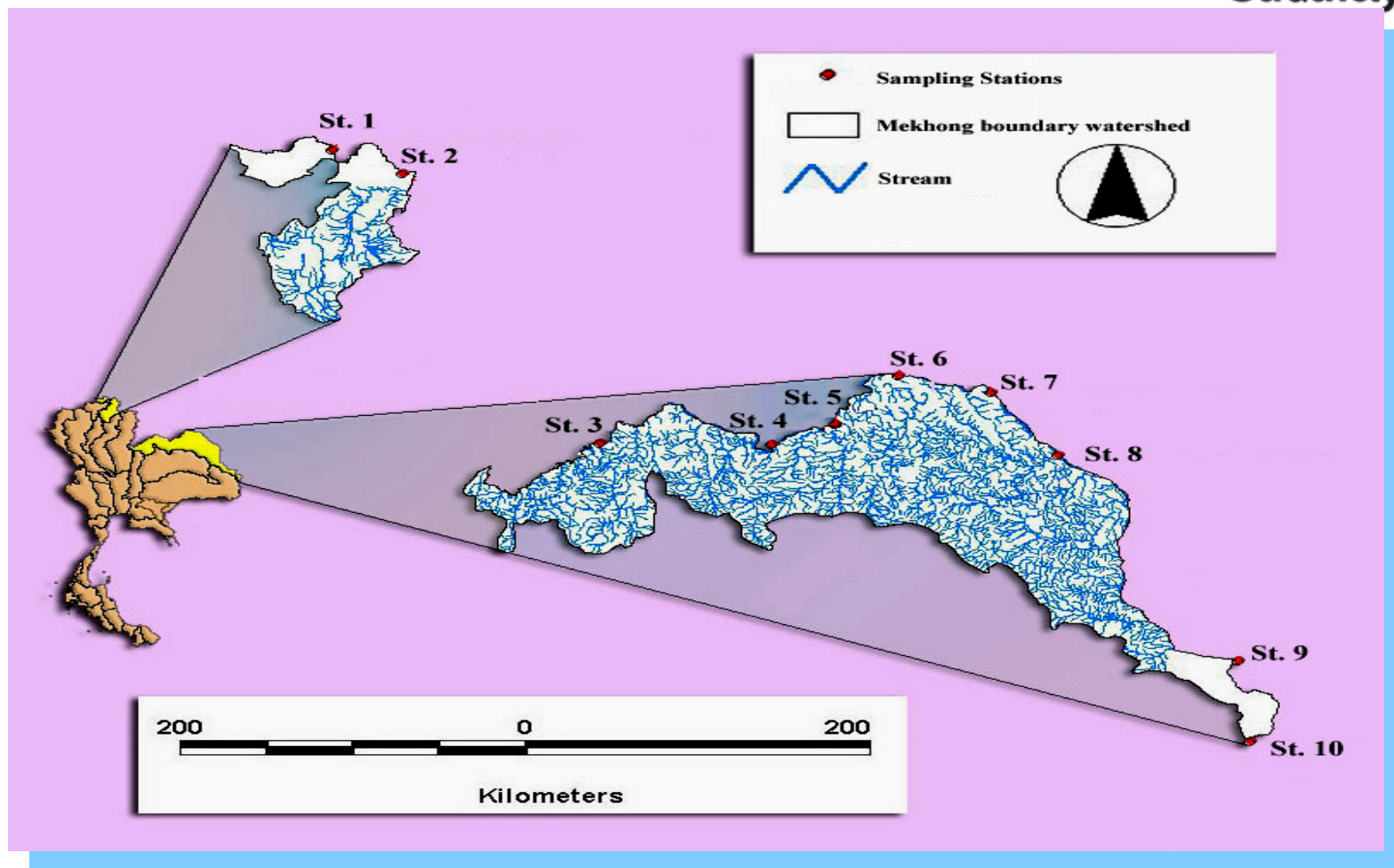


Figure 1 Locations of the sampling stations along the Mekong River.



Aim

The aim of this report is to examine the spatial distribution and seasonal variation of the PAHs and some heavy metals ion in the Mekong River, Thailand



Materials and methods

Analysis of PAHs in sediments

Weighed quantity (~0.2 g) of air-dried sediment was placed in a container



Added 20 ml of hexane

extracted for 50 minutes in an ultrasonic bath



centrifuge

Centrifugate



Spectrofluorometry

The fluorescence of diluted solution (EM = 360 nm, EX = 310 nm) was determined and compared with the fluorescence of standard chrysene solutions (UNEP, 1992).



HPLC

The extract was evaporated to dryness
in a rotary evaporator at 20-30 °C



the residue was transferred quantitatively into
a volumetric flask using acetonitrile.



Analysis of 16 PAHs in the extracts were performed
by HPLC-DAD (EPA 8310) using the standard
addition method.



Analysis of PAHs in water

500 ml of water from the Mekong River was passed through activated SPE-C18 column



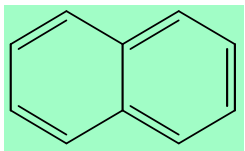
flow rate of 2 ml/min

The column was then eluted with hexane with a flow of 1 ml/min

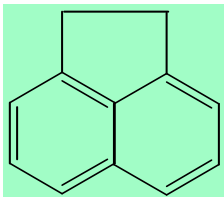


HPLC-DAD

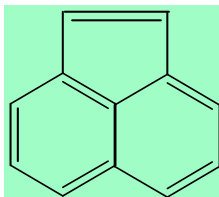
spectrofluorometry



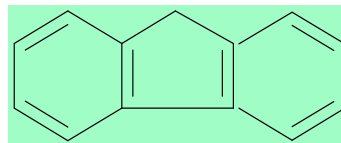
Naphthalene



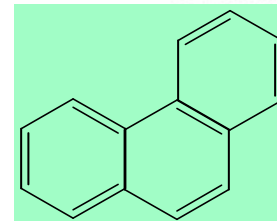
Acenaphthene



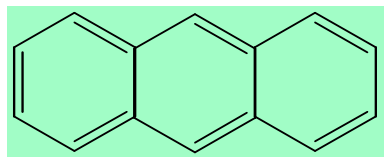
Acenaphthylene



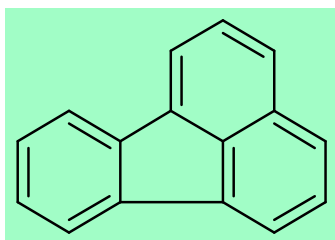
Fluorene



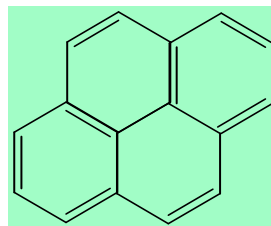
Phenanthrene



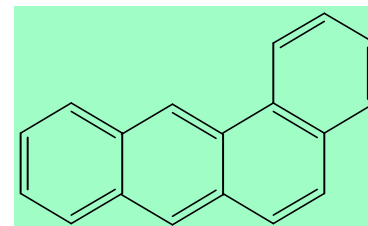
Anthracene



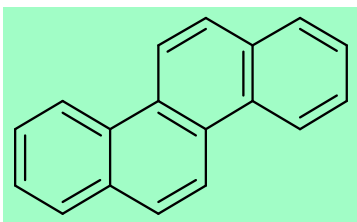
Fluoranthene



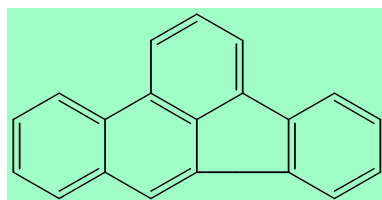
Pyrene



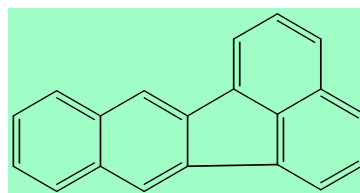
Benzo[a]anthracene



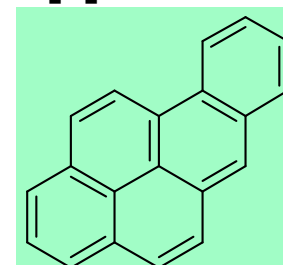
Chrysene



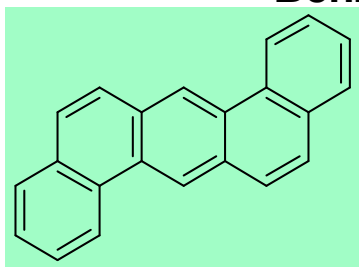
Benzo[b]fluoranthene



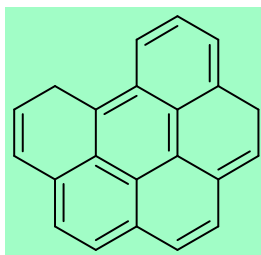
Benzo[k]fluoranthene



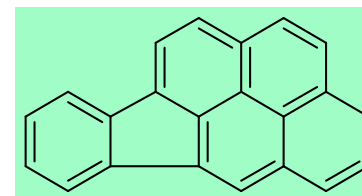
Benzo[a]pyrene



Dibenz[a,h]anthracene



Benzo[g,h,i]perylene



Indeno[1,2,3,cd]pyrene

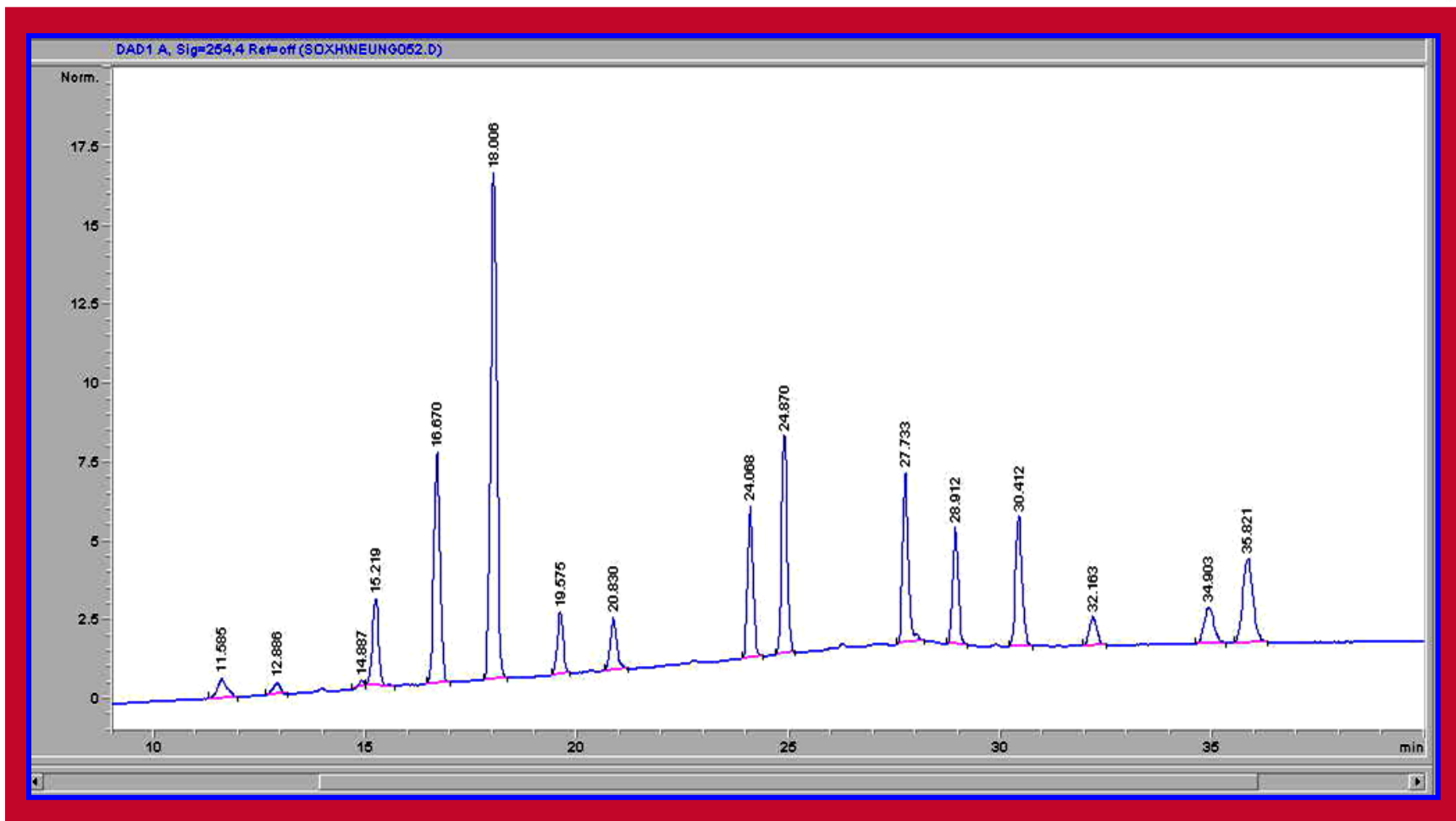
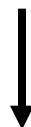


Figure 1 Standard chromatogram of 16 PAHs



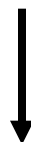
Analysis of heavy metals in sediments

Weighed quantity (~0.5 g) of air-dried sediment was placed in microwave-assisted digester



200 °C, 1 Hr

Added HNO₃ and heat until the solution clear



Analyzed by AAS



Analysis of heavy metals in water

1 L of water was preconcentrated and placed in microwave-assisted digester



200 °C, 1 Hr

Added HNO_3 and heat until the solution clear



Analyzed by AAS



Determination of organic carbon in sediment

2g of grinded sediment was placed in a flask



5 ml 2M K_2CrO_4 , 10 ml H_2SO_4

Swirled gently until the sediment was completely wetted before allowed to stand for a minimum of 30 min.



O-phenanthroline ferrous sulfate

Titrate with FeSO_4 until the solution has red-brown in color



Results and discussion



Table 1 %organic carbon in sediments from 10 stations

Station	% OC
1	0.69
2	0.67
3	0.80
4	0.69
5	1.00
6	1.10
7	1.78
8	1.29
9	0.81
10	1.10



Table 2 % sand, silt and clay in sediments

Station	Sand (%)	Silt (%)	Clay (%)
1	74.18	19.51	6.31
2	90.45	6.01	3.54
3	74.37	17.93	7.70
4	99.27	0.37	0.36
5	67.05	18.94	14.01
6	70.96	20.13	8.91
7	57.26	31.28	11.46
8	81.56	14.77	3.67
9	80.03	1.72	18.25
10	92.04	1.75	6.21

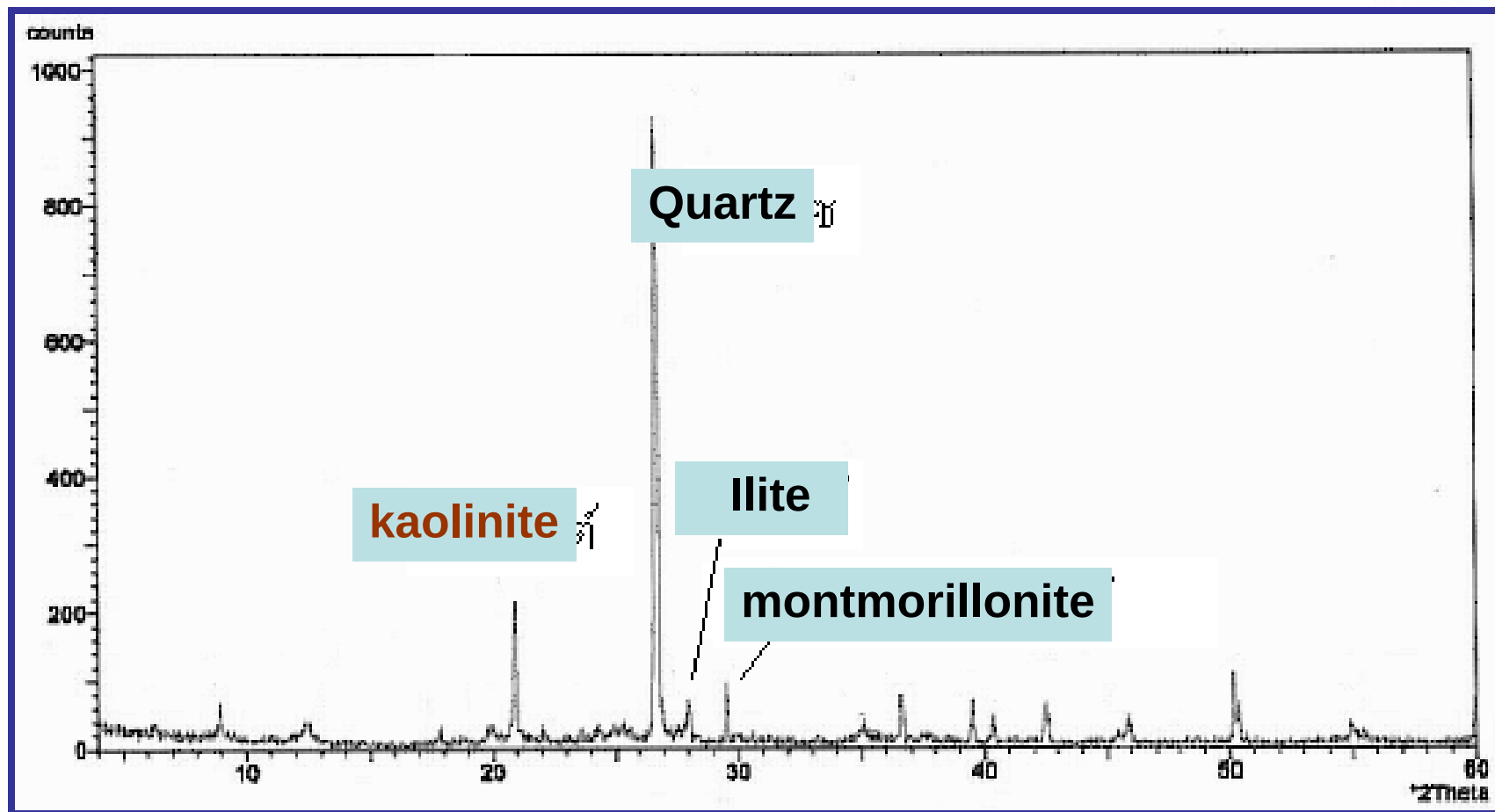


Figure 2 XPD spectrum of sediment from station 1

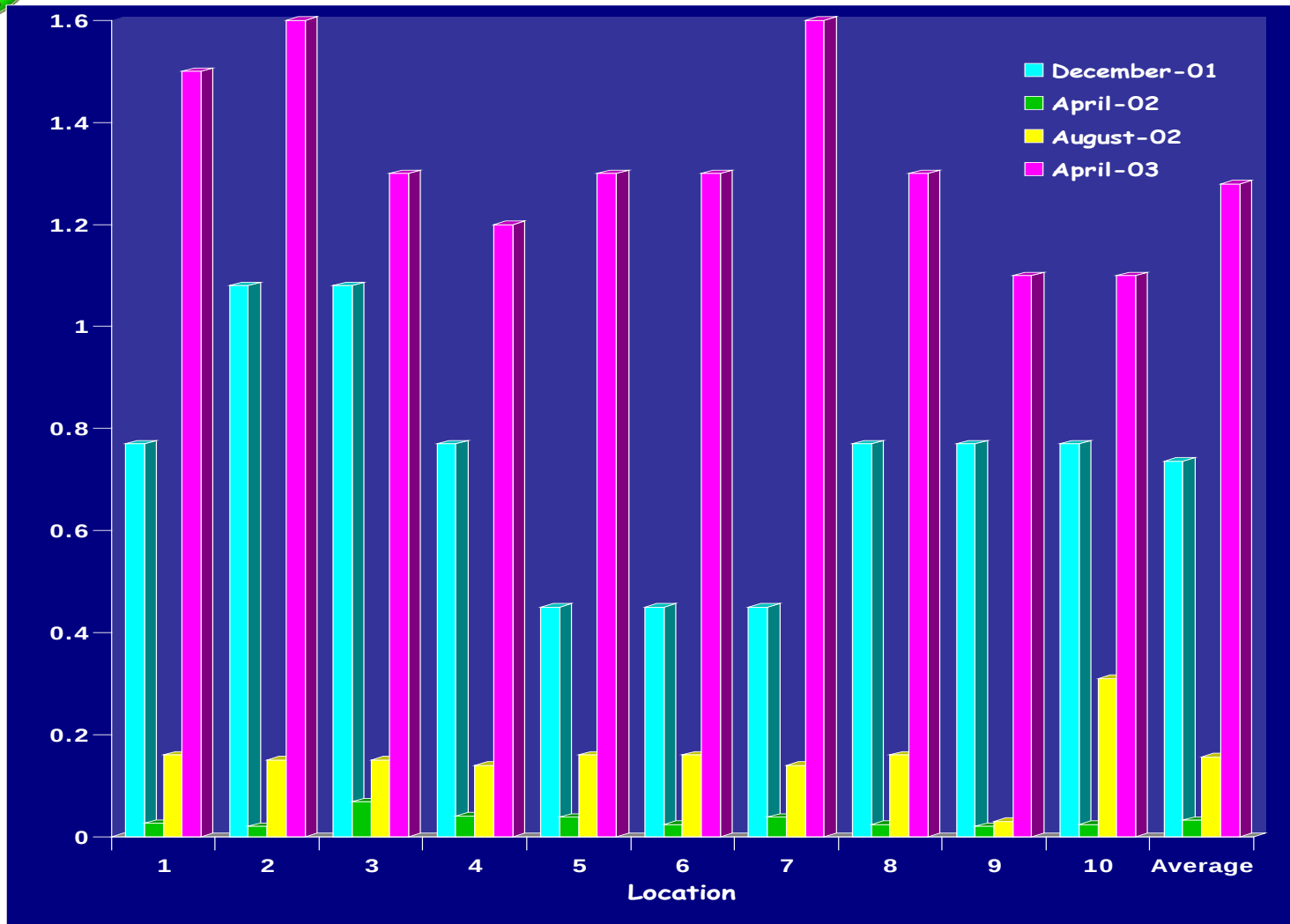


Figure 3 Total PAHs concentration in surface water (µg/L)

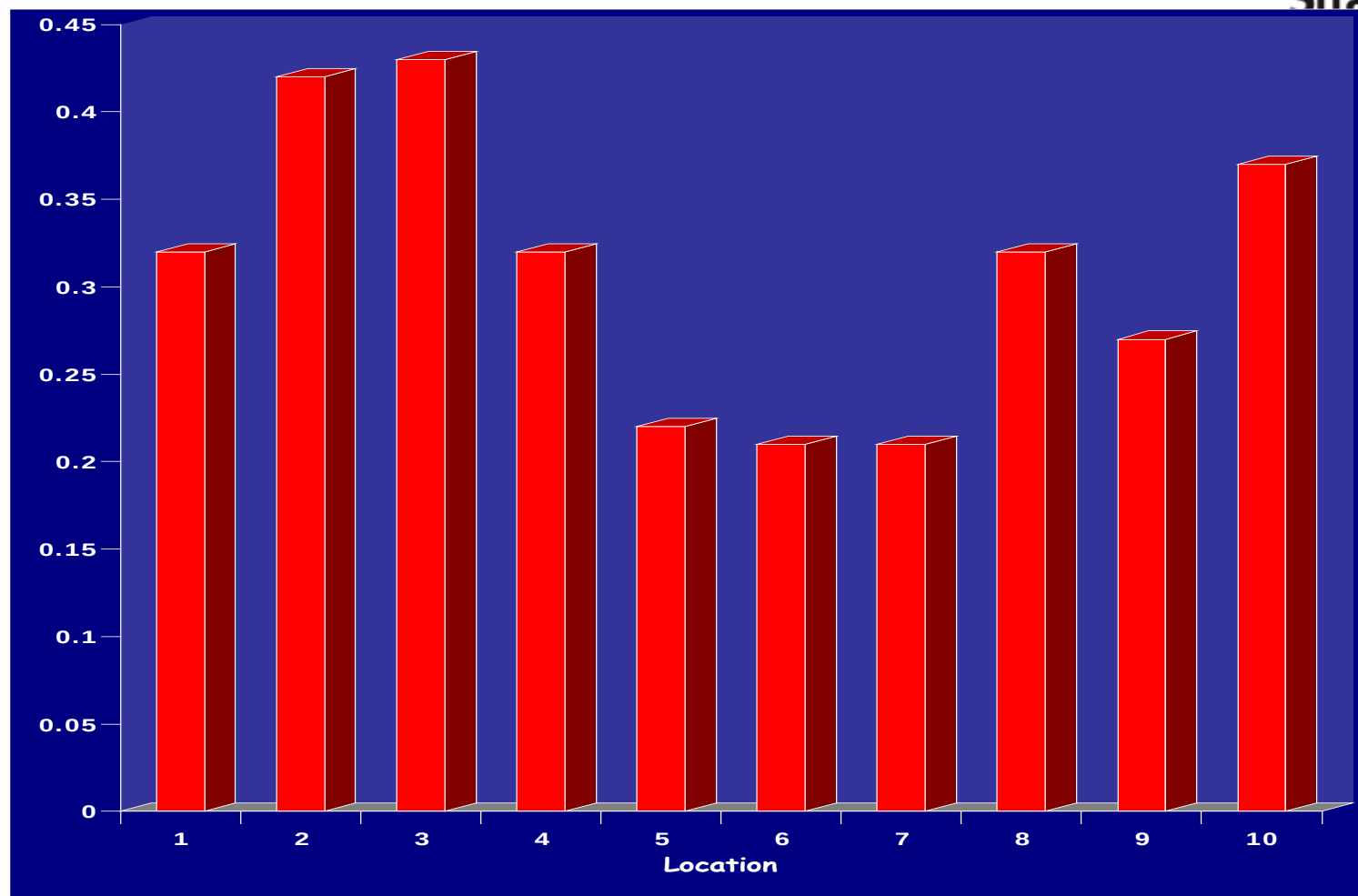


Figure 4 Average PAHs of all seasons in water from different stations along the Mekong River (mg/kg)

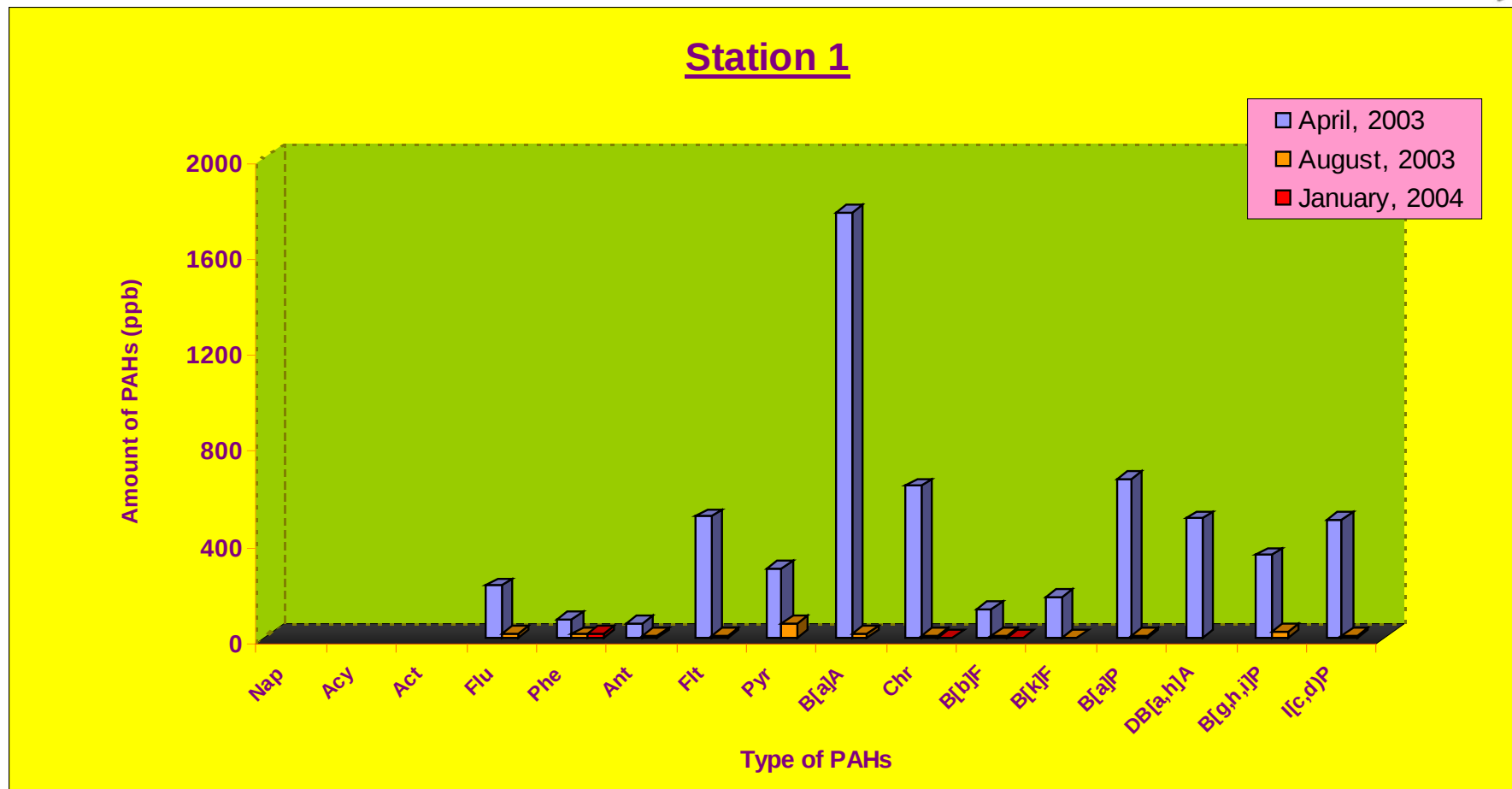


Figure 5 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 1 : GOLDEN TRIANGLE

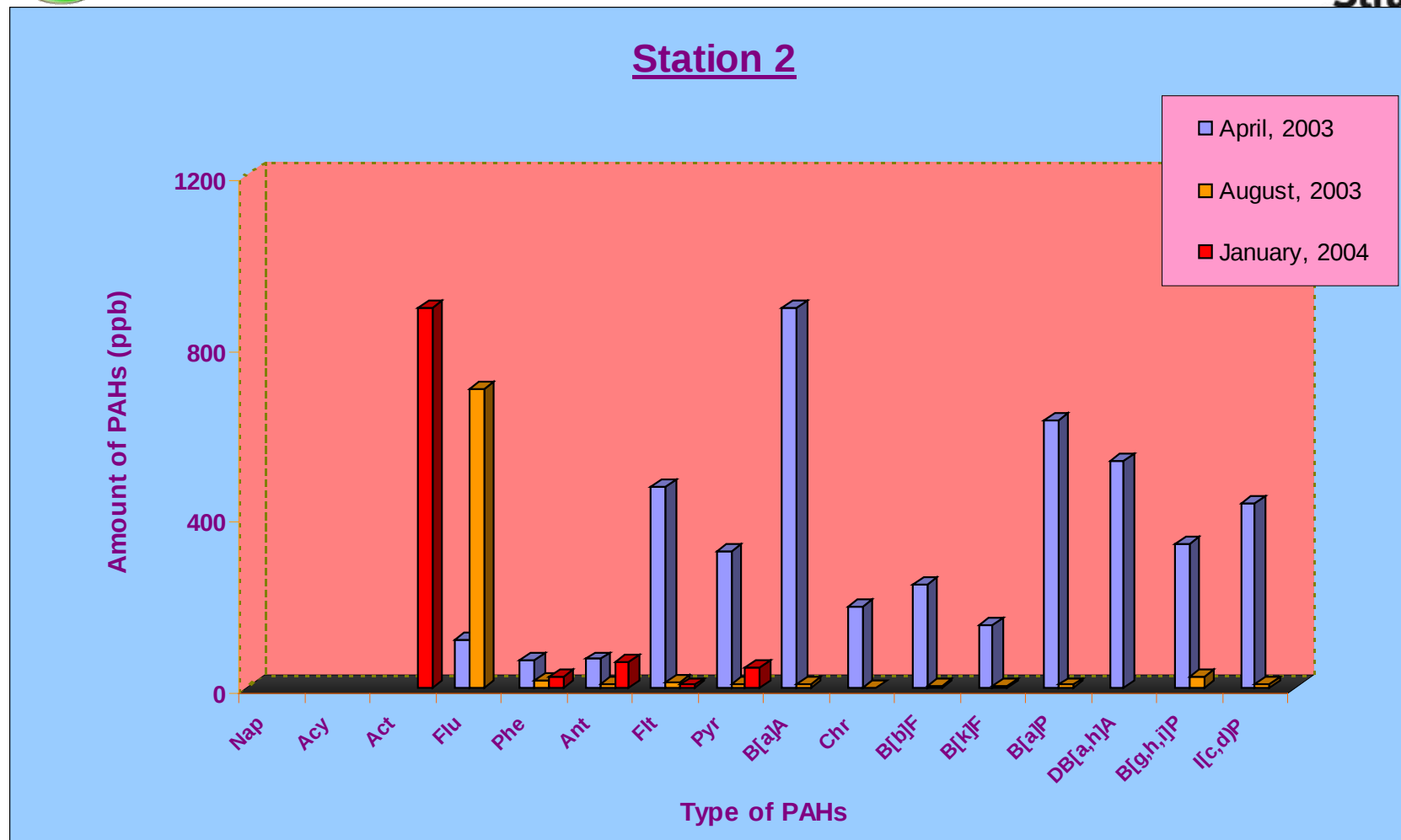


Figure 6 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 2 : **BAN CHEAM PONG**

A. Songsasen



Station 3

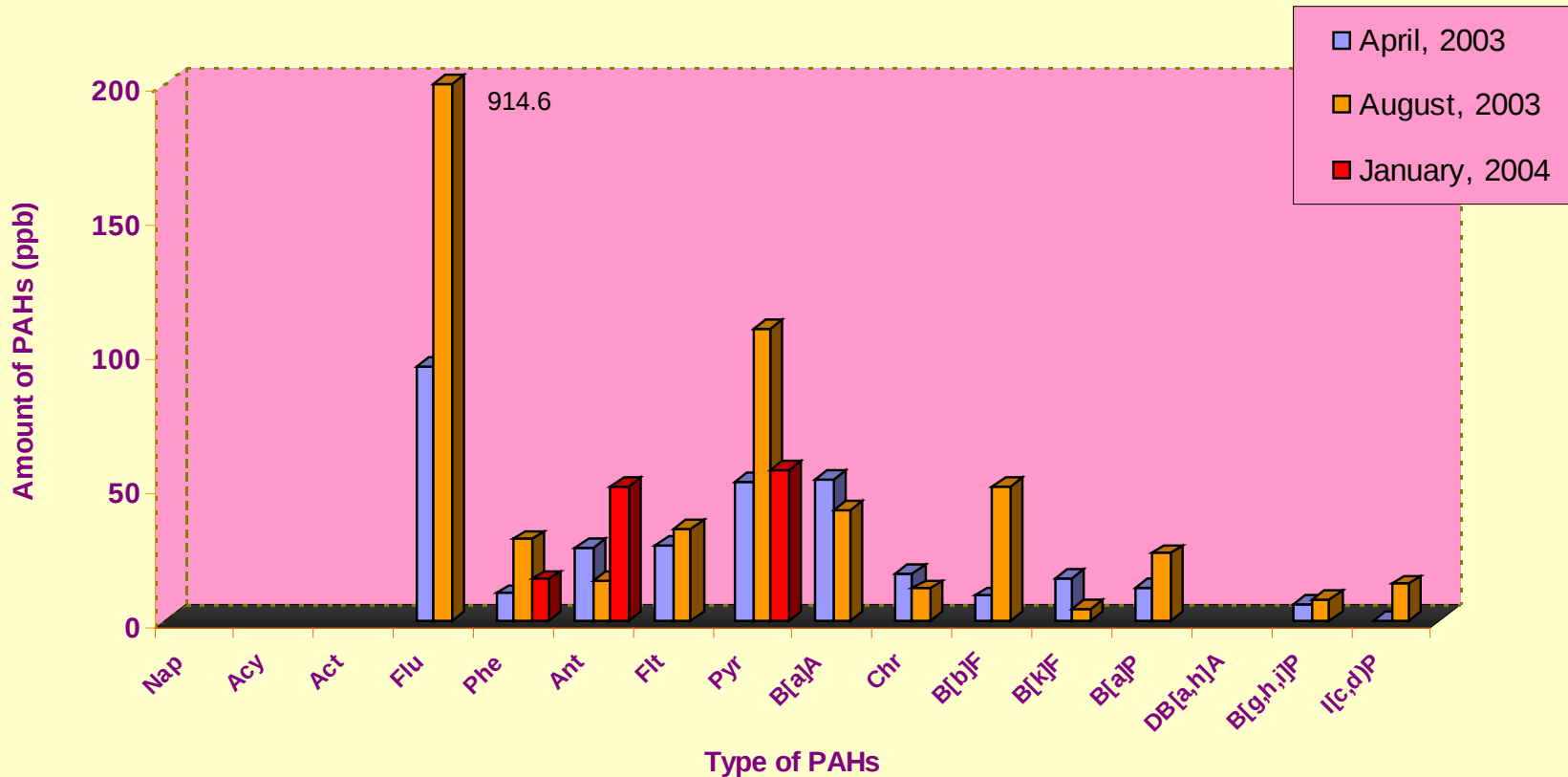


Figure 7 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 3 : A COMMUNITY CENTRE

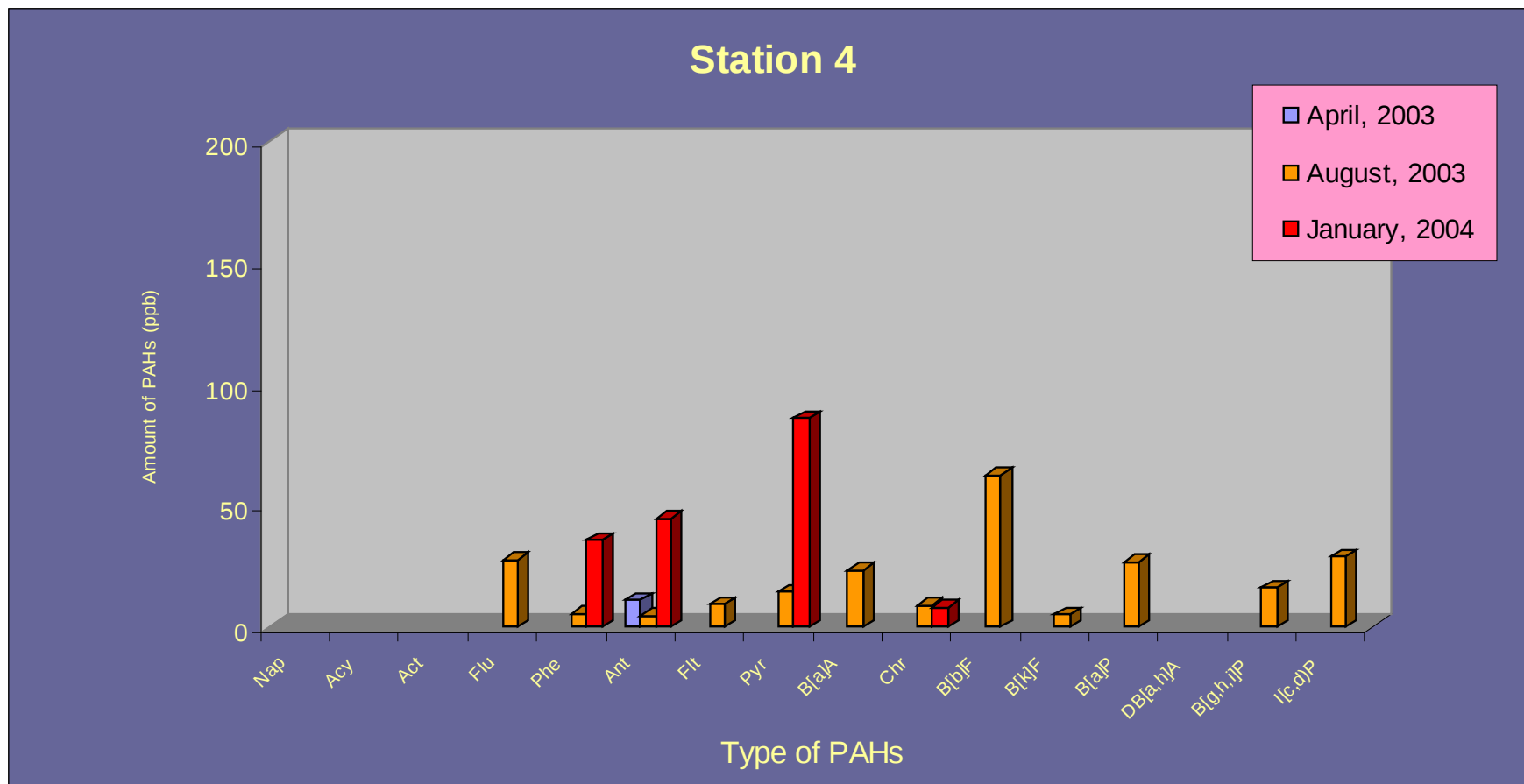


Figure 8 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 4 : **LAOS FRIENDSHIP BRIDGE**

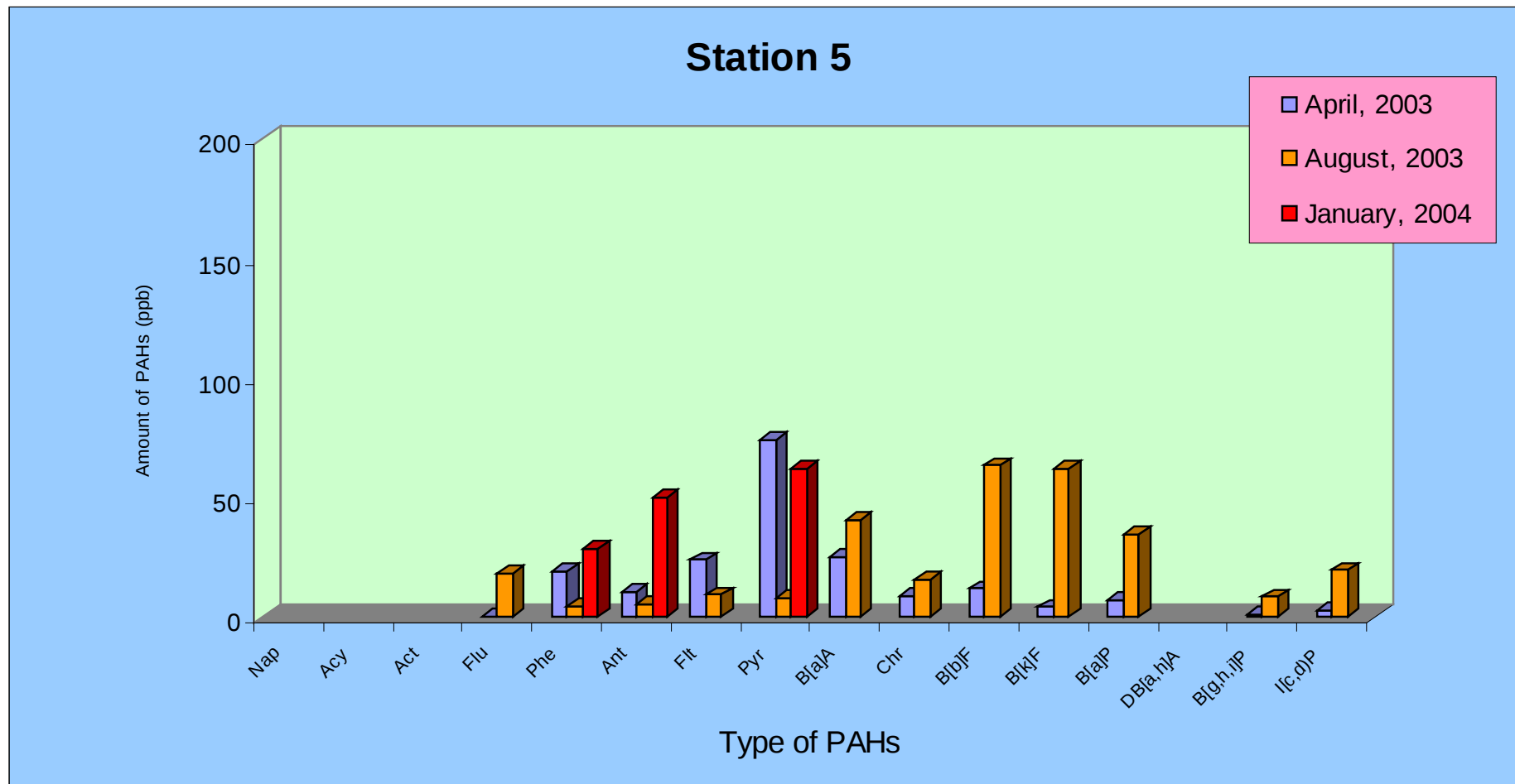


Figure 9 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 5 : **HUAILUANG**

A. Songsasen

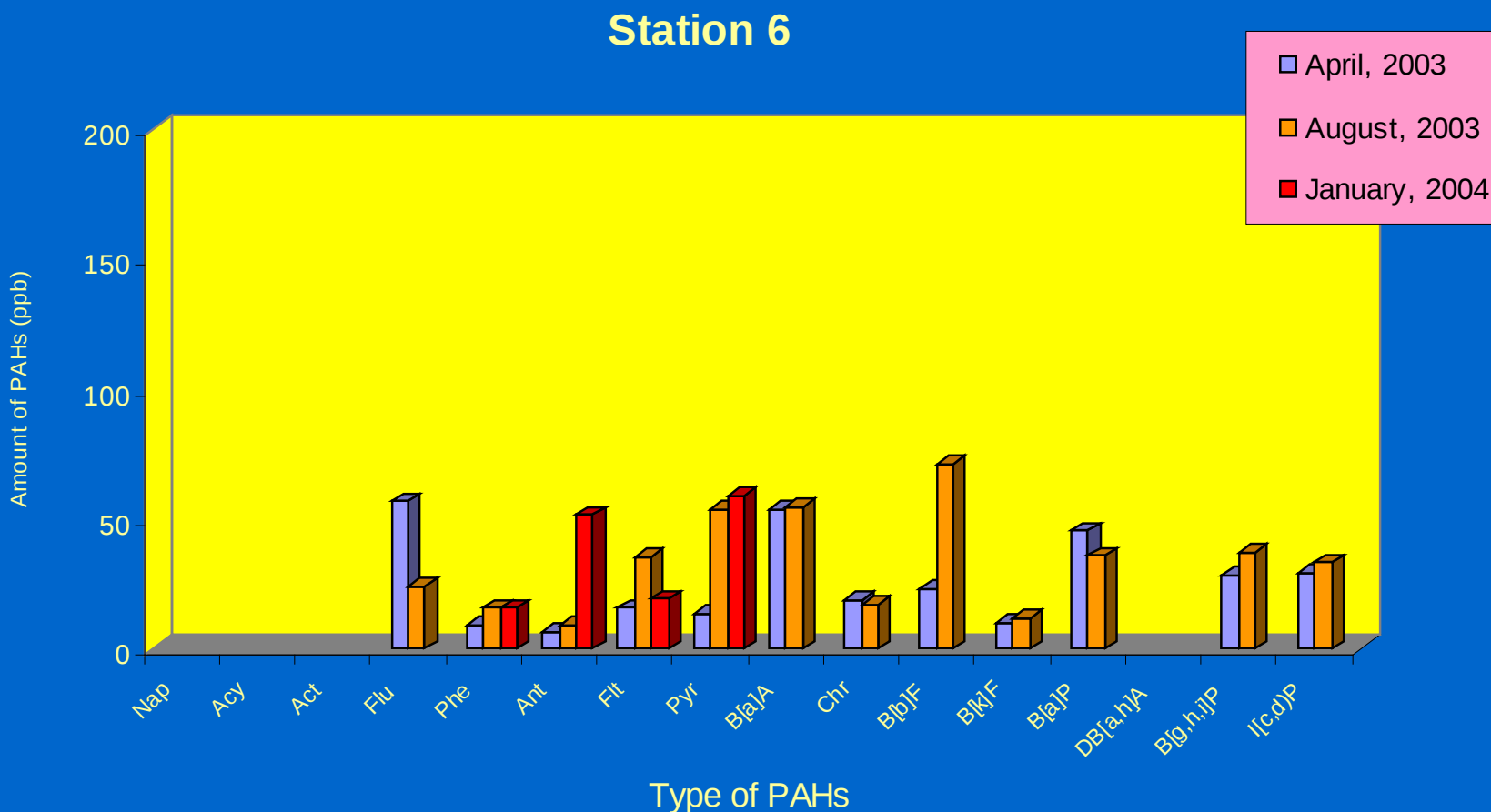


Figure 10 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 6 : **WAT AR HONG**

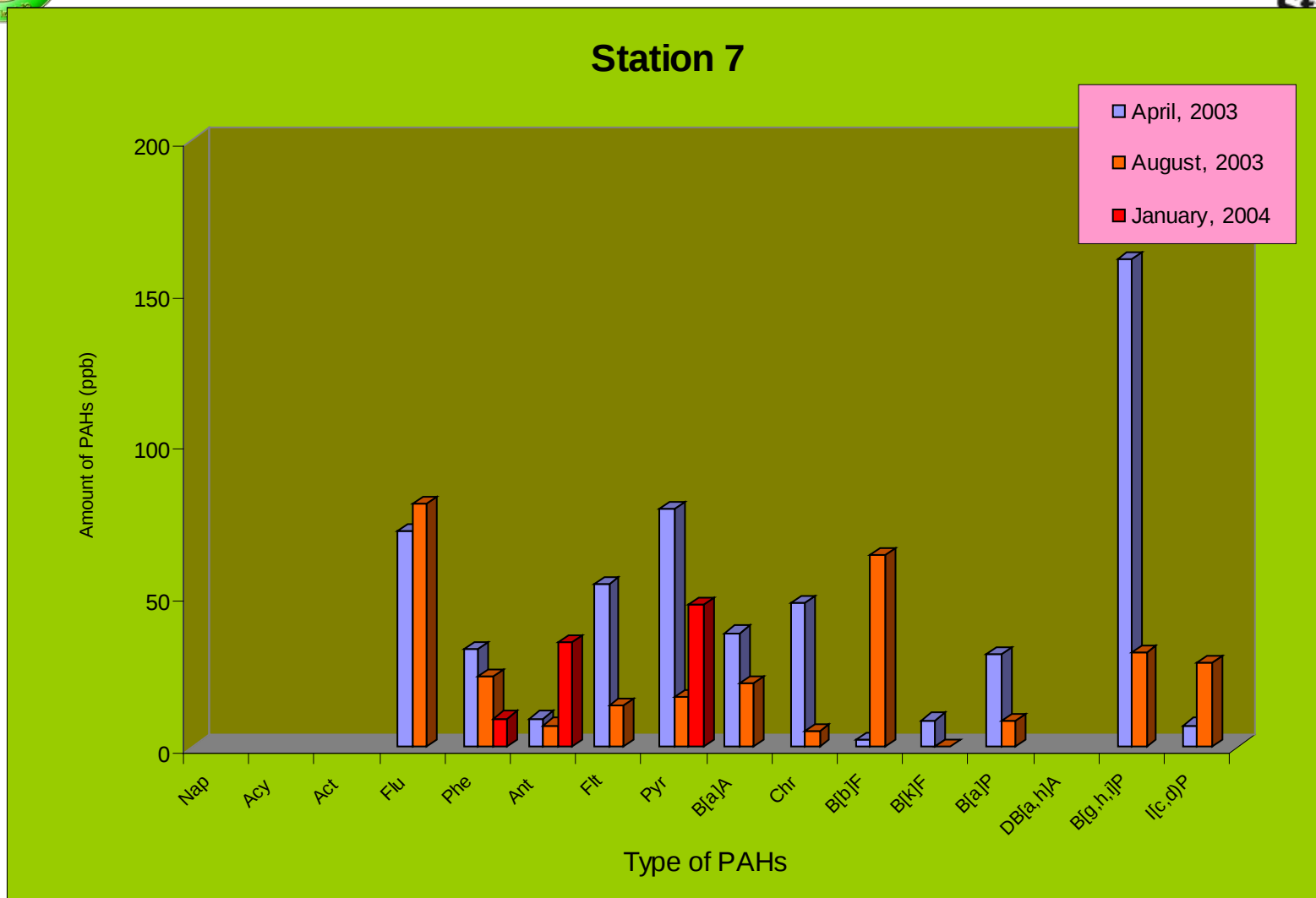


Figure 11 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 7 : **SRI SONGKHRAM RIVER**

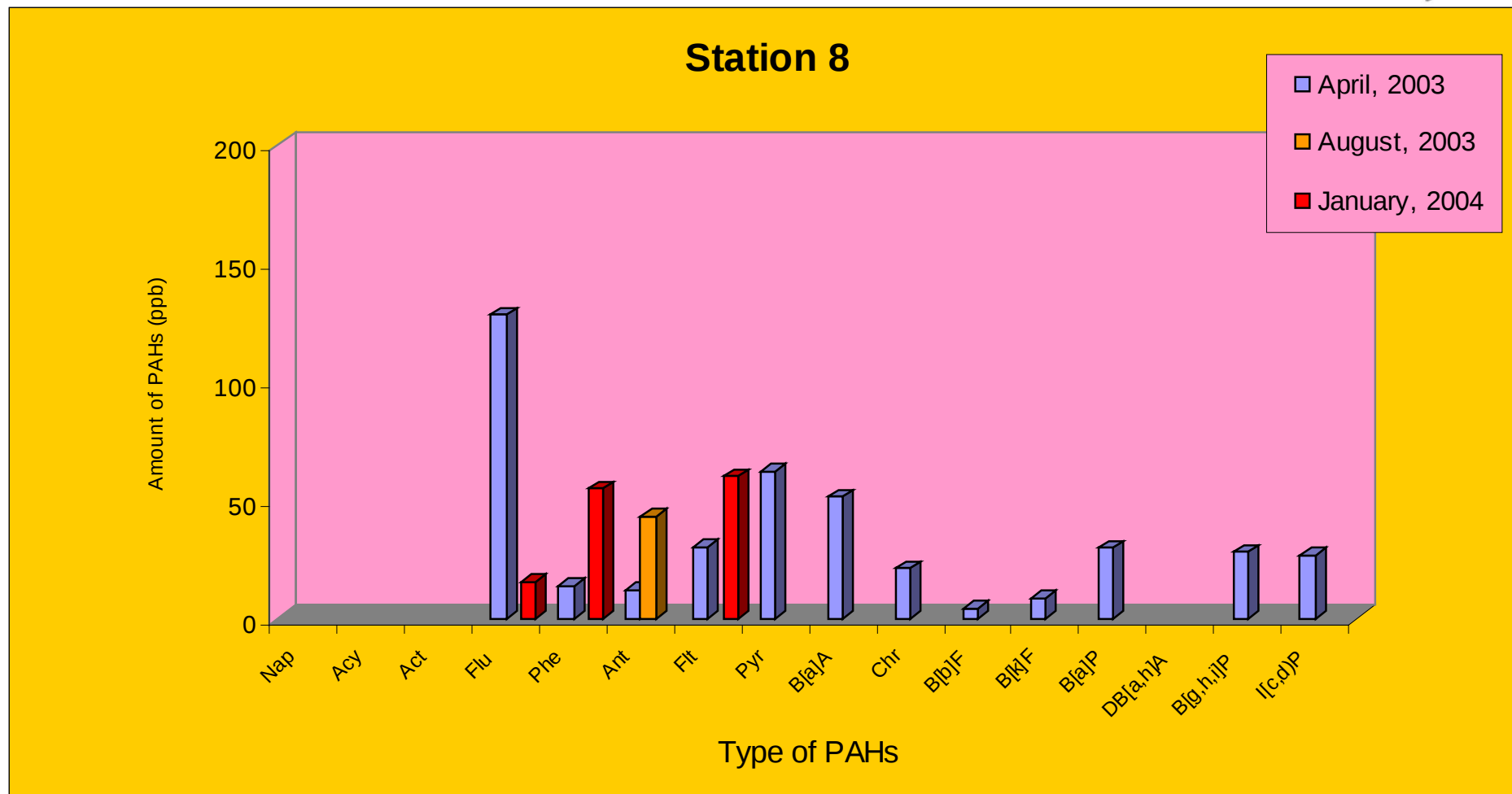


Figure 12 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 8 : **AMPHOE THAT PHRA NOM**

A. Songsasen

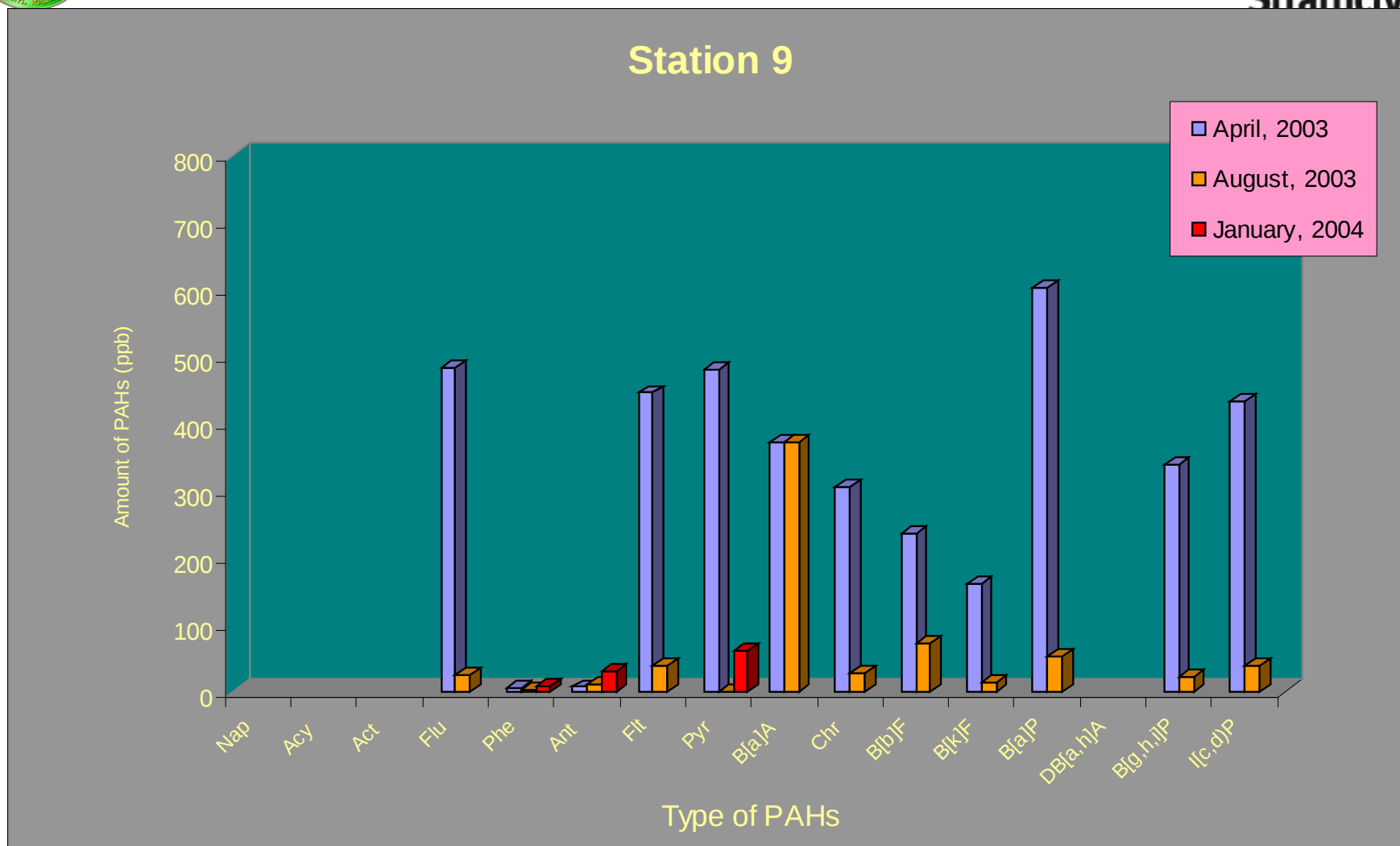


Figure 13 Seasonal variation of each PAHs in the Thai:Laos
Mekong River at station 9 : **WAT KHONG CHIAM BURAWAS**

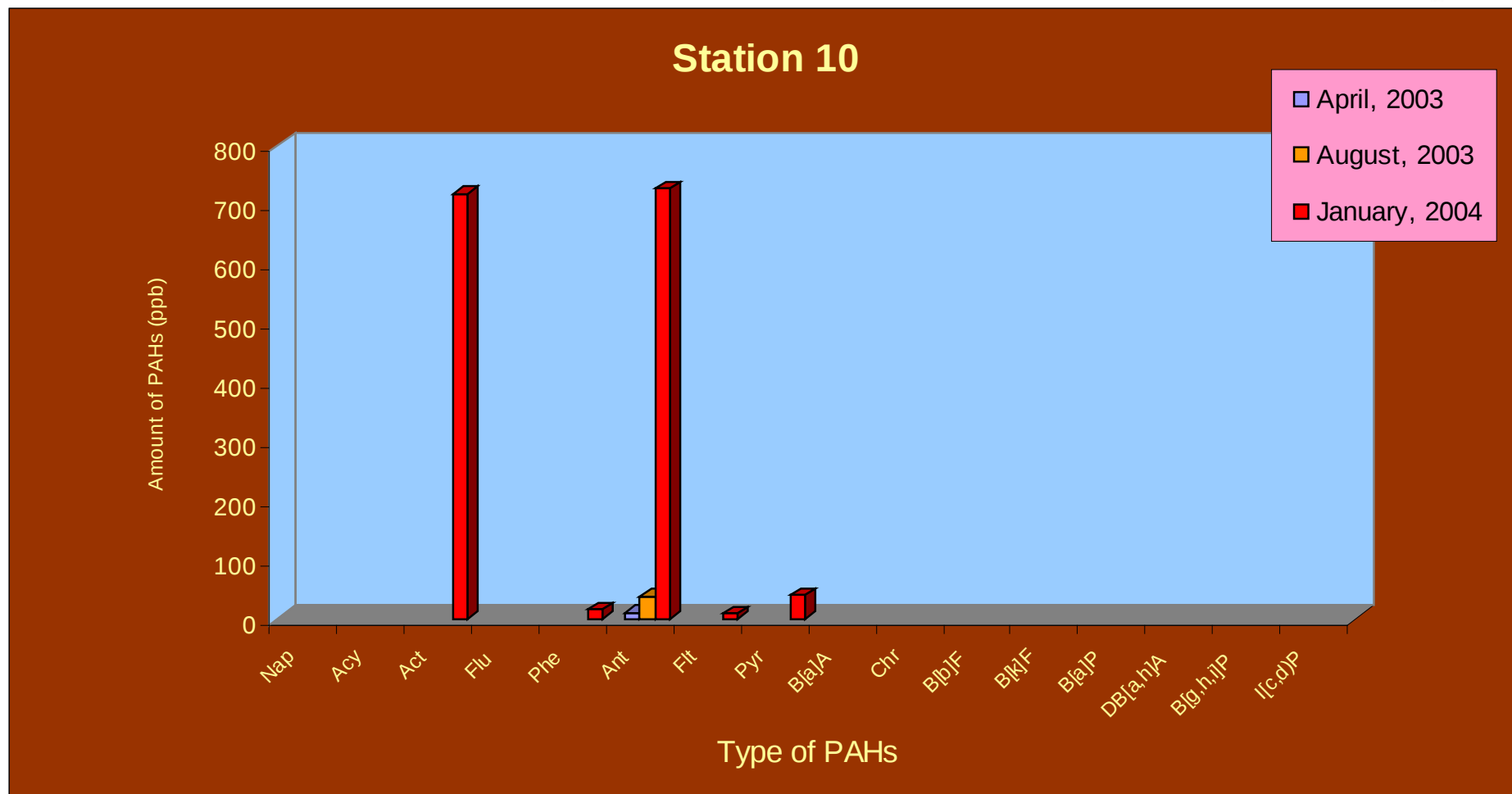


Figure 14 Seasonal variation of each PAHs in the Thai:Laos Mekong River at station 10 : **AMPHOE KHONG CHIAM**

A. Songsasen



- 1. the distribution of various PAHs was effected by the changing in season. In summer, the concentration of PAHs of all stations were higher than other seasons.**
- 2. The concentration of PAHs in station 1, 2 and 9 were quite high compare to other stations.**



3. The presences of carcinogenic PAHs (5-6) rings i.e. benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenzo[a,h]anthracene, benzo[g,h,i]perylene and indeno[1,2,3,cd]pyrene were observed in every station. This may effect the health problem to the life along the Mekong river.

4. This work shows the distribution of PAHs in the Mekong river at various locations and seasons. It seems that there is a seasonal variation associated with rain and Temp.

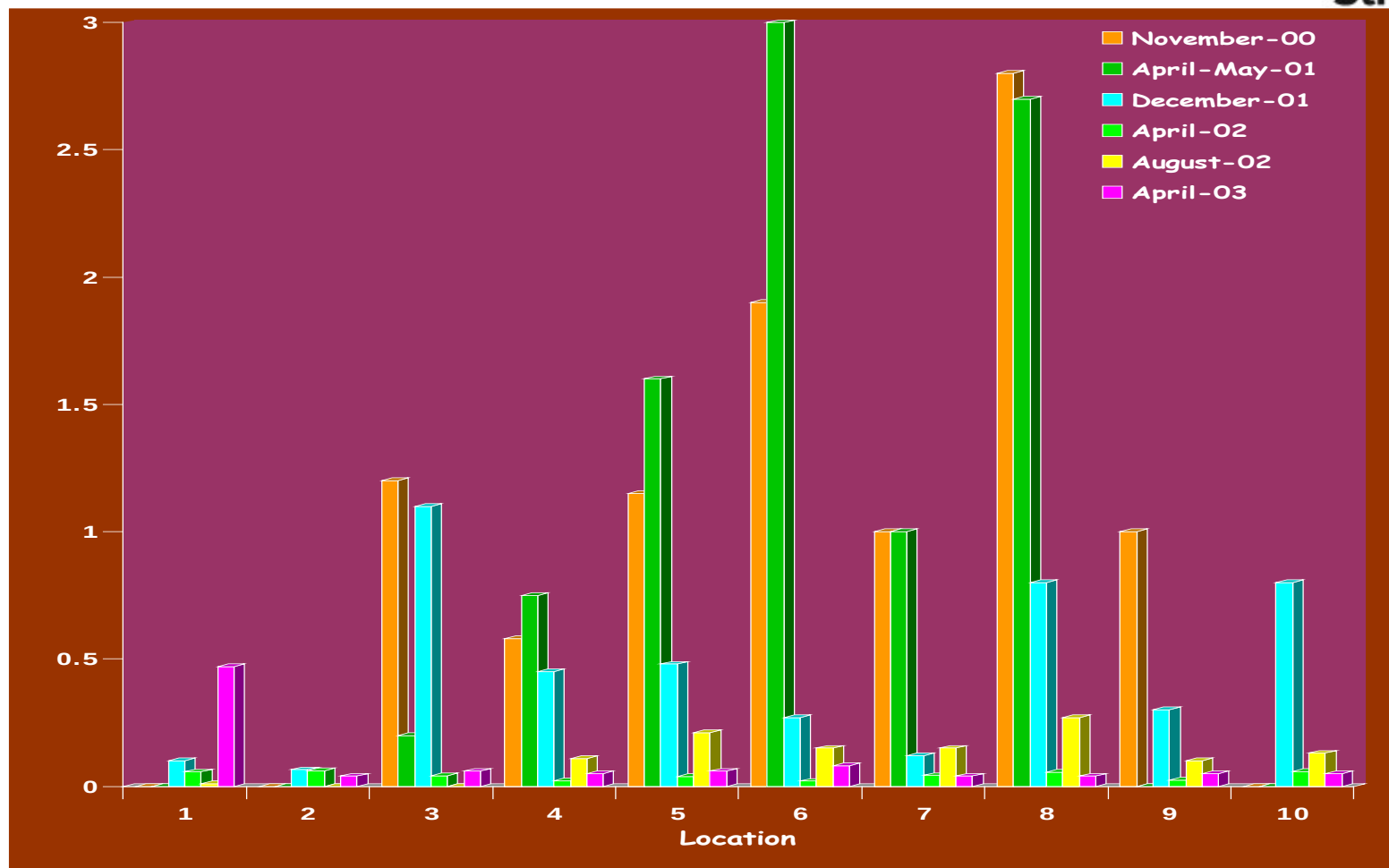


Figure 15 Total PAHs concentration in sediments (µg/g dry weight)

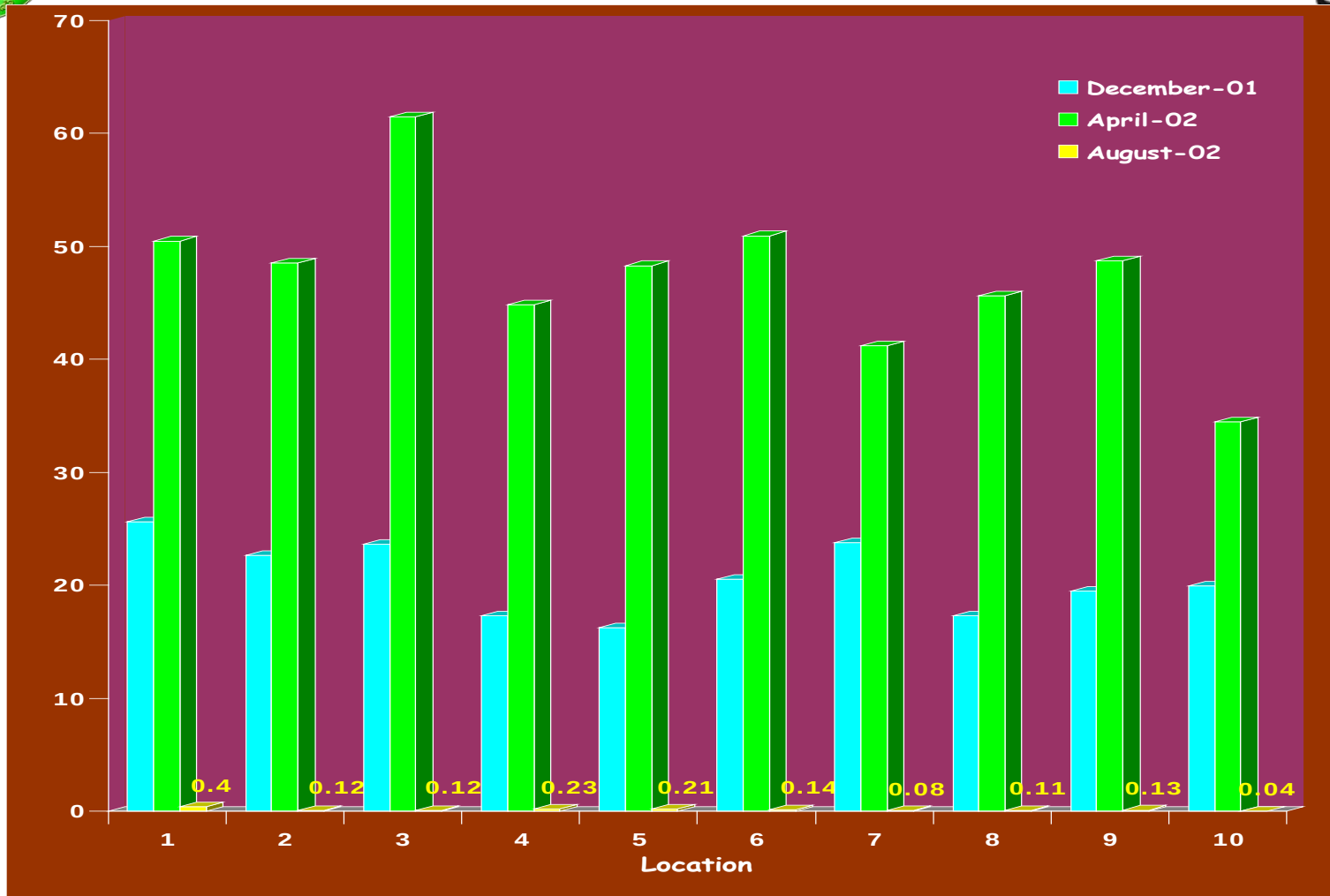


Figure 16 Seasonal variation of PAHs in sediment from different stations along the Mekong River (mg/kg)

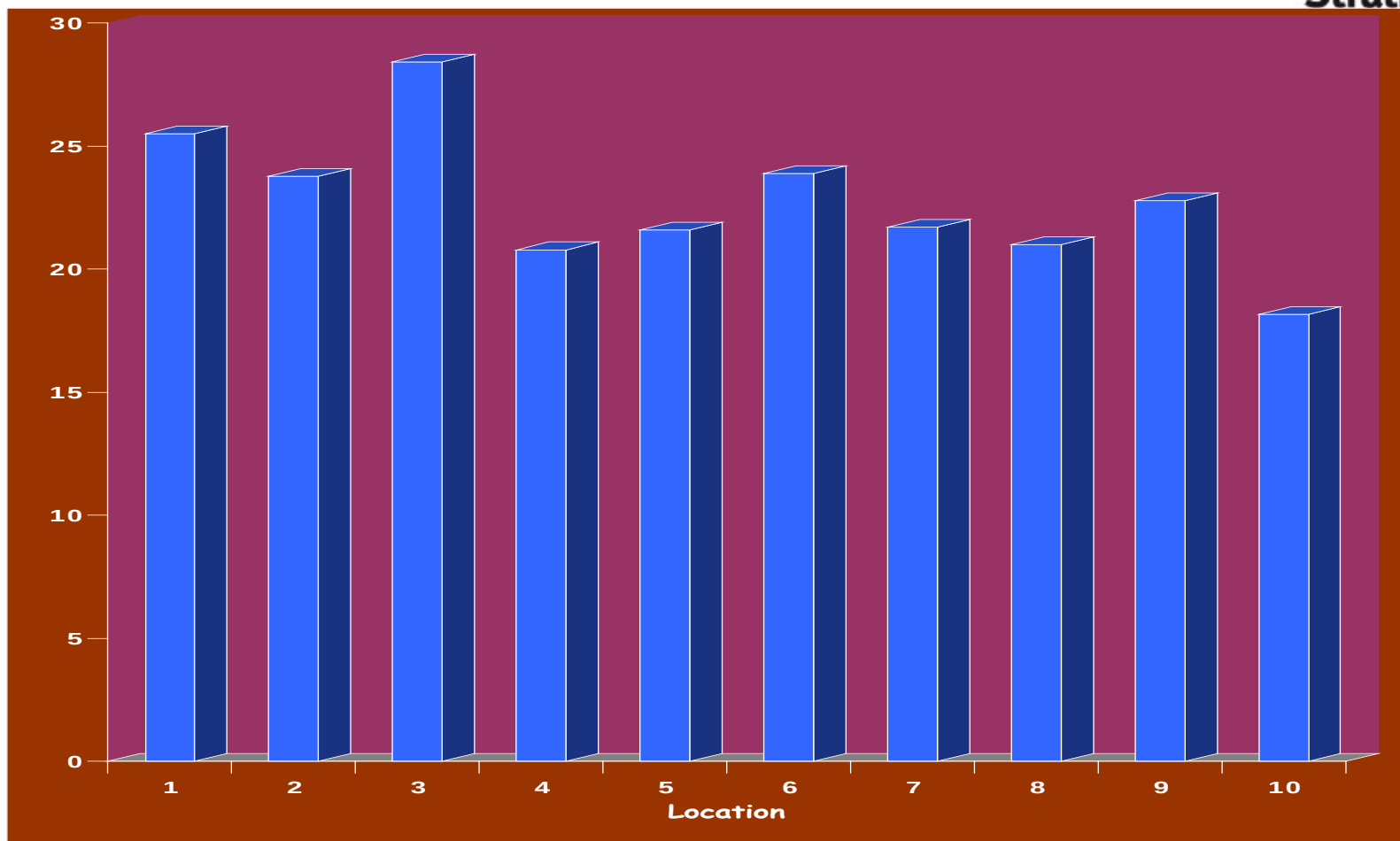


Figure 17 Average PAHs of all seasons in sediment from different stations along the Mekong River (mg/kg)

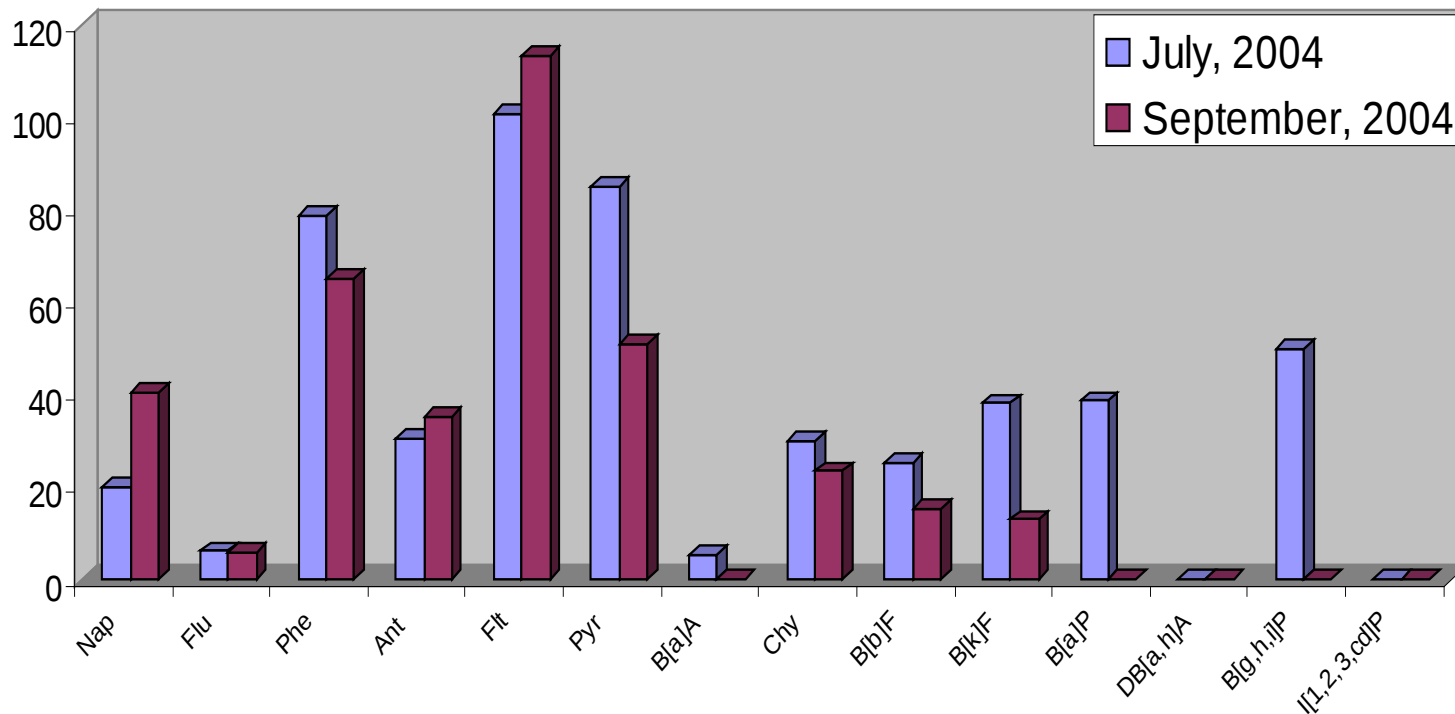


Figure 18 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 1 : **GOLDEN TRIANGLE**

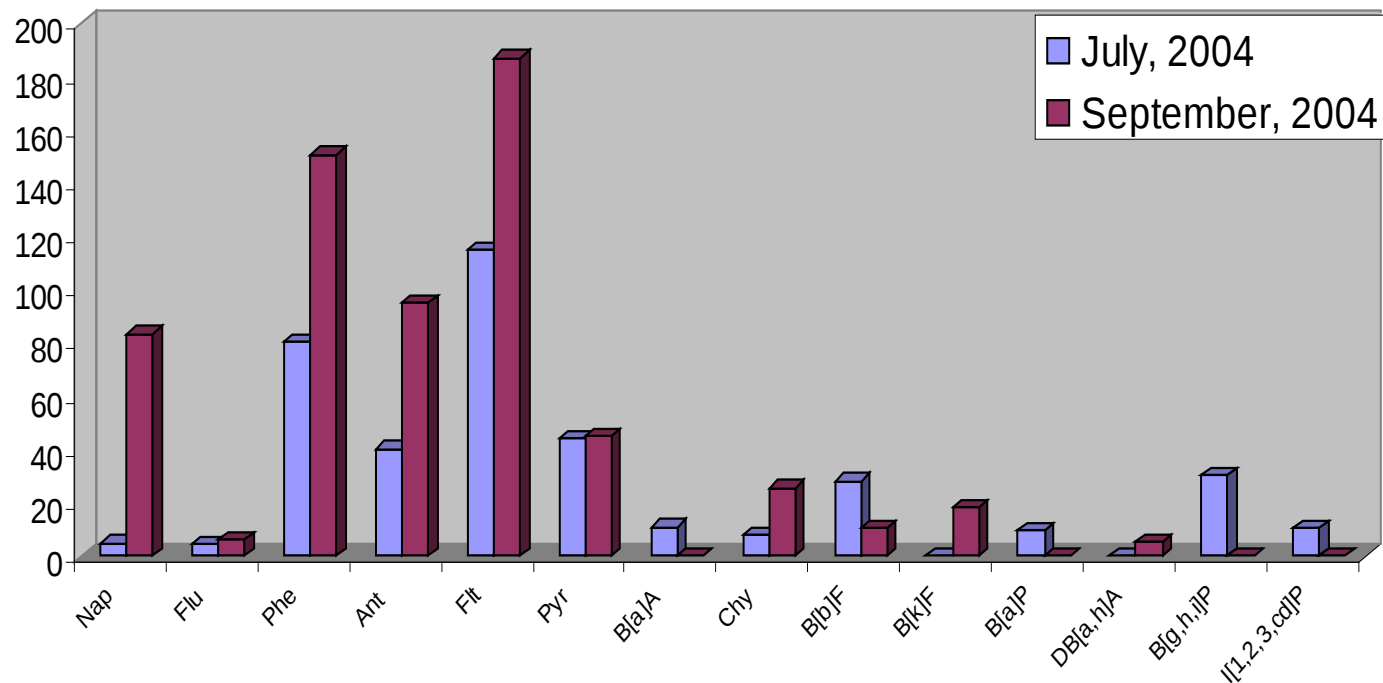


Figure 19 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 2 : **BAN CHEAM PONG**

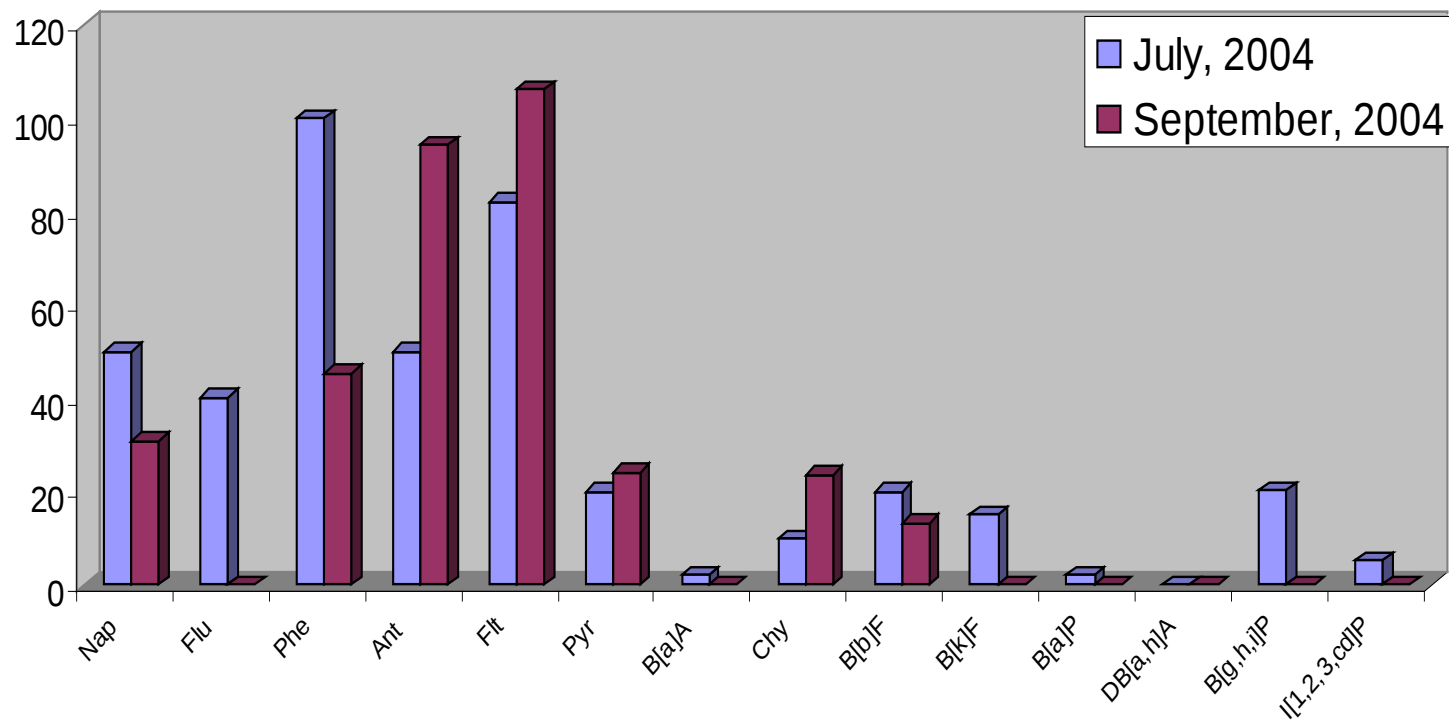


Figure 20 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 3 : **A COMMUNITY CENTRE**

A. Songsasen

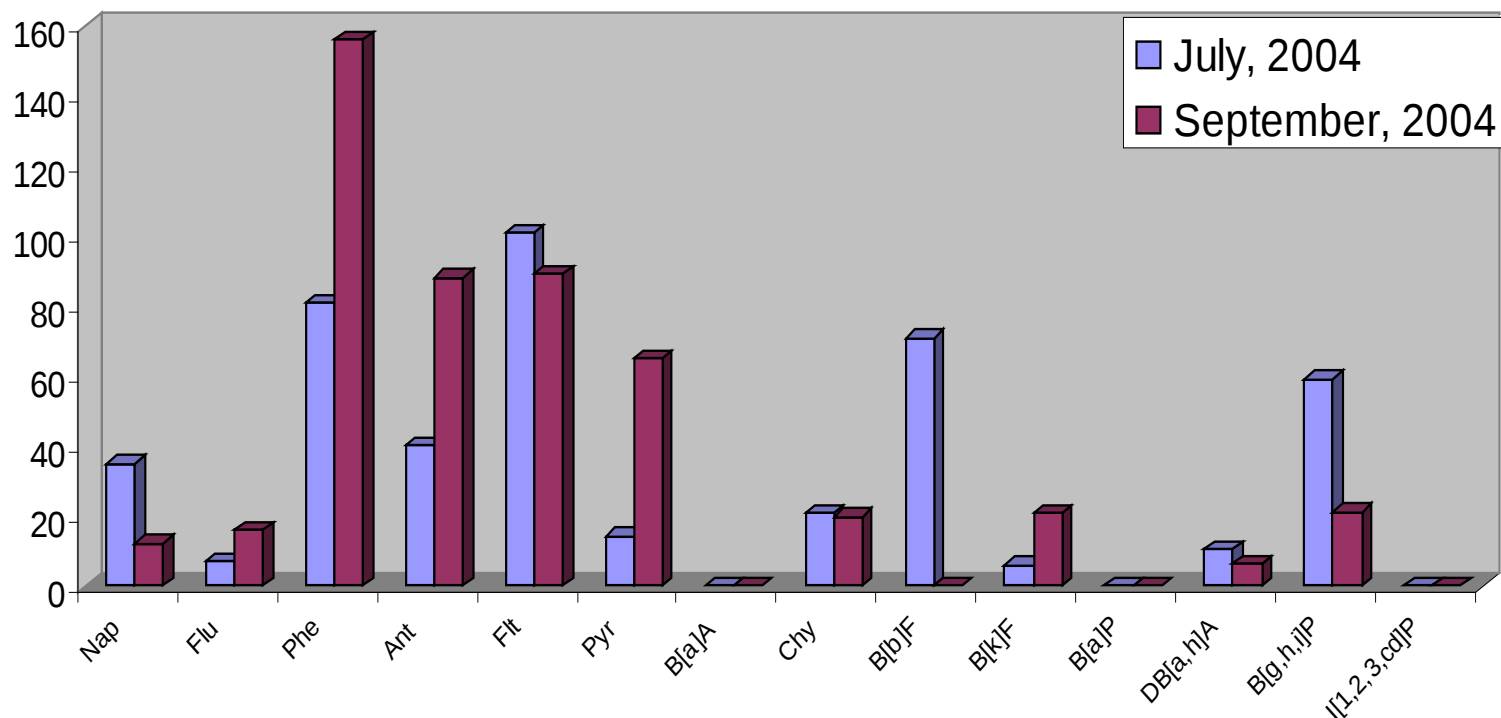


Figure 21 Seasonal variation of each PAHs in the sediment from the Thai:Laos Mekong River at station 4 : **LAOS FRIENDSHIP BRIDGE**

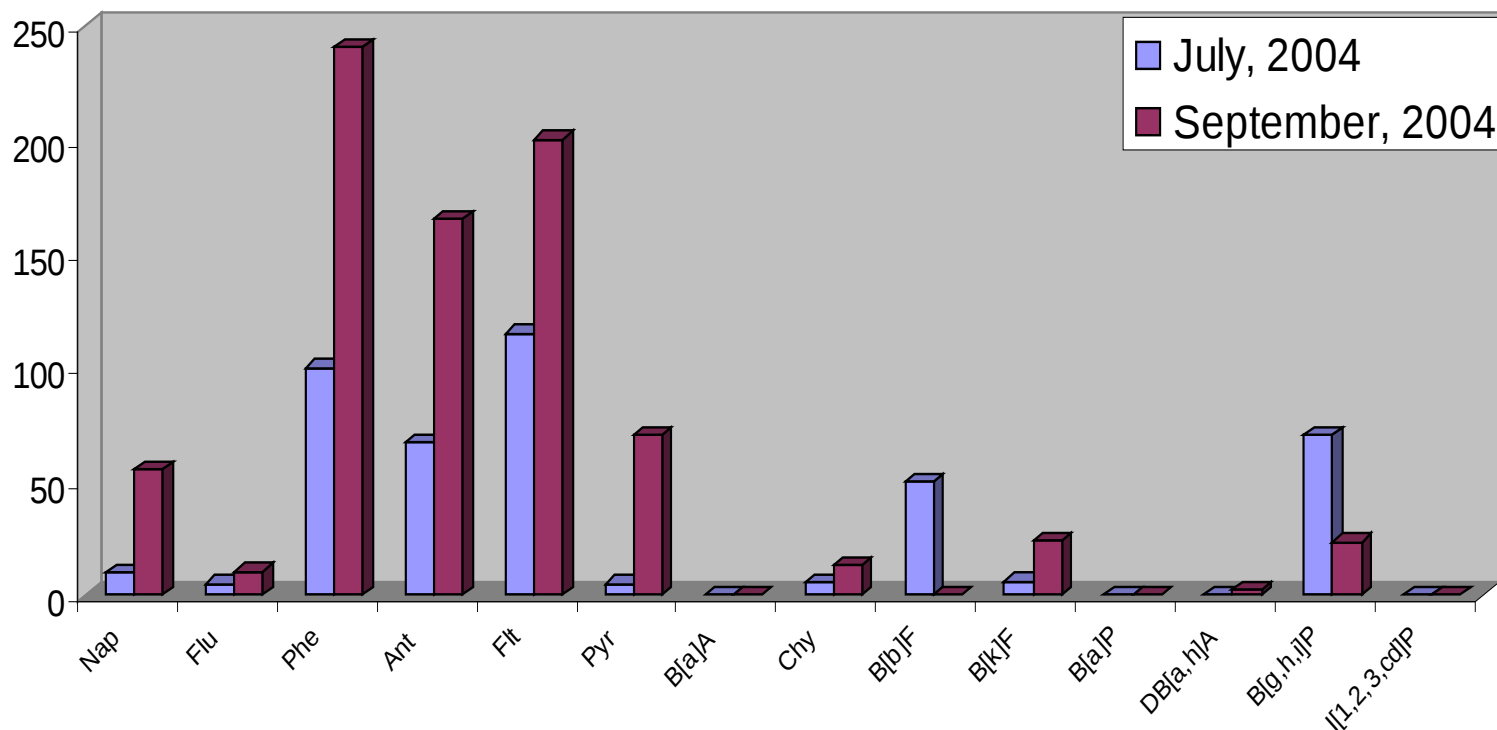


Figure 22 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 5 : **HUAILUANG**

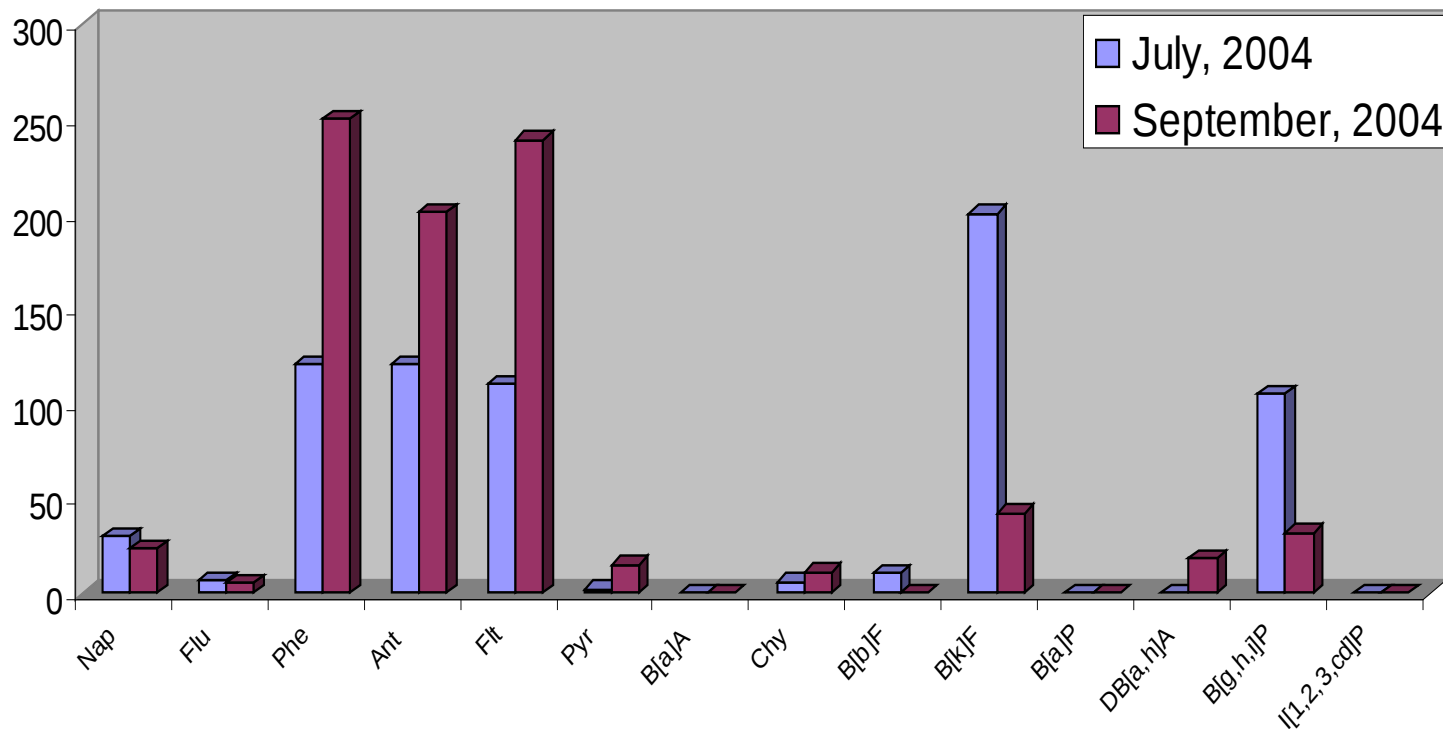


Figure 23 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 6 : **WAT AR HONG**

A. Songsasen

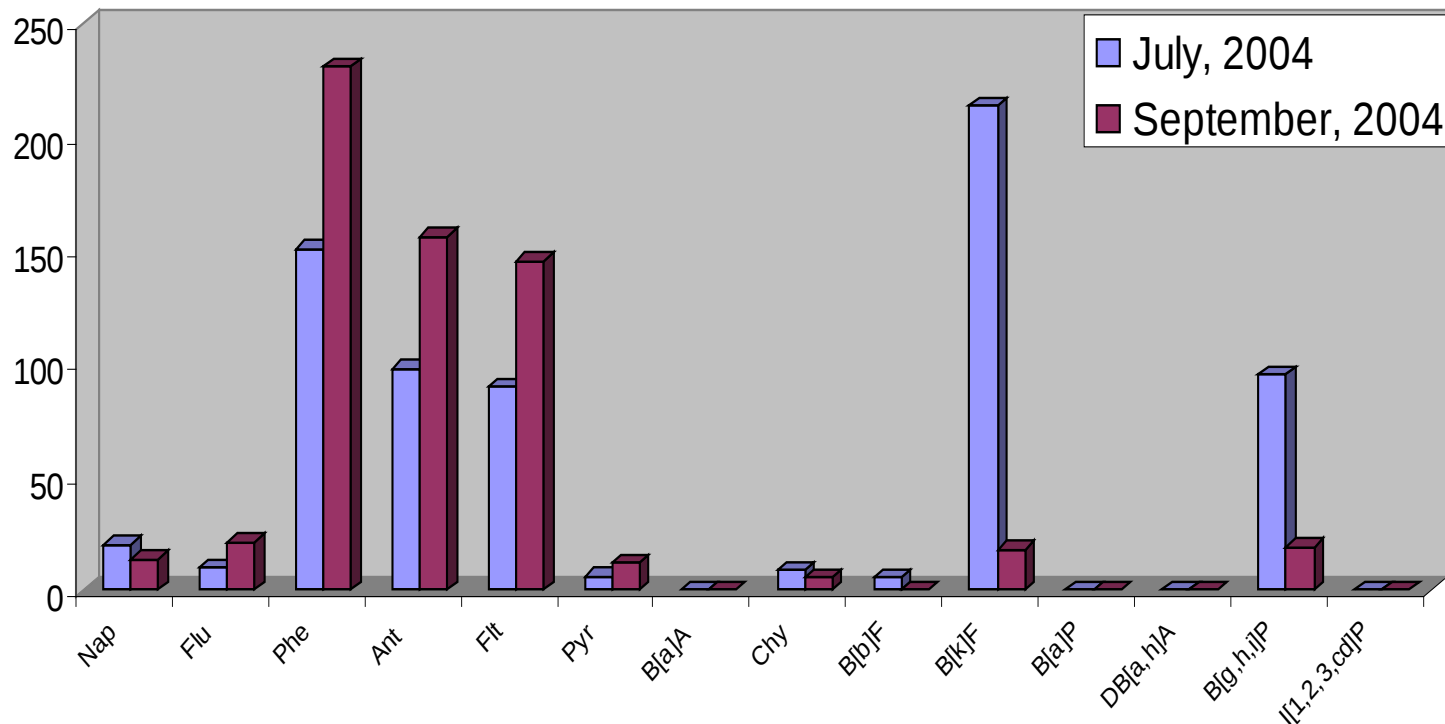


Figure 24 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 7 : **SRI SONGKHRAM RIVER**

A. Songsasen

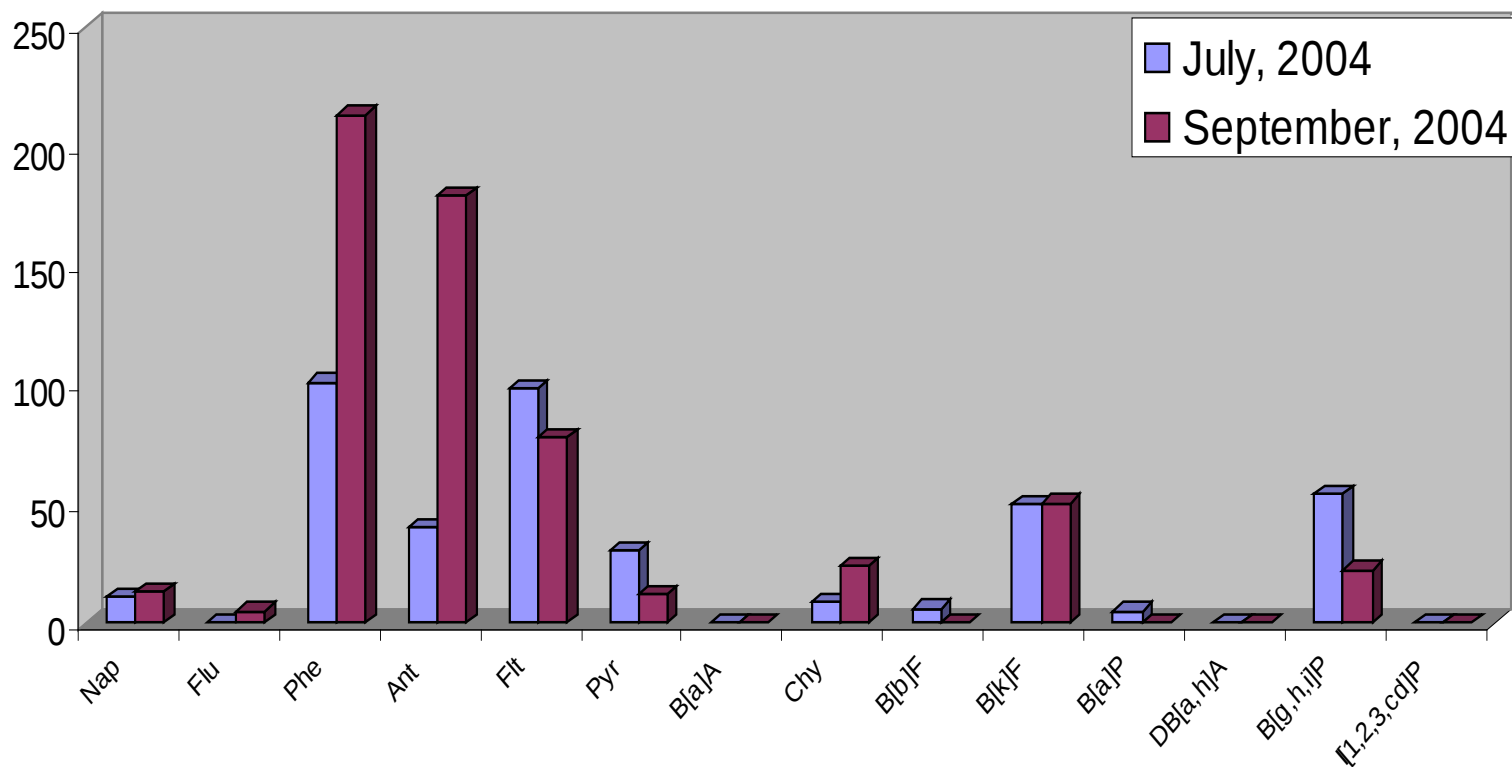


Figure 25 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 8 : **AMPHOE THAT PHRA NOM**

A. Songsasen

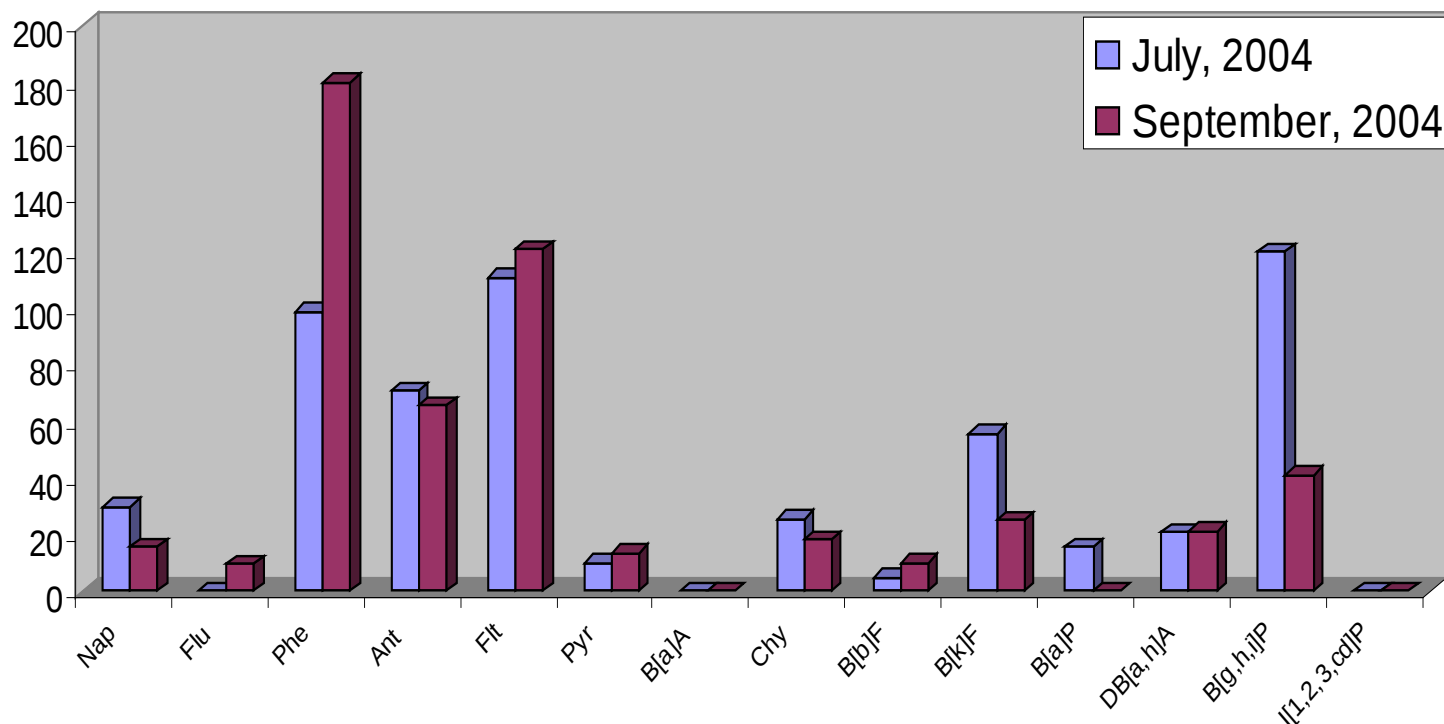


Figure 26 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 9 : **WAT KHONG CHIAM BURAWAS**

A. Songsasen

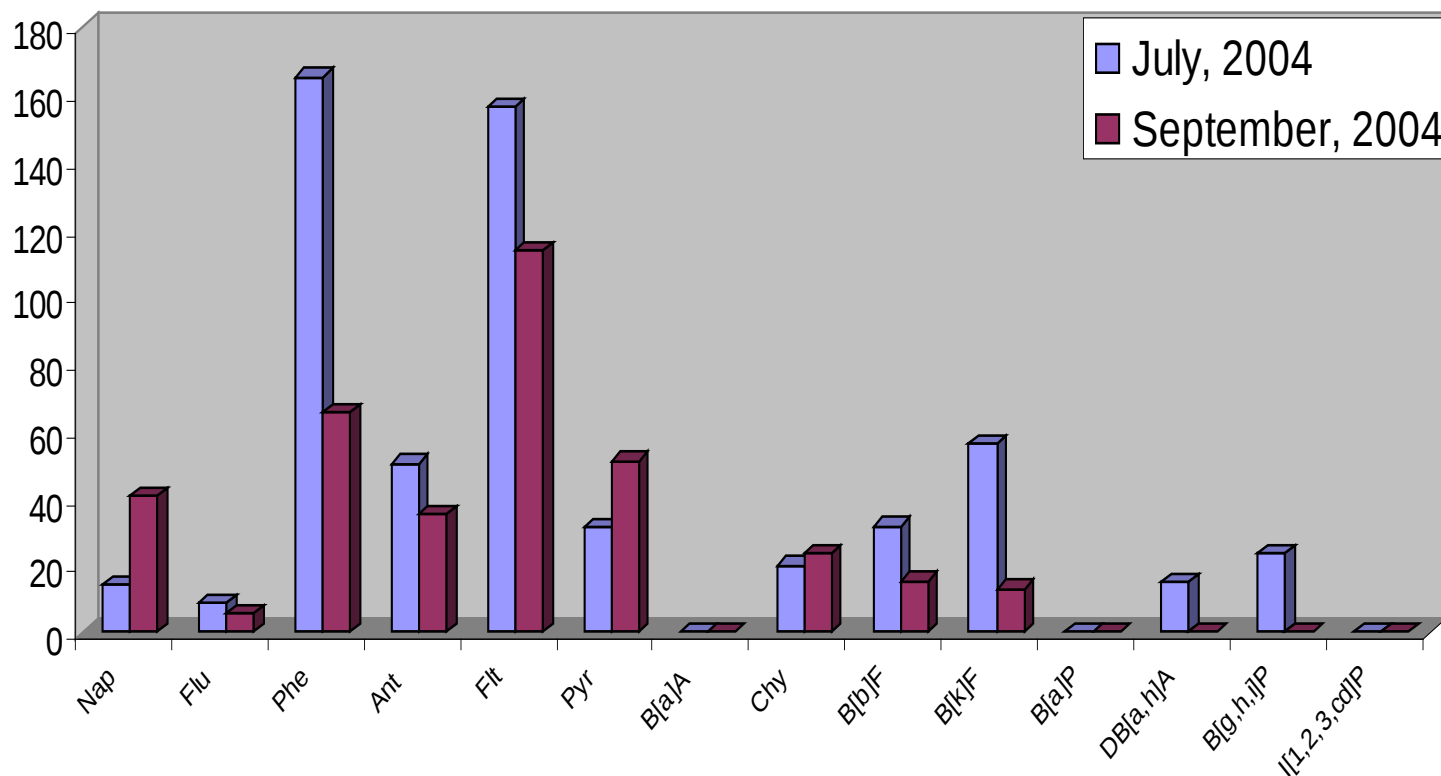


Figure 27 Seasonal variation of each PAHs in the sediment from Thai:Laos Mekong River at station 10 : **AMPHOE KHONG CHIAM**



- 1. the distribution of various PAHs was effected by the changing in season. In summer, the concentration of PAHs of all stations were higher than other seasons.**
- 2. The concentration of PAHs in station 3 was higher than other stations.**



3. The presences of carcinogenic PAHs (5-6) rings i.e. benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenzo[a,h]anthracene, benzo[g,h,i]perylene and indeno[1,2,3,cd]pyrene were observed in every station. This may effect the health problem to the life along the Mekong river.

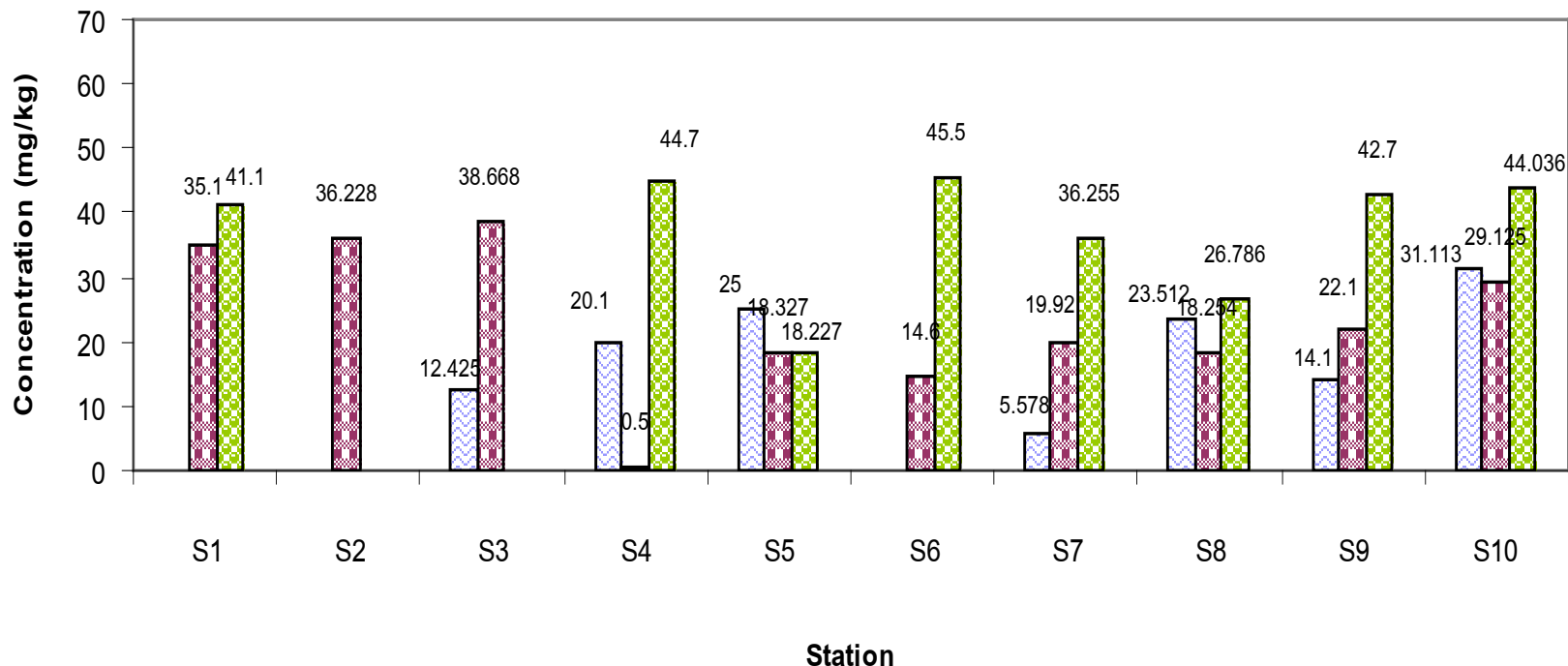


Figure 28 Concentration of Cd in sediment from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

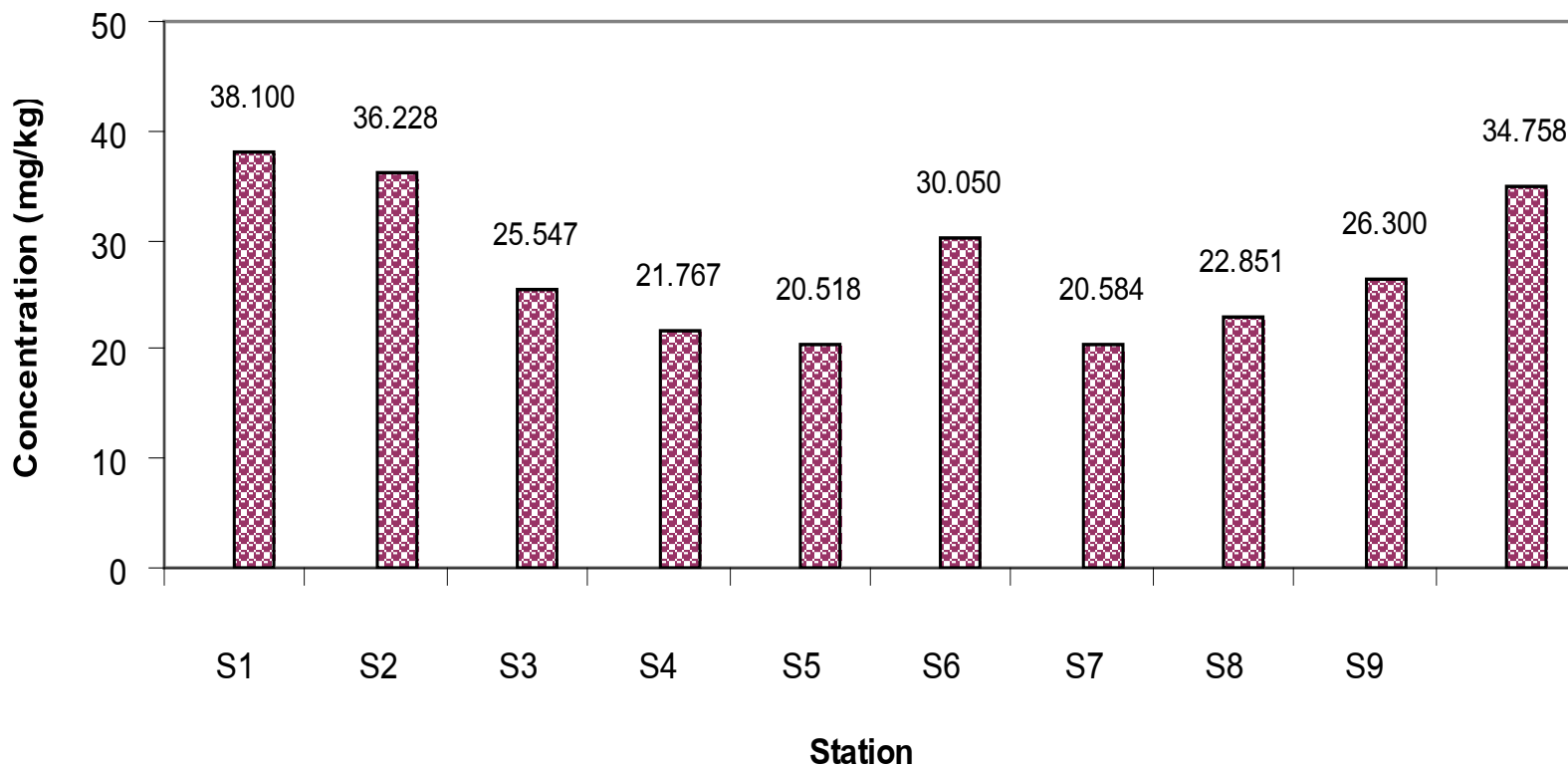


Figure 29 Concentration of Cd in sediment from the Mekong river (mg/kg) at various stations in 1 year

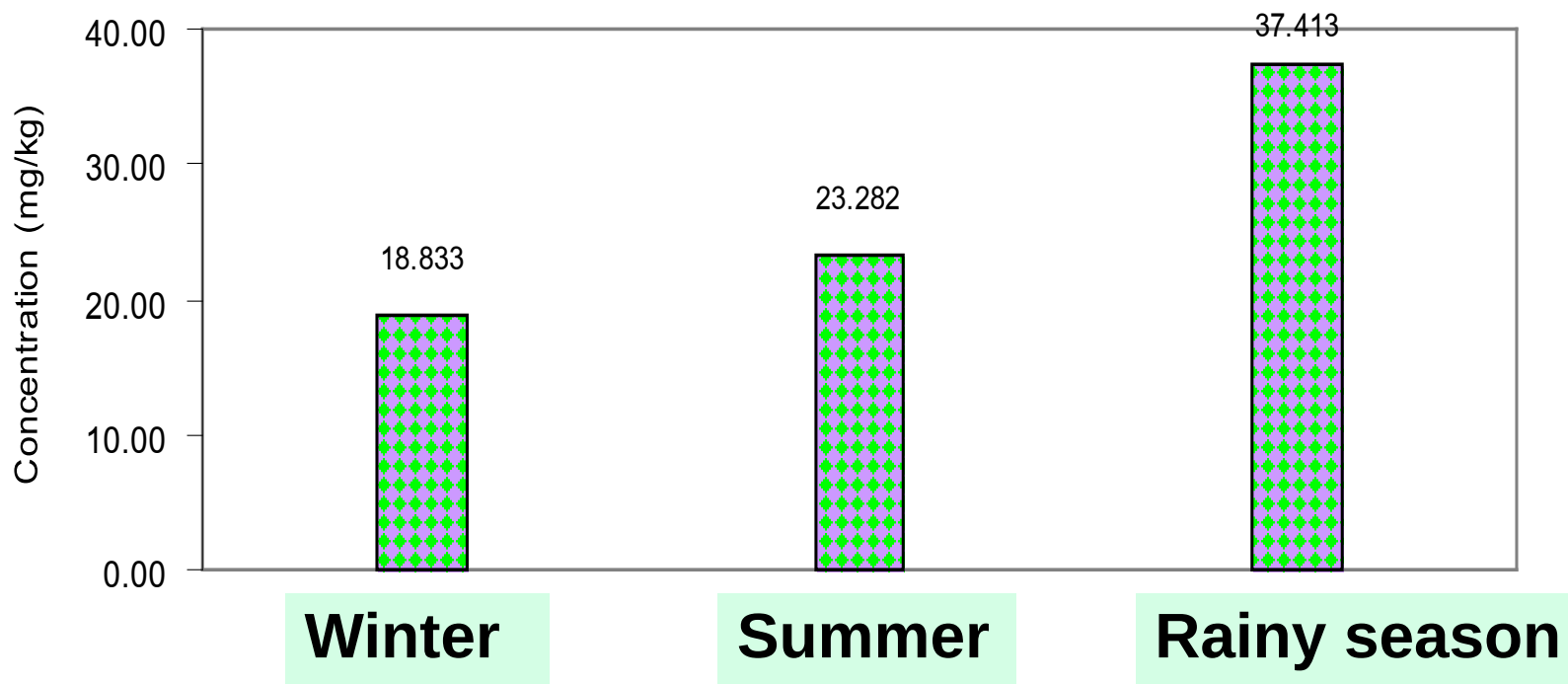


Figure 30 Seasonal variation of Cd in the Mekong River's sediment

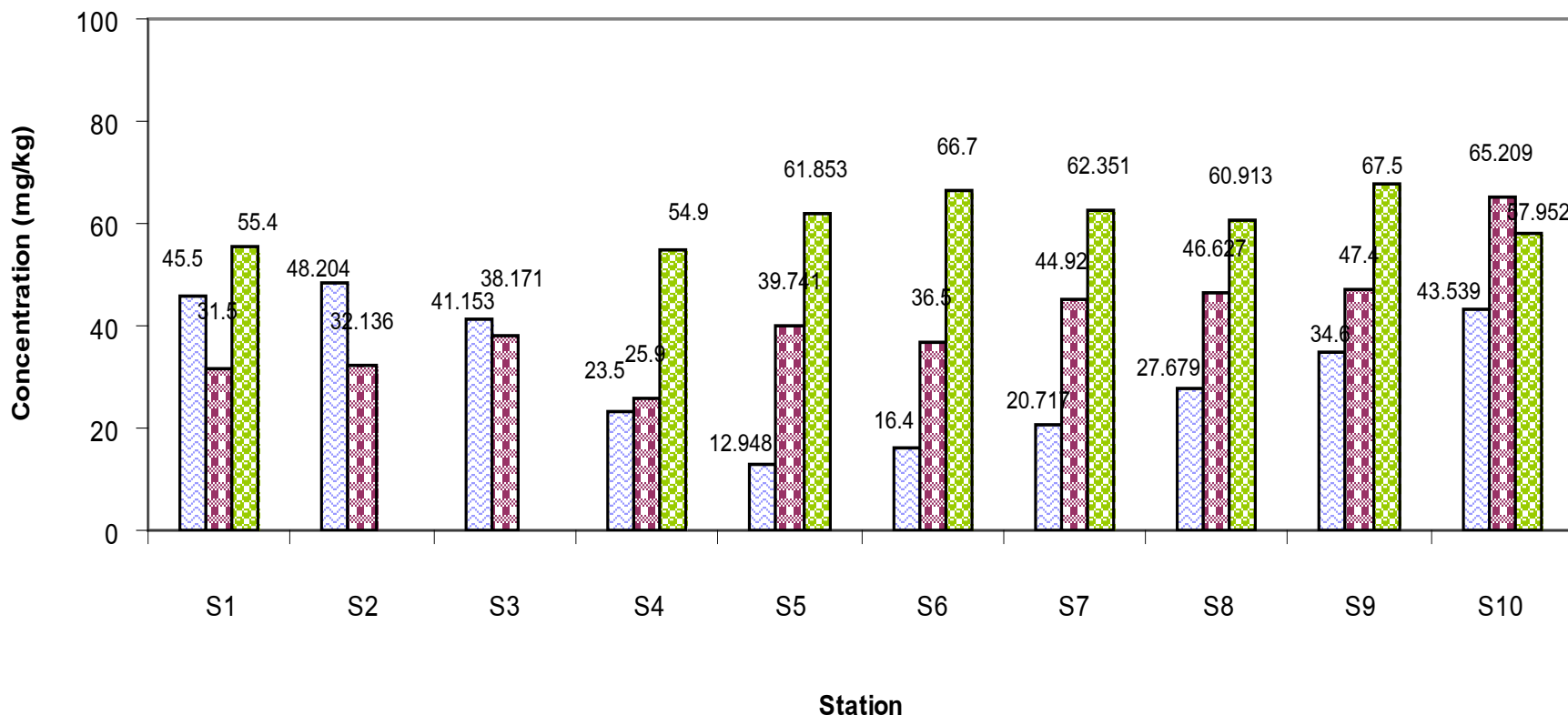


Figure 31 Concentration of Pb in sediment from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

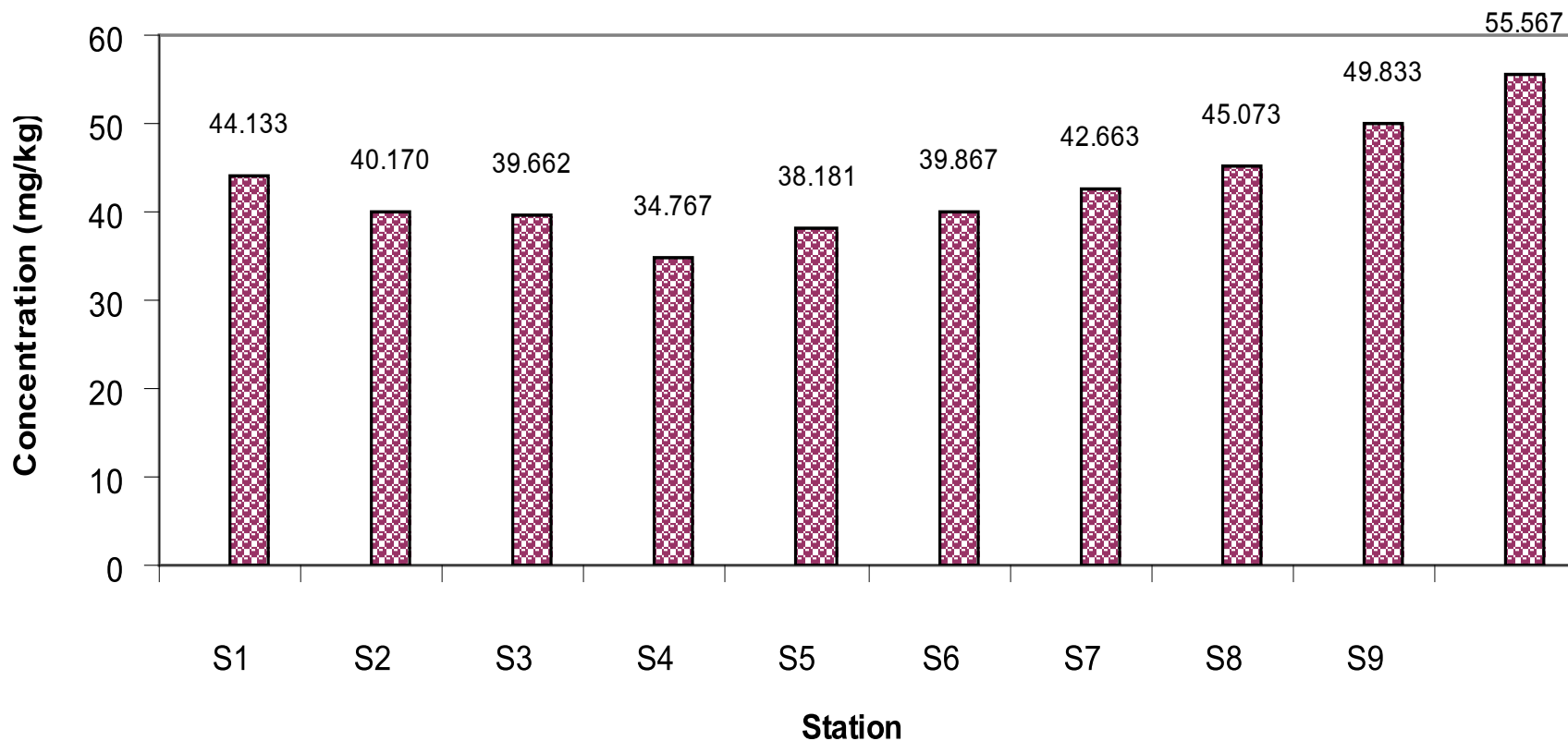


Figure 32 Concentration of Pb in sediment from the Mekong river (mg/kg) at various stations in 1 year

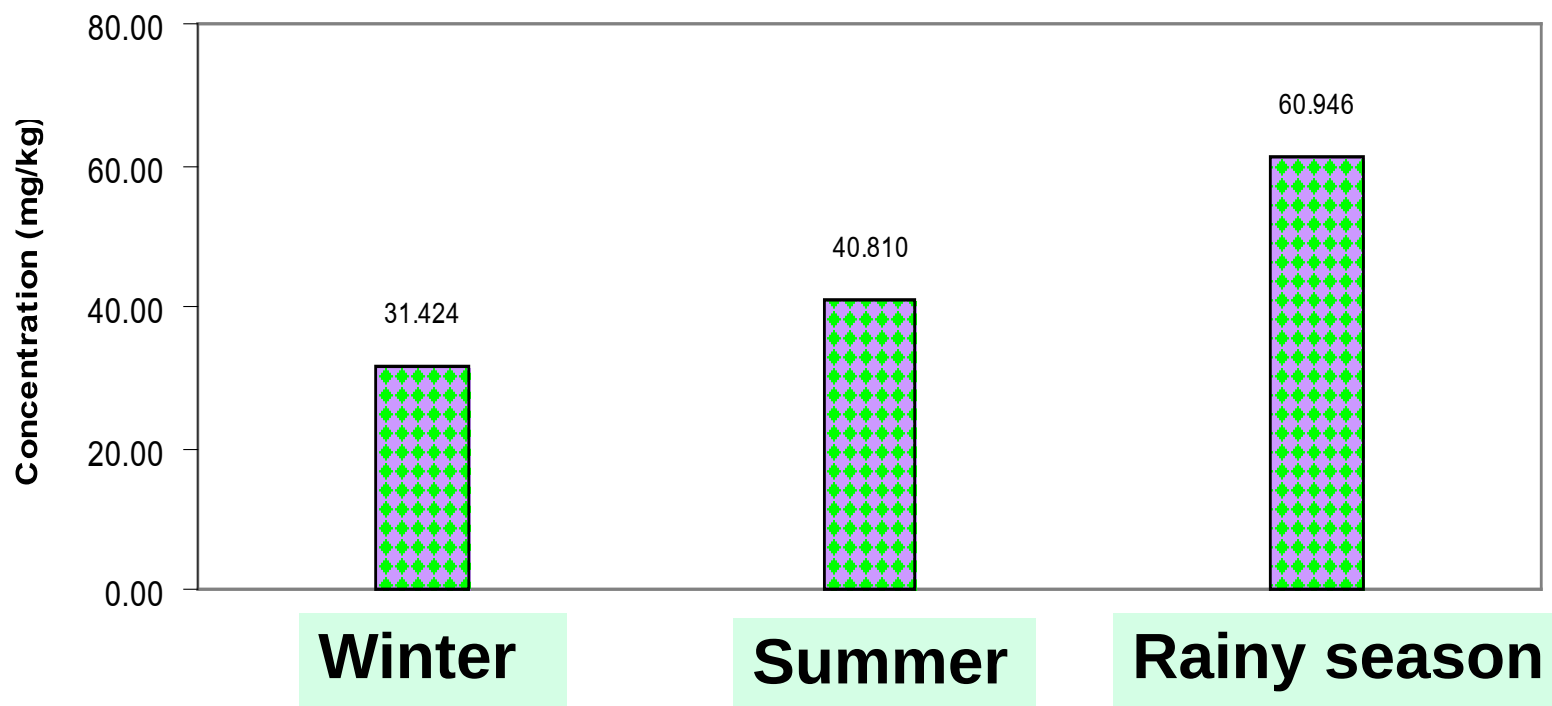


Figure 33 Seasonal variation of Pb in the Mekong River's sediment

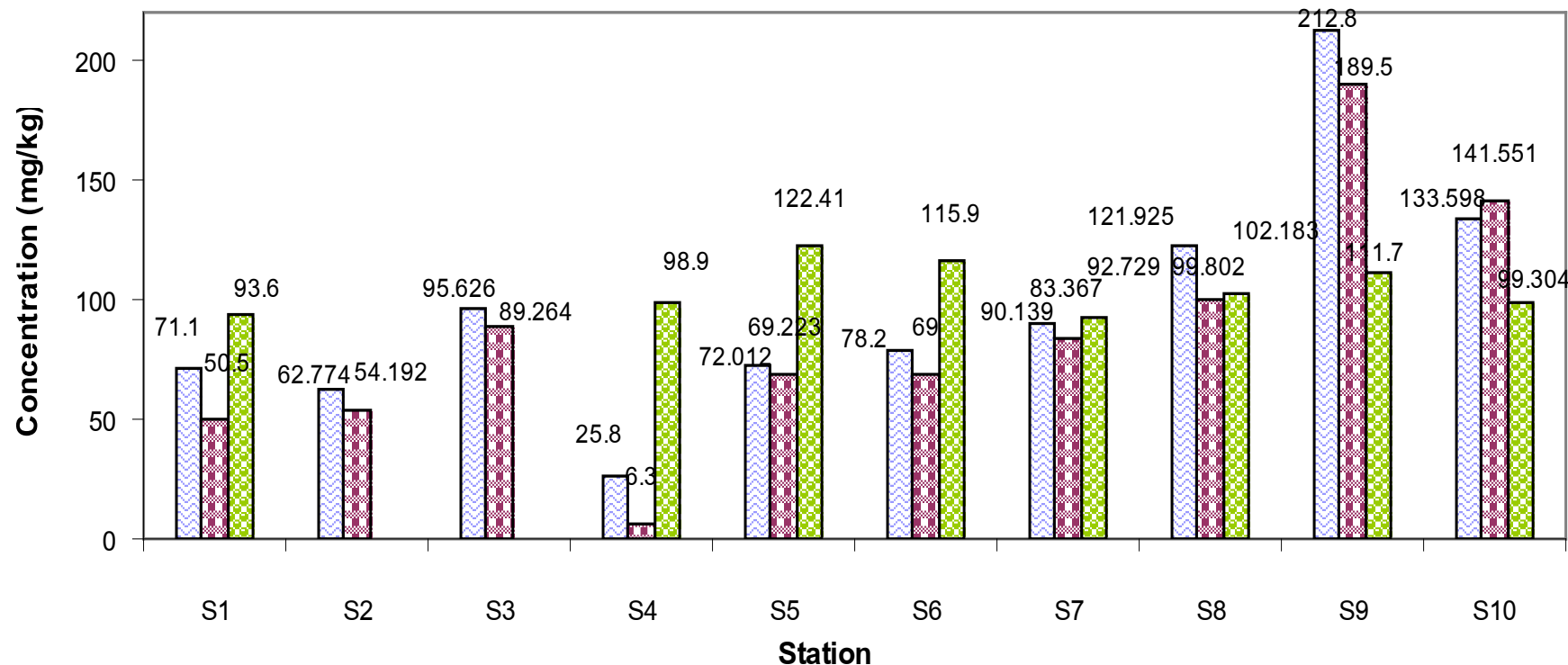


Figure 34 Concentration of Cr in sediment from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

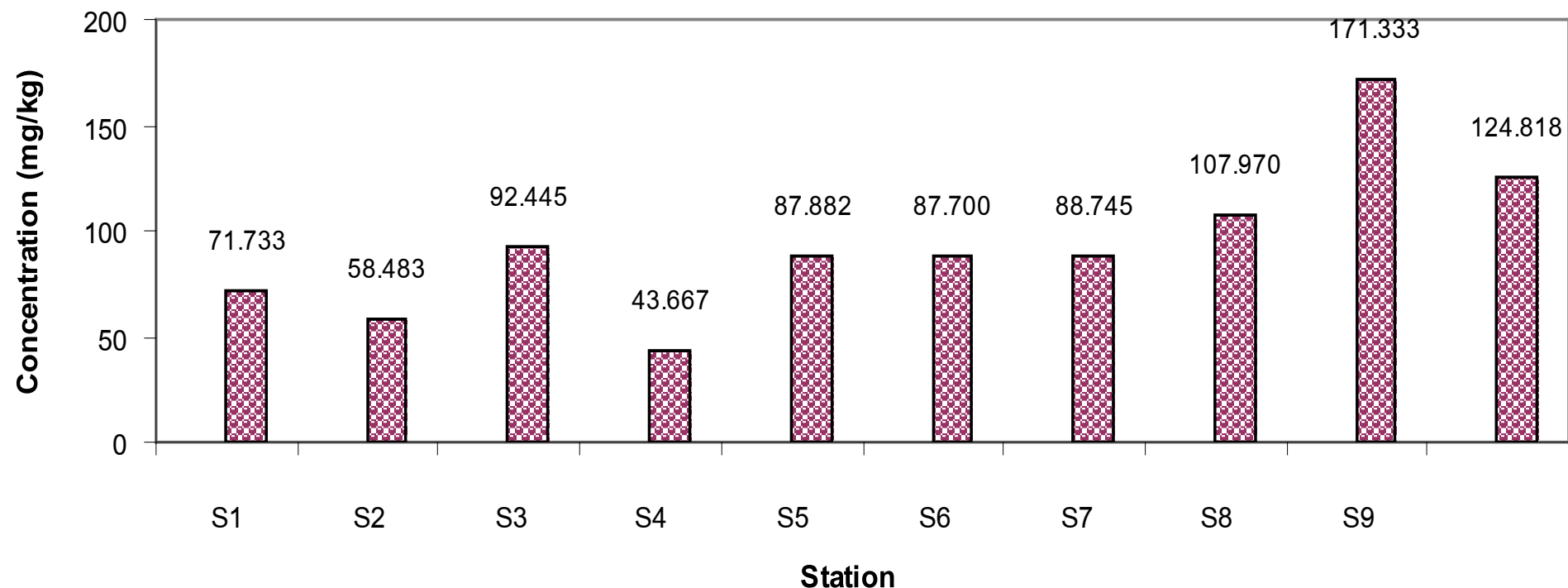


Figure 35 Concentration of Cr in sediment from the Mekong river (mg/kg) at various stations in 1 year

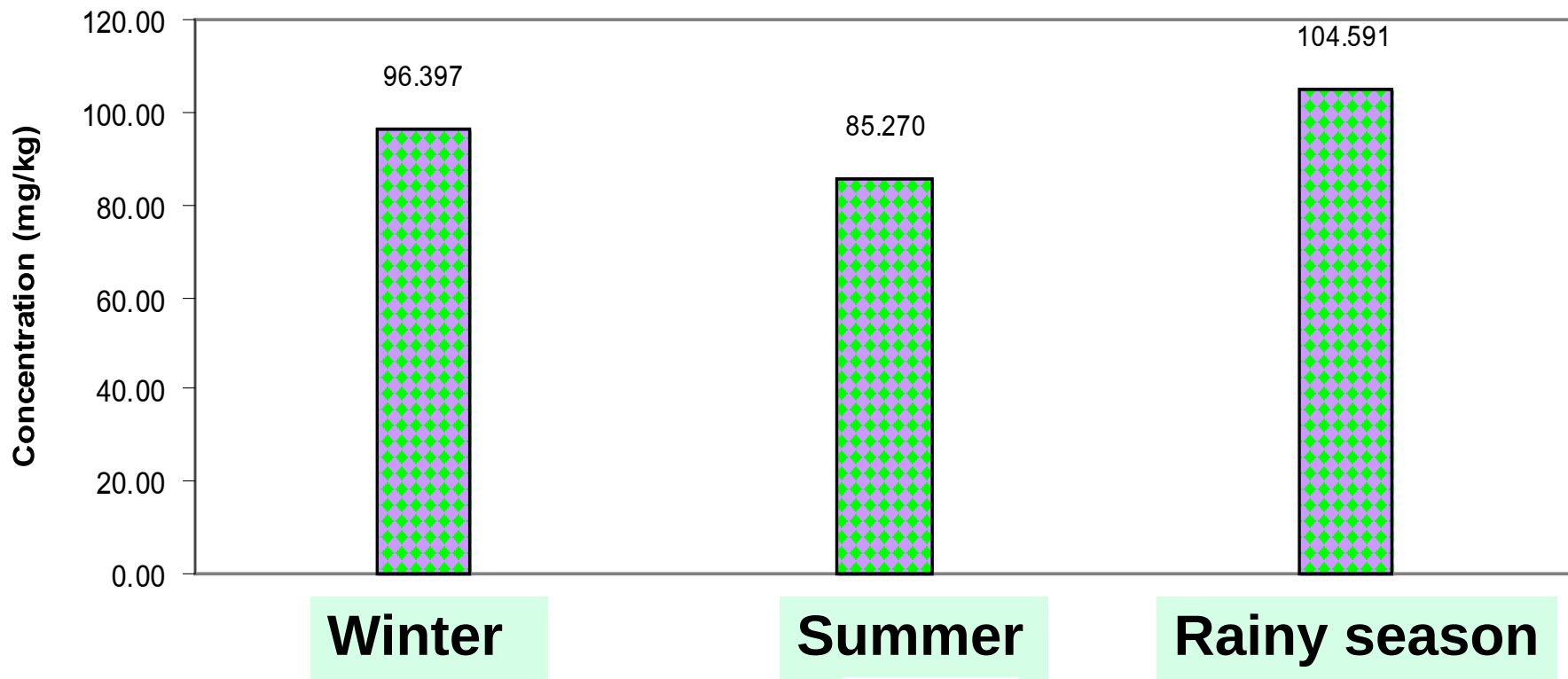


Figure 36 Seasonal variation of Cr in the Mekong River 's sediment

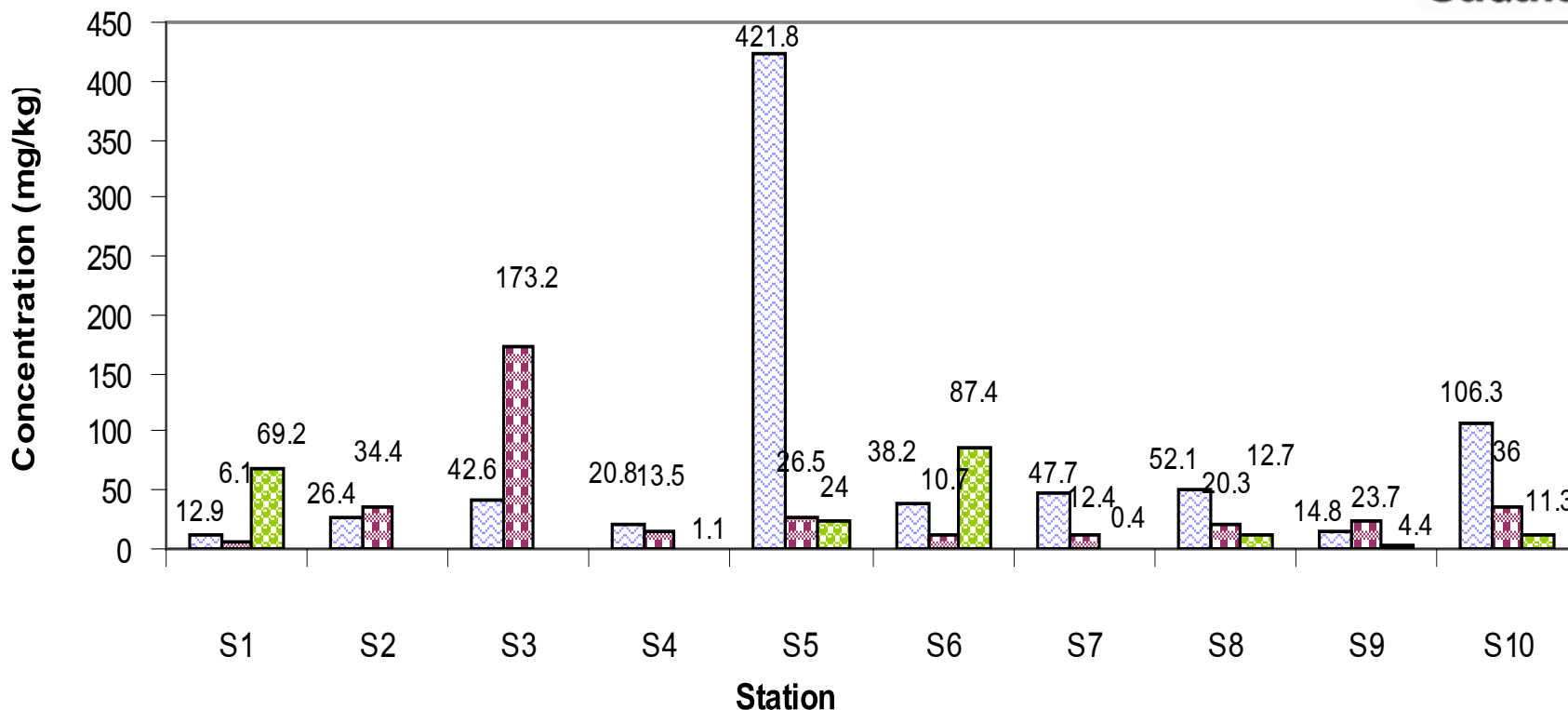


Figure 37 Concentration of Hg in sediment from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

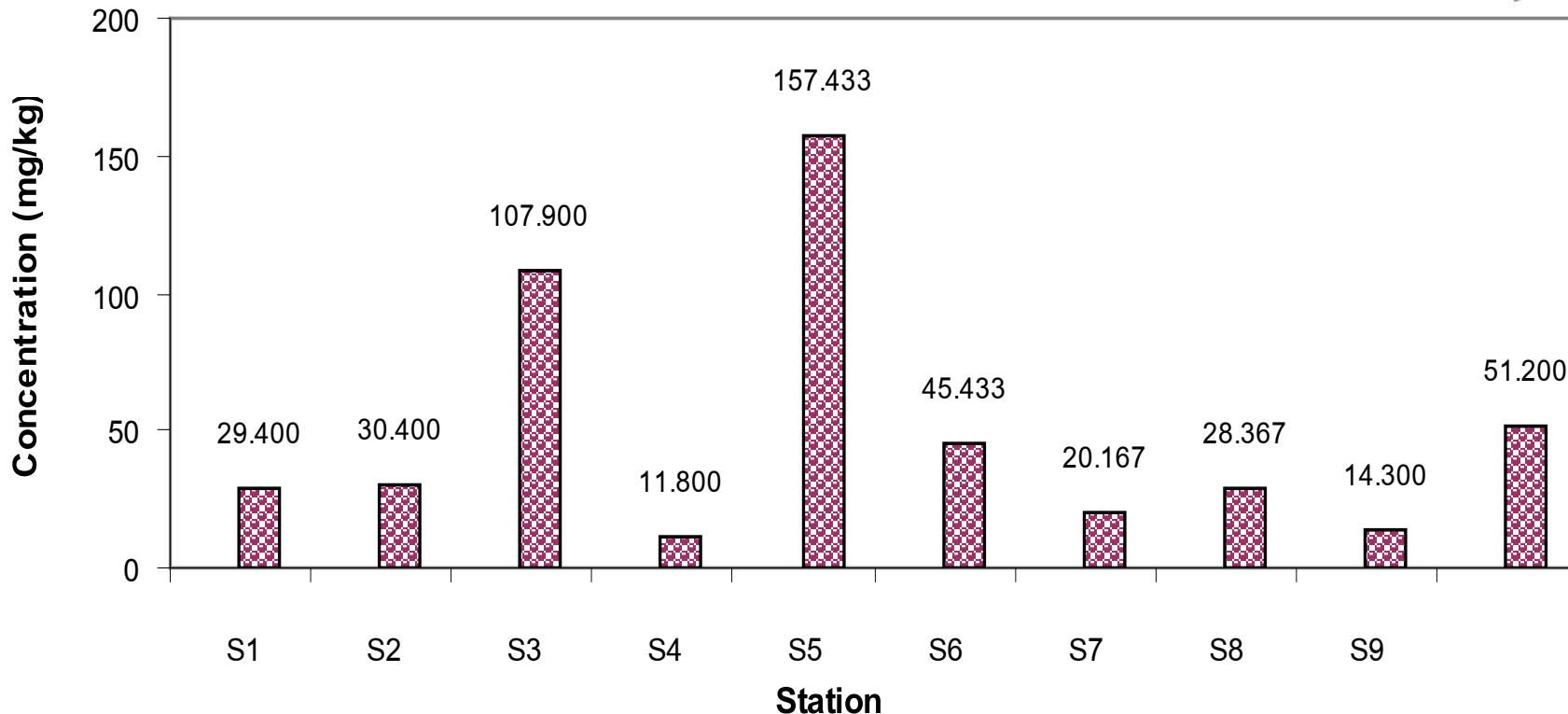


Figure 38 Concentration of Hg in sediment from the Mekong river (mg/kg) at various stations in 1 year

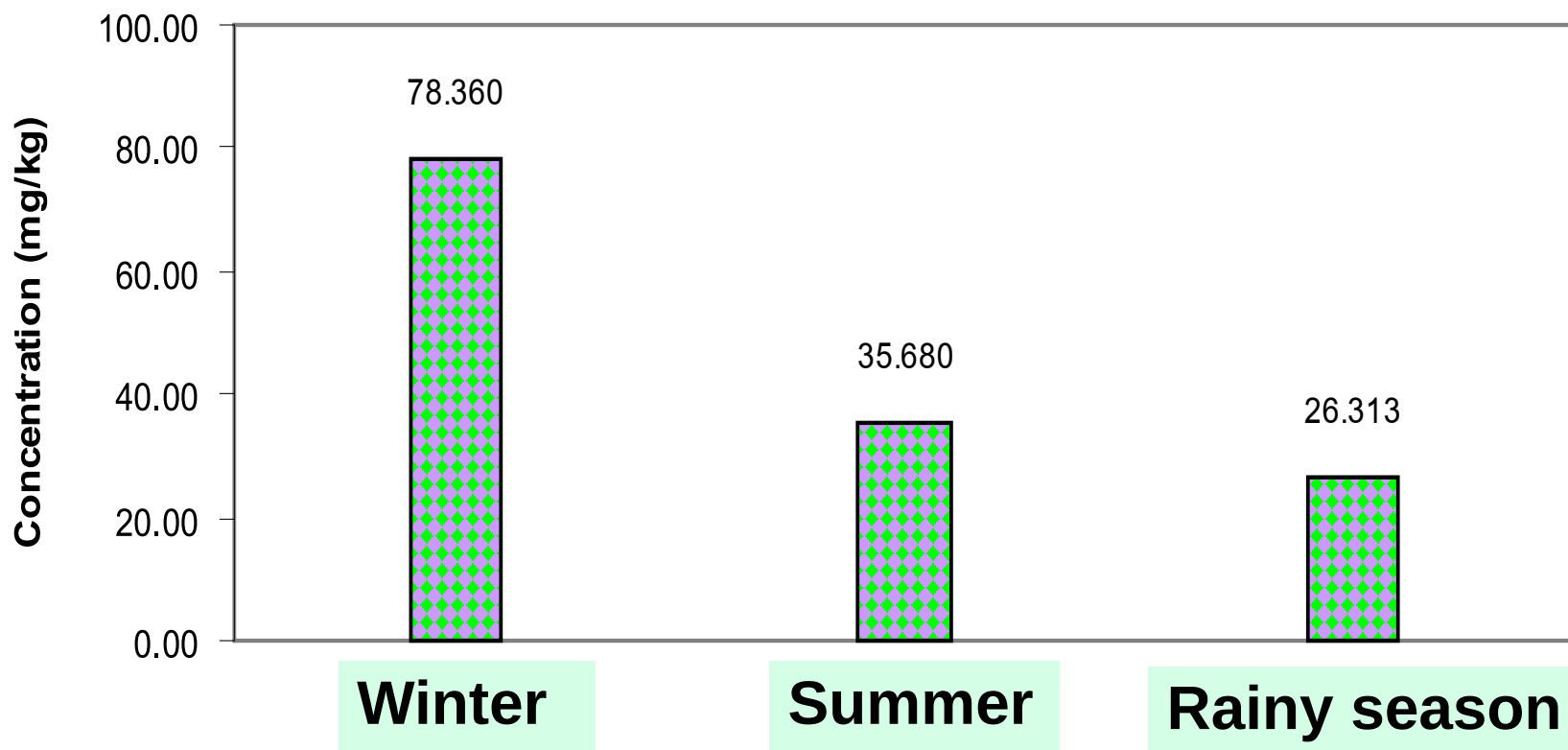


Figure 39 Seasonal variation of Hg in the Mekong River's sediment

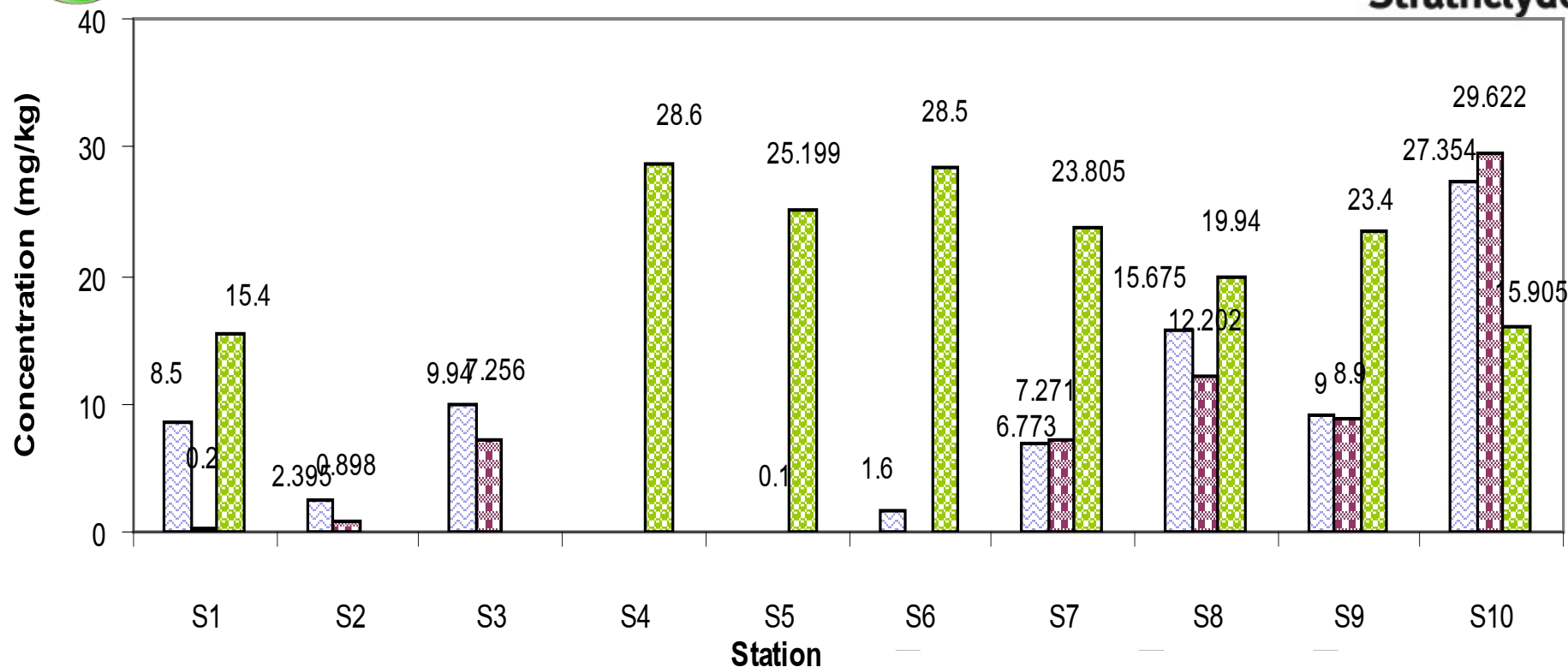


Figure 40 Concentration of Cu in sediment from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

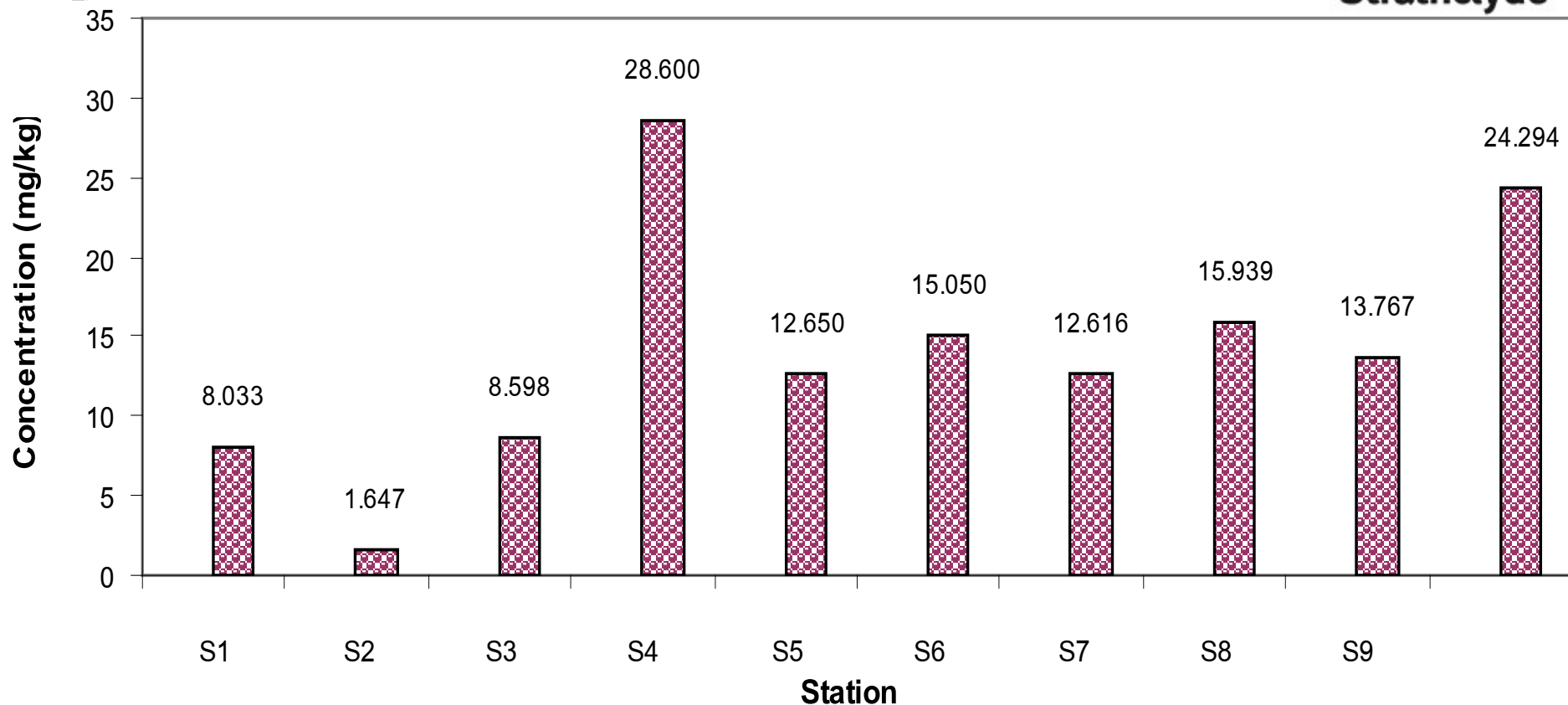


Figure 41 Concentration of Cu in sediment from the Mekong river (mg/kg) at various stations in 1 year

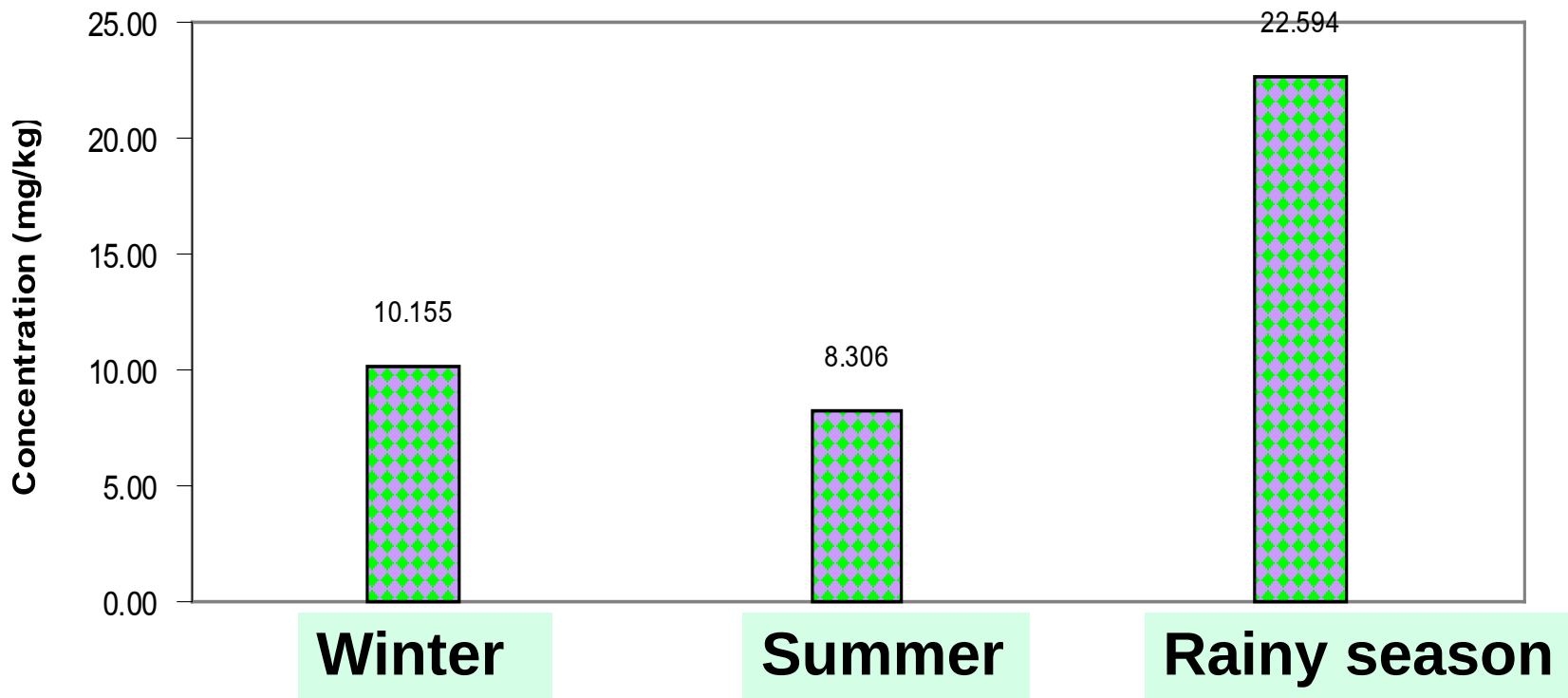


Figure 42 Seasonal variation of Cu in the Mekong River's sediment

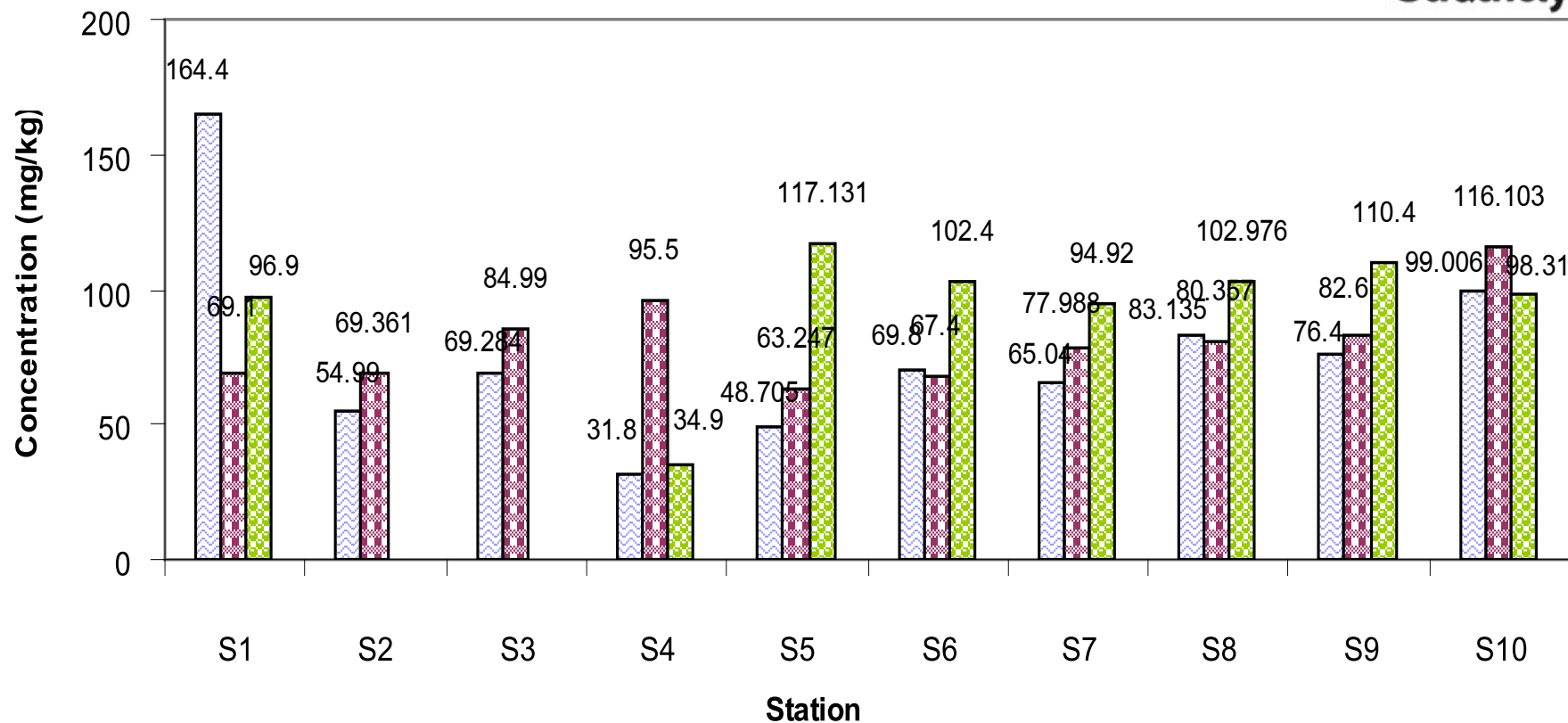


Figure 43 Concentration of Zn in sediment from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

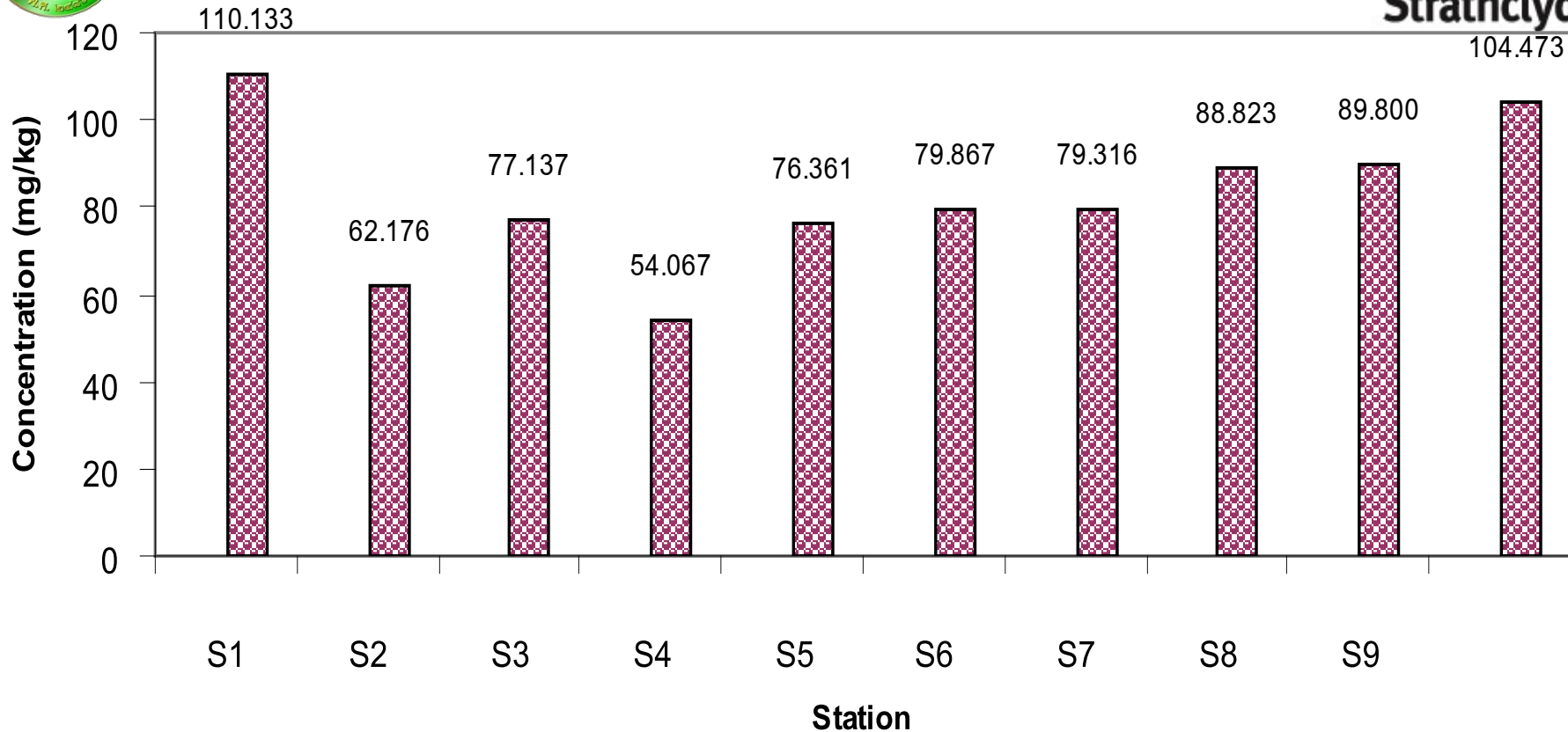


Figure 44 Concentration of Zn in sediment from the Mekong river (mg/kg) at various stations in 1 year

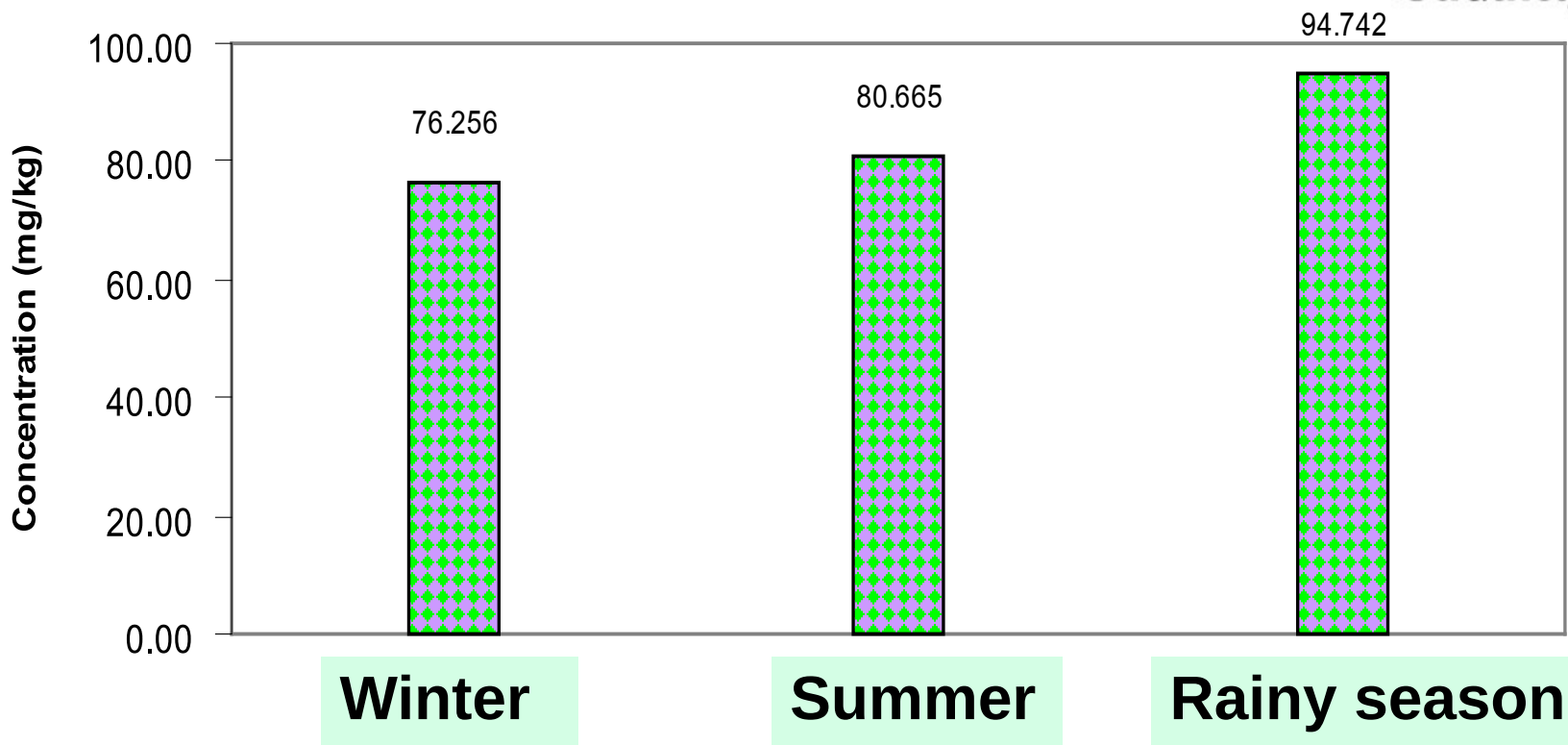


Figure 45 Seasonal variation of Zn in the Mekong River's sediment

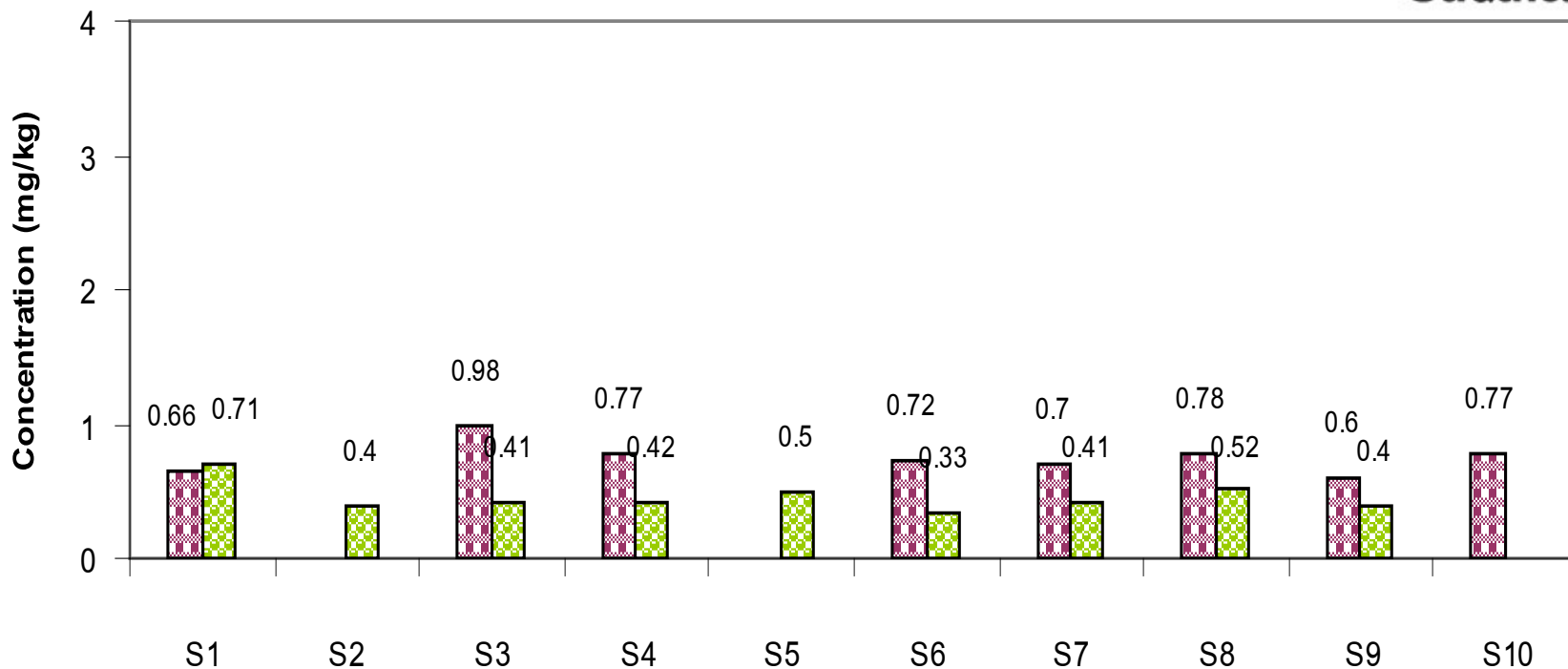


Figure 46 Concentration of Hg in water from the Mekong river (mg/kg) in Summer and Rainy season

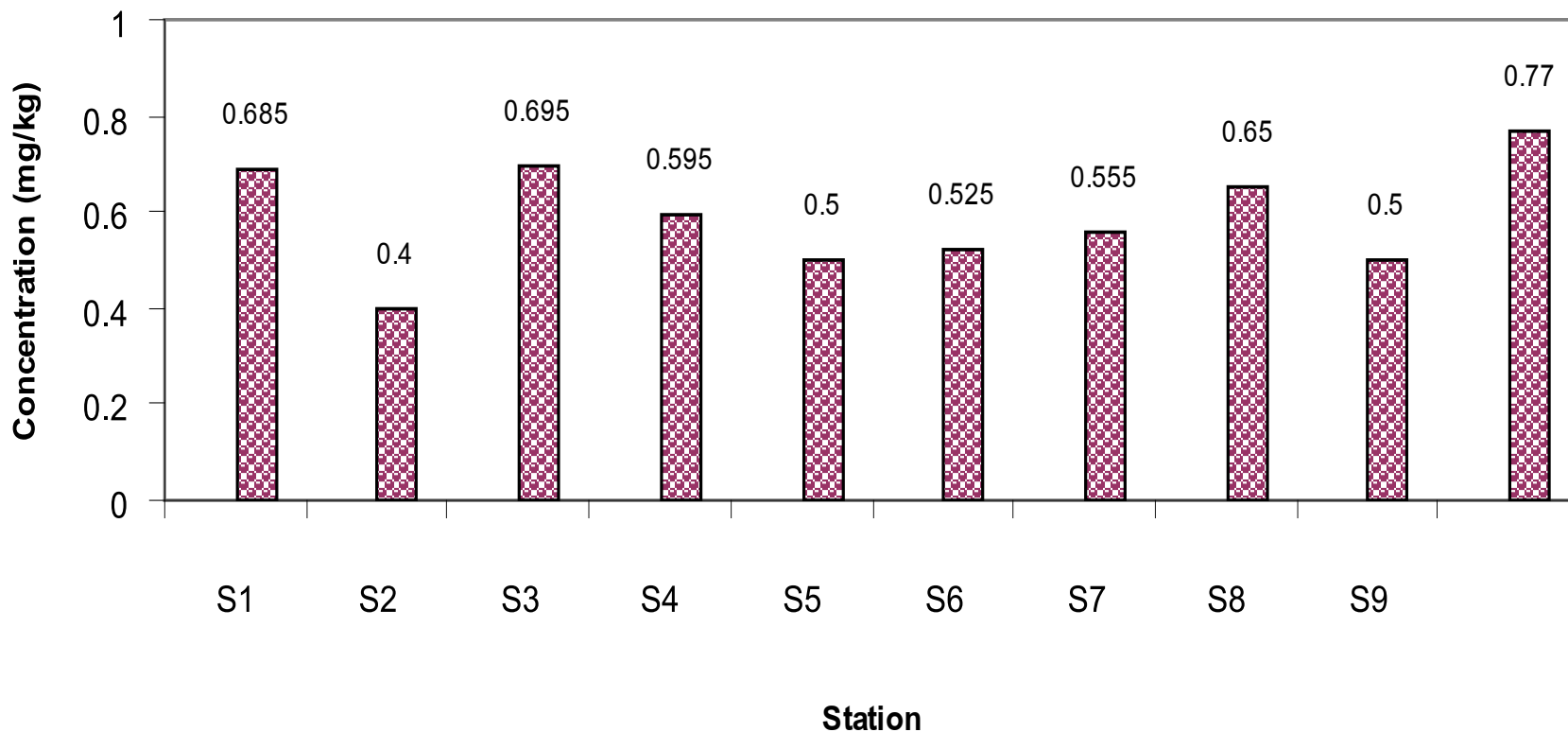


Figure 47 Concentration of Hg in water from the Mekong river (mg/kg) at various stations

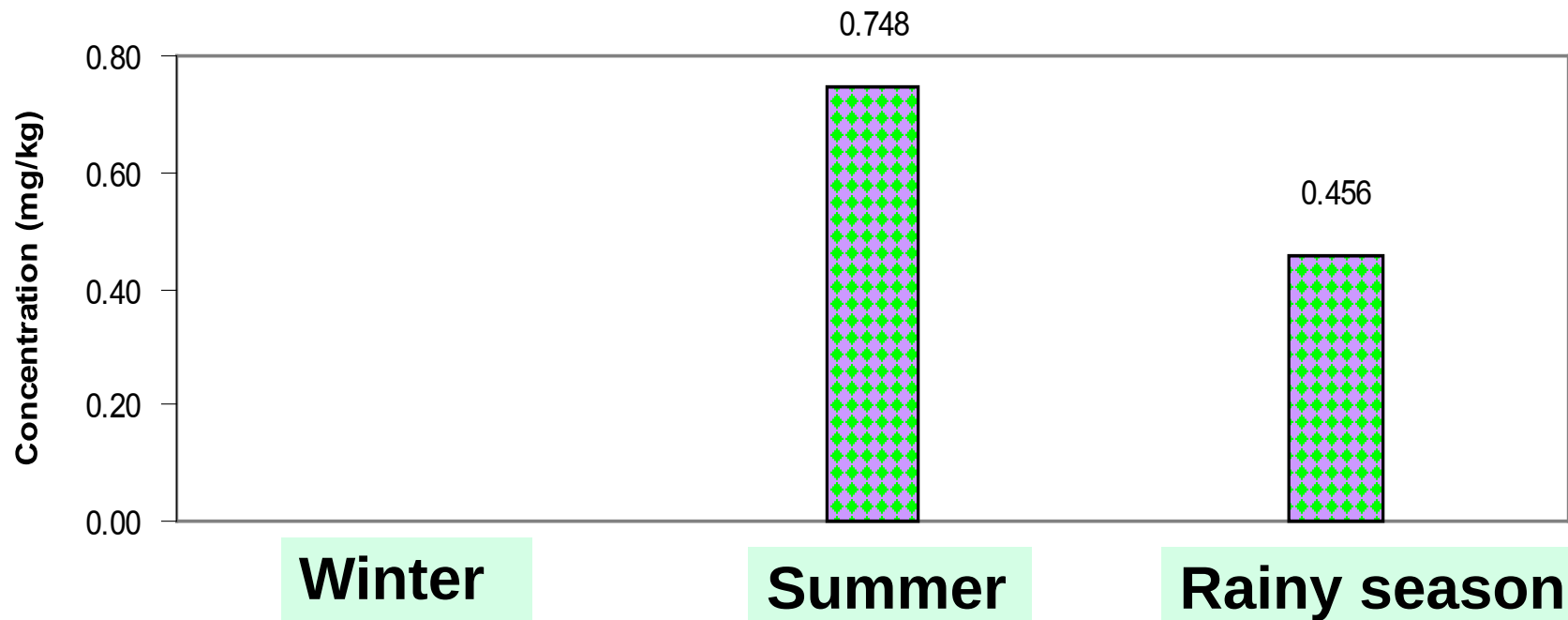


Figure 48 Seasonal variation of Hg in water from the Mekong River

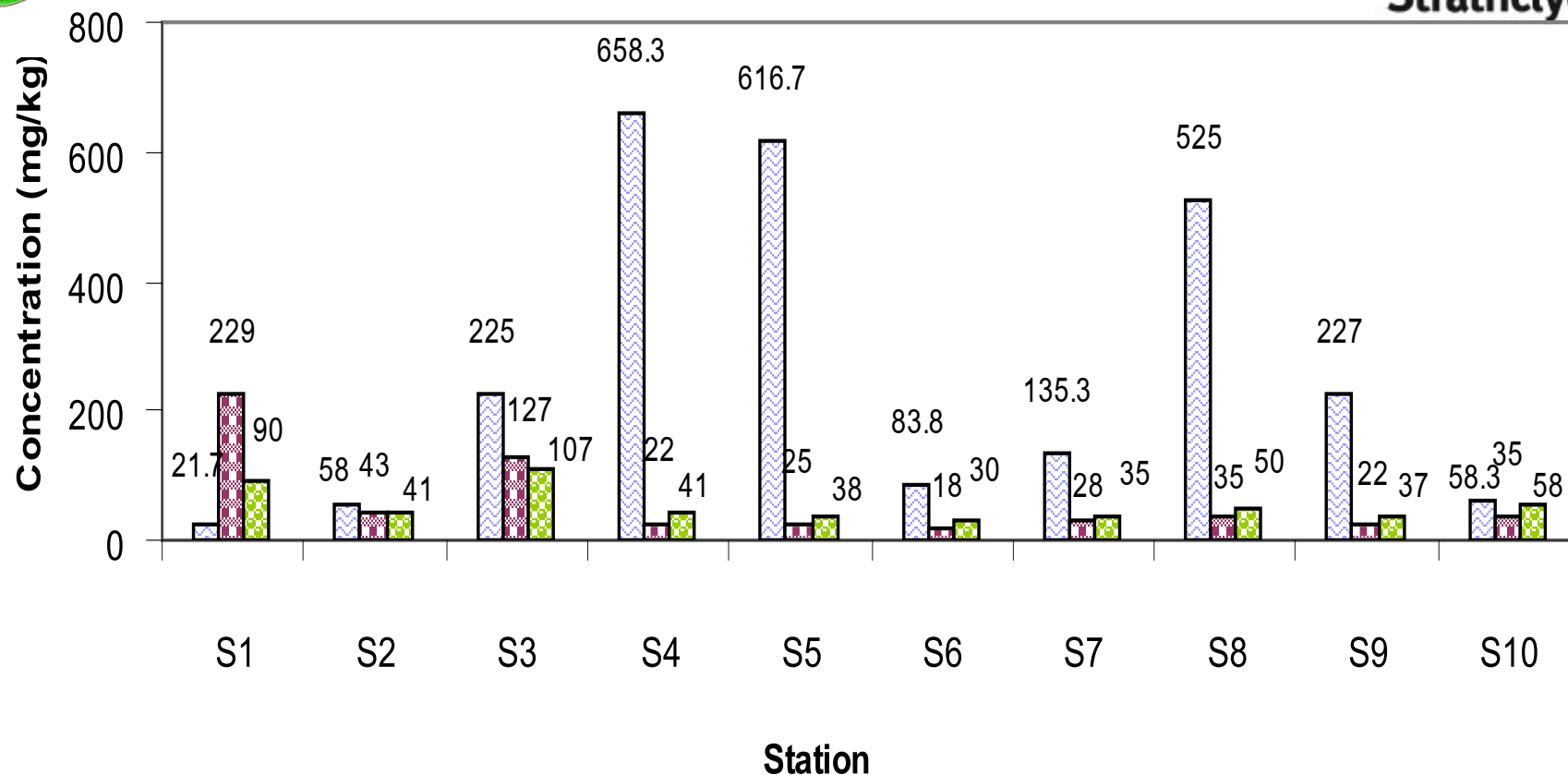


Figure 49 Concentration of Zn in water from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

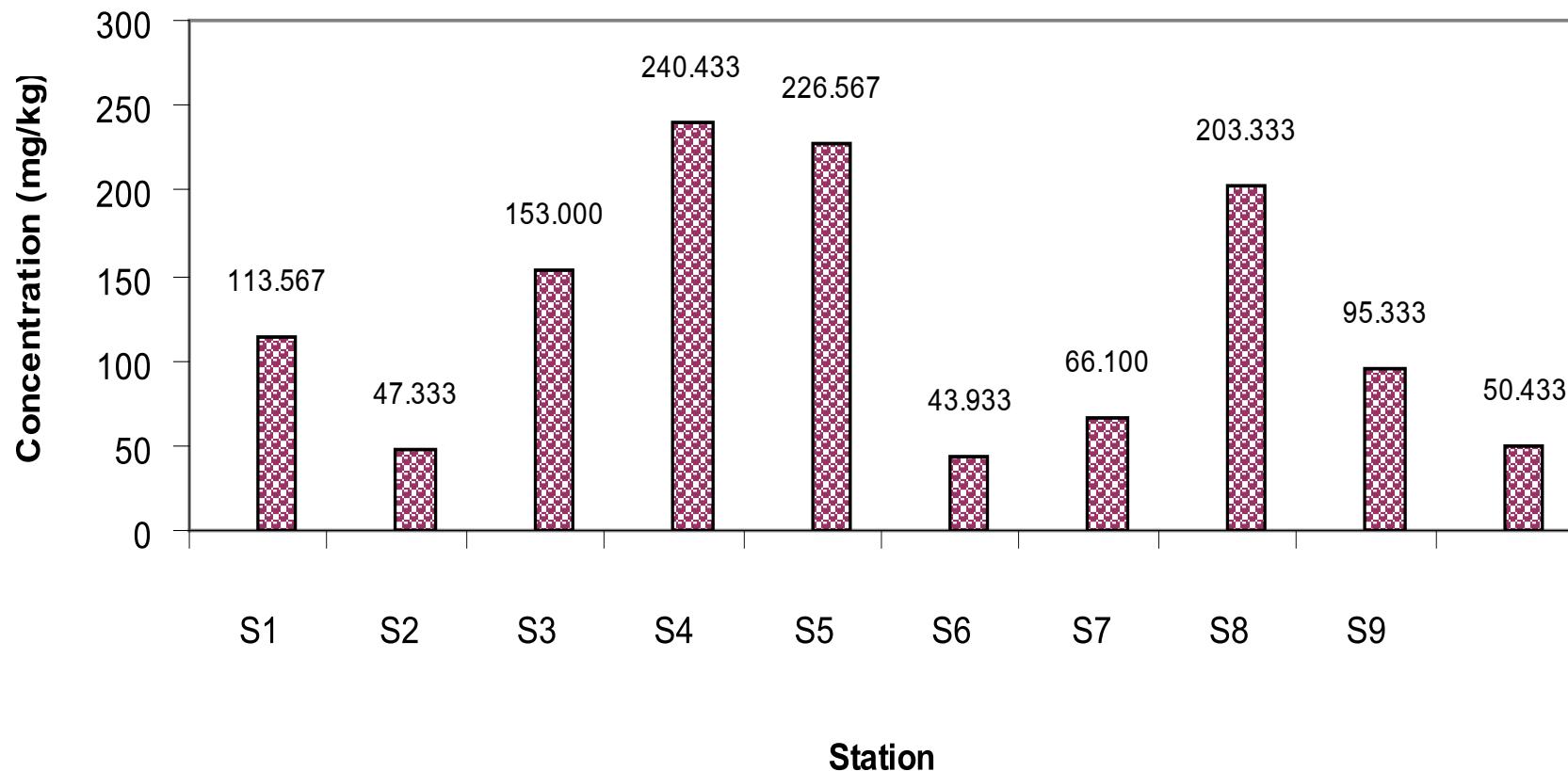


Figure 50 Concentration of Zn in water from the Mekong river (mg/kg) at various stations

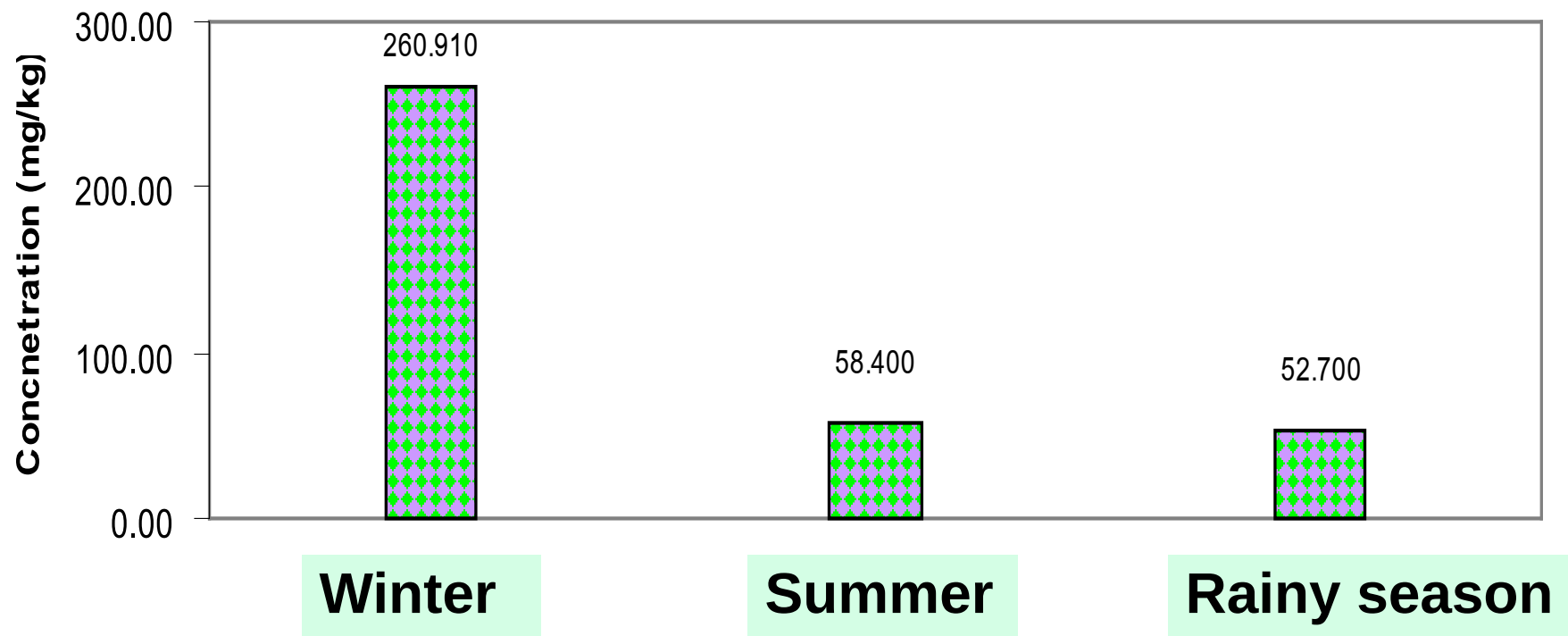


Figure 51 Seasonal variation of Zn in water from the Mekong River

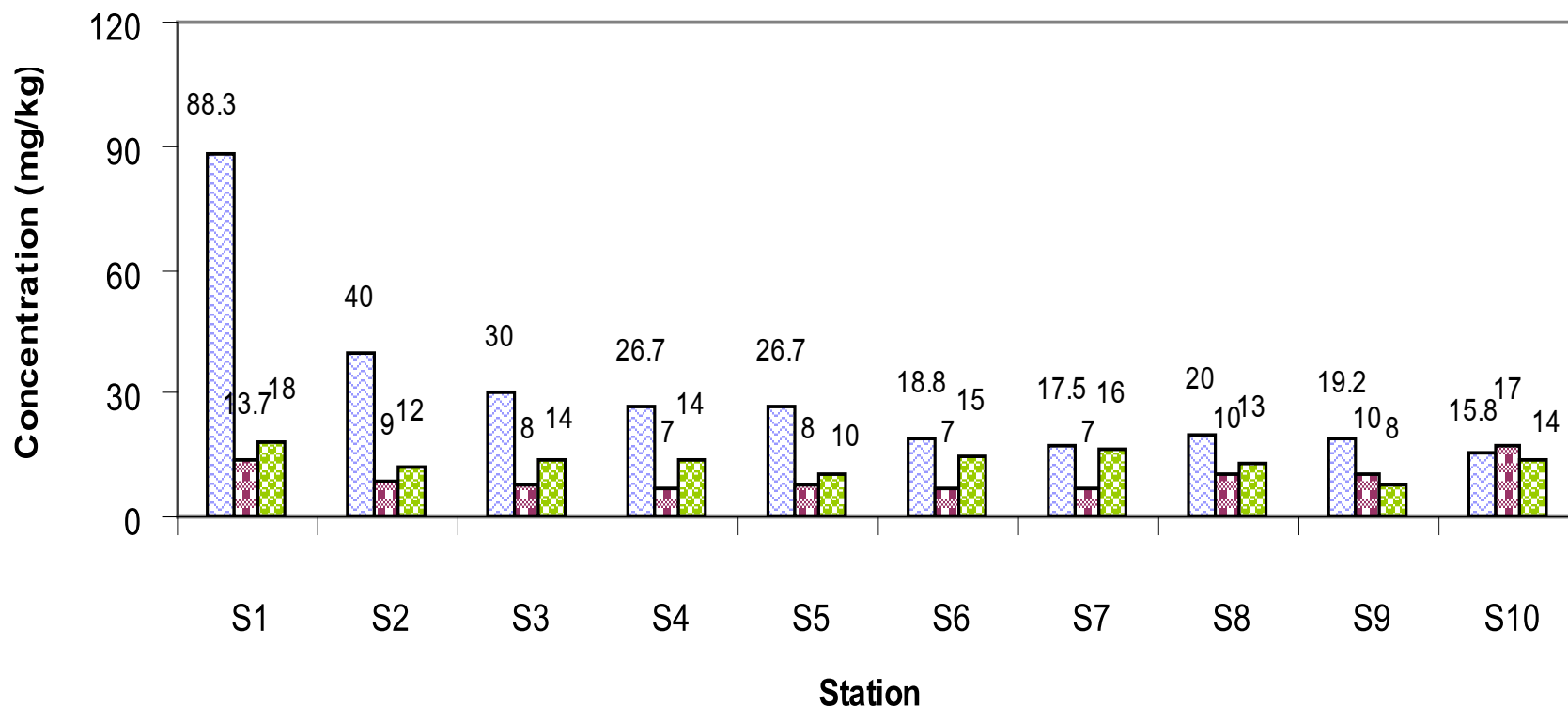


Figure 52 Concentration of Cu in water from the Mekong river (mg/kg) at various seasons , Winter, Summer, Rainy season

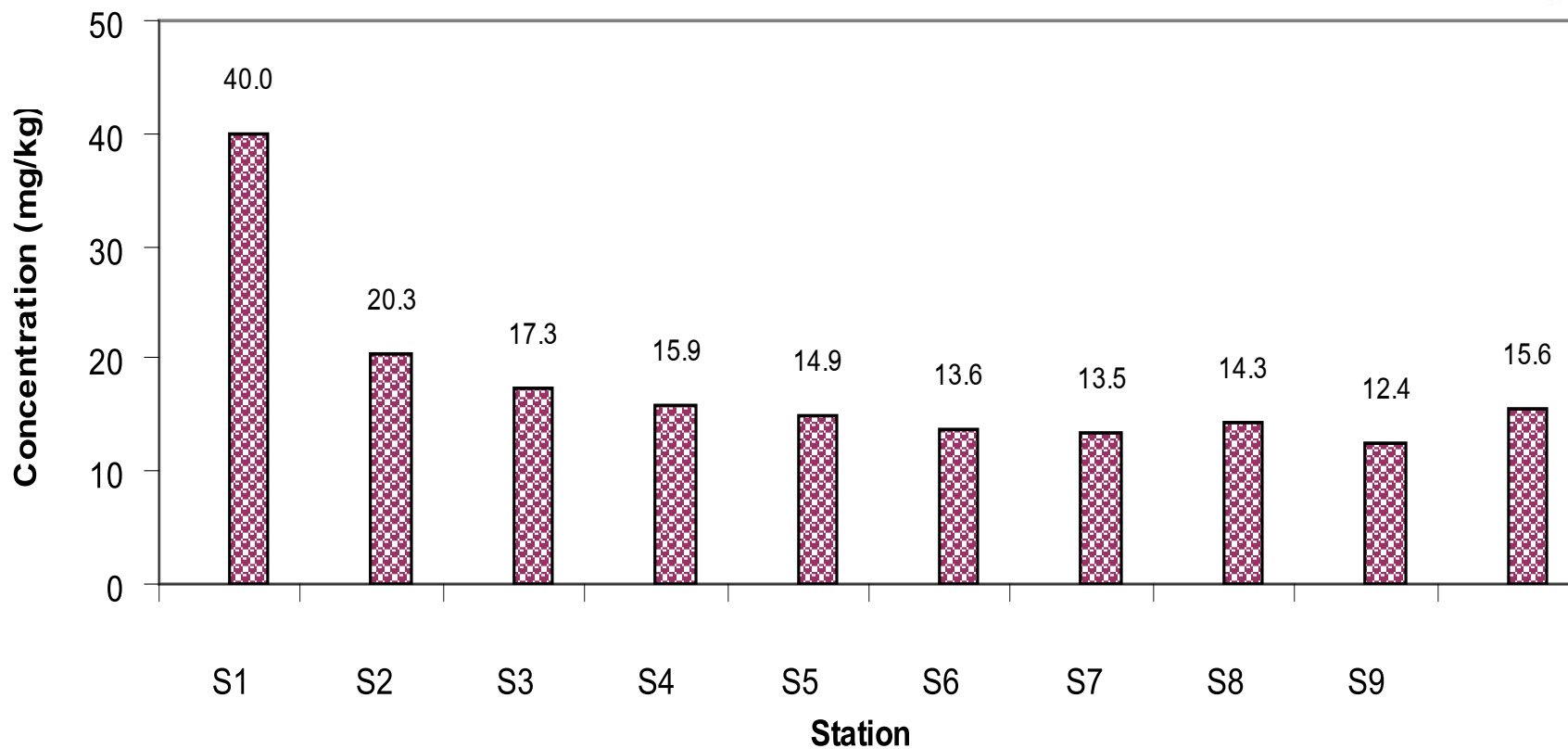


Figure 53 Concentration of Cu in water from the Mekong river (mg/kg) at various stations

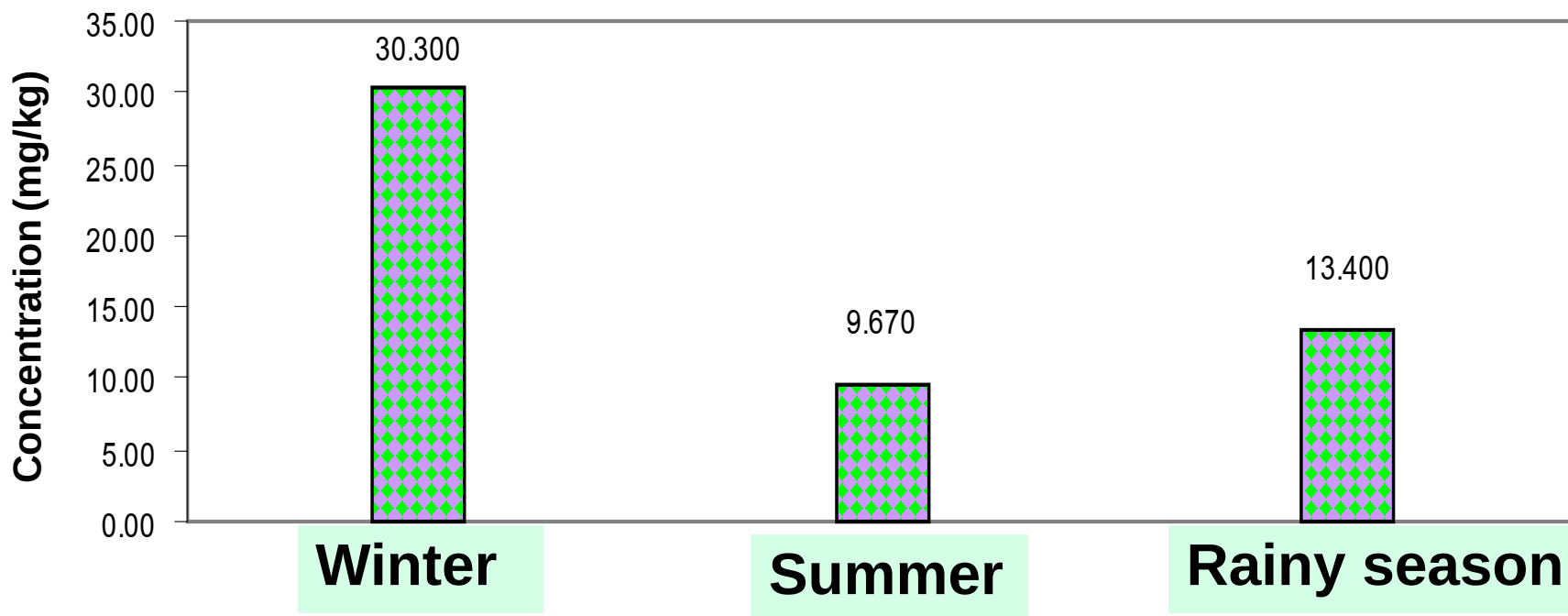


Figure 54 Seasonal variation of Cu in water from the Mekong River



Heavy metals in water

- 1. Concentration of Cd, Cr and Pb in water were very low in all samples**
- 2. Concentration of Cu and Zn in winter were higher than other seasons**
- 3. Concentration of Hg and Zn were high in the residential area (S3, S8 and S10) comparing to other areas**
- 4. Concentration of Cu was very high in S1**



5. Concentration of Hg, Zn and Cu still lower than the limit for the surface water of the department of pollution control (Thailand)

(Hg > 2ppb, Zn > 1000 ppb, Cu > 100 ppb)



Heavy metals in sediment

- 1. Pb, Cd, Cr, Zn and Cu were high in rainy season, but Hg was high in winter**
- 2. Concentration of Cd, Pb and Hg seemed to have high variation with the change in season**
- 3. As in water, the concentration of heavy metals were high in the residential area.**



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ปริมาณโลหะหนักในน้ำ

ปริมาณแคดเมียม ตะกั่ว และโครเมียม อยู่ในระดับที่ต่ำมากในทุกสถานที่สำรวจและทุกฤดูกาล

ปริมาณของสังกะสี และทองแดง จะมีค่าค่อนข้างสูงในช่วงฤดูหนาว (ธันวาคม 2544)

สถานีบริเวณแหล่งชุมชน เช่น S3 ว่าการอำเภอเชิงคัน S8 (ท่าน้ำอำเภอธาตุพนม) และ S10 (สถานีตำรวจ อำเภอโขงเจียม) จะมีปริมาณปรอทสูงกว่าบริเวณอื่นๆ ยกเว้นบริเวณสามเหลี่ยมทองคำก็จะมีปริมาณปรอทสูงมากเช่นกัน แต่อย่างไรก็ตามค่าสูงสุดนั้นยังต่ำกว่ามาตรฐานคุณภาพน้ำในแหล่งน้ำผิวดินของกรมควบคุมมลพิษ (ไม่เกิน 2 ppb)

ปริมาณสังกะสีนั้นค่อนข้างสูงในบริเวณแหล่งชุมชนเช่นเดียวกับปรอท แต่ค่าสูงสุดนั้นก็ยังต่ำกว่าค่ามาตรฐานคุณภาพน้ำในแหล่งน้ำผิวดินของกรมควบคุมมลพิษเช่นกัน (ไม่เกิน 1000 ppb)

ปริมาณทองแดงจะสูงมากบริเวณสามเหลี่ยมทองคำ นอกนั้นจะมีค่าใกล้เคียงกันตลอดทั้งลำน้ำ อย่างไรก็ตาม ค่าสูงสุดนั้นก็ยังต่ำกว่าค่ามาตรฐานคุณภาพน้ำในแหล่งน้ำผิวดินของกรมควบคุมมลพิษเช่นกัน (ไม่เกิน 100 ppb)



โดยภาพรวมพบว่าปริมาณค่อนข้างสูงทุกชนิด โดยปริมาณของโลหะหนักทุกชนิดยกเว้นปรอท จะมีปริมาณสูงสุด ในฤดูฝน (สิงหาคม 2545) โดยปรอทจะมีปริมาณสูงสุดในฤดูหนาว (ธันวาคม 2544)

ที่สถานีสามเหลี่ยมทองคำ จะพบว่าปริมาณแคดเมียม ตะกั่ว และสังกะสีสูงมาก เมื่อเทียบกับสถานีอื่น ๆ
ปริมาณแคดเมียม ตะกั่ว และปรอท ค่อนข้างจะมีความแปรปรวนตามฤดูกาลค่อนข้างมาก ในการสำรวจในแต่ละสถานี โดยที่ปริมาณสังกะสีจะมีความแปรปรวนต่ำที่สุด
โดยภาพรวม โลหะหนักจะพบมากในดินตะกอนในบริเวณที่เป็นแหล่งชุมชนโดยเฉพาะ

ปริมาณโลหะหนักในดินตะกอนในช่วงฤดูหนาว (ธันวาคม 2544) พบว่ามี

โครเมียม	ปนเปื้อนมากที่สุดเท่ากับ	212.8	mg/kg	บริเวณ	วัดโจงเจียมปุราวาส
สังกะสี	ปนเปื้อนมากที่สุดเท่ากับ	164.4	mg/kg	บริเวณ	สามเหลี่ยมทองคำ
แคดเมียม	ปนเปื้อนมากที่สุดเท่ากับ	31.1	mg/kg	บริเวณ	อำเภอโขงเจียม
ตะกั่ว	ปนเปื้อนมากที่สุดเท่ากับ	48.2	mg/kg	บริเวณ	อำเภอเวียงแก่น
ปรอท	ปนเปื้อนมากที่สุดเท่ากับ	421.8	mg/kg	บริเวณ	อำเภอโพนพิสัย
ทองแดง	ปนเปื้อนมากที่สุดเท่ากับ	164.4	mg/kg	บริเวณ	อำเภอโขงเจียม

ปริมาณโลหะหนักในดินตะกอนในช่วงฤดูร้อน (พฤษภาคม) พบว่ามี

โครเมียม	ปนเปื้อนมากที่สุดเท่ากับ	189.5	mg/kg	บริเวณ	วัดโจงเจียมปุราวาส
สังกะสี	ปนเปื้อนมากที่สุดเท่ากับ	116.1	mg/kg	บริเวณ	อำเภอโขงเจียม
แคดเมียม	ปนเปื้อนมากที่สุดเท่ากับ	38.7	mg/kg	บริเวณ	อำเภอเชียงคาน
ตะกั่ว	ปนเปื้อนมากที่สุดเท่ากับ	65.2	mg/kg	บริเวณ	อำเภอโขงเจียม
ปรอท	ปนเปื้อนมากที่สุดเท่ากับ	173.2	mg/kg	บริเวณ	อำเภอเชียงคาน
ทองแดง	ปนเปื้อนมากที่สุดเท่ากับ	29.6	mg/kg	บริเวณ	อำเภอโขงเจียม

ปริมาณโลหะหนักในดินตะกอนในช่วงฤดูฝน (สิงหาคม) พบว่ามี

โครเมียม	ปนเปื้อนมากที่สุดเท่ากับ	122.4	mg/kg	บริเวณ	อำเภอโพนพิสัย
สังกะสี	ปนเปื้อนมากที่สุดเท่ากับ	117.1	mg/kg	บริเวณ	อำเภอโพนพิสัย
แคดเมียม	ปนเปื้อนมากที่สุดเท่ากับ	45.5	mg/kg	บริเวณ	วัดอาสง อำเภอบึงกาฬ
ตะกั่ว	ปนเปื้อนมากที่สุดเท่ากับ	67.5	mg/kg	บริเวณ	วัดโจงเจียมปุราวาส
ปรอท	ปนเปื้อนมากที่สุดเท่ากับ	87.4	mg/kg	บริเวณ	วัดอาสง อำเภอบึงกาฬ
ทองแดง	ปนเปื้อนมากที่สุดเท่ากับ	28.6	mg/kg	บริเวณ	อำเภอเมือง จ.หนองคาย



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