



Qualitative and Quantitative Studies of Some Polycyclic Aromatic Hydrocarbons (PAHs) and Limnology of Euphrates river from Al-Hindiya Barrage to Al-Kifil City – Iraq

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دراسات نوعية وكمية لبعض المركبات الهيدروكاربونية الأروماتية متعددة الحلقات (PAHs) ولمنولوجية نهر الفرات من سدة الهندية إلى مدينة الكفل - العراق

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الخلاصة

أجريت الدراسة الحالية على نهر الفرات ابتداء من سد الهندية إلى مدينة الكفل (حوالي 292 كم) وبواقع خمس محطات موزعة على طول النهر للفترة من تموز 2005 ولغاية حزيران 2006. جمعت النماذج السطحية للمياه لدراسة مختلف الخواص الفيزيائية والكيميائية إضافة إلى دراسة نوعية وكمية الهائمات النباتية. كما تضمنت الدراسة قياس تركيز وتوزيع بعض المركبات الأورماتية الحلقية ومعرفة أصل هذه المركبات في نماذج المياه تحت السطحية و في الرواسب وفي نوعين من محارات المياه العذبة هما (*Pseudontopsis euphraticus* (الشمبلان (*Ceratopgyllum demersum* L. والبردي (*Typha domingensis* Pers). أظهرت النتائج بان درجة حرارة الهواء و الماء تراوحت بين (13-39 م) و(15-35 م) على التوالي. وتراوحت معدل جريان الماء في النهر بين 4 Cm/sec و 133.3 Cm/sec خلال الشتاء والربيع على التوالي .

أظهرت قيم كل من الـ pH والتوصيلة الكهربائية والملوحة تذبذباً بين (6.66 - 8.6) و(423.66 - 998.66 مايكروسيمنز/ثانية) و (0.26%- 0.62%) على التوالي. كانت مستويات الأوكسجين الذائب بين (5.1 - 13.33 ملغم/لتر) بينما سجلت قيم المتطلب الحيوي للأوكسجين قيماً تتراوح بين (1.43 - 7.13 ملغم /لتر) أظهرت الدراسة الحالية ان مياه النهر قاعدية وعسرة جداً حيث تراوحت قيم كلا من القاعدية والعسرة الكلية والكالسيوم والمغنيسيوم بين (74.6 - 175.33 ملغم /لتر) و(292.98 - 693.3 ملغم /لتر) و(149.63 - 55.3 ملغم /لتر) و(119.48 - 25.37 ملغم /لتر) على التوالي. وسجلت في الدراسة الحالية لكل من المواد الصلبة العالقة والمواد الصلبة الذائبة والكبريتات والكلورايد والفسفور الكلي والنيتروجين الكلي ونسبة النيتروجين الكلي/الفسفور الكلي قيماً تراوحت بين (11.4 - 204.5 ملغم/لتر) و(170.6 - 5885 ملغم/لتر) و(68.88 - 682 ملغم /لتر) و(54.65 - 145.95 ملغم/لتر) و(0.001 - 0.06 ملغم /لتر) و(0.02 - 1.32 ملغم/لتر) و(1.15 - 332.6 ملغم/لتر) على التوالي.

تم تشخيص 142 وحدة تصنيفية للطحالب في الدراسة الحالية ومعظمها تعود الى صنف الداتيومات (94 وحدة تصنيفية) والطحالب الخضراء (25 وحدة تصنيفية) ثم الطحالب الخضراء المزرقية (20 وحدة تصنيفية) وثلاث وحدات تصنيفية للطحالب الخضراء الذهبية ووحدتان تصنيفيتان للطحالب اليوغينية ووحدة تصنيفية للطحالب الخضراء المصفرة.

سجلت أعلى عدد من الوحدات التصنيفية في كل من المحطة رقم 2، 4 (109 وحدة تصنيفية)، ثم المحطة 5، 3 (91 وحدة تصنيفية) والمحطة 1 (88 وحدة تصنيفية) كانت الأجناس الشائعة في كل المحطات هي :- و *Cyclotella* و *Chlorella* و *Chlamydomonas* و *Cocconies* و *Euglena*.

أظهرت الدراسة الكلية إلى تذبذب قيم أعداد الهائمات النباتية بين (310 x 3492) خلية /لتر سجلت في المحطة 4 خلال تشرين الثاني 2005 و(310 x 207) خلية /لتر في المحطة 5 تم تقدير ستة عشر مركباً من مركبات الـ (PAH) المدرجة ضمن قائمة الملوثات الأولية من قبل وكالة حماية البيئة (USEPA) وهي Naphthalene و Ace naphthalene و Anthracene و Acenaphthlene و Fluorene و Phenanthrene و Flourantlene و Benzo(b) Flourantlene و chrysene و Benzo (a)Anthracene و Pyrene و Benzo (k) Flourantlene و Benzo (a) pryrene و Dibenzo(ah) Anthracene و Benzo (ghi)perylene و (Indeno (1,2,3 -cd) pyrene).

سجل في الماء اقل تركيز (0.06 مايكرو غرام/لتر) للمركب (Benzo(a)Anthracene) بينما سجل اعلي تركيز (1.19 مايكرو غرام/لتر) للمركب

Benzo (a) pyrene. اما في الرواسب فقد سجل اقل تركيز (2.18 نانو غرام / غرام وزن جاف) للمركب (Naphthalene) بينما أعلى تركيز (36.55 نانو غرام / غرام وزن جاف) للمركب (Benzo (a) pyrene). كانت تراكيز معظم مركبات الـ (PAH) في الماء والرواسب معنوية بين المحطات والفصول ($P < 0.01$).

سجلت الـ Naphthalene اقل قيمة من بين مركبات الـ PAH في المحار (*Unio tigris*) وكان تركيزه (0.05 نانو غرام/ غرام وزن جاف) بينما أعلى القيم كان للمركب Benzo(ghi) perylene وبلغ تركيزه (325.5 نانو غرام/ غرام وزن جاف) في المحار (*Pseudodontopsis euphraticus*). اوضحت النتائج أن اقل قيمة (0.3 نانو غرام/ غرام وزن جاف) كان للمركب Naphthalene في نبات الشمبلان (*Ceratophyllum demersum*) بينما أعلى القيم (225.5 نانو غرام/ غرام وزن جاف) كان للمركب Dibenzo(a,h) Anthracene في نبات البردي (*Typha domingensis*)
تم دراسة النمط التركيبي لمركبات الـ PAH في كل من الماء والرواسب والأحياء المائية حيث سجلت أدنى وأعلى قيمة (0.3 – 2.75 مايكرو غرام / لتر) و (2.19 – 56.92 نانو غرام/ غرام وزن جاف) لمركب الـ PAH ثنائي الحلقة وخماسي الحلقة في نماذج الماء والرواسب على التوالي.

تشير النتائج إلى أن معدل القيم لمركبات الـ (PAHs) الكلية (6.45 مايكرو غرام/لتر) و (167 نانو غرام/ غرام وزن جاف) سجلت لنماذج الماء والرواسب على التوالي، كما تمثل مركبات الـ (LMW-PAHs) و (HMW- PAHs) بحوالي (19.94% - 83.06%) و (13.78% - 86.22%) من المجموع الكلي لمركبات الـ (PAH) في الماء والرواسب على المركبات الـ (PAH) 6.45 مايكرو غرام / لتر و 167 نانو غرام / غرام وزن جاف) سجلت لنماذج الماء والرواسب على التوالي .

تراوحت نسب الكربون العضوي الكلي (% TOC) بين (0.64% - 1.6%) في المحطة 1 خلال الربيع والمحطة 4 خلال الخريف وبمعدل سنوي (0.99%) . سجلت علاقة معنوية موجبة بين %TOC والتركيز الكلي لمركبات الـ PAHs في الراسب ($R = 0.739$) ($P < 0.01$).

بلغت اقل قيمة (0.05 نانو غرام / غرام وزن جاف) للمركب ثنائي الحلقة في المحار (*Unio tigris*) بينما أعلى قيمة كانت (427.28 نانو غرام / غرام وزن جاف) للمركب الخماسي الحلقة في المحار (*Pseudodontopsis euphraticus*) . تم تقدير كمية الدهن في المحار وكانت القيم تتراوح بين (0.8 – 1.5 ملغم / غرام وزن جاف) خلال الصيف والشتاء في المحار (*unio tigris*) والمحار (*Pseudodontopsis euphraticus*) على التوالي وسجل ارتباط معنوي موجب بين كمية الدهن والتركيز الكلي للـ (PAH) في المحار .

تشير النتائج إلى أن تركيز المركب ثنائي الحلقة (0.33 نانو غرام/ غرام وزن جاف) سجل في النبات (*Ceratophyllum demersum*) بينما (388.93 نانو غرام/ غرام وزن جاف) سجل للمركب خماسي الحلقة في النبات (*Typha domingensis*) . أظهرت نتائج التحليل الإحصائي عدم وجود فروقات معنوية في تركيز مركبات الـ (PAH) بين نوعين المحار والنباتات بينما أظهرت فروقات واضحة بين الفصول باستثناء مركب الـ Naphthalene.

اعتمادا على نتائج النسب (Phen/ Ant) و (Flur/py) و (Bap/ Bghip) و (LMW- PAH) فان توزيع مركبات الـ (PAHs) في الماء والرواسب والأحياء المائية يأتي من أصل مصادر مختلفة (نفطي و حراري و هواء المدن) كما تم دراسة الإمكانية التراكمية لمركبات الـ (PAHs) من قبل الأحياء المائية من خلال حساب عامل التركيز الحياتي (BCF) وعامل الترسيب الحياتي التراكمي (BSAF)

كانت القيم المسجلة لعامل التركيز الحياتي BCF بين (0.12 – 1784) و (– 1000
12.88) بينما بلغت قيم عامل الترسيب الحياتي التراكمي (BSAF) (0.12 – 320) و
(8.51 – 152.3) في المحار (*Unio tigridis*) والمحار (*Pseudodontopsis*
euphraticus) على التوالي . أما في النباتات المدروسة فقد تراوحت بين (0.78 – 369.67
(21.34 – 1022) لقيم التركيز الحياتي (BCF) والقيم (0.07 – 10.56) و (– 10.54
0.33) لقيم الترسيب الحياتي التراكمي (BSAF) في النبات (*Ceratophyllum demersum*)
(والبردي (*Typha domingensis*) على التوالي .

Summary

The present study was conducted on the Euphrates river about 292km starting from Al-Hindiya barrage to Al-Kifil city in five selected sites distributed along the river during Jul.2005 to Jun.2006.

Surface water samples were collected to study different physico-chemical properties in addition to qualitative and quantitative study of phytoplankton. The study was also included measure the concentration and distribution of some Polycyclic Aromatic Hydrocarbons (PAHs) and predict their sources in the samples of subsurface water, sediments, two species of fresh water clams(*Unio tigridis* Muller 77 and *Pseudodontopsis euphraticus* Bourguigant 1852) and two species of aquatic plant (*Ceratophyllum demersum* L. and *Typha domingensis* Pers).

The results showed that air and water temperature were ranged between(13-39 C°) and (15-35 C°) respectively .The values of (4cm/sec and 133.3cm/sec) were recorded for water flow during winter and spring respectively .The values of pH, Electrical conductivity and salinity were fluctuated between(6.66-8.6), (423.66-998.66µs/cm) and (0.26‰-0.62‰) respectively.The levels of Dissolved Oxygen were between(5.1-13.33mg/L), while the Biological Oxygen Demand BOD₅ were ranged between(1.43mg/l-7.13mg/l).The results showed that the water of the river was alkaline in nature and very hard.

The levels of (74.7-175.33mg CaCO₃/l.), (292.98 - 693.3 mg CaCO₃/l), (55.3–149.63 mg CaCO₃/l) and (25.37–119.48mgCaCO₃/l) were recorded for total alkalinity, total hardness, calcium and magnesium ions respectively.

The results reffered to the values between (11.4 -204.5mg/l), (170.6-5885mg/l),(68.88-682mg/l), (54.65mg/145.95mg/l), (0.001-0.06mg/l), (0.02-1.32mg/l) and (1.15-332.6) for Total Suspended Solids, total dissolved Soilds, sulphate, chloride, total phosphorous, total nitrogen and TN/TP respectively.

The 145 Taxa of algae were identified in the present study and most of them belong to the classes Bacillaryophyceae (94 taxa), Chlorophyceae(25 taxa), Cyanophyceae(20 taxa), Chrysophyceae (3taxa), Euglenophyceae(2 taxa) and 1 taxa for Xanthophtceae. The high number of taxa was recorded at site 2, 4 (109 taxa) followed by site 3, 5 (91 taxa) and 88 taxa at site 1.

The community genera at all sites were *Oscillatoria*, *Chlamydomonas* , *Chlorella*, *Cyclotella ocellata*, *Cocconies placentula*, *Euglena* and *Phacus*. The qualitative study showed the fluctuation in the number of phytoplankton between(3492×10³cell/l)at site 4 during Nov. and (207×10³ cell/l)recorded at site 5 during Jun.

The sixteen Polycyclic Aromatic Hydro Carbon (PAHs) listed by USEPA as priority pollutants (Naphthalene, Acenaphthalene, Acenaphthene & Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a)Anthracene, Chrycene, Benzo(b) Fluoranthene, Benzo(k) Fluoranthene, Benzo(a) Pyrene, Dibenzo(a,h) Anthracene, Benzo(ghi) Perylene and Indeno (1,2,3-cd) Pyrene) were detected.

In water samples, the lowest value of (0.06µg/l) was recorded for Benzo(a) Anthracene, while the highest value of (1.19µg/l) for Benzo(a) Pyrene. In the sediment samples, the lowest concentration of (2.18ng/gDW) was recorded for Naphthalene, while the highest concentration of (36.55ng/gDW) for Benzo(a) Pyrene. The concentrations of most PAHs recorded in water and sediments were significant among sites and season ($P < 0.01$).

The lowest value among PAHs was 0.05ng/gDW for Naphthalene in clam *U. tigridis*, while the highest value of 325ng/gDW was for Benzo(ghi) Perylene in clam *P. euphraticus*. In plant species, the lowest value among PAHs was 0.33ng/gDW recorded for Naphthalene in *C. demersum* and the highest value of 225.5ng/g DW was for Dibenzo(a,h)Anthracene in *T. domingensis*. The results of statistical analysis referred to non significant differences in the concentration of PAHs in both species of clams and aquatic plants, while significant differences were recorded among seasons with the exception of Naphthalene.

The composition pattern of PAHs in water, sediment and aquatic organisms were determined. The lowest and the highest value of (0.31, 2.75µg/l) and (2.19 and 56.92ng/gDW) were recorded for 2 and 5 ring-PAHs in water and sediments respectively.

The results referred to the mean values of total PAHs were (6.45µg/l and 167ng/gDW) recorded for water and sediment respectively. The LMW-PAHs and HMW-PAHs represent (16.94%, 83.06%) and (13.78% and 86.22%) of the total PAHs in water and sediment respectively. The concentration of TOC% were between 0.64%-1.6% recorded at site 1 during spring and site 4 during autumn with mean value of 0.99%. Positive correlation was recorded for TOC% with total PAHs in the sediment ($r = 0.739$, $P < 0.01$).

The lowest value of (0.05ng/gDw) was recorded for 2 ring-PAHs in *U. tigridis*, While the highest value of (427.28ng/gDW) for 5 ring-PAHs in *P. euphraticus*. The fat content of clams was determined and the values were between (0.8-1.5 ng/gDW) recorded during summer and autumn in *U. tigridis* and *P. euphraticus* respectively. In plant *C. demersum*, the concentration of 0.33ng/g Dw was obtained for 2 ring-PAHs, while the value of (388.93ng/gDW) was recorded for 5 ring-PAHs in *T. domingensis*.

The concentrations of PAHs in both species of clams and plants were significant among seasons with exception of Naphthalene.

According to the values of the ratios (Phen./Ant, Flur/Py, BaP/BghiP and LMW-PAHs/HMW-PAHs), the distribution of PAHs in water, sediment and aquatic organisms may have the origin from different sources (Pyrogenic, Petrogenic and urban air). The accumulation potential of PAHs in aquatic organisms were also investigated by calculating Bioconcentration Factor (BCF) and Biosediment Accumulation Factor (BSAF). The values between (0.12-1784) and (12.88-1000) were recorded for BCF, while the values of (0.12-320) and (8.51-152.3) were for BSAF in *Unio tigridis* and *Pseudodontopsis euphraticus*. The values of BCF were (0.78-369.67) and (21.34-1022), while the values of (0.07-10.56) and (0.33-10.54) were for BSAF in *C. demersum* and *T. domingensis* respectively.

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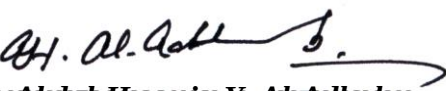
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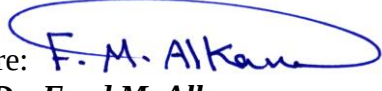
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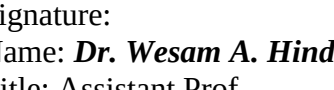
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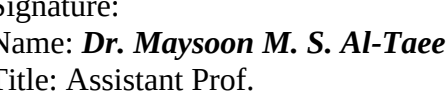
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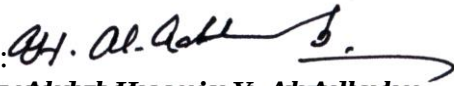
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Chapter One

Introduction & Literature Review

1-1: Introduction

Water is an essential resource that cycles through various reservoirs within and among ecosystems. It plays a key role in the over all functionings of the environment (Morgan *et al.*, 1993). Thus any effect upon resource due to addition of some materials and can be harmful to living organisms referred to as pollution (Weiner, 2000).

Water receives and dissolves numerous man-made chemicals, among their sources are industrial waste, domestic sewage, deposition from atmosphere and runoff from land (Crosby, 1998). Thus several types of pollutants enter the water cycle at any point and find their way in to all parts of the system. Among these are pathogens, nutrients, oxygen demanding waste, toxic chemicals, oil spills and heat (Morgan *et al.*, 1993; Kifferstien and Krantz, 2002).

There is a concern about the presence of Polycyclic Aromatic Hydrocarbons (PAHs) in the Environment especially Benzo(a)Pyrene (BaP) because of its carcinogenicity, teratogenicity, mutagenicity and toxicity. PAHs are commonly found in the environment since they are formed as a result of incomplete combustion of almost any organic material (Juhasz, 2000). Because there is few or no data available for PAHs compounds in Euphrates river which usually act as receiver for sewage, industrial effluents and urban and agriculture runoff, it is quite essential to obtain data base for these compounds .

The principal aims of the present work is to assess the water quality of Euphrates river before Al-Hindiya barrage to Al-Kifil city through:

- 1- The study of some physico-chemical properties of water as temperature, water flow, water pH, electrical conductivity, dissolved

oxygen, Biological oxygen Demand, total alkalinity, total hardness, calcium, magnesium, chloride ion, sulphate ion, total nitrogen and total phosphorous .

- 2- The qualitative and quantitative study of phytoplankton population .
- 3- The study of the seasonal variation in the concentration of sixteen PAHs compounds listed by USEPA as priority pollutants through :
 - A-The qualitative and quantitative determination of PAHs in water .
 - B- The qualitative and quantitative determination of PAHs in sediment
 - C- The qualitative and quantitative determination of PAHs in two species of fresh water clams (*Unio tigridis* and *Pseudodontopsis euphraticus*) and two species of aquatic plants(*Ceratophyllum demersum* and *Typha domingensis*).
 - D- The study of the seasonal variation in Total Organic Carbon(TOC%) and its relation to PAHs concentration in sediment .
 - E- The study of the sediment grain size distribution and its relation to PAHs concentration in sediment .
 - F- Determination the lipid content in tissues of both clam species and relation to PAHs level in sediment.
 - G- Determination the possible sources of PAHs in water, sediment and aquatic organisms.

1-2:Literature Review

1-2-1: Water pollution

The increase of population will lead to the development of more agriculture, Urbanization and industrialization, therefore more loading of pollutants from both runoff and atmospheric fall out (Gale and MacCarthy, 1999; Voe *et al.*, 2004) .The loss of any of the actual or potential beneficial uses of water due to human activity may be referred to as water pollution (Water Technology, 2006). It is a serious problem that is the leading worldwide cause of disease and death and it accounts for death of more than 14000 people daily(Larry, 2006).

The most toxic pollutants present in the aquatic system are Polycyclic Aromatic Hydrocarbons(PAHs), Heavy metals and Organochlorine that have detrimental effect on water quality and can be harmful to living organisms and aquatic life .These are considered to be Xenobiotic models for monitoring because of their ubiquity in the environment, their persistent, bioaccumulative properties and their potential toxicity (Riberio Oliveria *et al.*, 2005; Water technology, 2006).

1-2-2: Physico-chemical properties of water

The permanent changes to the physical or chemical properties of river will occur if it erodes through different geological strata, or even in response to climate changes .Human activities too are often have permanent effects upon river system(Dobson and Frid, 1998).

Temperature is a fundamental physical factor that affects the distribution of organisms in the habitat. So any change in water temperature causes the change in species composition, metabolic rate and increase the solubility of most toxic substances (Hodges, 1989; Al–Saad *et al.*, 2003). Temperature is an important factor that influences the behavior of pollutants through evaporation at high temperature(Weiner, 2000).

The water flow is the volume of water passing through the cross-section area of stream or river per unit time(Wetzell, 2001). It determines the degree and type of deposition and thus the nature of sediment (Wetzell and Likens, 2000) .Water flow is an important force that moves the pollutants into region far from their origin(Weiner, 2000).

Electrical conductivity(EC) is a good indicator of productivity and referred to dissolved salts as NaCl and NaHCO₃(Bartram and Ballance, 1996; APHA, 1999). Due to the sensitivity to temperature, EC-Meter must be temperature corrected if samples are to be measured at varying temperature (Smith, 2004).

Weiner (2000) referred that pH values of water affect the organisms that live there and most of them have adapted to a specific pH and may die if even slight pH changes occur.The solubility and ionic form of many substances and biological availability of essential nutrients as iron and phosphorous depend strongly on pH values(Smith, 2004).

Alkalinity is a measure of the pH-buffering capacity of water due to mainly to carbonic acid system in natural water as CO₂, H₂CO₃, HCO₃⁻ and CO₃⁼ (Smith, 2004). Because CO₂ is relatively abundant in water and carbonate are common, most fresh water contain bicarbonate alkalinity. Carbonate may be present when pH is high(Wetzell, 2001),so alkalinity and pH in fresh water seem to be correlated with each other(Kelly *et al.*, 1982).

Dissolved oxygen(DO) is one of the most important chemical variables in aquatic system .It is a major determinant of aquatic environment and thereby controls the solubility and toxicity of many substances(Smith, 2004).DO affects the capacity of water to receive organic matter without causing nuisance(Wetzell, 2001).

Hardness in water is due to the presence of as calcium and magnesium ions as well as ferrus and strenium (Batram & Ballance, 1996).It can be

computed from known concentration of calcium and magnesium (Wetzel, 2001). The major cations calcium, magnesium in addition to sodium and potassium are required in very low quantities, but their concentration in fresh water can influence the osmoregulation of organisms (Wetzel and Likens, 2000). The presence of calcium ion decreases the buffer capacity of water due to solubility of CO₂ in water, while magnesium ions tend to precipitate so present in low concentration in water as compared to calcium (Allen *et al.*, 2000).

Total suspended solid (TSS) referred to suspended material that does not pass through a filter (APHA, 1999). TSS may be living organisms, non-living organic matter or inorganic materials and may contribute to turbidity in many surface waters thus affect organisms that live in it in many ways (Smith, 2004).

Positive correlation occurs between Total Dissolved Solid (TDS) and salinity which referred to dissolved salts in water (Wetzel, 2001).

Sulfate is abundant, so it does not limit the growth of aquatic organisms and require in relatively low concentration in relation to availability in fresh water (Wetzel and Likens, 2000). The variation in its level in water depends on rainfalls, industrial and break down of sulphur containing organic matter (Batram and Ballance, 1996).

Since the availability of nitrogen and phosphorous may be less than the biological demand, environmental sources can regulate or limit the productivity of organisms in fresh water ecosystems (Wetzel and Likens, 2000). Phosphorous exists in natural water in essentially one chemical form, orthophosphate PO_4^- . It is considered to be the common phytoplankton growth limiting nutrient (Goldman and Horne, 1983). The soluble orthophosphate may be assimilated rapidly by the biota, therefore the concentration of orthophosphate at any given time is usually very low (Wetzel and Likens, 2000).

Nitrogen is an essential plant nutrient. Unlike phosphorous, nitrogen can occur in such concentration and forms which may be a water quality problem due to its toxicity, while the oxidation of certain forms of inorganic nitrogen is a significant component of Biological Oxygen Demand of some effluents and pollution water (Smith, 2004). Nitrate is an end product of aerobic decomposition of organic nitrogen matter (Bartram & Ballance, 1996). It is an important nutrient for plant, but toxic to fish and human at high concentration due to its mobility in the environment and do not adsorb to mineral & soil surface (Weiner, 2000).

In Kurdistan region of Iraq, numerous limnological studies were recently (Al-Barzigy, 1994; Rasheed, 1994; Ganjo, 1997; Ganjo and Aziz, 1997 and Muhammad, 2004).

Rasheed (1994) investigated various limnological variables on some water systems in Arbil Province. Limnological study on Ruwandiz river path within Arbil province were performed (Ganjo, 1997).

Limnology and phytoplankton ecology of Korre and Shaqlawa water courses were investigated for assessing nutrient status and phytoplankton distribution (Ganjo and Aziz, 2002). Sarchnar spring, Chaq-Chaq and Kliassan stream was studied for the definition of different limnological variables and assessment of aquatic life ecology (Muhammad, 2004).

Aquatic ecosystems in the south of Iraq were also studied widely. Limnological study was investigated on Tigris river between Mosul and Kut. The results referred that river water was fresh ($S_{\text{‰}} = 0.34$), very hard ($283 \text{ mg CaCO}_3/\text{l.}$), moderately alkaline water with dominant of sulphate and calcium ions. The density of phytoplankton was less than that of Euphrates river (Al-Lami *et al.*, 1999).

Ecological effect of Thar-Thar arm on water quality of Tigris river was studied. The high concentration of conductivity, Salinity and dissolved ions of the arm water influence the down stream river sites (Al-Lami *et al.*,

2001). In the other study on Tigris river before and after Baghdad, it was found that alkalinity is bicarbonate with the dominance of sulphate (Al-Lami, 2002).

Limnological characters of three lotic water system (Diyala river, Kalis and Saria Streams) nearby middle of Iraq were studied. The results referred to higher values of total alkalinity, hardness, calcium, magnesium chloride, sulphate, TDS and TSS were recorded in Diyala river as comparison with two other streams(Al-Saadi *etal.*, 2001).

The four lotic aquatic systems(Thar-Thar arm, Saddam, Euphrates and Tigris rivers), in the middle of Iraq were studied. The results referred to high levels of turbidity, salinity and hardness recorded in Saddam river, lowest values of E.C. and salinity which was measured in Tigris river, while higher levels of Dissolved Oxygen recorded in Thar-Thar arm(Al-Lami *etal.*, 2002).Different limnological characters of Shatt Al-Hilla river were studied. The results referred to high levels of alkalinity, hardness, calcium , magnesium, nitrate, nitrite and silica ions that influence seasonal variation of phytoplankton(Hassan and Al-Saadi, 1995). In the study of (Hassan, 1997) on the same river, it was found that the water was alkaline, oligohaline (0.5-1.16‰) and hard water with dominance of diatoms in comparison with other algae .

Some rivers and streams in Al-Qadisiya province were studied for definition of some physical and chemical properties of water .The results referred to fluctuated levels of turbidity, alkalinity, E.C., total hardness, calcium, magnesium, nitrate and phosphate(Habib *etal.*, 2002).

Physico-Chemical properties of Diwania river were studied.The results referred to high levels of total Hardness with allowable values of calcium, magnesium, sulphate and chloride(Alkam, 2002).Limnological properties of Diwania river after dryness period and low water level of Euphrates river

were studied .The results showed alkaline and hard water with fluctuation values recorded in different stations(Hassan, 2004).

The effect of industrial waste water discharged to Euphrates river in samawa city was assessed. The results referred to high levels of TSS,TDS,Total Hardness, total phosphate, nitrate and nitrite.However the river is not polluted according to BOD values recorded(Mashkur, 2002).Organic pollution was determined in Euphrates river/Al-Kufa city through the measuring of BOD. High level of BOD were recorded in the city center with low concentration in the station far from the city (Hassan and Hassan, 2004).

Euphrates river between Al-Hindiya barrage and Al-Kifil city was investigated .The results referred to alkaline, very hard and high values of Sulphate, also phytoplankton distribution was determined(Al-Fatlawi, 2005).In another study, the Euphrates river between Al-Hindiya barrage and Al-Kufa city was studied to investigate physico-chemical properties as well as distribution of heavy metals in water, sediment and some aquatic organisms (Salman, 2006).

1-3:Polycyclic Aromatic Hydrocarbons(PAHs)

1-3-1: Introduction to PAH s

The term "polycyclic aromatic hydrocarbons"(PAHs) commonly referred to a large class of organic compounds found through out the environment. Chemically, they consist of two or more fused aromatic rings made up of carbon and hydrogen atoms and are some time called polynucleic aromatic PNA (EHC, 1998; Sanders *et al.*, 2002; Booker, 2004).

PAHs concentration in the environment are often closely related to local and regional sources, although remote areas can be sites of PAH deposition through atmospheric processes and long range transport (Verrhiest *et al.*, 2001; Rhea *et al.*, 2005).PAHs are a group of over 100 different chemicals

that are formed during the incomplete combustion of organic substances as coal, oil and gas, wood, garbage. These may be found as a mixture containing two or more of these compounds and seem to be synergistic(ATSDR, 1996; Verrhiest *et al.*, 2001).

Considering their mutagenic, carcinogenic and teratogenic properties and their potential hazard to human health and natural life, they have attracted a good deal of attention (Al-Hamdi, 1989; Zaid and Imam, 1999; Basheer *et al.*, 2004). In the late 1800, PAHs become the first compounds known to be associated with cancer when occupational skin cancer was first documented in London chimney sweeps and in the German coal tar workers. Carcinogenic PAHs all fall in the high molecular weight category, having four or more rings. The sixteen PAHs have been listed as priority pollutants and regulated by the United State Environmental Protection Agency-USEPA(Prest, 2002; Akaishy *et al.*, 2004; Sarrazin, 2006). The PAHs compounds are generally generated by natural and anthropogenic processes and can be find their way into aquatic environment through various routes (Sanders *et al.*, 2002).

Anthropogenic input from incomplete combustion, oil spills, urban runoff, domestic and industrial waste water discharges. Moreover atmospheric fallout of vehicle exhaust and industrial stack emission have caused significant accumulation in environment(Zakaria *et al.*, 1996; EHC, 1998; El-Nemr and Abd-Allah, 2003; Doong and Lin, 2004; Zhu *et al.*, 2004).

The higher concentration of PAHs in the aquatic environment related to industrial activity and traffic density of the city close to these sources (Sanders *et al.*, 2002; Ogunfowokan *et al.*, 2003).

The relative contribution of urban runoff to receiving waters is site-specific, depending on the relative magnitudes of wet and dry weather discharges (Walker *et al.*, 1999). Table(1) shows some properties of sixteen PAHs (From EHC, 1998; Prest, 2002).

1-3-2:The source and origin of PAHs in the aquatic environment

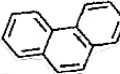
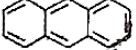
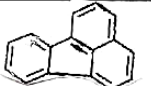
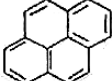
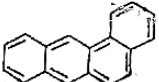
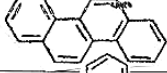
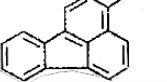
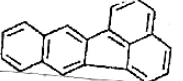
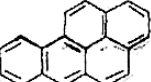
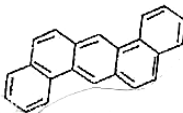
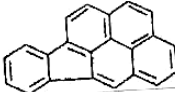
Polycyclic aromatic hydrocarbons are wide spread ubiquitous cotaminants in the environment (Doong and Lin, 2004). Water pollution by PAHs is believed to be associated with direct discharges from industrial processes ,municipal effluents and domestic sewage (point sources pollution). However, the impact of agriculture chemical, soil erosion and urban surface runoff (non-point or diffuse sources)should not be overlooked (Mai *et al.*, 2001; Zhu *et al.*, 2004). In order to investigate the non-point sources and origin of PAH, it is quite essential to determine PAHs concentration in atmosphere particles, urban run off, soil and sediment (Zhu *et al.*, 2004).

The sources of PAHs are both anthropogenic and natural in origin and include several source classes, mainly pyrogenic, petrogenic and diagenic (Sanders *et al.*, 2002; Dahle *et al.*, 2003).

PAHs of petrogenic origin are related to petroleum including crude oil and its refined products such as diesel fuel, Fuel oil from urban vehicles traffic (Carras, 1997; Doong and Lin, 2004).

The pyrogenic source of PAHs results from incomplete combustion of fossil fuels and other organic material .The other sources include vehicular and other exhaust emission, Crankcase oil, asphalt, coal tar, creosote (wood preservative), wood heating, cooking stoves and forest fires burning.

Table (1): some properties of sixteen PAHs compounds.

Compound	Abbr	Form.	Structure	Mol Wt.	Vapor pressu.	Log k_{ow}	Genotoxicity	Carcinogenicity
Naphthalene	Nap	$C_{10}H_8$		128	10.4	3.4	-	?
Acenaphthlene	Acpy	$C_{10}H_{12}$		152	8.9×10^{-1}	4.0	?	No studies
Acenaphthene	Acp	$C_{12}H_8$		154	2.9×10^{-1}	3.9	?	?
fluorene	Flu	$C_{13}H_{10}$		166	9.0×10^{-2}	2.4	-	-
Phenanthrene	Phen	$C_{14}H_{10}$		178	1.6×10^{-2}	4.5	?	?
Anthracene	Ant	$C_{14}H_{10}$		178	8×10^{-4}	4.6	+	+
Fluoranthene	Flur	$C_{16}H_{10}$		202	1.2×10^{-3}	5.2	+	+
Pyrene	Py	$C_{16}H_{10}$		202	6.0×10^{-4}	5.2	?	?
Benzo(a) anthracene	BaA	$C_{18}H_{12}$		228	2.8×10^{-5}	5.9	+	+
Chrycene	Chry	$C_{18}H_{12}$		228	8.4×10^{-5}	5.7	+	+
Benzo(b)Fluoranthene	BbF	$C_{20}H_{12}$		252	6.7×10^{-5}	6.2	+	+
Benzo(k)Fluoranthene	BkF	$C_{20}H_{12}$		252	1.3×10^{-8}	6.2	+	+
Benzo(a)Pyrene	BbP	$C_{20}H_{12}$		252	7.3×10^{-7}	6.0	+	+
Dibenzo(a,h)anthracene	DbA	$C_{22}H_{14}$		278	1.3×10^{-8}	6.2	+	+
Benzo(ghi)Perylene	BghiP	$C_{22}H_{12}$		276	1.3×10^{-11}	7.0	+	-
Indeno(1,2,3-cd)Pyrene	IND	$C_{22}H_{12}$		276	1.3×10^{-8}	-	+	+

Note: +(positive)carcinogenic, genotoxic; -(negative)non-carcinogenic, non-genotoxic; ?questionable parentheses.

The mixture of PAHs compound produced during these processes depends on the starting source material, temperature of the fuel to the air ratio and generally results in highest percentage of parent PAHs with more four rings (Benner *et al.*, 1990; walker *et al.*, 2002; Stout and Uhler, 2002; Kang *et al.*, 2005).

The nature of PAHs was derived from terrestrial precursors. Pyrene is indicator of non-anthropogenic terrestrial input of carbon (Ribiro Oliveira *et al.*, 2005; Mitra and Bianchi, 2003) had the highest concentration among the individual PAHs measured in the superficial Sediments from Savannah river in the southeastern state of Georgia, USA at station close to forested terrain (Sanders *et al.*, 2002).

The high concentrations of pyrene in kara sea, Russia were found in the area of strong terrigenous influence and the most probable source was decaying peat products being transported to kara sea by both large and small river(Dahle *et al.*, 2003).

The source of PAHs in black river and Ashtabula river, Ohio was studied. The result indicated that traffic(58 %, 5 %), coke oven (26%, 44%) and wood burning coal tar(16%, 5%) are the major PAHs source to black river and Ashtabula river respectively (Christensen and Bzdusek, 2005).

In a study to determine the source and vertical distribution of several PAHs compound in the sediment collected from Khour Al-Zubair/North West Arabian gulf, it was found that the highest concentration of the PAHs was associated with surficial sections of the sediment core which indicates that navigation, oil pollution and burning of fossil fuel could be source of these compounds (Al-Hamdi, 1989).

The abundance of PAHs with four to six ring hydrocarbons in the bottom sediment of Kara sea are generally of pyrogenic origin from fossil fuels and recent organic material combustion, while the dominance of two and three

aromatic hydrocarbons indicate a relatively stronger petrogenic origin (Dahle *et al.*, 2003).

Several PAHs molecular ratios such as methyl phenanthrene/phenanthrene (Mphe/phen), fluoranthene/pyrene, (flur/py), anthracene/chrycene(An/Chry) and Benzo(b)Fluoranthene/Benzo(k)fluoranthene (BbF/BkF) were used to determine the emission sources (wood head and Matthiessen, 1999; yunker *etal.* , 1996 ; Walker *et al.*, 2002).

Petroleum often contains more thermodynamically stable compounds such as naphthalene, fluorathene and pyrene. These are usually the abundant compound of pyrolytic PAHs . So Flur/ py ratio greater than one related to pyrolytic while less than one related to petrogenic (Sirece *et al.*, 1987; Budzinsky *et al.*; 1997).

Methyle phen/phen ratio was used to understand the distribution and source of PAHs in sediments in south east Asia. The results indicated that malaysian urban sediment are heavily impacted by petrogenic PAH(Zakaria *et al.*, 2002).Compounds including phen/Ant, flur/py, Chry/BaA were also used to determine possible PAHs origin (vrana *etal.*, 2001).

The possible source of PAHs contaminants in the surface sediment and water from Gao-ping river/Taiwan was calculated. The results referred to the ratio Chry/BaA was greater than one confirming the petroleum hydrocarbons from the leakage of crude oil and refined products from urbon vehicle traffic (Doong and Lin, 2004).

The origin of PAHs was evaluated in the bösiben creek,Saxony/Germany by three origin indices(flu/py, chry/ BaA, phen/Ant). The result indicated that PAHs were of pyrolytic origin, possibly including contamination by theisen slude, the only products of the smelting process of copper production in the region (vrana *etal.*, 2001).

The phen/Ant ratio can provid useful information for distinguishing PAHs of various origin. Sediments with phe/An > 10 were mainly from

petrogenic origin, while $\text{phen} / \text{Ant} < 10$ were typical of pyrolytic (Soclo *et al.*, 2000 and Yang, 2000) .

The NaP/Phen ratio may be used for detection the presence of fresh water PAHs(Page *etal.*, 1999). In the study to determine the origin of PAHs in surfacial sediment from Savannah river, total PAH and selected individual PAHs ratio were determined. Perylene > 20% Σ PAHs refferd to PAHs in digenic source, Σ NaP > 15% of Σ PAHs indicated petrogenic source, while Phen/Ant < 10 and Flur/py > 1 referred to pyrogenic origin (Sander *et al.*, 2002).

1-3-3:Transport and fate of PAHs in aquatic environment

An important aspect of PAHs behavior is that after entering aquatic environment, they partition between water, sediment and biota(Kayal and Connel , 1995). The spatial distribution of PAHs was sites – specific and the proximity to sources was the most important determining factor for the distribution of these compounds (Doong & Lin, 2004) . Thier transport and fates are determined by some physico-chemical properties as molecular weight, solubility, vapor pressure and octanol / water partition coefficient (EHC, 1998).

Atmosphere is a major transport pathway, where PAHs are present in both vapor and particulate phase. The vapor phase consists of predominantly lower molecular weight of PAHs while higher weight PAHs condence on to very small particulate to form particulate phase(Brookes, 2004)

Golomb *etal.*, 2002 found that higher dry deposition can be attributed to local emission source and greater deposition may be attributed to incorporation of pollutants into precipitating clouds that sweep up emission from regional source as far as hundreds of kilometers away.

Atmospheric PAHs could directly contribute to surface water through deposition and in directly through urban surface run off . The value of PAHs input via runoff into water was lower than PAHs input via atmospheric

deposition suggesting ion of PAHs in the solid and urban surface (Zhu *et al.*, 2004).

The distribution of PAHs in aquatic compartments (sediment, water and organisms) was determined by interaction of processes such as bioconcentration, sorption, dissolution and volatilization (Narbone *et al.*, 1999) .

The following processes determined the fate of PAHs compounds in the aquatic environment :-

1- **Dissolution :**

Because they are hydrophobic, PAHs compounds are slightly soluble in water and their solubility decrease with molecular weight increase. The arrangement of molecules(linear or perifused molecules) affect the solubility of PAHs linear is less soluble than angular arrangement (Neff, 1979; ATSDR, 1996).

2 – **Volatilization:**

Volatilization is the most important route by which PAHs compound dissipate. This was reflected in vapor pressure characteristics that determine the persistence of PAHs in the aquatic environment.Two to three rings PAHs, are very volatile, while four or more rings show in significant volatilization loss under environmental condition (Neff, 1979 ; Cerniglia, 1992).

3-Soprtion

PAHs with few aromatic rings are weakly adsorbed and so could be easily and rapidly desorbed, while PAHs with large number of aromatic rings are strongly adsorbed so microbial degradation was very limited (Amir *et al.*, 2005).PAHs in water column were not only related to water solubility,but also depend on structural and physicochemical properties of PAHs (Narbonne *et al.*, 1999).

4-Photodegradation

PAHs are subjected to various degradation processes which modify their structure and physico-chemical properties. The most important process was the photo-oxidation in the presence of O₂ and UV. solar radiation forming products which may be more toxic than parent PAHs(Monson *et al.*, 1995).

Laboratory and few in situ experiments have demonstrated the photo toxic effects of PAHs to numerous organisms from multiple trophic levels, including algae, invertebrates and vertebrates occupying both water column and sediment(McDonald and Chapman, 2002; Gensemer *et al.*, 1998). Erickson *et al.*, (1999) found that the photo induced toxicity of PAHs was directly influenced by the amount of PAHs and level of U.V. intensity. However, it is found that there is no relation between amount of PAHs and phototoxicity. One explanation may be that, although PAH is more toxic in the presence of UV, the phototoxic response was caused by the presence of other contaminants (Voe *etal.*, 2004).

Factors that influence either exposure to PAHs or exposure to U.V. will influence the impact of photo-induced toxicity on aquatic organisms(Ireland *etal.*, 1996).Also natural environmental factors as turbidity can reduce the amount of U.V. that penetrate water column, attenuating photo induced toxicity(Oris *et al.*, 1990).

It is thought that absorption of U.V. energy by PAHs followed by transfer of energy to molecular O₂ resulted in the generation of free radical of oxygen, which can damage biological membranes(USEPA, 1993; Mekenyan *etal.*, 1994).

The phototoxicity of anthracene to green algae *Selenastrum capricornutum* was assessed using flow cytometry to measure cell size, cellular chlorophyll concentration and cell viability. The results indicated that there was a significant interaction between anthracene and UV-A radiation, which in combination caused significant toxic effect that inhibited

algal growth, also caused significant greater number of non viable cells.(Gala and Giesy, 1994).

The phototoxicity of several PAHs to some fresh water algae was determined. The 7,11-dibenz[e,g]carbazole and benzo(a) pyrene were photo toxic, while 7,12-di methyle benz[a] anthracene, dibenz[a,g] acridine and non carcinogenic PAHs ACP and pyrene were not photo toxic and the photo toxicity of Benzo(a)pyrene was due to the production of photo toxic 3,b-quinone and was probably the result of production of intermediate by the interaction of light with quinine(Warshawisky, 1995).

Phototoxicity of anthracene to aquatic plants *Lemna gibba* L.G-3(duckweed) were investigated by monitoring photosynthesis process through measuring chlorophyll a, carbon fixation and electron transport .the results referred to inhibition of photosynthesis that lead to inhibition of plant growth(Huang *etal.*, 1997).

Epibenthic *Hyaella azteca* has the ability to avoid the effects of photo induced toxicity of PAHs to some extent by hiding in leaves when this substrate was available, so behavioral responses and habits that affect aquatic organisms can influence the extent to which occur due to photo induced toxicity occurs (Hatch & Burton, 2002).

The PAHs can photoperiod of exposure to U.V. radiation affected the photo induced toxicity of PAH. Also specific and /or history specific factor determine the ability of an aquatic organisms to repair photo activated PAHs damage during dark period (Budzinsky *et al.*, 1997; Weinstein, 2002).

5-Biodegradation

The principal biotic force in the biodegradation of pollutants in the environment is microorganisms . These include bacteria, actinomycetes, protozoan, fungi, yeast and algae(Crosby, 1998).According to previous studies, a wide variety of microorganisms have the ability to degrade low molecular weight PAHs as naphthalene(Cerniglia, 1992), Acenaphthene

(Johannes *et al.*, 1998), phenanthrene (Sack *et al.*, 1997a; Lisowska and Dlugonski, 1999, Langworthy *et al.*, 2002), while high molecular weight PAHs containing four or more fused benzene rings are generally resistant to microbial attack, although some bacteria (Schneider *et al.*, 1996; Aitken *et al.*, 1998), fungi (Stanley *et al.*, 1999 and Valentin *et al.*, 2005) and algae (Lindquist and Warshawsky 1985; Warshawsky *et al.*, 1988; Warshawsky *et al.*, 1995) are capable of transforming some compounds.

The rate of microbial degradation increases directly with decrease molecular weight and octanol/water partition coefficient K_{ow} (Juhasz and Naidu, 2000). Numerous species of fungi have the ability to degrade PAHs compounds (Sutherland *et al.*, 1992) and degradative mechanisms reported are metabolic, where an alternate carbon source is utilized for energy and growth, while the PAH is transformed as a consequence of this growth (Juhasz and Naidu, 2000).

A number of physical, chemical and biological factors may influence the rate and extent of PAHs degradation (Lei *et al.*, 2005). Phenanthrene degradation by natural flora present in sea water sample from Guayanilla Bay were quite slow. Addition of KNO_3 , H_2O_2 and then inoculation with indigenous bacteria, *Alteromonas* sp. will increase degradation rate within 125 hr. (Zaidi and Imam, 1999).

The degradation of naphthalene and phenanthrene was investigated in several marine harbor sediments. The addition of molybdate, a specific inhibitor of sulphate reducing microorganisms inhibited PAH mineralization which suggested that many marine harbor sediment contain microorganisms capable of anaerobically oxidize PAHs (Hayes *et al.*, 1999).

The effect of nutrient concentration on the biodegradation of PAHs by oil-degrading bacteria isolated from aquatic environment were studied. The results indicated that additional amounts of inorganic nutrients enhanced the degradation rate significantly when compared with normal reduced

quantities of these nutrients (Zeiara *et al.*, 1999). PAHs biotransformation is often multi-step process consisting of different possible pathways in which several enzymes were involved (Kisro and Irah, 1998).

Most aquatic organisms have the ability to remove significant fraction of PAHs from water through the mixed function oxygenase(MFO)enzyme system which are responsible for metabolism of PAH. The MFO is located in the liver of vertebrates and hepatopancreas of invertebrates can convert lipophilic PAHs to toxic and more soluble products(Crosby, 1998; Juhasz and Naidu, 2000).

The metabolism of PAHs starts with oxidation which lead to the formation of phenols, quinines and diols through the activity of cytochrome P450. Further oxidation to diol-epoxide and phenol-epoxide-some of these are carcinogenic interacting with DNA, RNA and protein (Lppa"nen and kukkonen, 2000).

The fresh water green algae *Selenastrum capricornutum*, *Scenedesmus acutus*, *Ankistrodesmus braunil* have the ability to completely metabolize benzo(a)pyrene to dihydrodiols through the activity of dioxygenas enzyme. The degradation of Bap by algae was dependent on the dose of light energy emitted and absorb , the dose of PAHs to which the algae are exposed and species and strain of algae. The transformation of BaP in marine and fresh water algae was species specific and dependent on the presence and activity of enzymes localiced in the cells of green and Chara algae .The most important enzyme system for detoxification of carcinogen are O-diphenol oxidase ,cytrocrom P450 and peroxidase (Kisro &Irah, 1998).

6-Bioconcentration of PAHs

Bioconcentration and bioaccumulation of contaminants are of a special importance because some aquatic species have demonsrated an ability to biocncentrate contaminants in water to high level(Brooks, 1997). Aquatic organisms are known to absorbe and accumulate PAHs from water

and sediment and widely distributed throughout organisms and found in all internal organs, but particularly those rich in lipid (EHC-202, 1998). The gut, liver, kidney and gall bladder are common sites of PAHs concentration, metabolism and excretion in vertebrates (Brooks,1997).

Uptake and accumulation of PAHs by marine organisms are dependent on the bioavailability of PAHs, the organism size, ingestion rate, growth rate, membrane permeability, ventilatory rate gut residence time and osmoregulation. Environmental factors such as temperature, oxygen content, pH and salinity can also influence the uptake of PAHs (Juhasz and Naidu, 2000).

Sediment-adsorbed PAHs are not readily assimilated by benthic animals. When accumulation of PAHs from sediment occurs at all, it may be attributed in large part to uptake of PAHs desorbed from sediment particles into the interstitial water (Neff, 1982) and the concentration of chemicals in interstitial water was primary determinant of sediment toxicity not the bulk in the sediment (Swartz *et al.*, 1979).

The bioconcentration of PAHs by aquatic plants involve several processes which include the partitioning of PAHs between the sediment and root system of plant and the movement of PAHs between the root and shoot (McGiynn and Livingston,1997). Two species of faunal invertebrate *Rhepoxynius abronius* and *Armandia brevis* from sediment of Hudson Raitan Estuary (New York USA) were used for assessing bioaccumulation potential of PAHs. The interstitial water (IW) was probably the major route of uptake of low molecular weight PAHs for both species and sediment ingestion was a much more important uptake route of high molecular weight PAHs for *Armandia brevis* (Meador *et al.*, 1995).

The fresh water oligochaete *Lumbriculus variegatus* was selected to study bioaccumulation, depuration and biotransformation of pyrene and benzo(a)pyrene. The results indicated that biotransformation rate is very

slow so it affecting elimination rate and degree of bioaccumulation. The *Lumbriculus variegatus* as a prey can transfer PAHs in to higher level of organisms in the food chain (Leppnen & Kukkonen, 2000).

Bioconcentration factor BCF(the ratio of PAHs in an organism to that in water) and biosedimen accumulation factor BSAF (the ratio of PAHs in sediment to that in water)were used to determine bioaccumulation of pollutants by an organisms (EPA, 2000). Bioconcentration factors for several PAHs in the clam *Rangia cuneata* were ranged from 6 to 236 suggesting that bivalve can accumulate PAHs more rapidly (Eisler, 1987).

Kisro and Irha, 1998 Studied the uptake, accumulation and biotransformation of typical carcinogenic PAHs ,benzo(a)pyrene in the Baltic Sea algae brown (*Fucus vesiculosus* and *Chorda filum*);Red (*Furcellaria lumbicalis*) ;Green(*Enteromorpha intestinalis* and *Cladophora glomerata*) and Chara algae *Chara* .It is found that the brown algae are able to bioaccumulate large quantities of carcingen .For green and Chara algae the percentage of transformed PAHs were between 42-49%.

1-3-4:Bioindicators of PAHs in aquatic system

There are many taxa which are known to be a good biological indicator of water quality and their absence may be used as evidence for organic pollution. Where organic loading is very high, macroinvertebrate are limited to the few most tolerant species particularly Oligochaete worms &certain Chironomid larvae. A slightly lower organic loading allows pollution tolerant mollusks to persist (Dobson &Frid, 1998).

Different species of aquatic organisms may beauseful tools for most laboratory and field studies related with biomonitoring of any change in the environment. Fish which is easy to collect and identify can be used for assessing the effect and response to exposure to PAHs .The soft shell clam

is a good bioindicator and amphipod is a suitable for sediment toxicity (Strand, 2006; Landrum *et al.*, 2003; Fent, 2003).

Fishes are located at the highest level of magnification process for xenobiotics of PAHs, heavy metal and chlorinated pesticides (Ribero Olivetia, 2005) and PAHs metabolites in fish may be useful marker for assessing exposure to PAHs (Leadly *et al.*, 1999).

Despite significant accumulation of PAHs in fish, there was no induction of cytochrom P450 (Cyp, 1A)-dependent monooxygenase activities responsible for metabolism of PAHs. This has been attributed to the elevated content of other compounds such as heavy metal, some of which can act as inhibitor to MFOs enzyme system. Another explanation is may be due to enzymatic adaptation could have lost some of their sensitivity to PAHs (Tuviken *et al.*, 1999 and Shaw *et al.*, 2004).

Tumor survey in bottom-dwelling fish have been used widely as an indicator of contamination and for monitoring the success of clean up action. In fresh water ecosystem, the brown bullhead *Aneirus nebulosus* develops skin and liver tumor in response to contaminant exposure, with the most persuasive linkage to polycyclic aromatic hydrocarbon –contaminated sediments (Pinkney, 2005).

The most aquatic plants can be a useful indicator of water quality. The chlorophyll was used as indicator to detect the effect of PAHs mixture on aquatic plants *Lemna gibba* and *Myriophyllum spicatum* (Marwood *et al.*, 2001).

The benthic macroinvertebrate oligochaete are suitable group for monitoring water quality and used as bioindicator of organic pollutants in Ankara stream (Kazanci & Girgin, 1998).

Among the most aquatic organisms used for monitoring pollutants in aquatic environment are molluscs. They are one of largest groups in the animal kingdom with over 80000 known species include snails, mussels

,limpets ,clams ,oyster as well as octopus and squid. The mollusks can serve as indicator of sediment toxicity ,bioaccumulation of organic and inorganic compounds like heavy metals and PAHs and most of them have limited capacity to metabolize PAHs and shown to accumulate very large amounts of these compounds. However mollusks also shown to have large mortality rates following oil spills (Salanki *et al.*, 2003).

Different types of clams have the ability to live and grow in polluted water so they can be used as pollution indicator (Graczyk *et al.*, 1998). Several factors can limit their availability and distribution as Dam construction, sedimentation, mininig oil drilling in addition the discharge of pollutants from different sources(MaFarland, 1995)

Marvin & Howell, (1995) explained that because of their filtration nutrition of suspended particulaes from water column, colonization species of mollusks have the effect on contaminant levels as PAHs and heavy metals in the sediments, increase in TOC and transion particle size distribution of sediment from sand to silt (Howell *et al.*, 1993).

The mussel *Dreissena polymorpha* was used to study the accumulation of PAHs .The results indicated that the mussel placed in both the water column(upper position)and the sediment surface(lower position)had the ability to accumulate PAHs as fluoranthene, pyrene, chrycene and Benzo(a)Anthracene found in the sediment ,but not detectable in water column (Roper *etal.*, 1997).

The bivalve mollusks *Mytilus edulis* and oyster of the genera *Ostrea* and *Crassostrea* have received far more attention than other aquatic invertebrates,plants or fish . They are excellent subjects for monitoring pollutants as heavy metals and Benzo(a)pyrene because they filter largel quantities of water.(Neff, 1979 ;Brooks, 1997).

The clam *Macoma nasuta* was used to study the bioaccumulation potential of PAHs in sediments taking in significant organic carbon and

organism lipid and abiota\sediment accumulation BSAF(McFarland, 1995). The Baltic clam *Macoma balthica* was used to indicate cytologic and physiologic alteration in the tissue and organs as biomarkers responses to contaminated Sydney Harbour sediment, Nova Scotia, Canada(Tay *et al.*, 2003).

Researchers used the oyster *Crassostrea gigas* embryo and larvae as sensitive tool for assessing sediment quality when PAHs or metal are suspected contaminants. They found that oyster have the ability to accumulate soluble fraction of PAHs (Geffard *et al.*, 2003).

In a study to calculate biota-sediment accumulation factors(BSAF), individual PAHs concentration in fresh water mussel, marine clam and sediment were determined to study bioaccumulation condition. It was found that petrogenic PAHs are more bioavailable than pyrogenic PAHs indicating that increased soot carbon content of sediment resulted in the decrease of bioavailability of pyrogenic PAHs(Thorsen *et al.*, 2000).

The bivalve shellfish clam are marine invertebrate have the ability to accumulate pollutants as PAHs, polychlorinated bipheynel (PCBs)and chlorinated pesticides .They are known to be a good indicator of pollution in marine environment(Gagnon, 2004).They have several characteristics of "bioindicator organism" as sedentariness, capacity to bioaccumulate contaminants without be affected by them ,accessibility and longevity in addition the contamination rate of these organisms correlate directly with biotope contamination levels (Dawe *et al.*, 1991).

Among the most molluscs used for monitoring pollution in fresh water environment is *Corbicula fluminea* .It is suitable candidate because of its wide geographic distribution and availability (Abaychi &Mustafa, 1988;Al-muddafar *etal.*, 1992;Narbone *et al.*, 1999; Salman , 2006).

Crbicula fluminea has the ability to accumulate sediment associated PAHs as anthracene, phenanthrene, pyrene and benzo(a)pyrene.

Assimilation for injected material may be significant for more strongly sorbed compound(BaP), while PAHs with low Kow value become biologically unavailable more rapidly and efficiently excreted (Narbone *et al.*, 1999).

In monitoring programe ,The Asiatic clam *C. fluminea* were placed at four locations within the Anacostia Estuary to study the accumulation of bioavailable contaminants .The results indicated that the clams in all locations had high levels of PAHs and some pesticide significantly above control (Phelps, 2004). In other study, *C. fluminea* was used in monitoring project of Anacostia Estuary in an attempt to find the contaminant source area .The result indicated that the clam accumulates high levels of PAHs (2196ng/g)were associated with industrial park area in Prince Georges county(Phelps, 2005).

Recently, Rigonata *et al.*(2005) indicated that fresh water *C. fluminea* was a typical bioindicator for determination of genotoxic contaminants which accumulate in their tissues and cause DNA-damage to hemolymph, digestive glands and gill tissues .

In Iraq, the *C. flumnea* was used as biological indicator of petroleum hydrocarbons pollution in Shatt Al-Arab river, Basrah .The analysis of its tissues indicated the presence of petroleum hydrocarbon residue ranged from 13.1 to 34.6 mg/kg. A significant relationship between petroleum and lipid content of clams indicate that this organisms tend to accumulate petroleum hydrocarbons in its tissue (Al-Saad, 1983).

1-3-5:PAHs in Water

Due to their hydrophobic nature, PAHs entering the aquatic environment exhibit high affinity for suspended particulate in the water column .As PAHs tend to sorb to these particulates, they are setteled out of water column on to sediment.Thus PAHs concentrations in water are quite

relative to the concentration in the bottom sediments (Moor & Ramamoorthy, 1984).

There are several factors which play essential role in removing the PAHs from water. It was found that water treatment process including chlorination plays an essential role in removing the PAHs from drinking water. Chlorine react with PAHs to produce Quinones and polychlorinated aromatics, some of which may be toxic to aquatic environment. The rate of oxidation of PAHs in water depends on PAH type ,temperature and pH (Neff, 1979).

Low molecular weight PAHs are highly volatile and rapidly metabolized by bacteria and other aquatic organisms. The potential for their accumulation to toxic levels is very small except when introduced in large quantities as occurs in petroleum spills(Brooks, 1997).

Oxidation of three PAHs compounds fluorene, phenanthrene and acenaphthene, with UV radiation combined with hydrogen peroxide has been studied .The results indicated that disappearance rates of PAHs are increased with respect to those from UV radiation alone. Both UV radiation and UV/hydrogen peroxide oxidation of PAHs yield numerous intermediate compounds thus removing PAHs from water (Beltran *et al.*, 1996).

Oxidation of organic pollutants have been though to remove PAHs from water. The rate of oxidation depends on light intensity, temperature and increasing dissolved oxygen .So the rate of photodegradation may be high in summer than in winter.Also the microbial degradation in summer play essential role in removing PAHs from water column(Neff, 1979&Al – Timari, 2001).

PAHs concentration in fresh water vary widely depending upon factors as proximity of water body to the source, source type and season (Moore and Ramammorthy, 1984).

According to (WHO, 1998), concentration of individual PAHs in surface &coastal waters from highly industrially polluted rivers are

generally($0.05\mu\text{g/l}$). Concentration above this level indicate contamination by PAHs mainly through industrial point sources and shipyard ,atmospheric deposition and urban runoff .Also concentration of total PAHs exceeding ($10\mu\text{g/l}$) suggested contamination by PAHs .

In general, most samples of surface water contain individual PAHs at levels of up to($0.05\mu\text{g/l}$) ,but highly polluted river had concentration of up ($6\mu\text{g/l}$).The PAHs levels in ground water are within the range($0.02\text{--}1.8\text{Mg/l}$) and drinking water samples contain of the same order of magnitude (EHC-202, 1998).

The total PAHs concentration in water from Jiulong river & Western Xiamen Sea,China ranged from($6.96\text{--}26.9\mu\text{g/l}$).The high concentration found at station might be associated with intense urban and industrial development and activity of boat and ship traveling in the area which may discharged black smokes throughout their movement. (Maskaoui *et al.*, 2002).The residue of seven PAHs pollutants in microlayer and subsurface water samples collected from Alexandria Coast, Egypt were analyzed .The total PAHs levels in microlayer ranged from(0.103 to $0.523\mu\text{g/l}$), while it ranged in subsurface samples from(0.013 to $0.120\mu\text{g/l}$). The western Harbor location recorded the highest level of PAHs over another locations(El-Nemr and Abd-Allah, 2003).

The concentration of freely dissolved PAHs in an urban stream in Milwaukee country, Wisconsin at high flow and base flow were estimated. Concentration of freely dissolved PAHs as well as concentration of total PAHs at high flow averaged about 20 times greater than at base flow .This suggested the potential for immediate toxicological impacts on stream biota is greater at high flow because of increased concentration of bioavailable PAHs(Crunkilton &Devita, 1997).

Water samples from 16 sites in Columbia river were collected at high and low flow condition.The results indicated that in the absence of

additional sources, mechanisms such as volatilization, dilution and settling of suspended particles can act to reduce significantly the concentration of contaminants as PAHs and organochlorine compounds along the river flow path and elevated concentration of many compounds tend to be diluted during period of high discharge (Macarthy & Gale, 1999).

In the study investigated at Staout Lawrence water near Quebec city-Canada, it is found that concentration of PAHs and other pollutants in the river water varied from one season to the next, from one year to the next and depending on the source of Quebec city water. The dissolved PAHs concentration peaks in winter, when concentration three to four times above late summer levels, due to the burning of wood in winter thus generating PAHs. Also concentration of PAHs are linked with river flow (Environment Canada, 2006b).

The waste water treatment plant represent important sources of contaminants to a receiving water. Determination of PAHs & PCBs from waste water treatment drawn from the effluent of Montreal Urban community, Canada and surface water samples from St. Lawrence river were investigated. The average concentration of total 13 PCBs and total 14 PAHs in the effluent were $(0.0013 \pm 0.71 \mu\text{g/l})$ and $(0.326 \pm 229 \mu\text{g/l})$ respectively. PAHs concentration in effluent did show clear seasonal pattern that increased during winter period (Pham *et al.*, 1999).

The concentration of PAHs in particulate and dissolved phase were analyzed in the lower Mississippi river and Gulf of Mexico. The results indicated that total PAHs abundance in river samples was higher in November (Cp: 1300-7000 ng/g; Cw: 77-430 mg/g) than in April (Cp: 1100-1700 ng/g; 12-25 ng/g), despite high suspended solids concentration in April. Concentration profile in the lower Mississippi river indicate that compositional differences in PAH particle-water distribution were a function of seasonal discharge across the year (Mitra & Bianchi, 2003).

The mean levels of PAHs in water bodies of Hang Zhou, China was higher in summer(34.4-67.7µg/l) than in winter(4.7-15.3µg/l). One possible explanation of this phenomena could be sorption of PAHs on to suspended solids in river may be the main contribute factor for high PAHs concentration in summer. Another possible explanation may be increased atmospheric input PAHs in summer (Zhu *et al.*, 2004).

The results of other studies referred to quite different phenomena. The lowest PAHs in summer in comparison with spring and autumn are believed that this might attribute to seasonal change in the degradation intensity, also high temperature in summer may be important environmental factor lead to increase volatilization of light PAHs compounds. (Witt, 1995 & Al-Timari *et al.*, 2003).

In Iraq there was increase in the petroleum hydrocarbon concentration in Khor Al-Zubair & North West Arabian Gulf. This may be due to development of industrial, agriculture and urbanization and increasing navigation activity, so additional amounts of pollutants find their way in to water (Al Timari *et al.*, 2002).

Al-Timari *et al.*, (2003) showed that the variation in the level of dissolved & suspended matter of Petroleum hydrocarbon in water from Shatt Al-Arab, Khor Al-Zubair and other regional water of Iraq may due to petroleum leakage as a result of industrial process or waste of loading and transportation of ships.

Levels of Total hydrocarbons concentration had been measured in water sediment from Um Qaser and four stations of Iraqi marine water. The high level was recorded in Um Qaser port during July may due to large depth and high water flow thus dilution level of petroleum hydrocarbons in water (Nasir, 2004). The levels of PAHs in the water of South of Iraq were determined. The major PAHs compounds recorded in the sites of Shatt Al-Arab and north west Arabian Gulf were Acenaphthene, Anthracene and

Benzo(ghi)Perylene(Al-Saad, 1995).in other study ,it is found that the concentrations of PAHs in Shatt Al-Arab river were higher than those recorded in the north west Arabian Gulf(Al –Saadi *et al.*, 1998).

Al-Timari(2000a) assessed the oil pollution in Shatt Al-Arab water by monthly variation of PAHs levels .The values were ranged between(21-55 ng/l) with detection of High Molecular Weight –PAHs .

1-3-6:Bioremediation of PAHs from Water

Because of industrialization, the extent of accumulated PAHs in the environment at present is significantly higher than that in the past. While it is best to avoid further producing of these compounds, efforts to limit the introduction of these compounds in to the environment by treating point pollution sources should always be made(Hsu, 2004).There is continuous interest in the clean-up of contaminated sites by biological means because of the improvements in sustainability that they offer(Collins&Willey, 2004).

Because PAHs normally degrade very slowly in the environment, strategies are needed to reduce the high level of these contaminants on hazardous waste sites. Developing a bioremediation technology that can degrade PAHs of all shapes and sizes is difficult because PAHs differ greatly in their degree of biodegradability. Typically the greater the number of fused rings ,the more resistant to biodegradation. However there is possibility to develop strategies for utilizing microbes to remove PAHs mixture from contaminated sites (Warshawsky, 1998). Numerous genera of microorganisms, bacteria have been observed to degrade the low molecular weight PAHs as naphthalene, acenaphthene and phenanthrene (Cerniglia, 1992).

The success of any bioremediation strategy is dependent on the characteristic of the microorganisms. The microflora must possess the

capacity to degrade a wide range of contaminants, thereby reducing the toxicity of these contaminants (Juhsz & Naidu, 2000).

Algae found in the environment are capable to produce their own food through photosynthesis and are present in a wide range of size from unicellular to structure comparable to terrestrial plants (Graham & Wilcox, 2000).

Warshawsky *et al.*, (1995) found that algae are essential components of aquatic ecosystem and their contribution on the degradation and detoxification of recalcitrant PAHs and their potential mutagenic intermediates must be considered to develop strategies for removal of the carcinogenic PAHs from contaminated ecosystem.

Lindquist and Warshawsky (1985) and Warshawsky *et al.* (1988) demonstrated the oxidation of benzo(a)pyrene by Green algae *Selenastrum capricornutum* resulted in the formation of dihydrodiols via dioxygenase enzyme. Another study on the same bacteria has proved its ability to completely metabolize BaP (Warshawsky, 1998). So there is a possibility to its application in clean-up of contaminated sites.

Experiments were carried out with two bacterial species and one algal species. In these studies BaP was first incubated with the algae and followed by one of bacterial sp., the percentage of BaP that has been degraded and mineralized was greater than first incubated with bacteria only. These suggested that algae in conjugation with bacteria may lead to complete degradation of PAHs such as BaP (Warshawsky, 1998).

The potential tool in the bioremediation technology is aquatic plants. Number of studies have indicated that certain plant orders (Malpighiales, Brassicales and Asterales taxa) have the ability to accumulate contaminants as heavy metals and they may be beneficial for the phytoremediation of organic pollutants (Collins & Willey, 2004).

Recently due to its low cost and relatively high efficiency, treatment using aquatic plants combined with microbial degradation became popular, however in a study two aquatic plants *Ceratophyllum demersum* and *Najas graminea* were used to study their efficiency to sorb PAHs compounds as phenanthrene and pyrene. The results indicated that the two aquatic plants demonstrated great potential in application used for treating waste water containing PAHs due to low energy and the cost of devices (Hsu, 2004). Zebra mussel *Dreissena polymorpha* have increased the water clarity in lake St-Clair and lake Erie, USA due to their extensive particle filtration. The potential for contaminants accumulation from both suspended and algae were examined. The result indicated a higher accumulation of contaminants sorbed by algae (Gossiaaux *et al.*, 1998).

1-3-7:PAHs in sediment

Sediments serve as contaminant sources and sinks (EPA, 2000; Wong, 1999). Most contaminants as PAHs, polychlorinated biphenyl (PCBs), chlorinated pesticides, herbicides and heavy metals are usually found in concentration order of magnitude higher in the sediment than in water column especially when they are hydrophobic and resistant to chemical or biological degradation (Ingersoll *et al.*, 1997a; SFEI, 1998; Geismar, 2002). They exert toxic effect on the indigenous fauna of the sediment and can be source of contaminants for bioaccumulation in the food chain (Larsson, 1985).

Concentration of contaminants may influence by physical sediment factors as well as proximity to sources. Sediment with more silty and clay and higher total organic carbon (TOC) have higher concentration of pollutants than sediments with sandy and low (TOC) sediment (SFEI, 1998).

Total organic carbon in sediment was found to be a good indicator for the degradation rate of low molecular weight of PAHs (LMW-PAHs) in

subtidal marine sediment, so relationship between degradation rate and sediment TOC can be used to provide improved and site-specific prediction of the initial time-course of LMW- PAHS con. in sediment after oil spills (Hinga *et al.*, 2003).

Due to high hydrophobicity and thereby lower water solubility, the PAHs have high affinity to organic particulate matter. These properties cause them to accumulate in the sediment (EHC-202, 1998; Juhnsen *et al.*, 2005). Sixteen PAHs concentration were found at low to moderate levels ranging between 44-166 ng/g dry weight in the fine fraction (less than 63 μm indimeter) of marine sediment in the north Aegean sea, Greece and between 45-148 ng/g dry weight in the coarse fraction (63-2000 μm) of sediment (Papadopoulou & Samara, 2002).

Poor relationship was obtained between sediment grain size and total PAHs in the sediment from Baltimore Harbor (Ashley & Baker, 1999).

The highest total PAHs concentration in the sediments from Kara sea shelf, Russia (335 ng/g) was found at station in the north of Gulf of Ob, Russia. This station also had relatively high concentration of TOC dominated in silty sediment samples which indicate that fine grained sediment has the highest amount of organic fraction (Dahle *et al.*, 2003).

In the study to determine PAHs concentration in water, sediment and snow lakes in Grand Teton National Park, the result indicated that concentration of PAHs in sediment samples were consistently larger than in water sample, but varied among sampling events and locations and significant correlation was found between detectable PAHs in sediment and TOC because PAHs have the high affinity to sediment organic carbon (Rhea *et al.*, 2005).

The level of PAHs in sediment vary, depending on the proximity of sites to human activity. High con. of PAHs in sediment are high in highly industrialized and urbanized locations (Ashley & Baker, 1999; Zhu *et*

al.,2004) and can reach 10,000 ng/g to several hundred thousands in heavily industrialized area(Brooks, 1997).

Surface sediment collected from Savannah river located in the southeastern state of Georgia,USA were analyzed .The results indicated that there was high spatial variability in the total PAHs concentration from(29 to 5,375 ng/g)with average 1216 ng/g .The highest concentration was in the adjacent to urban and industrialized area (Sanders *et al.*, 2002).

The total PAHs concentration in the sediment collected from Jiulong river estuary and Western Xiamen sea ranged from(59-1177ng/g with the mean concentration of 334ng/g (Maskaoul *et al.*, 2002).

The conentration of sixteen PAHs classified as USEPA priority pollutants were analyzed in samples from sediments locations within the northeastern and southern regions of Singapores marine waters .The highest con. of total PAHs 84920 ng/g was recorded at a site adjacent to petrochemical refinery .Among the sixteen PAHs, chrycene, Indeno (1,2,3-cd)pyrene and Benzo(a)Anthracene were most abundant in the sediment (Basher *et al.*, 2004).

In a study to determine the PAHs concentration in the surface runoff and sediment of Lagos, Osogboan iie-ife western area of Nigeria, it is found that con. of PAHs in sediment are higher than in runoff, indicating that sediment is a sink of PAHs and represents along time deposition of PAHs (Ogunfowokan *et al.*, 2003).

PAHs concentration and pattern of distribution in the sediments are change according to weathering and ageing and reflected longer periods of time(Vrana *et al.*, 2001). In a study to determine the historical record of PAHs and heavy metal in flood plain sediment from Rhine river(Hessisches Ried, Germany).

PAHs in sediment has been found to partition into a biologically available fraction and an unavailable fraction. Chen (2001) found that sediments

PAHs levels are not directly responsible for many of biological effects that have been seen in benthic organisms .

In laboratory experiment, the concentration of PAHs in the Harbor sediments collected from New York Harbor was depends on the degradation and desorption rates which were often more than two orders of magnitude slower than that observed for freshly added hydrocarbons (Brownell & LeBlanc, 2002).

In a study to explain the behavior of aromatic hydrocarbons in the sediment of EYE estuary–Devon, the result indicated that PAHs pollutants in the sediment resulting from river runoff to a receiving estuary are associated with suspended sediments rather than in bottom sediment . This can be explained by sorption coefficient on suspended and bottom sediments(Herrmann and Hubner, 1982).

Despite similar PAHs sources from two cores within lower Hudson river Estuarine(East river in NewYork and Newark bay in Newjersey), sediments and associated PAHs have undergone distinctly different depositional processes .The results indicated that in urban coastal areas,Physical factors that influencing time of sediments resuspension and deposition may be of primary importance over particle geochemistry in determining wheather PAHs will likely equilibrate between sediments and pore waters(Mitra *et al.*, 1999a).

Specific composition and physical changes in particulate organic matter may be responsible for controlling observed PAHs distribution coefficient in the field. Sediment associated PAHs concentration varied with depth at two sites in Elizabeth river inVrginia, USA .Decreased in PAHs concentration with depth could be due to increase in PAHs input to river estuary with time and there is significant heterogeneity in PAHs distribution coefficient in estuarine sediment which may attribute to sediment deposition patterns, PAHs sources and sediment geochemistry (Mitra *et al.*, 1999b).

In Iraq, numerous studies were done to determine the quality and quantity of total Hydrocarbon pollutants in the aquatic system and limited to Southern of Iraqi water where the activation of oil production , refining and transportation (Al-Saad, 1983; Al-Hamdi, 1998; Al-Saad & Bedair, 1989; Al-Saad,1995; Al-Saad & Al-Timari, 1998; Al-Saad *et al.*, 1995; Al-Saad *et al.*, 2000; Al-Timari *et al.*, 2002 & Nasir, 2004).

The distribution of PAHs in the superficial sediment from Shatt Al-Arab river and north west Arabian Gulf were studied. The Values of(3.8-76ng/g) were found in the Shatt Al-Arab river(Al-Saad, 1987).In other study done by Al-Saad and Al-Timari(1989), the values of(0.5-2.1ng/g)were recorded for PAHs in Hor Al-Hammar in Basrah.

High concentration of PAHs 40 ng/g dry weight was obtained from the sediment of Khour Al-Zubair in the north west Arabian Gulf and associated with superficial sediment core which indicate that navigation, oil pollution and burning of fossil fuel could be the sources of these compounds. No significant relationship was found between sediment grain size and total organic carbon and PAHs concentration in the sediment(Al- Hamdi, 1989). The origin of PAHs detected in the sediment of Kuwait water was from natural and burninig processes(Al-Timari, 2000b).Some of Low Molecular Weight-PAHs were detected in the sediment samples collected in the south Arabian Gulf region(Fowler *et al.*, 1993).

Chapter Two

Materials and Methods

2-1: The study area

The Euphrates river is one of the important river for water supply and irrigation .It is formed by union of two rivers Kara and Murad in Turkey ,then flows through Syria in to Iraq .It is the Longest river in West Asia about(2800km) and encompasses (765831 km²) watershed (Wikipedia, 2006).

In Iraq, the river enters its delta between Hitt and Ramadi. It is divided into two main channels, Shatt Al-Hindiya and Shatt Al-Hilla. At Samara, they rejoin and flow southeast wards till it joins the tigris river (WHO-Unicef, 2000).

Structural modifications to the river such as the construction of barrages have clear and effective permanent effects upon a river system as reduction of water flow and altered pattern of sedimentation and biological change (Dobson and Frid, 1998).Construction of barrages on the Euphrates river has greatly reduced fresh water flow that would dilute pollution (Hoh *et al.*, 2000).

Hindiya barrage is one of these that was built on the left of Euphrates where it branches into Shatt Al-Hindiya and Shatt Al-Hilla about(150km) south of Ramadi dam and (135km) south of Faluja dam to regulate the distribution of water (Al–Masudi, 2000).

The Five sites were selected along the river to collect studying samples, starting from the site before Al-Hindiya barrage toAl- Kifil city to investigate water quality and taking in significant its close to area where contamination was expected to be high and from different sources . Figure (1) showed the selected sites along the Euphrates river under the study.

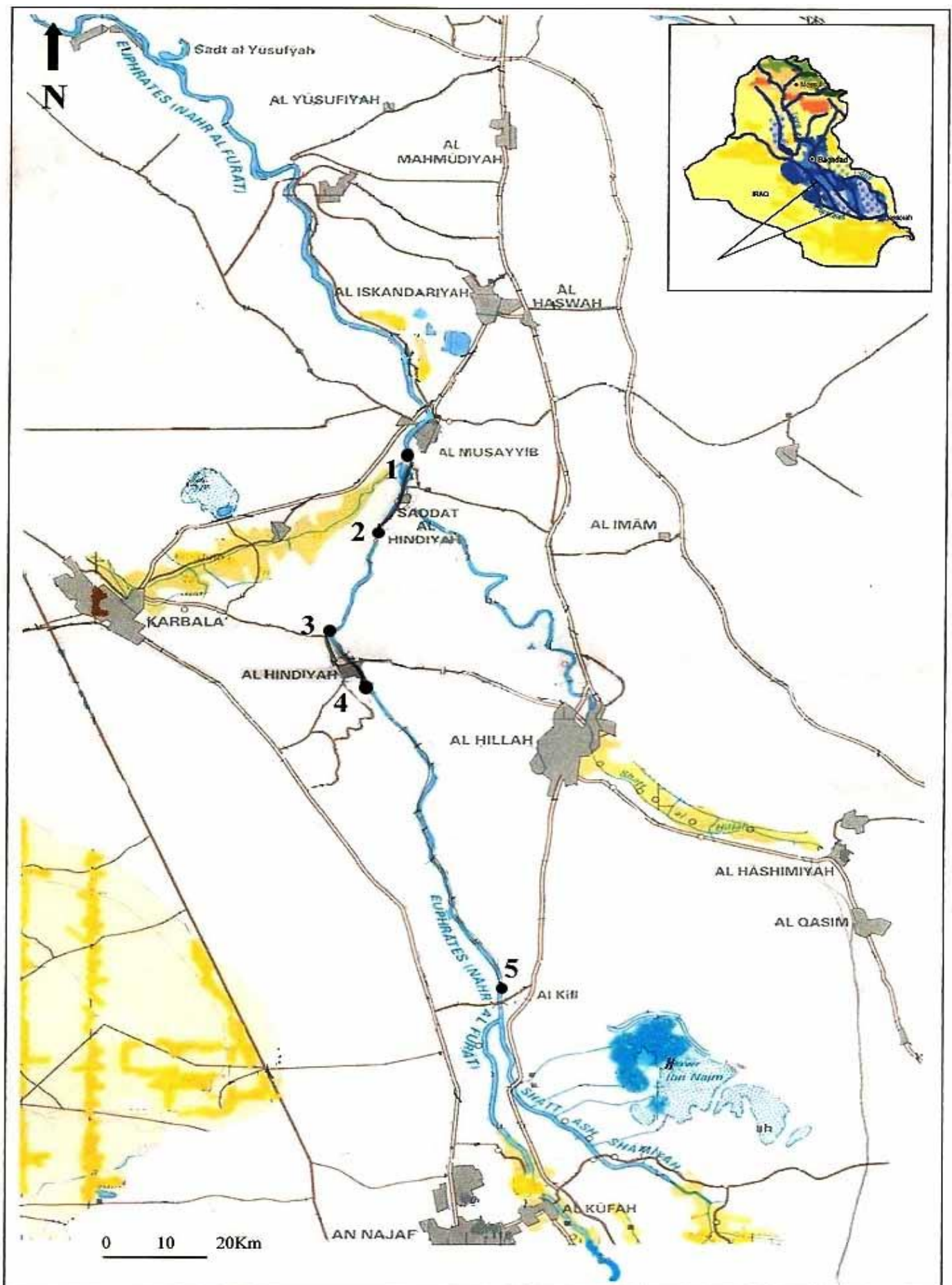


Figure (1): Map represents study sites on the Euphrates river

● Study sites

2-2:Description of study sites :

Site one

It is located on the main Euphrates river before dividing in two channel about 3 km away from Cement factory .The water level is high due to rendering of water by the barrage. Aquatic plants as *Ceratophyllum demorsum*, *Potamogeton pectinatus*, *Typha domingensis* and *Phragmites australis* were observed .

Site two

It is established 15 km away from site one after passing the river along Hindiya barrage city. The river in this site is affected by human and agricultural activities. Aquatic plants as *Phragmites australis* and *Typha domingensis* were observed .

Site three

It is located in an agricultural area about 45km away from site two in the north of Al-Hindiya city. Intense agricultural activities were observed with the presence of buffalo. The water from small drainages nearby were directly discharged into the river

Site four

It is located about(20km)away from site three after passing the river along Hindiya city directly adjacent to populated area .Domestic and industrial effluents are directly discharged in to the river .Due to sedimentation ,the water level is very low with the presence of aquatic plants as *C. demorsum*, *T. domingensis*, *P. australis* and *P. pectinatus* .

Site five

It is located in Al- Kifil city (100 km)away from site four .The river is affected by human and agricultural activities .It is observed the increase of river width with sedimentation that allow the growth of plants as *P. australis* and *T. domingensis* .

2-3:Laboratory instruments and chemical used

Table(2):Instruments Used:

Instrument	Company
1-pH-meter	BDH
2-E.C.-meter	BDH
3-Sensitive Balance	BDH
4-Vacum pump	BDH
5-Spectrophotometer	BDH
6-Hot plate	BDH
7-Oven	BDH
8-Shaker	Alpha chemica
9-Incubator	Fluka
10-Rotary evaporator	Alpha chemica
11-Light compound microscope	Fluka
12-Water refrigerator circulator	BDH
13-Autoclave	Fluka
14-Grap sampler	BDH
15-Water sampler	Merck
16-Computarized HPLC	KNAUER
17- Plankton net	-

Table(3):Chemicals used:

Chemical	Company
1. Acetonitrile	BDH
2. Ammonia	BDH
3. Ammonium chloride	BDH
4. Ammonium molybdate	BDH
5. Ammonium hydroxide	BDH
6. Ascorbic acid	BDH
7. Barium chloride	BDH
8. Benzene	Alpha chemica
9. Calcium chloride	Fluka
10. Carbon tetra chloride	Alpha chemica
11. Canada balsam	Fluka
12. Diphenyl amine indicator	BDH
13. Ethanol	Fluka
14. Erichrom black T	BDH
15. Ferrous ammonium sulphate	Merck
16. Formalin	
17. Glycerol	BDH
18. Hexane(analytical grade)	Scharlau Heozzl
19. Hydrochloric acid	Fluka
20. Hydrogen peroxide	Merck
21. Iodine	Merck
22. Aluminum Oxide	BDH
23. Lugol's solution	Merck
24. Methyl orange	BDH
25. Millipore filter paper (0.45µm)	Sartorius
26. Manganese chloride	Merck
27. Murexide	BDH
28. N- naphthyl ethylene diamine	Fluka
29. Nitric acid	BDH
30. Phenolphthalein	Merck
31. Potassium iodide	BDH
32. Potassium dichromate	Fluka
33. Potassium hydrophosphate	BDH
34. Potassium persulphate	BDH
35. Sodium nitrate	BDH
36. Sodium thiosulphate	BDH
37. Sodium carbonate	Merck
38. Sodium chloride	BDH
39. Sodium hydroxide	Fluka
40. Sodium fluoride	BDH
41. Silica gel	Woelm pharma
42. Silver nitrate	BDH
43. Sulphuric acid	BDH
44. Sulphanil amide	BDH

2-4:Sample collection and Field work:

Sample collection was carried out for a period from July 2005 to June 2006. Five sites were selected on Euphrates river, started from the site before Hindiya barrage to Al- Kifil city for assessing the effect of pollution on river properties. Samples were collected in there replications.

Surface water samples (30 cm) from each site were analyzed monthly for definition of Physical, chemical properties, while sediments and aquatic organisms were collected seasonally for qualitative and quantitative study of polycyclic aromatic hydrocarbons (PAHs).

1. At each site pre-cleaned poly ethylene containers were rinsed with water then filled, stoppered and labeled for analysis purposes .
2. Measurement of Air and water temperature were made in the field by Mercury filled celesium thermometer with scale marked from (0 to 100C°) .
3. Field E.C.-meter (L 17–Bischof) was used to measure electrical conductivity.
4. Water pH was measured by pH–meter which has been calibrated prior to use by standard pH buffers (4,7,9) .
5. Winkler clear glass bottles were filled with water followed by addition of reagents(ml $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$, ml of alkali iodide solution and ml of concentrated H_2SO_4)for measuring dissolved oxygen, while dark botteles were filled for biological oxygen demand BOD_5 determination (APHA,1999).
6. Phytoplanktons were sampled at each station using plankton net with mesh size 50 μm and were preserved immediately using Formalin solution (10 %) for identification purposes(Smith, 2004).Preservation of liter water in Logul's solution and concentrate to 10 ml for counting Phytoplanktons(Parson *et al.*, 1984).

7. Subsurface water(0.5m) were collected using pre-cleaned dark glass bottle(1 liter)in metallic holder around the bottle connected with arope that lowered in to water and allows rest briefly to ensure that it filled with water and then pulled in. Two liter of water were transferred to dark bottle containing 60 ml of carbon tetra chloride CCL₄ solvent (Al-Saad, 1983).Sample botteles then finally closed with aluminum foiled lined cap.
8. Surface sediment samples were collected with a grab sampler, put in a foil aluminum papers.
9. Four species of aquatic plants which are *C. demorsum*, *T. domingensis*, *P. australis* and *P. pectinalis* and two species of clam *U. tigridaes* and *P. euphraticus* were collected ,washed with tap water.
- 10.On return back to the laboratory, water samples were stored at 4 C° till analysis and sediment samples were freezed at -20C° .The aquatic organisms washed with distilled water, dried on papers, wrapped in aluminum papers, labeled and freezed at -20 C° till analysis(Kayal and Gnnell, 1995).

2-5: Laboratory Work

2-5-1:Equipment and Glass Ware cleaning process:

1. All equipment that will contact the sample were protected from contamination between the time of washing and time of sampling .
2. All sample containers and laboratory glass ware used in analytical processes washed by detergents with hot water, often for 24 hr. soaked with 10% HCL followed by rinsing with distilled water (Smith, 2004).
3. All glass ware were used for PAHs compounds determination cleaned before and after use by washing with detergent followed by rinsing

with tap water and then distilled water and rinsed with solvent. The glassware should then be drained dry and heated in furnace at 200 C° for 15- 30 minutes (APHA, 1999).

2-5-2: Analytical Processes

1- Salinity :

Salinity was determined using electrical conductivity as shown below in the formula:

$$S_{‰} = E.C. - 14.78 / 1589.09$$

The results were expressed as part per thousands as shown by (Markereth *et al.*, 1978) and recommended by (APHA, 1999).

2-Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD₅):

Dissolved oxygen was determined according to Azide- modification of Winkler method (APHA, 1999). The results were expressed as mg/l, while BOD₅ was determined as follows :

$BOD_5 \text{ mg/l} = \text{Initial dissolved oxygen} - \text{dissolved oxygen for 5 day incubation}$ as described by (APHA, 1999).

3-Total Alkalinity :

Total Alkalinity was determined according to the procedure shown by (Lind, 1979). 50 ml of water sample is titrated with H₂SO₄ (0.02 N) and the results expressed as mg/l .

Alkalinity as mg(CaCO₃)/ l = $A \times B \times 50000 / \text{ml sample}$

A = ml of H₂SO₄ titrant

B = Normality of H₂SO₄

4- Total hardness

EDTA titrimetric method was used to determine Total hardness as recommended by (Lind, 1979). Twentyfive ml of water sample was diluted to fifty ml by distilled water and titrated with Standard EDTA–disodium solution (0.01 N) using Erichrome Black T as indicator .

Total Hardness as mg $\text{CaCO}_3/\text{l.} = A \times B \times 1000/\text{ml sample}$

A = ml EDTA titrant for sample

B = mg CaCO_3 equivalent to ml EDTA–disodium solution titration.

5- Calcium concentration(Ca^{+2})

Calcium concentration was determined by EDTA titrimetric method as described by (APHA, 1999), using Murexide as indicator .

Calcium as mg $\text{CaCO}_3 / \text{l} = A \times B \times 400.8/\text{ml sample}$

A = Volume of Na_2EDTA used for titration

B = mg CaCO_3 equivalent to ml EDTA titrant

6- Magnesium concentration(Mg^{+2}):

Magnesium concentration was calculated from the difference between milli equivalent Hardness and Meq Ca^{+2} using the following formula (APHA, 1999):

Milligram $\text{Mg}^{+2} = 12.16 (\text{Meq Hardness} - \text{Meq } \text{Ca}^{+2})$

Meq Hardness = (mg Hardness / l $\times 0.01988$)

Meq $\text{Ca}^{+2} = (\text{mg } \text{Ca}^{+2} \times 0.0499)$

7- Sulphate ion :

Sulphate ion was determined according to turbidimetric method as described by APHA (1999). 10 ml of filtered sample was diluted to 50 ml by distilled water. SO_4^- ion present is precipitated in an acidic medium with barium chloride forming barium sulphate crystal which absorb light at 420nm. Calibrated curve was prepared to determine SO_4^- concentration and the results expressed as mg /l

8- Chloride Ion

Chloride ion was determined according to the procedure described by APHA (1999). Fifty ml sample was titrated with Silver nitrate using $\text{K}_2\text{Cr}_2\text{O}_7$ as indicator .

$\text{Cl}^- \text{ mg/l.} = (A-B) \times N \times 35.450 \times 1000/\text{ml sample}$

A = ml of AgNO_3 titrant in Blank

B= ml of AgNO₃ titrant in sample

N= Normality of AgNO₃

9-Total Suspended Solids(TSS):

A well-mixed sample was filtered through a weighed standard glass fiber filter and the residue retained to constant weight at 103 -105C°. TSS was determined from the difference between dry and initial weight (Smith, 2004).

mgTSS/l = A- B ×1000 /ml sample

A = weight of filter and dried residue(mg)

B = weight of filter(mg)

10- Total Dissolved Solids(TDS):

A well-mixed sample was filtered through a standard glass fiber filter and the filtrate was evaporated in a weight at (180C°). TDS was determined from the difference between the weight (Smith, 2004).

mgTDS/l=A- B ×1000/ml sample

A = weight of dried residue and dish(mg).

B = weight of dish (mg)

11-Total Organic Carbon (TOC%):

TOC% was determined according to (Gaudette *et al.*, 1974).

TOC % = 10 (1 – T/S)[1×0.003 (100/w)]

T = sample titrant = ml Ferrous Ammonium Sulphate

S = mel Ferrous for blank titrant.

10 = Volum of K₂Cr₂O₇

1 = Normality of K₂Cr₂O₇

0.003 = 12/ 4000 = Meq weight of carbon

12-Total phosphorous :

Persulphate digestion method was used according to (Eisenreich *et al.*, 1975) as described by (Smith, 2004). Digestion reagent K₂S₂O₈C₅ml and H₂SO₄ (5ml) was added to 25 ml unfiltered sample, then autoclave for thirty

minutes at 120C°.Orthophosphate ion was determined according to Murphy and Riley (1962).

Light absorbancy by blue complex formed was measured at 882nm.Calibrated curve was prepared to read concentration and the results expressed as mg/l

13-Total Nitrogen

Persulphate method was used according to(MacKereth *e tal.*, 1978) as described by Smith (2004).All nitrogenous compounds in the sample was oxidized to nitrate at(100-110C°) then cadmium reduction method was used to convert nitrate to nitrite .Calibrated curve was prepared to read total nitrogen concentration and the result expressed as mg /l.

2-5-3: Qualitative and Quantitative studied of phytoplankton

2-5-3-1:Quantitative study

The counting of phytoplankton was done according to the method explained by Al-Zubaidy, 1985.The result expressed as cell/l

2-5-3-2:Quanlitative study

Phytoplankton was identified to genus and when possible to species using identification textbooks: Germain, (1981) and Hadi *etal.*, (1984) for diatom, while Prescott, (1973); Desikachary, (1959) were used for algae.

2-5-4: Qualitative and Quantitative studied of of PAHs

2-5-4-1:Chemical for PAHs Analysis :

Solvents used for sample proccessing and analysis were (Hexan, Carbon tetra chloride and Acetonitrile). They purified and for analytical grade. Triply distilled water was also used for all steps of analytical processes(USEPA, 1999). Silica gel(70–150mesh)used in column chromatography for clean up procedure it was first pre–cleand by soxholet extraxtion with CCl₄ for six hour, then activated by heating at 250C° for 12 hr., cooled and deactivated with water (10%).After deactivation, silica gel

was kept in tightly closed dark glass and used within 72 hr. after preparation (Kayal and Connell, 1995). Also neutral Aluminium oxide was pre-cleaned, activated and deactivated in the same way. Heating at 120 C° for 12 hr sodium carbonate and anhydrous sodium sulphate.

2-5-4-2: Extraction of PAHs from water :

The PAHs compounds in water were determined using Liquid – Liquid extraction method as described by UNEP (1989).

1-On returning back to the laboratory, bottle sample containing two liters of water with 60 ml carbon tetra chloride (CCl₄) was shaken for one hour, then the contents of the bottle were transferred to separatory funnel and allow the organic layer to separate from water phase for a minimum of ten minutes .

2- Extraction procedure was repeated with another 60 ml of CCl₄ and the combining extracts were transferred into the flask .

3- After extraction, anhydrous sodium sulphate was added to the extract to remove any fraction of water present .

4-The organic extract was then evaporated to dryness by rotary evaporator (50C° bath temperature and 10 C° temperature of water refrigerator circulator) and 30 ml of Hexan was added to the flask .

Because the extract contains complex components, the clean up procedure was undertaken by column chromatography using 10gm of deactivated silica gel packed in glass column(250mm×15mm I.D.).

The column was pre-eluted with 10ml of Hexan, then the extract was passed through the column followed by elution with 50ml Benzene to separate all PAHs compounds due to its high nonpolarity (Al Saad, 1983 and Maskaoui *et al.*, 2002).

Both Hexan & benzene were evaporated to dryness by rotary evaporator and the residue was dissolved with 5 ml Acetonitrile, then concentrated to ml under gentle N₂ .The extract was stored at (– 20 C°) until analysis by HPLC .

2-5-4-3:Extraction of PAHs from sediments :

PAHs are slow to degrade in the environment and sediments in particular are sinks where chemicals tend to concentrate (Environment Canada, 2001). Quantification of PAHs in sediment is quite essential to understand environmental quality of aquatic system ,so many extraction and purification techniques have been proposed but not single method is commonly recognized as the best one .The following methods have been used by authores:

- Liquid–Liquid extraction(Miles *et al.*, 1975)
- Soxholet extraction method (Frington and Tripp, 1975; Al–Hamdi , 1989; Sanders *et al.*, 2002 and Ogunfowokan *et al.*, 2003)
- Sonication method (Zhu *et al.*, 2004; Sarrazin *et al.*, 2006).
- Accelerated solvent extraction ASE(USEPA, 1999).

The efficiency of each technique is afunction of different factors such as partition of a compound between organic and water phase, interference of sample matrix and losses due to evaporation .

In the present study, traditional soxholet extraction method with a combination of other technique was used despite takes(6 to 24 hr.) to performed and require large amounts of solvent, but has been proved to be more efficient .

- Briefly stated, samples were allowed to thaw at room temperature
- About 100 gm of wet sediment sample was weighed in to Whatman extraction thimble that has been pre–extracted, then placed in a soxholet extractor and extracted dis continuously with 250 ml Hexan for 12 hr.
- Allow the extract to cool for 30 minute with elution of soxholet apparatus with 10 ml Hexan to separate PAHs compounds expected to be adsorbed .

- The extract was carefully reduced to about 10 ml on rotary evaporator and transferred in to clean separatory funnel. To this 20 ml of triply distilled water was added and mixture washed with 30 ml of (0.1M) Na_2CO_3 (Ogunfowokan *et al.*, 2003). This step is necessary to remove saponified lipids .
- The organic layer was separated and dried with anhydrous Na_2SO_4 .
- Non-saponified lipids and other complex components that interference with sample matrix must be removed by chromatographic column. 10 gm of silica gel(70 -150 mesh) was placed in the glass column(10.5mm I.D. and 300mm length) followed by 10gm neutral aluminum oxide and 1-2 cm anhydrous sodium sulphate. Activated copper was added to the top to remove reduced sulphur (Sanders *et al.*, 2002).
- The column was first eluted with hexan, then the dried extract was passed through the column followed by 30 ml Hexan .
- A separate sample of sediment was dried over night in an oven at 120°C and reweighed to determined water content .

2-5-4-4:Determination of PAHs in Clam :

2-5-4-4-1:Extraction Procedure

- Samples of both species of clam were allowed to thaw at room temperature.
- Twenty five individuals of each sample were used with three replicates .
- Soft tissues of clam were removed and put in mixer for homogenization(Gagnon *et al.*, 2004).
- About 10gm of the homogenate was placed in a thimble for soxholet extraction for 24 hr. with 250 ml hexan and amount of anhydrous sodium sulphate were added for removing water (NOAA, 2000; Gagnon *et al.*, 2004).
- Other steps of extraction were done in the same manner of sediment.

2-5-4-4-2:Lipid determination

According to the results of previous studies, it was found that there was positive correlation between lipid content and corresponding total PAHs level (Kayal and Connell, 1995; NOAA, 2000).

- 10 gm of wet homogenate tissue was put in a thimble with addition of anhydrous sodium sulphate and place in an extractor apparatus .
- 200 ml of hexan were put in the pre-weighed flask for extraction(24 hr).
- Solvent allow to evaporate to dryness and re-weighed the flask .
- The difference between the weight of flask referres to lipid content .

2-5-4-5:Extraction of PAHs from aquatic plant :

Aquatic plants are known to adsorb and accumulate PAHs from water. Therefore two types of plants were selected *C. demersum* & *T. domingensis*.

- At least about 50 gm of each plant was dried in fan-incubator at 15 C° and sieved through 63 mesh metal sieve(Ibrahim, 1999).
- 10 gm of dried sample with three replicates was put in pre – extracted cellulose thimble and soxholet extraction with 250ml Hexan for 12 hr.
- The other steps of extraction were done in the same manner of sediment
- All samples then stored at - 20C°till analysis .

2-5-5:Blank

Laboratory reagents and glassware blanks were analyzed with each set of samples to check for interference that may have been introduced during the extraction and analytical procedure(Sanders *et al.*, 2002; Doong and Lin, 2004).The water, sediment and aquatic organisms samples were re-extracted and treated as blank(Al-Saad, 1983).

2-5-6:Calibration

A standard solution of sixteen US EPA priority PAHs was obtained from Sigma-Aldrich company as PAHs calibration mixture in order to compare the retention times and spectra of compounds in the standard with those in the sample . The standard calibration contain the following compounds :

Naphthalene, Acenaphthalene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Benzo(a) anthracene, Chrycene, Benzo (b) Fluoranthene, Benzo(k) Fuoranthene, Benzo(a) pyrene, Dibenzo (a,h) anthracene, Benzo (ghi) Perylene and Indeno(1,2,3-cd) pyrene.

2-5-7 PAHs analysis

The PAHs extracts of water, sediment, plants and clams were analyzed by high performance liquid chromatography(KNAUER) series system at the college of Pharmacy/Medicine Hawler University.

The mobile phase was HPLC-grade acetonitrile and Distilled water in a linear gradient program as follows:

<u>Retention time</u>	<u>water%</u>	<u>Acetonitrile%</u>
0-2 65		35
2-16 10		90
16-22 5		95

Ten µl of sample was injected into a stationary phase capillary column with a dimension of(15cm×4.6mm ID) and determined with UV detector at 254 nm . The flow rate of mobile phase was kept at 1.5 ml/min. The peak in the chromatogram were identified by comparing of the retention time and spectra of standard with those in the sample .

2-6: Bioconcentration Factor(BCF) and Biosediment Accumulation factor (BSAF)

Accumulation factor were calculated according to EPA, 2000 as follows:

$BCF = \text{con. of PAH in organism (ng/gDW)} / \text{con. in Water } (\mu\text{g/l})$

$BSAF = \text{con. in } \underline{\text{organism (ng/g)}} / \underline{\text{Lipid content (ng/g)}}$

$\text{Con. in Sediment (ng/g)} / \text{TOC (ng/g)}$

2-7: Statistical analysis

The results were statistically analysed according to the statistical program (SPSS) .All data were treated with the analysis of variance (ANOVA) to detect the variations of different variables at sites and sampling time. The mean, standard deviation and the significance at the probability (99%) of each data were calculated .Also the values of correlation coefficient were calculated to show the correlation among different variables under the study.

Chapter Three

3- Results

3-1: Physical and chemical properties

Different physico-chemical properties of water samples were studied and the figure from(2-20) show monthly variation of these properties, while(index1/table1) and(index1/table2)explain the significancy in the term of F concentration from table of variance analysis and correlatioon coefficient among different properties respectively.

3-1-1: Air &water temperature

In general, July 2005 was the hottest month while December 2005 was the coldest during the period of the study. The maximum air temperature(39C°) was recorded during July 2005 at site 5, while minimum air temp. (13C°) was during December at site 2. The lowest surface water temperature (15C°) was recorded in December at site 1, 2 and 3 and in January 2006 at site 2, whereas the highest value(35C°) was recorded in July, August 2005 and June 2006 at site 5. The results of statistical analysis show the significant differences ($P<0.01$) in the concentration of Air and water temperature between the study months with positive correlation between air and water temperature ($r=0.973$, $P<0.01$).

3-1-2: Water Flow

The concentration of water flow were ranged between 4cm/Second in January 2004 at site 5 and 13.33cm/second in March 2006 at site 2 and site 3. Statistical analysis shows significant differences among the months ($P<0.01$). Water flow was postively correlated with EC ($r=0.444$, $P<0.01$), Total alkalinity ($r=0.401$, $P<0.01$) and total nitrogen ($r=0.340$, $P<0.01$).

3-1-3: Water pH

In Euphrates river, the pH concentration were fluctuated between (6.66 and 8.6) at site 5 during September 2005 and December 2005

respectively. A significant differences ($P<0.01$) were recorded among the study months with no significant differences among the sites. Negative correlation was observed between water pH and each of Air temperature ($r=-0.391$, $p<0.01$) and water temperature ($r=-0.424$, $P=0.01$)

3-1-4: Electrical Conductivity (EC)

The lowest and highest concentration of EC ($423.66\mu\text{S}/\text{cm}$) and ($998.66\mu\text{S}/\text{cm}$) were recorded in May 2006 and November 2005 at site 1 respectively. Fluctuations in EC concentration were significant among the study months ($P<0.01$) and negative correlation was recorded for EC with air temperature ($r=-0.412$, $P<0.01$) and water temperature ($r=-0.376$, $P<0.01$) and water flow ($r=-0.444$, $P<0.01$).

3-1-5: Salinity (S‰)

Salinity concentration were ranged between 0.2573‰ during May 2006 and 0.619‰ during November 2005 at site 1 with significant differences among the study months.

3-1-6: Dissolved Oxygen (DO)

At Euphrates river sites, the maximum dissolved oxygen concentration ($13.33\text{mg}/\text{l}$) was obtained at site 5 during September 2005 and the minimum concentration ($5.1\text{mg}/\text{l}$) was measured at site 3 during May 2006. Statistical analysis results show significant differences in the concentrations of DO among the study months with no significant differences among the sites.

3-1-7: Biological Oxygen Demand (BOD₅)

The lowest and highest concentrations were $1.43\text{mg}/\text{l}$ recorded during January 2005 at site 3 and $7.133\text{mg}/\text{l}$ in May 2006 at site 2 respectively. The changes in BOD₅ concentrations were significant among the months ($P<0.01$) and not significant among the sites. Positive correlation was recorded between BOD₅ and water temperature ($r=0.332$, $P<0.01$)

3-1-8: Total Alkalinity

The total alkalinity concentration were ranged between (74.6mg/l to 17533mg/l) recorded in January 2006 at site 4 and in April 2006 at site 2 respectively. The change in total Alkalinity concentrations were significant among sites and study months. Positive correlation was recorded between total alkalinity and water flow ($r=0.401$, $P<0.01$), while negative correlation recorded with EC ($r= -0.399$, $P<0.01$) and DO ($r= -0.342$, $P<0.01$).

3-1-9: Total Hardness

The total hardness concentration were ranged between (292.98mg/l.) to (693.3mg/l) recorded in April 2006 at site 2 and November 2005 at site 5 respectively. The fluctuation in Total hardness concentration were significant among sites and study months($P<0.01$).

3-1-10: Calcium and Magnesium

The lowest & highest concentrations of calcium ion were 55.3mg/l 2006 and 149.629 mg/l recorded at site 2 during January 2006 and August 2005 respectively. The change in calcium concentrations were significant among the study months and sites. Positive correlation was recorded for calcium ion with air temperature ($r=0.492$, $P<0.01$), water temperature ($r=0.573$, $P<0.01$) and total hardness ($r= 0.375$, $P<0.01$).

Magnesium concentration was ranged between (25.37 – 119.48 mg/l) recorded in February 2006 and November 2005 at site (5) respectively. Significant differences were recorded among the study months. Positive correlation was recorded for magnesium with total hardness ($r=0.664$, $P<0.01$).

3-1 -11: Total Suspended Solids (TSS)

The TSS concentration recorded during the study period were ranged between (11.4-204.5 mg/l).The lower concentration was recorded at site 5 during February 2006, while highest concentration recorded in November 2006 at site 4. Significant differences were observed among sites and study

months. Positive correlation was recorded for TSS with air temperature ($r=0.482, P<0.01$) and water temperature ($r=0.459, P<0.01$).

3-1-12: Total Dissolved Solids (TDS)

The lowest concentration of TDS (170.6mg/l) was recorded in November 2005 at site 5, whereas the highest level (5885mg/l) was observed in August 2005 at site 2. Significant differences were recorded among sites and study months ($P<0.01$).

3-1-13: Sulphate ion

Sulphate ion concentrations were fluctuated between 68.88mg/l. and 682 mg/l. in May 2006 at site 1 and in October 2005 at site 5 respectively. The changes in concentrations were not significant among sites, whereas significant among the study months ($P<0.01$).

3-1-14: Chloride ion

The lowest concentration of chloride (54.65mg/l) was recorded in November 2005 at site 1, while the highest value (145.95mg/l) was observed in April 2006 at site 5. It is clear from the statistical analysis that significant differences were found among the sites and study months. Positive correlation was recorded for chloride with dissolved oxygen ($r=0.234, P<0.01$).

3-1-15: Total Phosphorous

The total phosphorous concentrations were fluctuated between (0.001-0.06 mg/l) in November 2005 at site 5 and in August 2005 at site 4 respectively. The results of statistical analysis showed significant differences among months ($P<0.01$) and not significant among the sites.

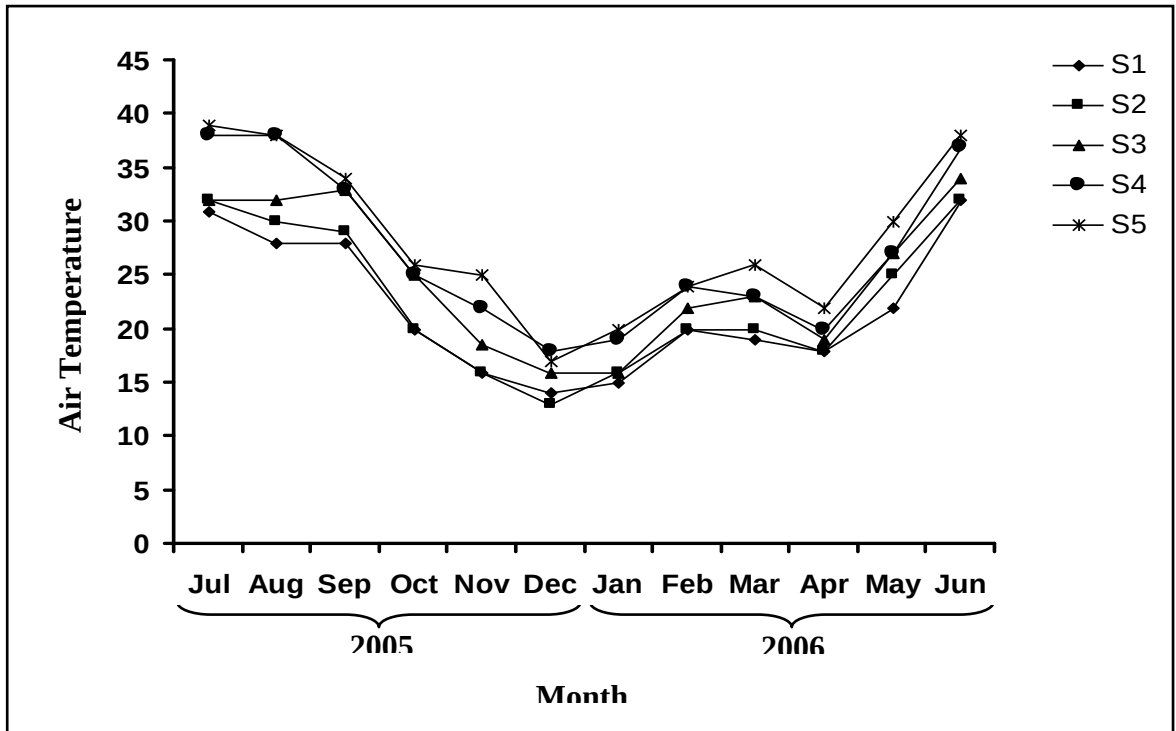
3-1-16: Total Nitrogen

The lowest and highest total nitrogen concentrations were (0.015mg/l.) recorded in November 2005 at site 1 and (1.32mg/l) in Feb. 2006 at site 4 respectively. Statistical analysis results showed significant differences among the study months ($P<0.01$). Positive correlation was

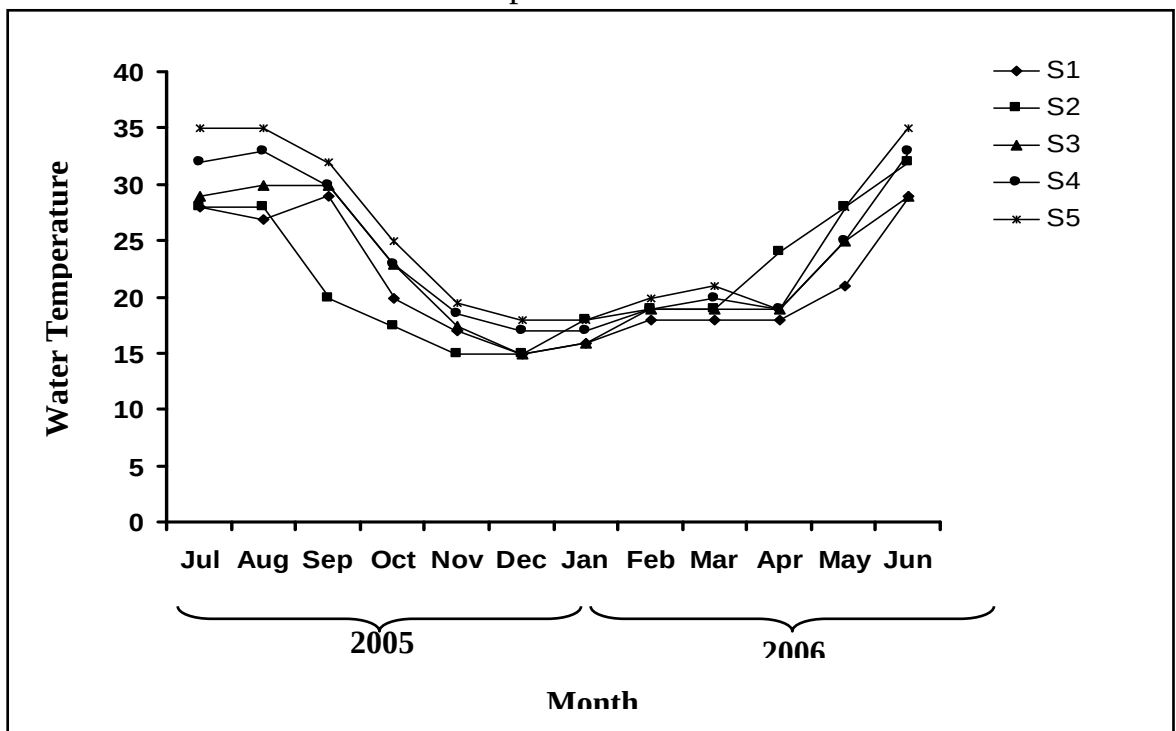
recorded for Total nitrogen with water flow($r=0.340, P<0.01$) and sulphate ion($r=0.457, P<0.01$), while negative correlation was observed with EC($r=-0.344, P<0.01$) and calcium ion($r=-0.352, P<0.01$).

3-1-17: Total Nitrogen: Total phosphorous ratios (TN/TP)

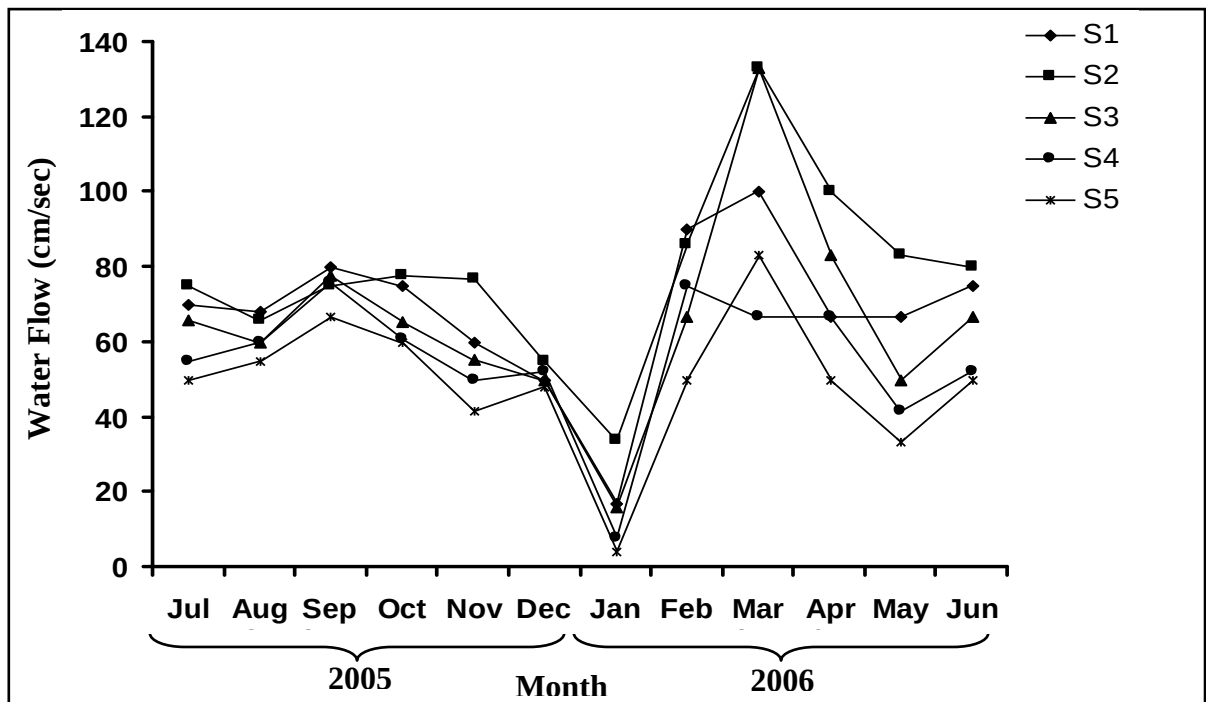
The TN: TP ratios were ranged between (1.15:1-332.7:1) at site 4 and site 2 during August 2005 and October 2005 respectively. Different ratios were recorded during the study period and most of them referred to phosphorous as limiting factor for algae growth with exception in some period which is less than 9:1 referred to nitrogen as limiting factor.



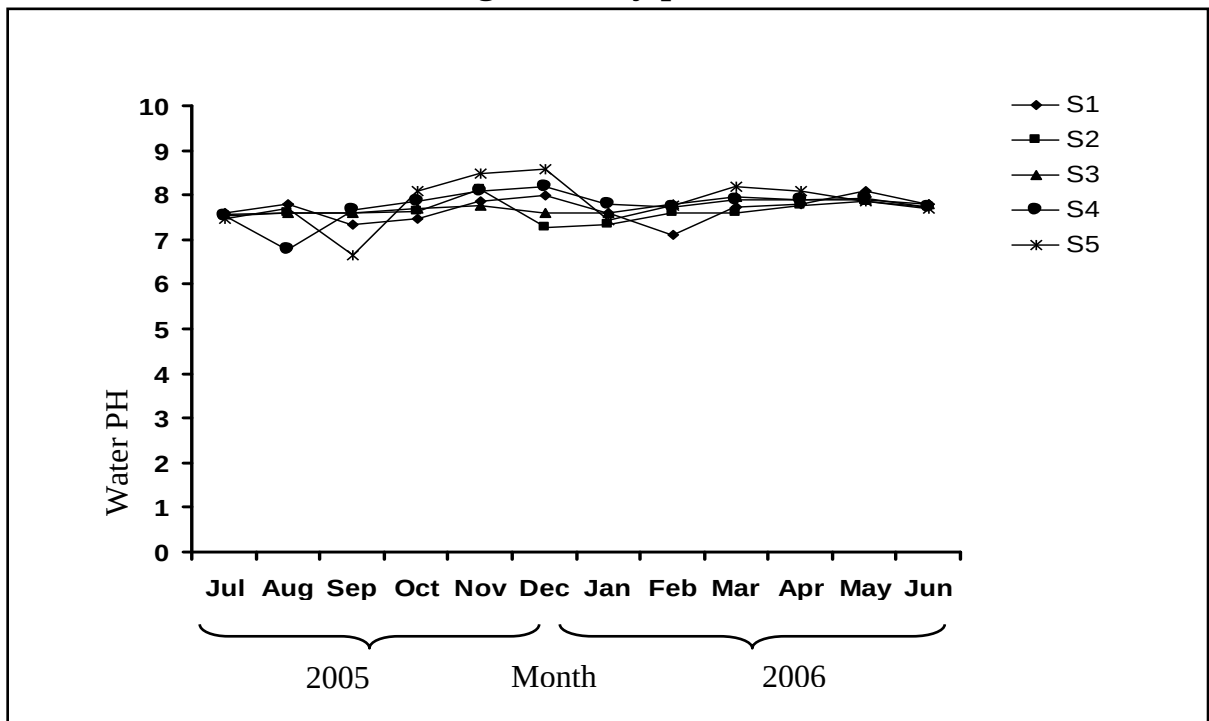
Figure(2) Air temperature recorded in Euphrates river sites during the study period



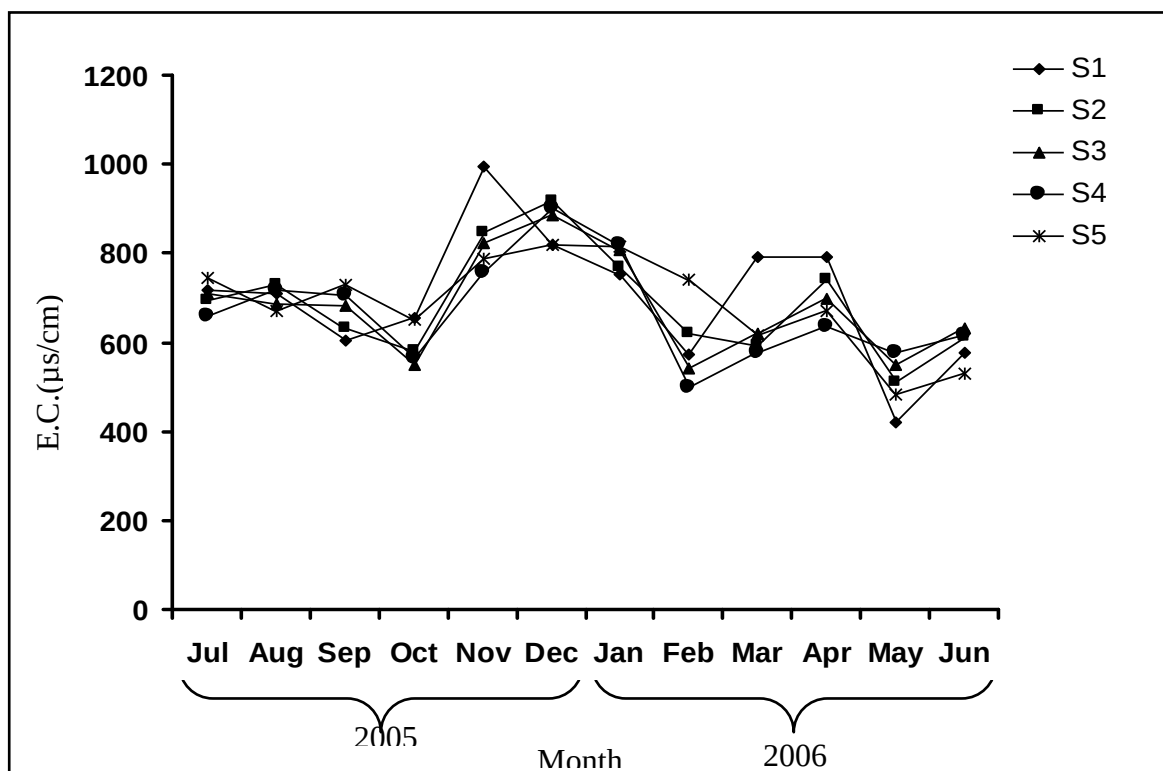
Figure(3): water temperature recorded in Euphrates river sites During the study period



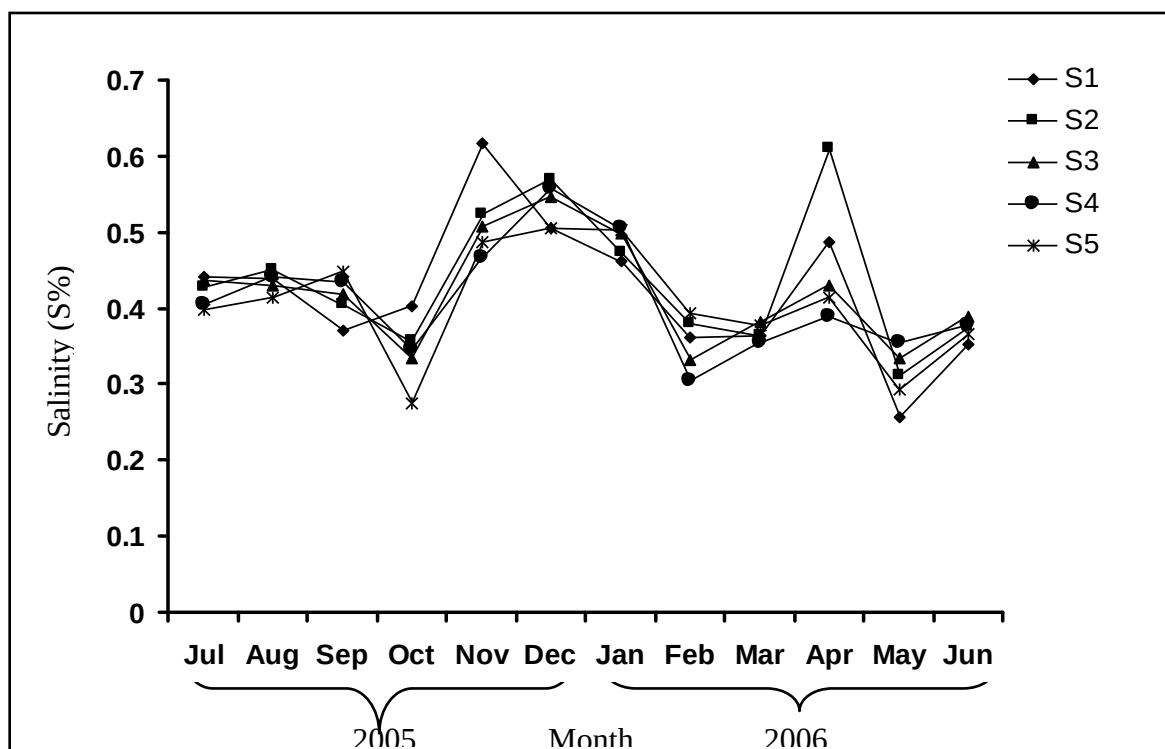
Figure(4):Water flow(cm/Second) recorded in Euphrates river sites during the study period.



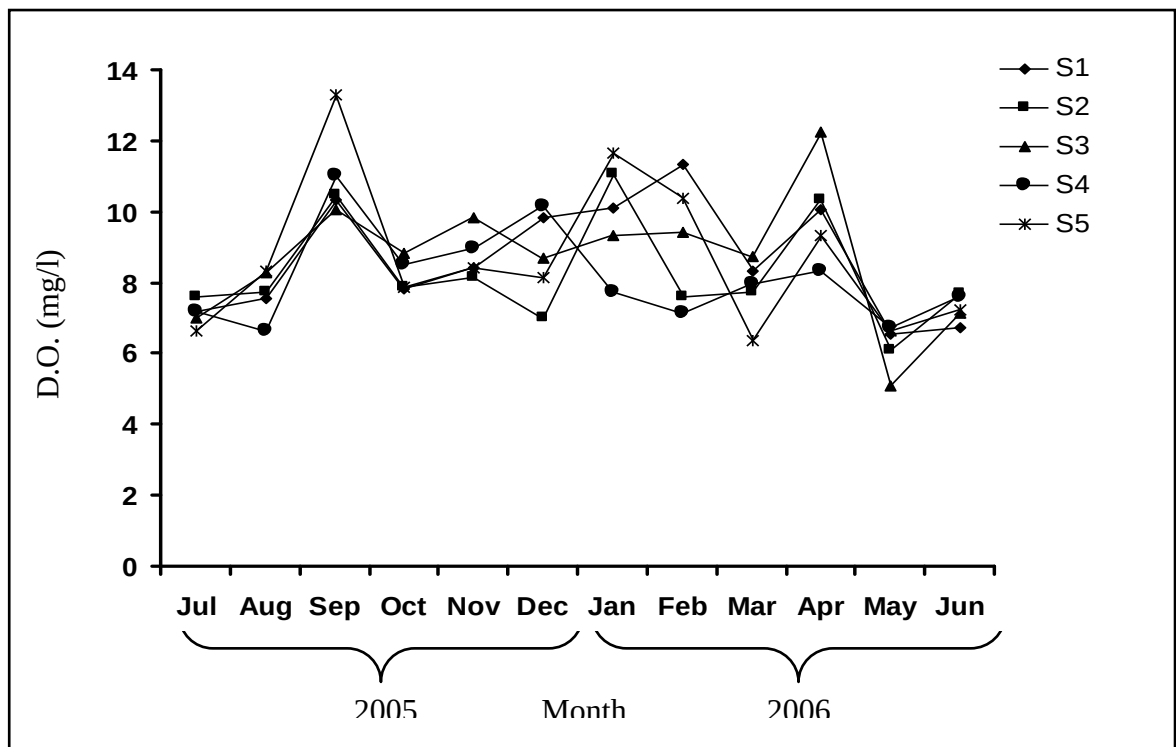
Figure(5):Water pH recorded in Euphrates river sites during the study period



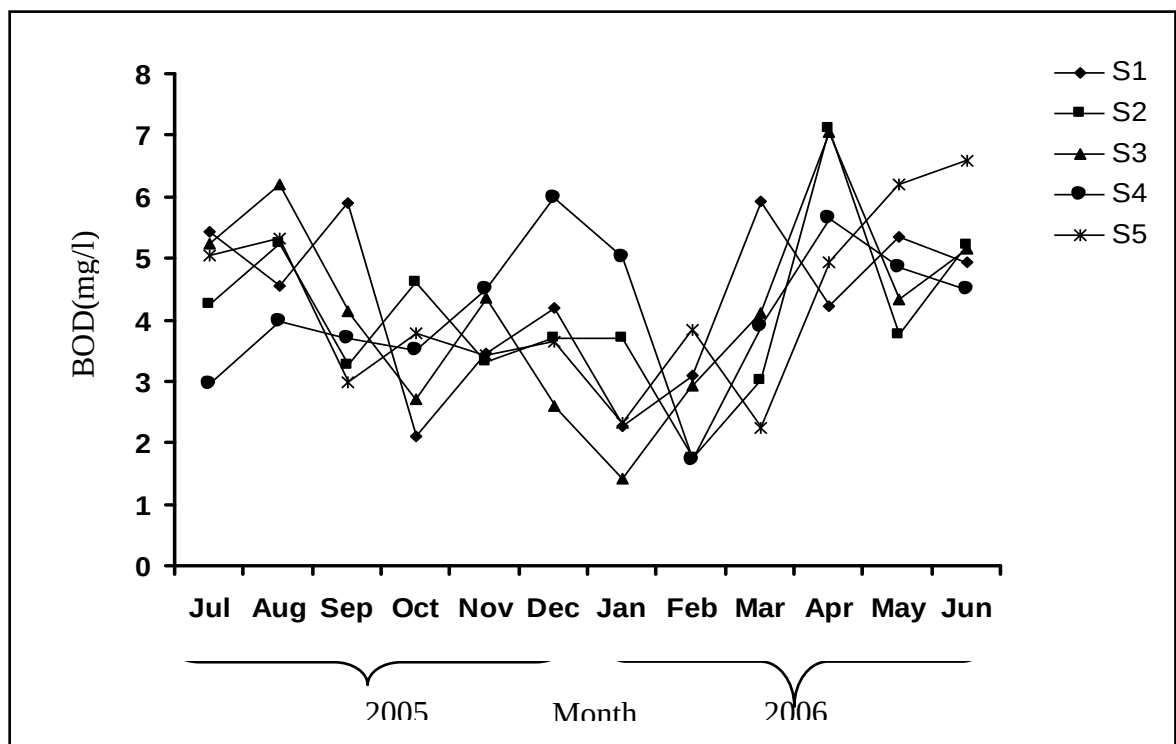
Figure(6):Electrical conductivity EC($\mu\text{s}/\text{cm}$) recorded in Euphrates river sites during the study period



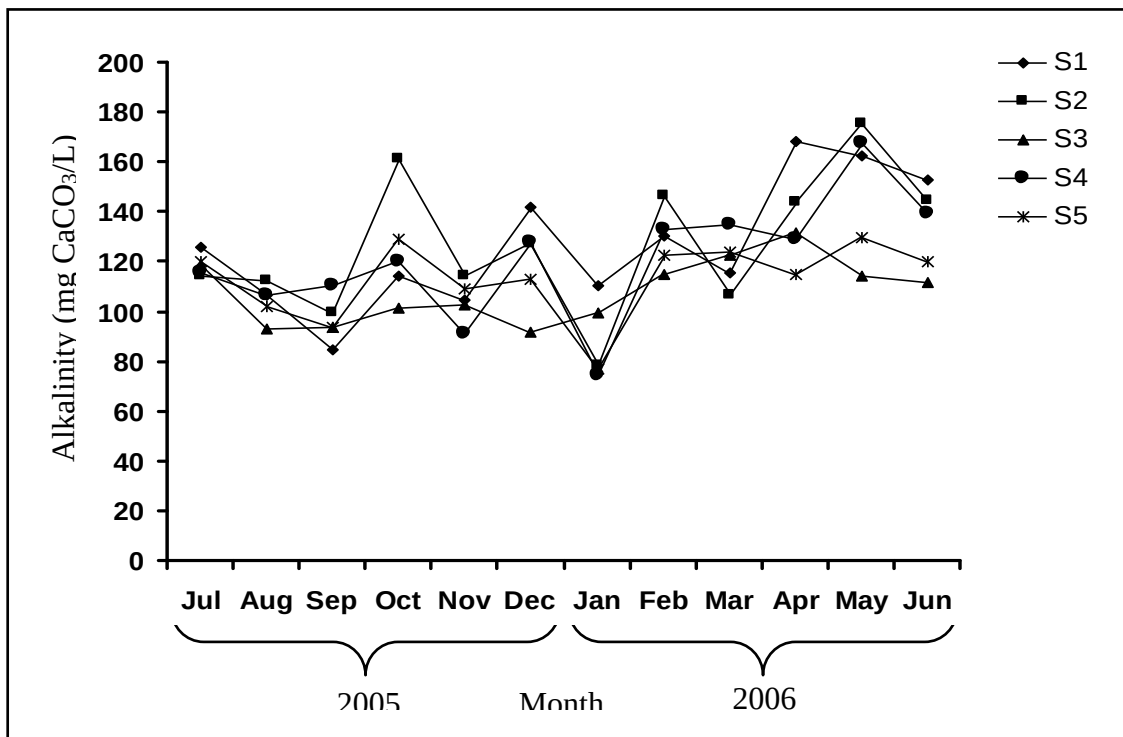
Figure(7):Salinity(S%) recorded in Euphrates river sites during the study period



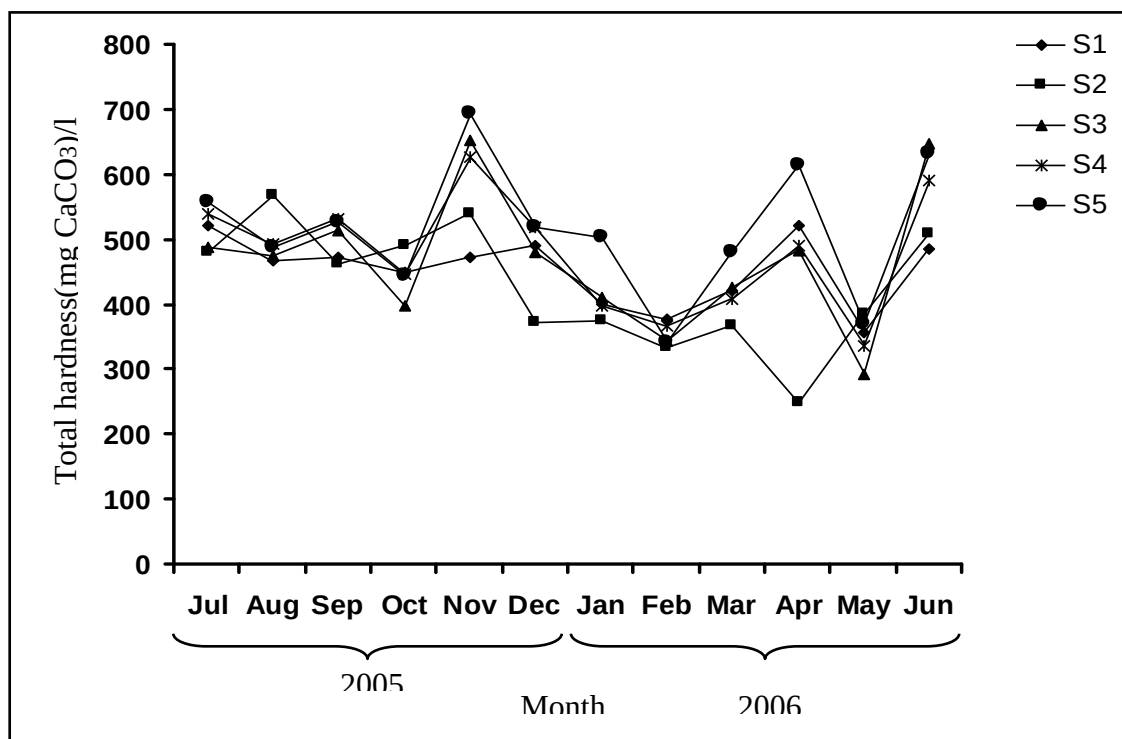
Figure(8):Dissolved Oxygen DO(mg/l) recorded in Euphrates river sites the study period



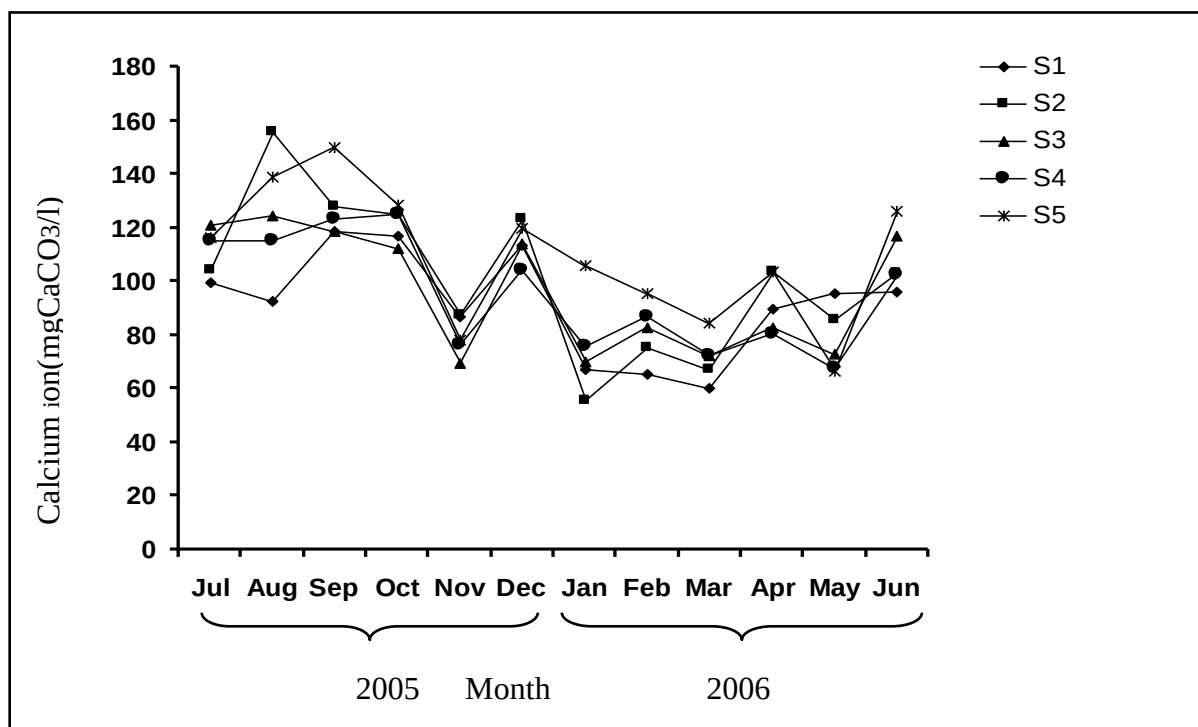
Figure(9):Biological Oxygen Demand BOD(mg/l) recorded in Euphrates river sites during the study period



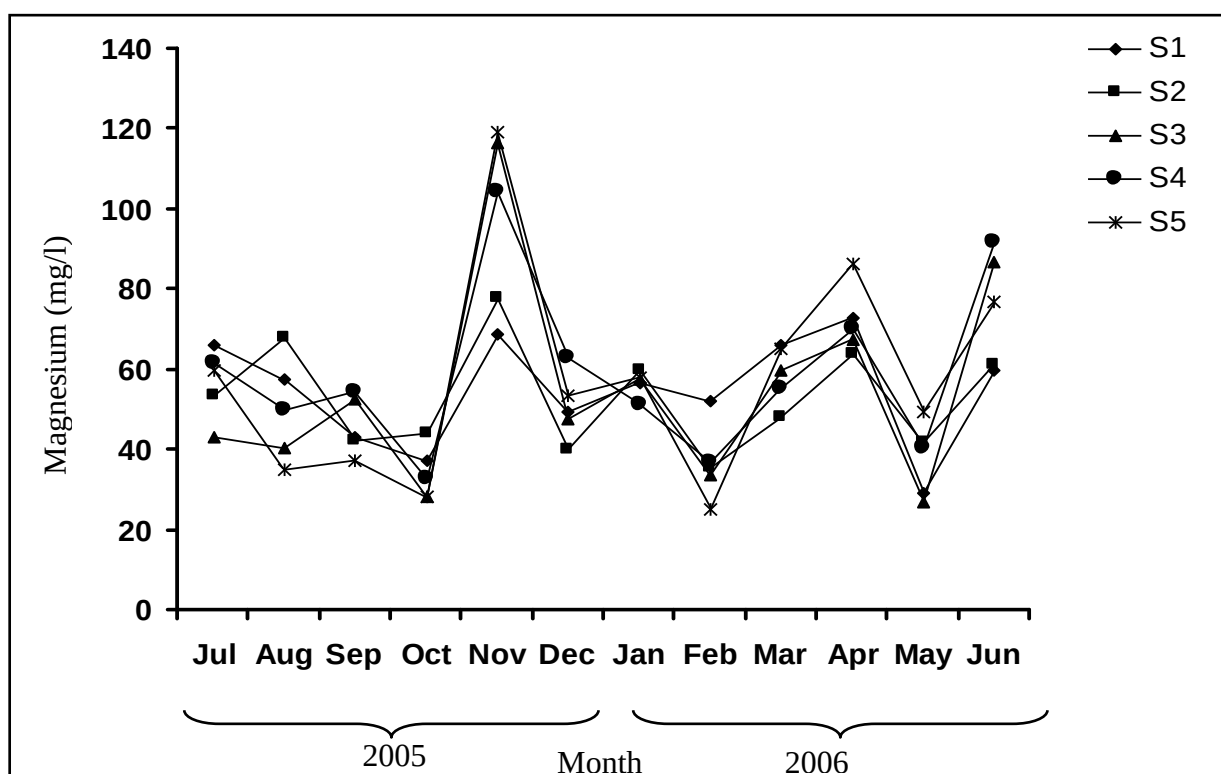
Figure(10):Total alkalinity(mgCaCO₃/l.)recorded in Euphrates river sites during the study period.



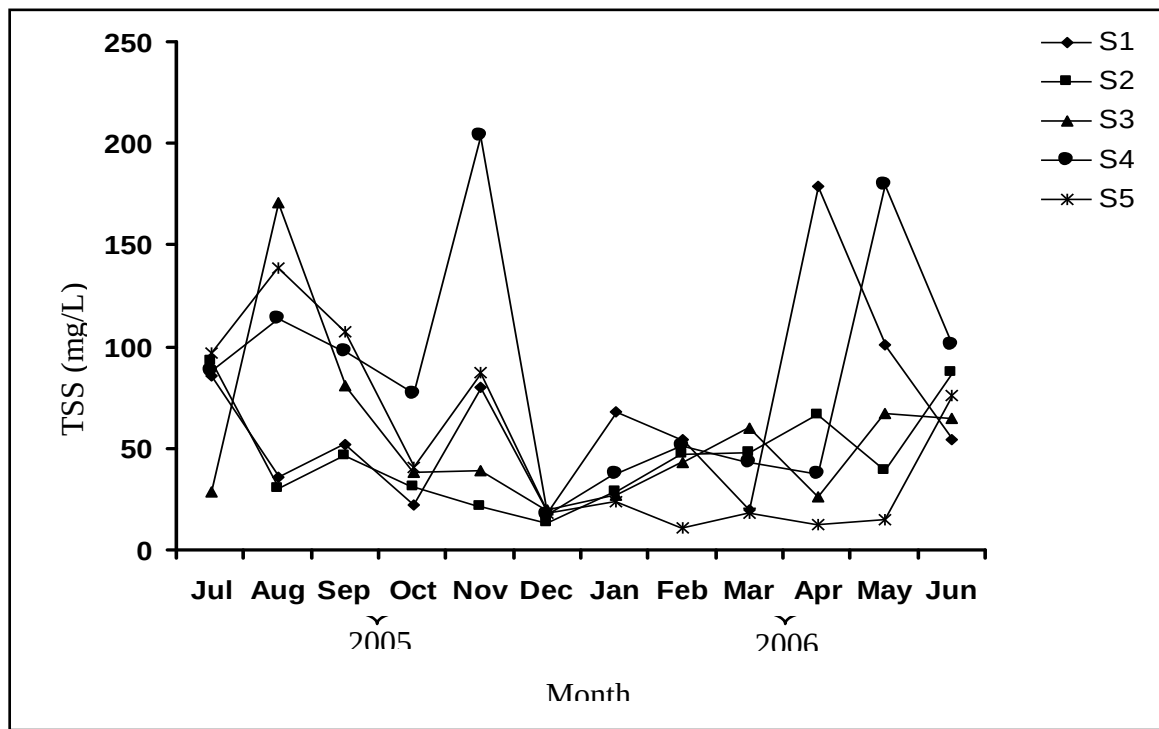
Figure(11):Total hardness(mg CaCO₃/l) recorded in Euphrates river sites during the study period.



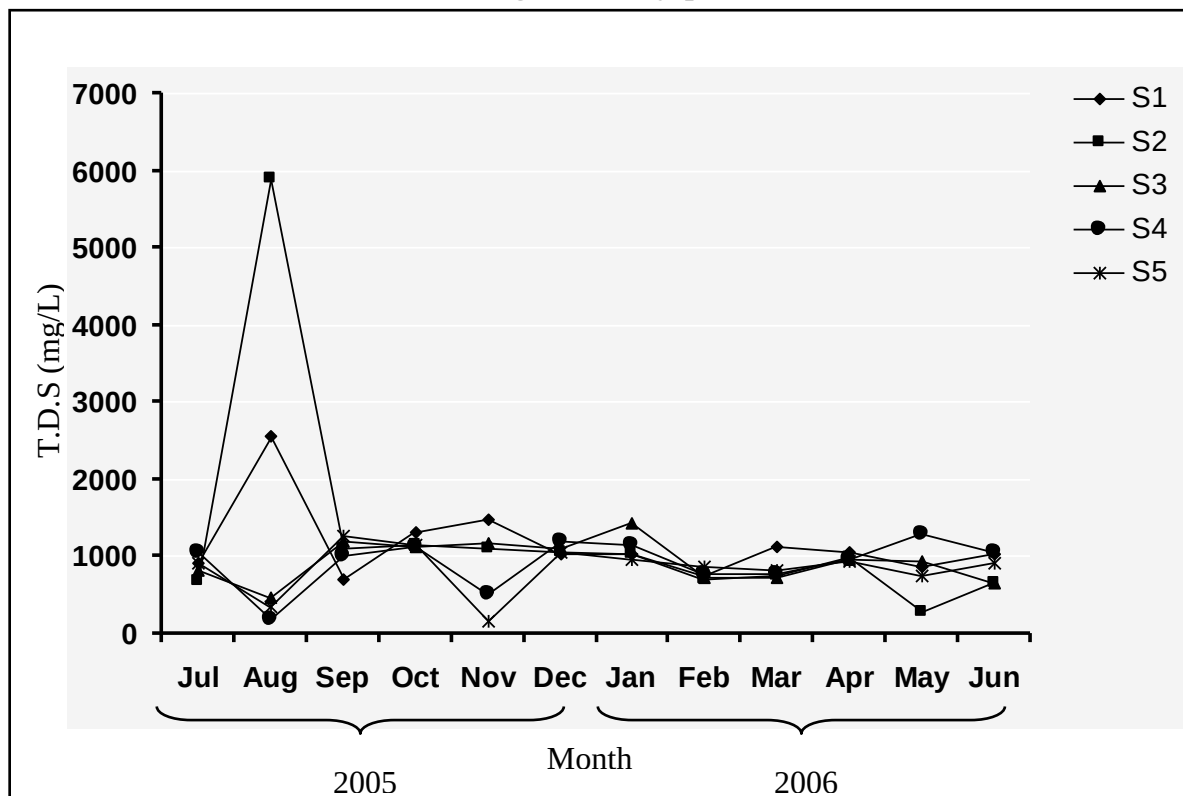
Figure(12):Calcium concentration (mgCaCO₃/l)recorded in Euphrates river sites during the study period



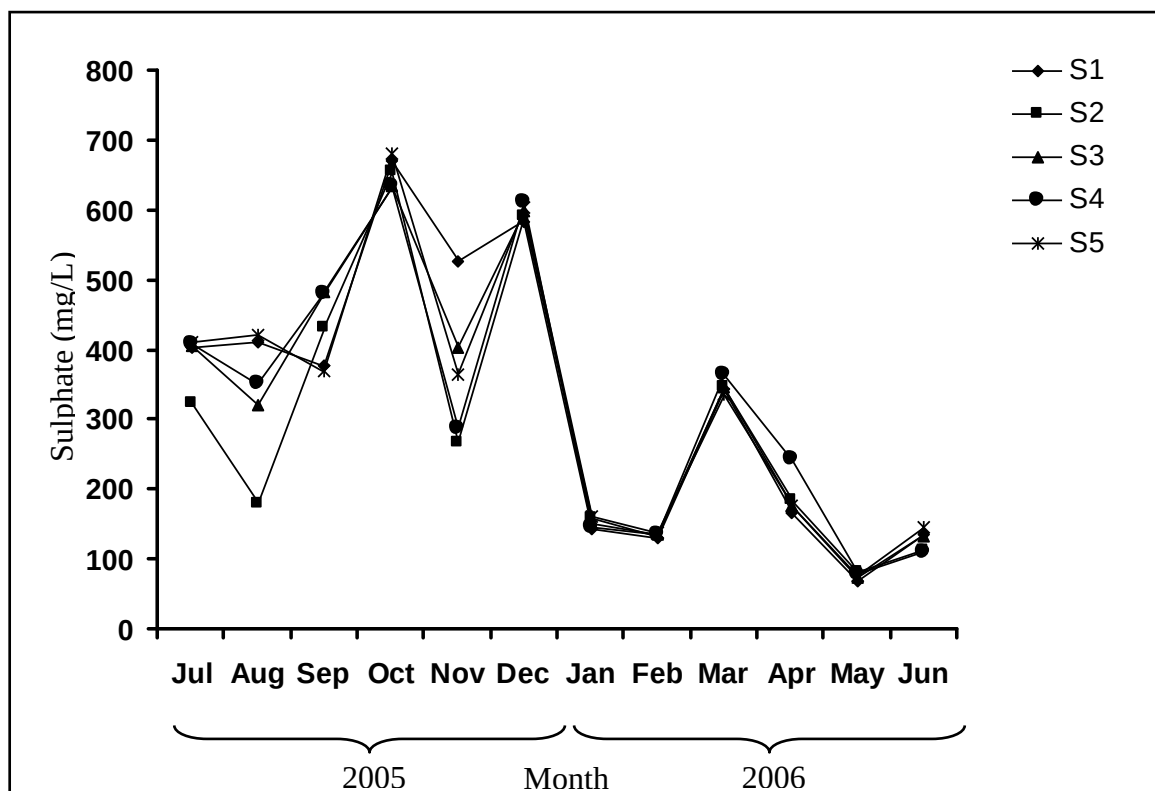
Figure(13):Magnesium concentration (mgCaCO₃/l)in Euphrates river sites during the study period.



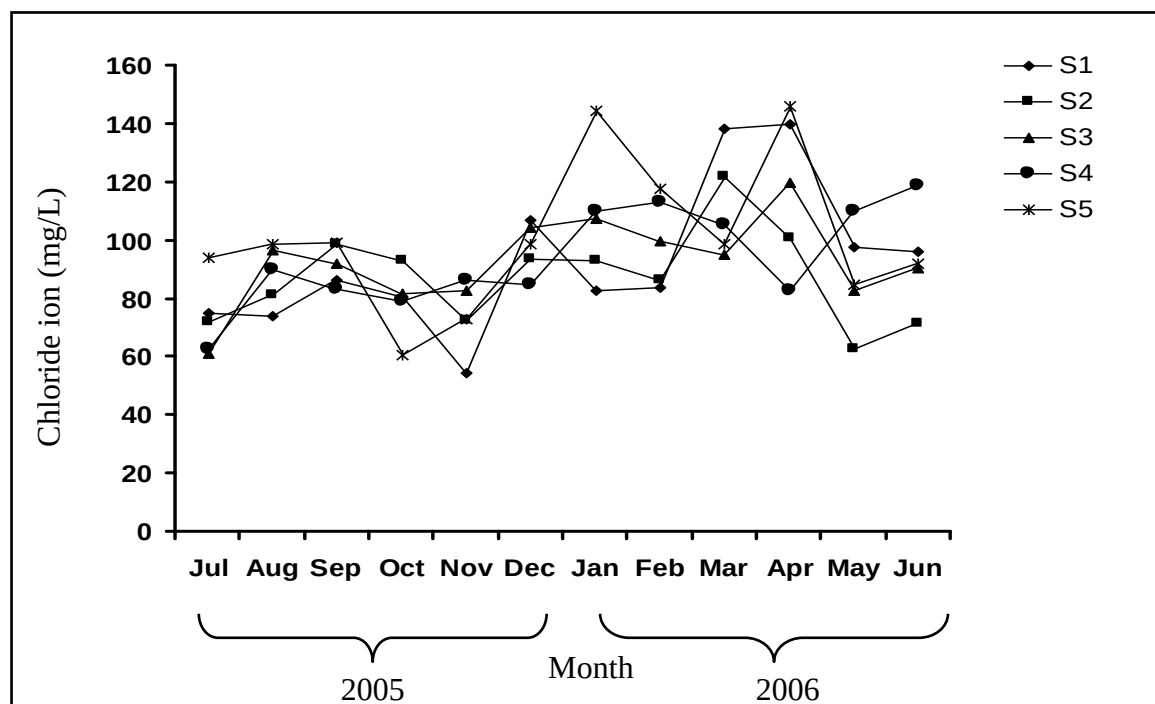
Figure(14):Total Suspended Solids(TSS) recorded in Euphrates river sites during the study period



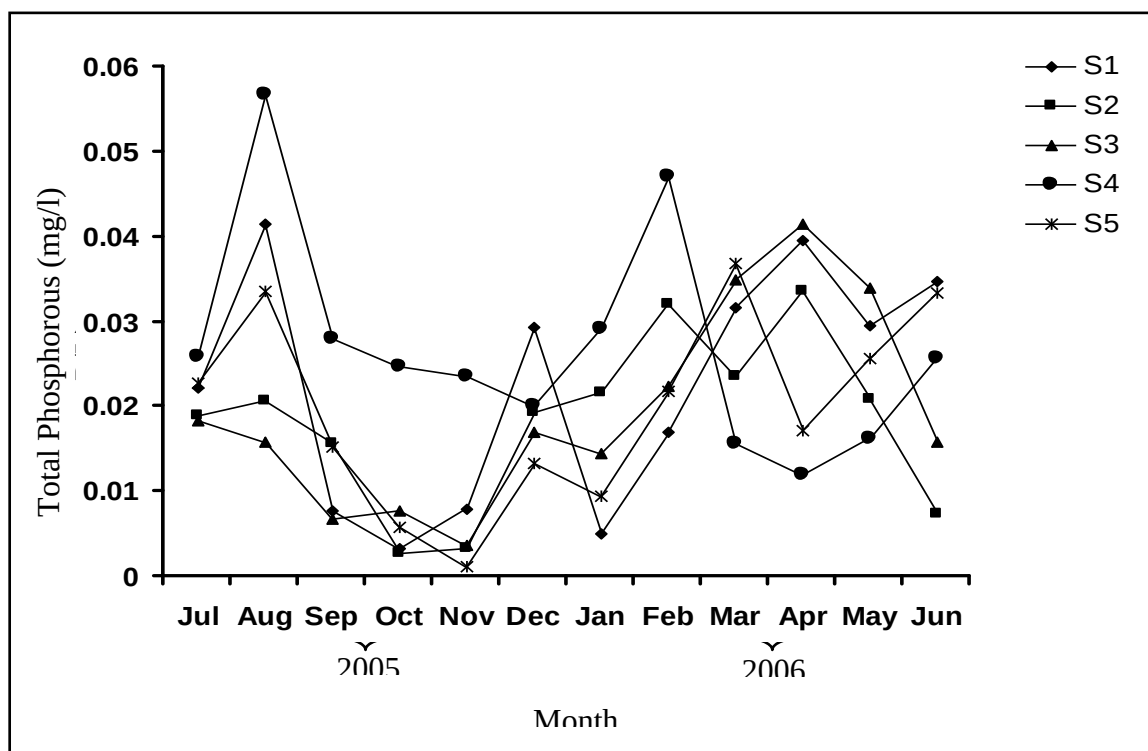
Figure(15):Total Dissolved Solids(TDS) recorded during the study period



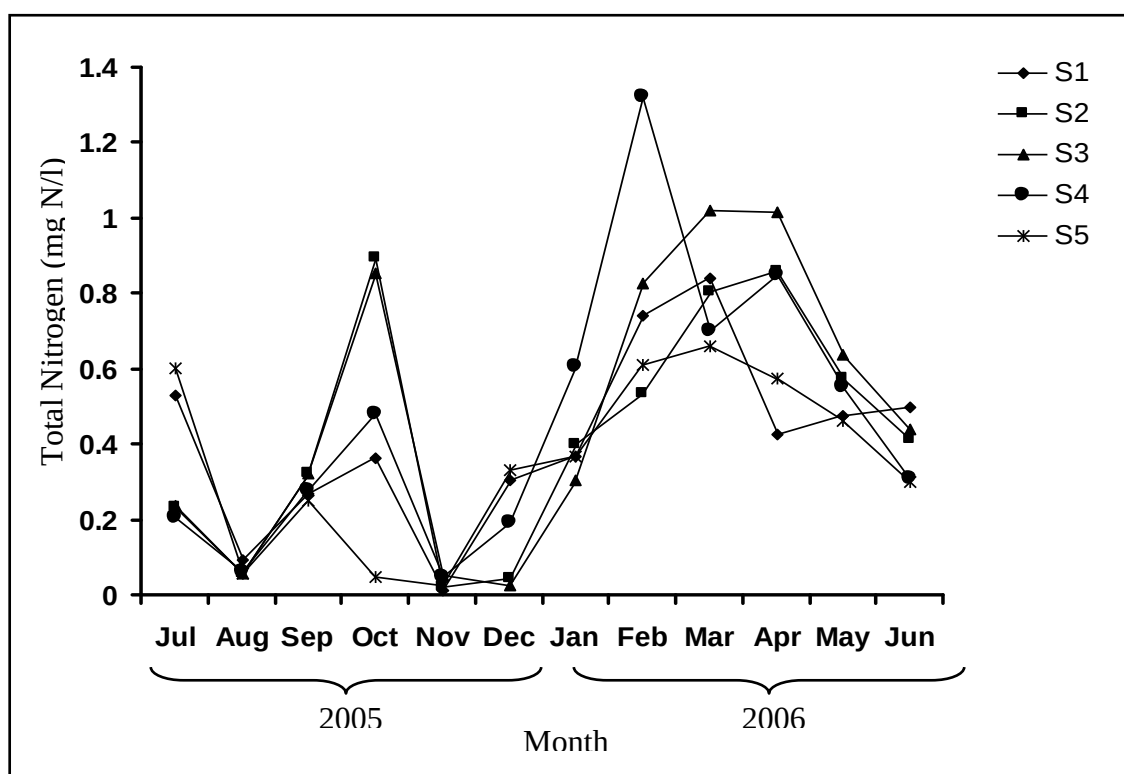
Figure(16):Sulphate concentration (mg/l) recorded in Euphrates river sites during the study period



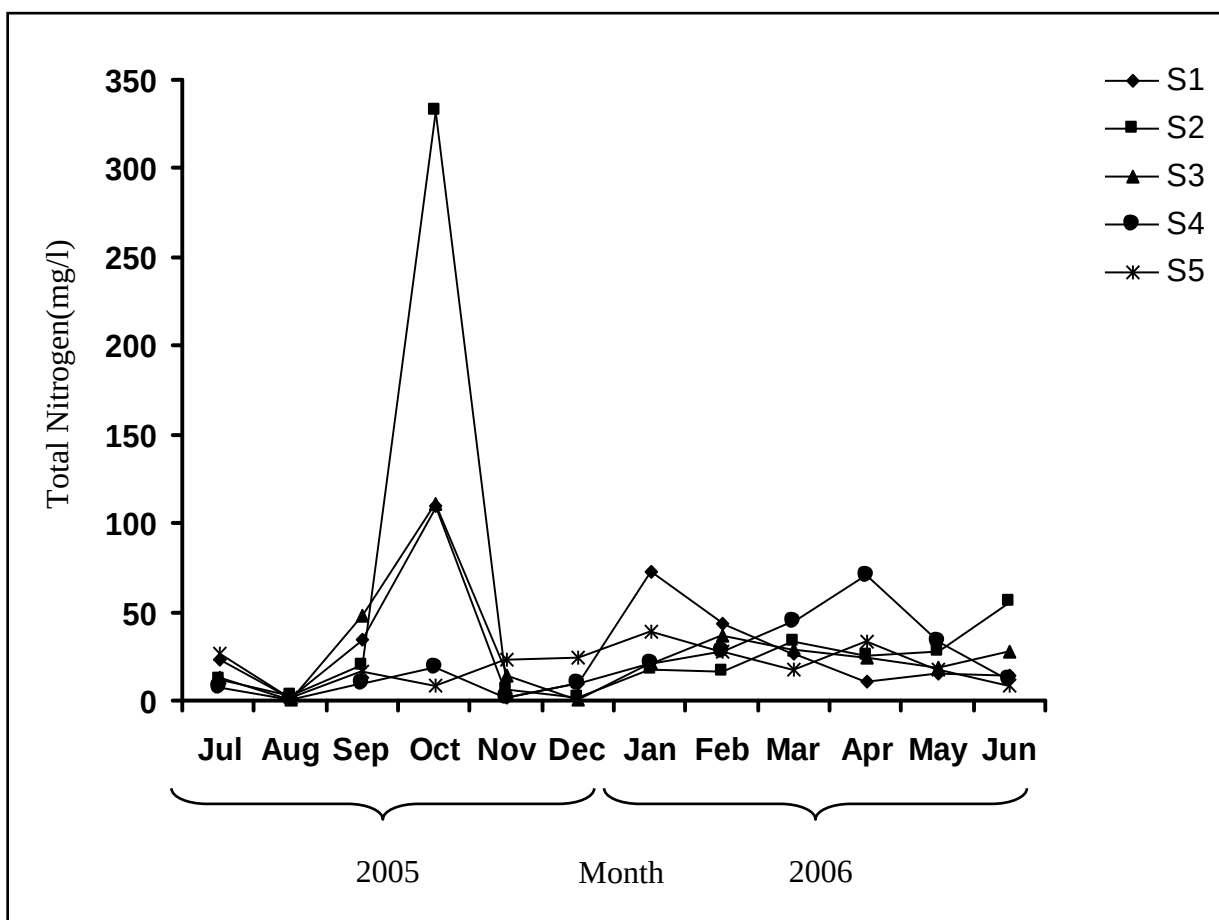
Figure(17):Chloride ion(mg/l) recorded in Euphrates river sites during the study period



Figure(18):Total phosphorous (mg/l) recorded in Euphrates river during the study period



Figure(19):Total nitrogen(mg/l) recorded in Euphrates river during the study period



Figure(20):Total phosphorous/Total nitrogen(TP/TN) recorded in Euphrates river during the study period

Table (4):The range and Mean $\pm$ S.D. of some phsico-chemical properties of water samples of Euphrates river sites during the study period(Jul.2005 –Jun.2006).

Properties	Site(1)	Site(2)	Site(3)	Site(4)	Site(5)
Air temperature	14-32 21.92 $\pm$ 6.29	13-32 22.58 $\pm$ 6.73	16-34 24.79 $\pm$ 6.74	18-38 27.17 $\pm$ 7.39	17-39 25.75 $\pm$ 11.26
Water temperature	15-29 21.08 $\pm$ 5.04	15-28 19.13 $\pm$ 7.42	15-30 22.63 $\pm$ 5.75	17-33 23.88 $\pm$ 6.45	18-35 25.46 $\pm$ 7.14
Water flow	17-100 68.2 $\pm$ 20.77	34-133.3 78.52 $\pm$ 23.78	16-133.3 65.9 $\pm$ 27.19	8-76 55.32 $\pm$ 18.04	4-83.3 49.33 $\pm$ 18.38
Water pH	7.14-8.1 7.69 $\pm$ 0.27	7.35-8.3 7.74 $\pm$ 0.26	7.58-7.96 7.74 $\pm$ 0.14	6.8-8.2 7.77 $\pm$ 0.35	6.66-8.6 7.85 $\pm$ 0.52
Electrical conductivity	423.66-998.66 685.85 $\pm$ 148.63	513.33-919.33 689.26 $\pm$ 118.3	543.3-886.0 683.4 $\pm$ 112.77	500-903.33 671 $\pm$ 116.4	485.0-816.66 681.63 $\pm$ 105.9
Salinity	0.26-0.62 0.42 $\pm$ 0.09	0.31-0.61 0.44 $\pm$ 0.09	0.33-0.55 0.42 $\pm$ 0.07	0.31-0.56 0.41 $\pm$ 0.07	0.28-0.51 0.41 $\pm$ 0.08
Dissolved Oxygen	6.56-11.36 8.7 $\pm$ 1.59	6.13-11.01 8.3 $\pm$ 1.52	5.10-12.26 8.74 $\pm$ 1.78	6.66-11.03 8.18 $\pm$ 1.34	6.37-13.33 8.7 $\pm$ 2.11
BOD₅	2.13-5.93 4.3 $\pm$ 1.32	1.76-7.13 4.09 $\pm$ 1.36	1.43-7.06 4.5 $\pm$ 1.61	1.73-6 4.2 $\pm$ 1.17	2.26-6.6 4.21 $\pm$ 6.6
Total alkalinity	84.66-168.66 126.69 $\pm$ 25.53	78.66-175.33 127.21 $\pm$ 27.78	92-132 108.22 $\pm$ 12.87	74.6-139.33 121.05 $\pm$ 24.11	77.33-130 113.11 $\pm$ 15.5
Total hardness	358.39-523.2 453.7 $\pm$ 53.35	334-568 453.28 $\pm$ 80.11	292.98-653.3 468.39 $\pm$ 106.67	336.15-626.6 479.75 $\pm$ 89.63	342.72-693.3 513 $\pm$ 101.79
Calsium ion	60.39-118.63 91.7819.6	55.3-155.96 97.85 $\pm$ 23.75	69.47-124.51 96.42 $\pm$ 22.93	67.62-125.05 95.38 $\pm$ 21.08	66.57-149.63 109.47 $\pm$ 25.19
Magnesium ion	29.21-72.73 54.95 $\pm$ 13.27	35.57-78.02 52.84 $\pm$ 13.03	26.97-116.58 55.07 $\pm$ 25.87	32.84-104.26 59.4 $\pm$ 21.23	25.37-119.48 57.96 $\pm$ 26.98
Total suspended solid	18.26-179.6 64.65 $\pm$ 44.9	13.7-93 46.34 $\pm$ 24.82	20-171.4 55.78 $\pm$ 41.16	18-204.5 87.68 $\pm$ 57.43	11.4-139 54.2 $\pm$ 44.96
Total dissolved solid	709.3-2565 1155.8 $\pm$ 494	272.8-5885 1286 $\pm$ 1471.3	469.3-1430.8 945.78 $\pm$ 275.95	177.3-1300 923.25 $\pm$ 319.25	170.6-1266 843.8 $\pm$ 310.46
Sulphate ion	54.65-139.95 93.1 $\pm$ 25.29	62.65-121.96 87.35 $\pm$ 16.44	60.99-119.96 82.89 $\pm$ 18.34	93.79-17.14 93.79 $\pm$ 17.14	60.71-145.95 100.69 $\pm$ 25.25
Chloride ion	54.65-139.95 93.1 $\pm$ 25.29	62.65-121.96 87.35 $\pm$ 16.44	60.99-119.96 82.89 $\pm$ 18.34	62.65-118.62 93.79 $\pm$ 17.14	60.71-145.95 100.69 $\pm$ 25.25
Total phosphorous (TP)	0.003-0.04 0.022 $\pm$ 0.014	0.003-0.034 0.018 $\pm$ 0.01	0.004-0.042 0.02 $\pm$ 0.012	0.012-0.057 0.02 $\pm$ 0.013	0.001-0.04 0.02 $\pm$ 0.011
Total nitrogen (TN)	0.02-0.84 0.41 $\pm$ 0.24	0.023-0.90 0.43 $\pm$ 0.31	0.03-1.02 0.48 $\pm$ 0.38	0.05-1.32 0.42 $\pm$ 0.38	0.03-0.66 0.36 $\pm$ 0.23
TN/TP	1.9-110.6 30.73 $\pm$ 32.17	2.34-332.6 46.36 $\pm$ 91.35	1.48-111.6 29.25 $\pm$ 28.98	1.15-71.43 21.48 $\pm$ 19.96	1.76-39.36 20.66 $\pm$ 10.87

3-2:Qualitative and quantitative of phytoplankton

Table(5) shows that the number of phytoplankton belongs to taxa detected at river sites during the study period. Index(2)/table(1) shows the significance for phytoplankton taxa number among sites and seasons, while the index(2)/tables(2-6) explain the composition species of phytoplankton recorded during the study period.

A total of 145 taxa were identified in the samples collected during the study period. They belong to the classes, Bacillariophyceae(94taxa), Chlorophyceae(25taxa), Cyanophyceae(20 taxa), Euglenophyceae(2 taxa), Chrysophyceae(3taxa) and (1 taxa) for Xanthophyceae. Diatom found to be the most abundant group(65 % of the total taxa). This abundance was most pronounced in the term of cell numbers reaching 80.61 % of the total number followed by Chlorophyceae(11.7%), Cyanophyceae(4.95%), Xanthophyceae(1.45%), Euglenophyceae(0.79%) and Chrysophyceae (0.04%). Site 4 was distinguished by the high number of taxa (109 taxa) of which 70 taxa belong to Bacillariophyceae, 19 taxa belong to Chlorophyceae, (15taxa) to Cyanophyceae, (2taxa) to Euglenophyceae, 2taxa to Chrysophyceae and 1taxa to Xanthophyceae. At site 2, also a total of 109 taxa were observed followed by 91 taxa recorded at site 3 and 91 taxa at site 5. However the low number of taxa (88) was recorded at site. The 53 taxa was shared among the sites, in Bacillariophyceae(34taxa), in Chlorophyceae(8 taxa), in Cyanophyceae (7 taxa) and (2 taxa) in Euglenophyceae, 1taxa in Chrysophyceae and 1taxa in Xanthophyceae.

The community genera at all sites were, in Cyanophyceae, *Oscillatoria sp*, in Chlorophyceae, *Chlamydomonas sp* and *Chlorella sp*, in Bacillariophyceae, *Cyclotella ocellata* and *Cocconies placentula* and in Euglenophyceae *Euglena sp* and *Facus sp*. The quantitative study showed remarkable seasonal variation in the total number of phytoplankton population. The higher number of the total phytoplankton population

($3492 \times 10^3 \text{ cell/l}$) was recorded at site 4 during November 2005 while the lower number ($207 \times 10^3 \text{ cell/l}$) was observed at site 5 during June 2005. The total counts of phytoplankton population were ranged between 1042×10^3 - $3108 \times 10^3 \text{ cell/l}$ at site 1 during December 2005 and October 2005 respectively, (347×10^3 - $3015 \times 10^3 \text{ cell/l}$) at sit 2 during January 2006 and November 2005 respectively, (751×10^3 - $2838 \times 10^3 \text{ cell/l}$) at site 3 during February 2006 and November 2005 respectively and (623×10^3 - $3492 \times 10^3 \text{ cell/l}$) at site 4 during January 2006 and November 2005 respectively. The number of phytoplanktons of (207×10^3 - $1857 \times 10^3 \text{ cell/l}$) were recorded at site 5 during June 2005 and October 2005 respectively. The number of diatoms was ranged between (41×10^3 - $3132 \times 10^3 \text{ cell/L}$) at site 5 and site 4 during June 2005 and November 2005 respectively, while the number of green algae were ranged between (22×10^3 - $437 \times 10^3 \text{ cell/l}$) at site 4 and 3 during February and November 2005 respectively. The high number of Cyanophyceae ($345 \times 10^3 \text{ cell/}$) was recorded at site 3 during August 2005, while no record of Cyanophyceae at site 1 and 4 during February 2006 and at site 2 during September 2005. A significant difference was observed among the study months. *Dinobryon sp.* Was not recorded during the study period at site 5 and site 4 and *Meringosphaerea spinosa* at site 5. High numbers of species were recorded for some genera, 17 species for *Nitzschia*, and 15 species for *Navicula*, 12 species for *Cymbella*, 7 species for *Gomphonema*, 6 species for *Fragilaria* & *Synedra* and 5 species for each of *Cyclotella* & *Scendesmus*. The high numbers of some genera were recorded at all sites as *Oscillatoria*, *Chlamydomonas*, *Chlorella*, *Cyclotella*, *Synedra*, *Navicula*, *Nitzschia* and *Cymbelal*.

Table(5): Monthly changes in the number of phytoplankton (cell $\times 10^3/l$) belong to classes below and total number counted at river sites during the study period

Site(1)						
Date	Cy	Chl	B	X	Chr	E
Jul	31	165	1694	9	-	-
Aug.	179	253	1324	18	4	4
Sept	45	202	1432	-	-	18
Oct.	281	197	2595	18	4	13
Nov.	49	313	1366	89	-	22
Des.	17	223	771	-	9	22
Jan.	95	148	877	-	9	4
Feb.	-	428	773	-	-	22
Mar	54	66	1366	-	-	-
Apr.	22	125	1361	-	-	13
May	82	276	2095	147	-	-
Jun.	182	192	1172	94	13	4

Site(2)						
Date	Cy	Chl	B	X	Chr	E
Jul	40	61	1022	8	-	-
Aug.	53	84	769	10	31	9
Sept.	-	147	879	25	9	4
Oct.	57	200	2260	42	40	18
Nov	62	176	2749	10	-	18
Des.	4	92	285	10	-	4
Jan.	27	75	208	15	-	22
Feb.	40	95	328	-	-	-
Mar.	14	94	1430	4	4	31
Apr	231	221	1330	10	18	13
May	9	179	1642	-	9	36
Jun.	9	61	536	-	-	-

Site(3)						
Date	Cy	Chl	B	X	Chr	E
Jul	49	93	603	45	-	4
Aug.	343	131	967	18	-	-
Sept	223	231	1261	250	4	-
Oct.	4	356	1419	67	-	31
Nov	17	437	2366	-	18	-
Des.	142	111	639	89	-	-
Jan.	4	115	638	-	-	22
Feb.	13	68	661	9	-	-
Mar	116	151	468	58	4	18
Apr	35	272	1193	-	8	22
May	9	186	1012	67	4	8
Jun.	31	197	966	80	13	9

Site(4)						
Date	Cy	Chl	B	X	Chr	E
Jul	13	236	1642	-	-	-
Aug.	222	160	1321	18	4	13
Sept.	13	118	2277	-	4	-
Oct.	22	111	2245	-	-	-
Nov	-	329	3132	-	4	27
Des.	17	206	675	36	-	13
Jan.	58	139	418	-	4	4
Feb.	47	22	836	9	4	4
Mar.	4	241	1892	4	-	13
Apr	155	276	1168	-	4	9
May	9	205	1022	-	-	22
Jun.	249	182	948	22	4	-

Site(5)						
Date	Cy	Chl	B	X	Chr	E
Jul	80	111	606		4	13
Aug.	393	159	683	-	-	-
Sept	-	75	1546	-	-	-
Oct.	155	146	1548	-	-	8
Nov	49	276	1094	-	4	36
Des.	13	142	606	-	4	27
Jan.	9	30	698	-	-	13
Feb.	134	169	408	-	-	-
Mar	4	98	1330	-	-	36
Apr	70	142	1134	-	-	36
May	-	107	1605	-	4	31
Jun.	94	53	60		-	-

Total					
Date	S. 1	S.2	S.3	S.4	S.5
Jul	1899	1131	794	1891	814
Aug.	1782	956	1459	1738	1235
Sept.	1697	1064	1969	2412	1621
Oct.	3108	2617	1877	2378	1857
Nov	1839	3015	2838	3492	1459
Des.	1042	395	981	947	792
Jan.	1133	347	779	623	750
Feb.	1223	463	751	922	711
Mar.	1486	1577	815	2154	1468
Apr	1521	1823	1530	1612	1382
May	2600	1875	1286	1258	1747
Jun	1644	606	1296	1405	207

Note: Cy=Cyanophyceae,Ch=Chlorophytcea,B=Bacillarophyceae,
X=Xanthophyceae, Chr=Chrysophyceae, E=Euglenophyceae

3-3:Polucyclic Aromatic Hydrocartbon(PAHs)

3-3-1-:PAHs in water

The concentration of PAHs in water were determined. Figures(21,22,23) showed the seasonal changes in the concentration of PAHs in water samples

3-3-1-1:Individual PAHs in water

Sixteen PAHs listed by USEPA as priority pollutants were detected and the chromatogram peak of both Acenaphthene and Flourene appear as one peak figures (25-29). The significancy of PAHs concentration in water samples were demonsreated in (index 3/table 1)

3-3-1-1-1:Naphthalene (NaP)

The highest concentration of low molecular weight PAH, Naphthalene(1.65µg/l was recorded at site 2 during autumn, while no concentration were detected at site 1 in all seasons, site(2 and 4) in summer, site 3 in autumn and spring, site 4 during summer and autumn and site(5) during summer and winter. The annual mean concentration of NaP was (0.31µg/L.) and represent (4.75%) of the total PAHs. Statistical analysis showed that concentration recorded were significant differences among study sites and seasons.

3-3-1-1-2:Acenaphthalene (AcpY)

The results referred to mean concentration of AcpY. which was ranged between(ND-0.28µg/l) at site 1 and 2 respectively with the annual mean of (0.07µg/l). The highest value(0.074µg/l) was recorded at site 2 during winter. No concentration were detected at site (1,2,4,5) during summer, at all sites during autumn, at site 4 during winter and site 1 and 3 during spring._AcpY. represents (0.93%) of the total PAHs. Significant differences was recorded among study sites($P < 0.01$) and seasons ($P < 0.05$).

3-3-1-1-3: Acenaphthene & Fluorene (AcP & Flu)

The results showed high concentration of AcP. & Flu. ($1.7\mu\text{g/l}$) at site 3 during summer and no concentration were recorded at all sites during autumn at site (3,4) during spring and winter respectively. The annual mean concentration of AcP. & Flu. reached $0.203\mu\text{g/l}$. The mean percentage of AcP. & Flu. to the total PAHs was (2.85%). Statistical analysis referred to significant differences of AcP. & Flu. concentration among sites and seasons ($P < 0.01$).

3-3-1-1-4: Phenanthrene (Phen)

The highest concentration of Phen. ($2.03\mu\text{g/l}$) was recorded at site 3 during summer and no detected concentration were observed at sites 1 and 4 during summer and spring respectively, while the annual mean concentration reach $0.41\mu\text{g/l}$. The recorded mean percentage of Phen. to the total PAHs concentration was (6.34%). The results of statistical analysis referred to significant relationship of Phen. concentration among sites ($P < 0.01$) and significant among seasons.

3-3-1-1-5: Anthracene (Ant)

The results explain that no concentration were recorded during summer at sites 2 and site 4, while the highest concentration of ($0.44\mu\text{g/l}$) was recorded at site 3 during the spring with the annual mean concentration of ($0.15\mu\text{g/l}$). Ant-represents (1.53%) of the total PAHs recorded during the study. Statistical analysis show no significant relationship of Ant-concentration among sites and seasons ($P < 0.01$).

3-3-1-1-6: Fluoranthene (Flur)

The results indicated that Flur. Concentrations in water samples ranged from no at site 1 during summer and winter, site 2 during summer, site 3 during summer and spring and site 5 during spring and summer to ($0.44\mu\text{g/l}$) at site 3 during the spring with the annual mean concentration of ($0.08\mu\text{g/l}$). The mean percentage of Flur. to the total PAHs was (2.78%).

Statistical analysis showed no significant differences of Flur concentration among sites and seasons ($P < 0.01$).

3-3-1-1-7 :Pyrene(Py)

The highest concentration of Py. ($1.22\mu\text{g/l}$) was recorded at site 3 during the summer, while the compound was not recorded at site(1,2) during summer and site(3) during autumn. The annual mean concentration recorded was($0.27\mu\text{g/l}$). The four ring PAHs, Pyrene represents (4.05%)of the total PAHs. The statistical analysis shows significant relationship for Py. concentrations among sites and seasons($P < 0.01$).

3-3-1-1-8: Benzo(a) Anthracene(BaA)

The results indicated that the highest concentration of BaA. ($0.21\mu\text{g/l}$) was recorded at site 5 during the spring. The compound was not recorded at sites(1,2,4) during summer, site 2 during the autumn and sites(1,3) during spring. The annual mean concentration ($0.06\mu\text{g/l}$) was recorded for all sites. BaA. represents (0.87%) of the total PAHs recorded during the study period. Statistical, analysis showed no significant differences for BaA. concentration among sites and seasons.

3-3-1-1-9 : Chrycene (Chry)

The concentration of Chry was ranged between no detected concentration recorded at site 2 during summer and sites(1,5) during the winter and ($2.24\mu\text{g/l}$) recorded at site 5 during the spring with the annual mean concentration of($0.65\mu\text{g/l}$)at the study sites. The mean percentage of Chry to the total PAHs recorded for water samples was 10.15%. Statistical analysis referred to significant relationship of Chry concentration among seasons($P < 0.01$).

3-3-1-1-10 : Benzo(b) Fluoranthene (BbF)

The results referred to no concentration were recorded at site 1 during summer, autumn and winter, site 2 at all seasons, site 3 during autumn and spring, site 4 during summer, winter and site 5 during winter,

while the highest value($1.35\mu\text{g/L}$) recorded at site 3 during summer with the annual mean concentration of ($0.17\mu\text{g/L}$). BbF represent as(2.454%) of the total PAHs recorded at the study sites. Statistical analysis referred that there is no significant relationship of BbF concentration among sites and seasons ($P<0.01$).

3-3-1-1-11: Benzo(k)Fluoranthene(BkF)

The highest concentration of BkF($3.31\mu\text{g/l}$) was recorded at site 5 during spring, while no concentration were recorded for sites 1,2,4 and 5 during summer, site 2 during autumn and winter, site 4 and 5 during winter. The concentration($0.61\mu\text{g/l}$) was obtained as the annual mean. The concentration of(9.48%) was recorded as percentage for BkF to the total PAHs. The results of the statistical analysis recorded no significant differences of BkF concentrations among sites,while significant among seasons($P<0.01$).

3-3-1-1-12: Benzo(a)pyrene(BaP)

The lowest concentration of BaP($0.04\mu\text{g/l}$) was observed at site 1 during winter, while the highest value($4.35\mu\text{g/L}$) was recorded at site 5 during spring with the annual mean concentration of($1.19\mu\text{g/L}$). The mean percentage of BaP (18.66%)was recorded during the study period. The concentrations of BaP in the water samples were significant among season ($P<0.01$).

3-3-1-1-13: Dibenzo(a,h)anthracene (DbA)

The highest concentration of DbA($3.318\mu\text{g/l}$) was recorded at site 2 during winter, while no concentration were detected at sites 2 and 4 during summer and site 1 and 5 during spring. The annual mean concentration of DbA was ($0.662\mu\text{g/l}$)andrepresents as 10.146% of the total PAHs. Statistical analysis indicated that there is significant relationship of DbA concentration among sites and seasons($P<0.01$).

3-3-1-1-14:Benzo(ghi)Perylene(BghiP)

The maximum concentration of BghiP(5.164µg/l)was recorded at site 1 during spring, while no concentration were recorded for BghiP at sites 1 and 4 during winter. The annual mean concentration of BghiP was 1.0µg/l and represents as 16.092% of the total PAHs. The fluctuation in the concentrations of BghiP were significant among seasons($P<0.01$), but not significant among sites.

3-3-1-1-15 :Indeno(1,2,3-cd)Pyrene(IND)

The concentration of IND was ranged between no detected concentration at site 1 during spring and(2.807µg/l) recorded at site 5 during winter with annual mean concentration of(0.598µg/l).The mean percentage of IND was (9.098%) to the total PAHs. Statistical analysis showed significant differences of IND concentrations among sites and seasons ($P<0.01$).

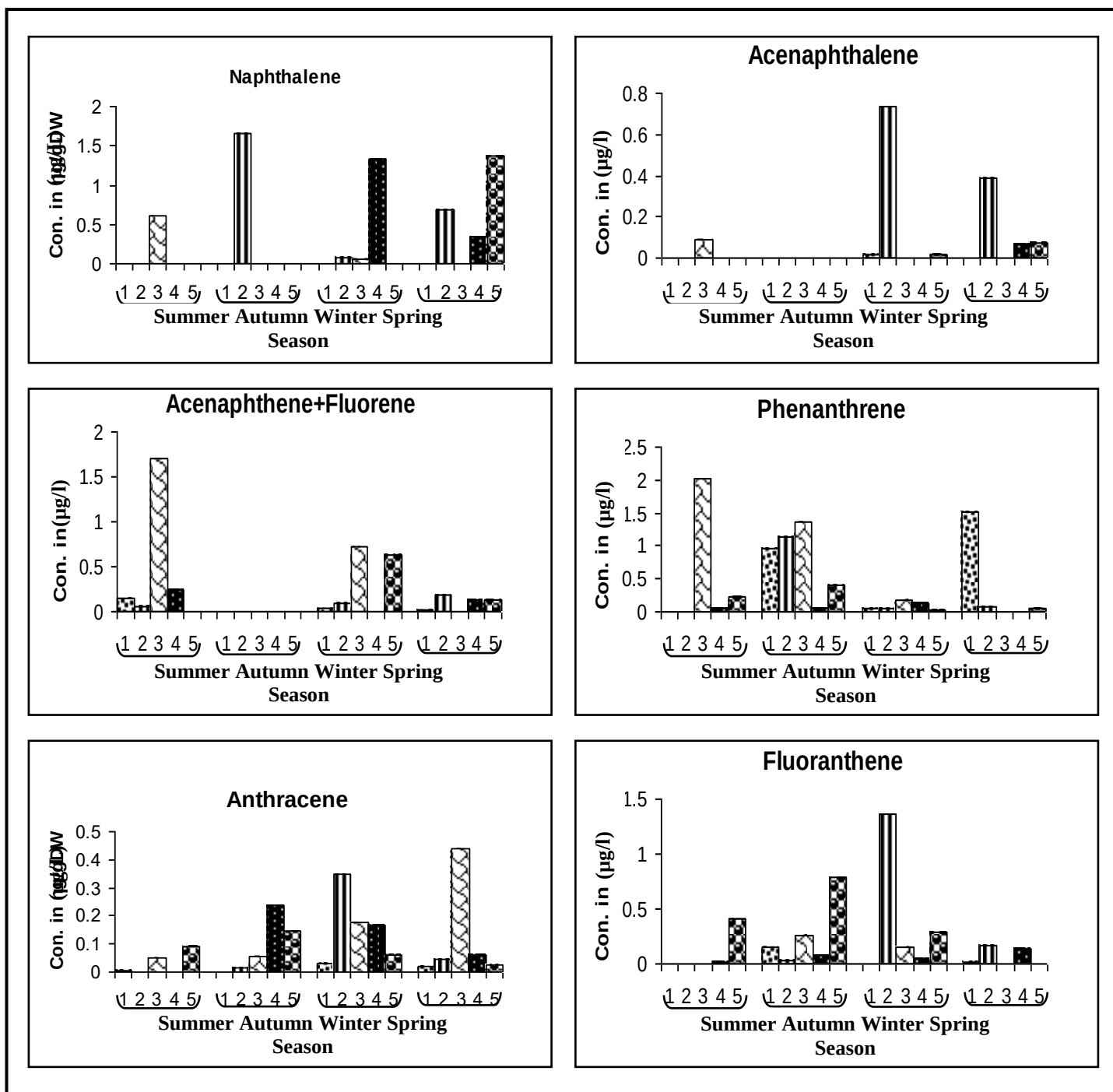


Figure (21): Seasonal changes in the concentrations of Naphthalene, Acenaphthalene, Acenaphthene&Fluorene, Phenanthrene, Anthracene and Fluoranthene in the water samples of Euphrates river sites (1-5) during the study period (Jul. 2005 – June 2006).

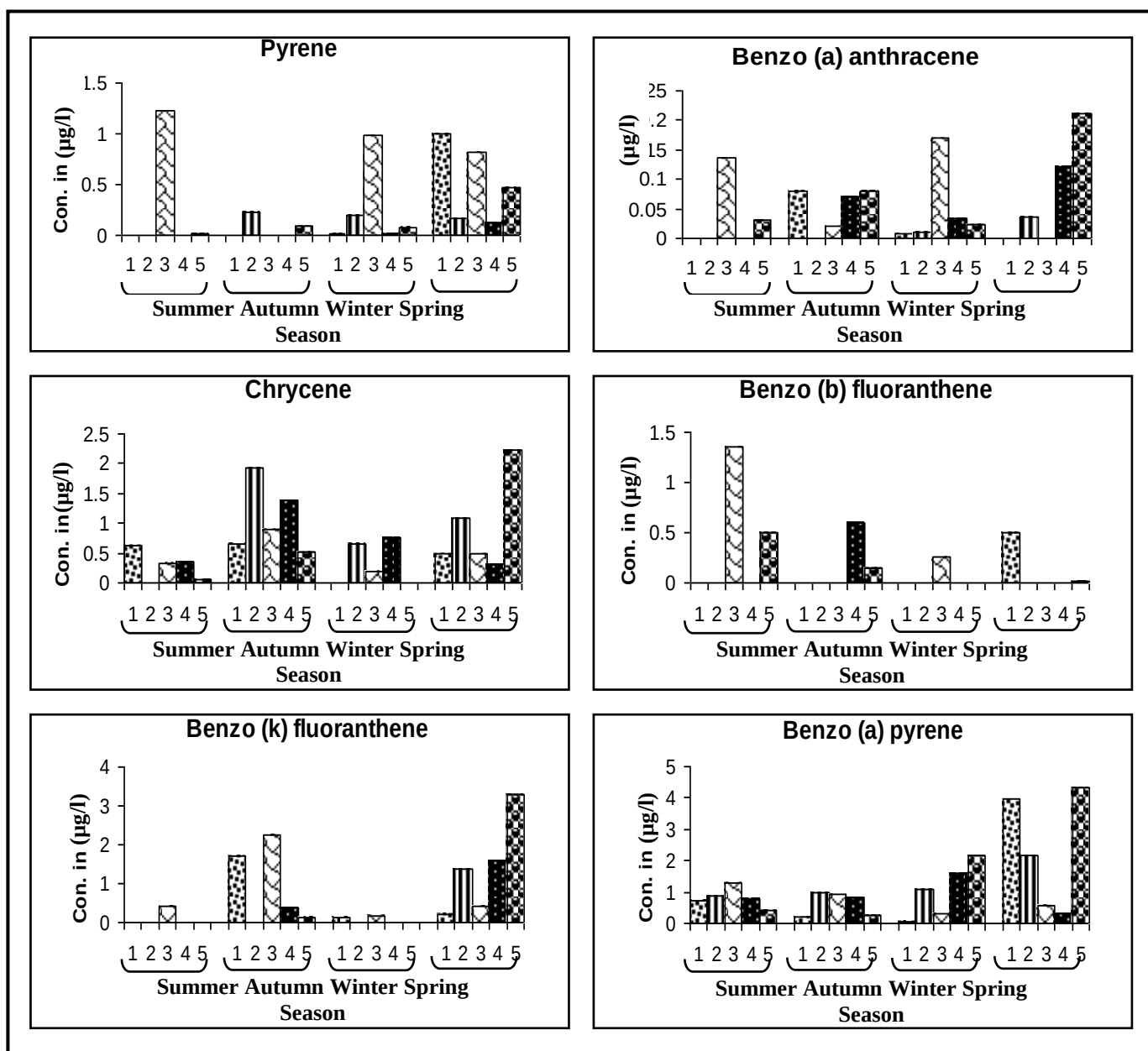
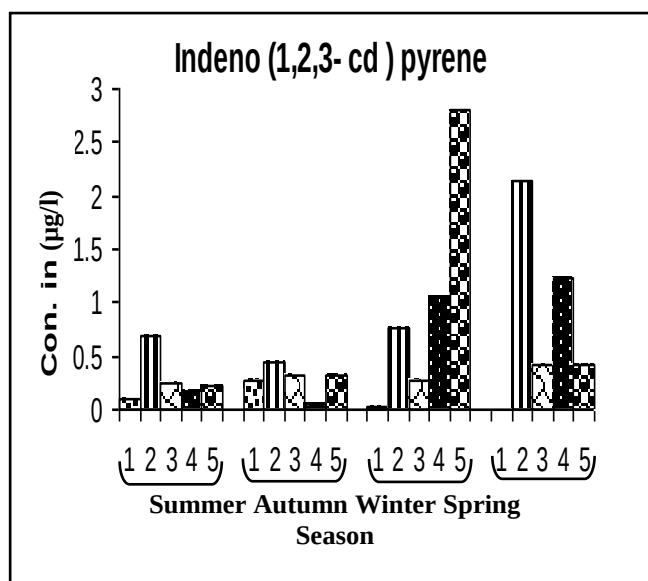
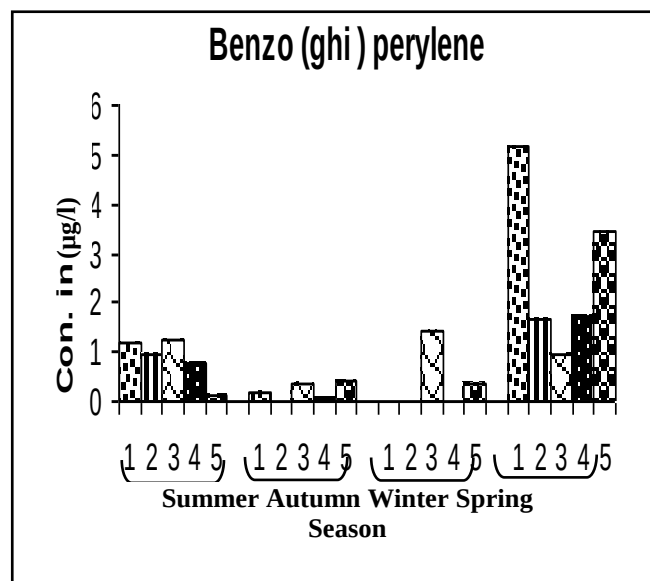
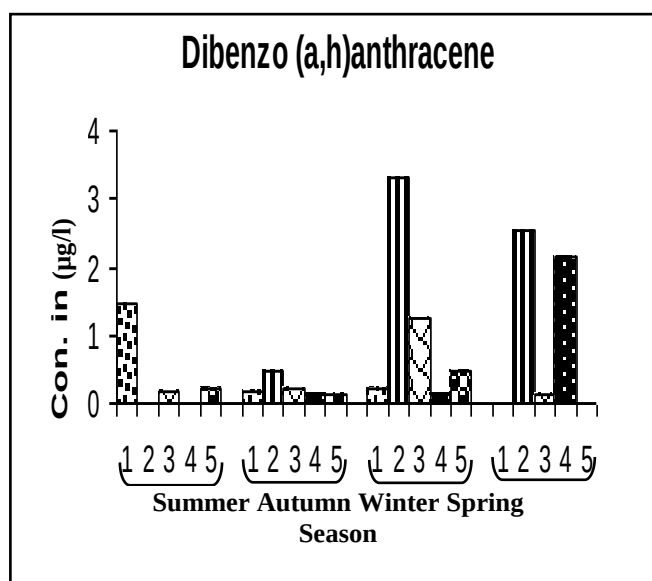
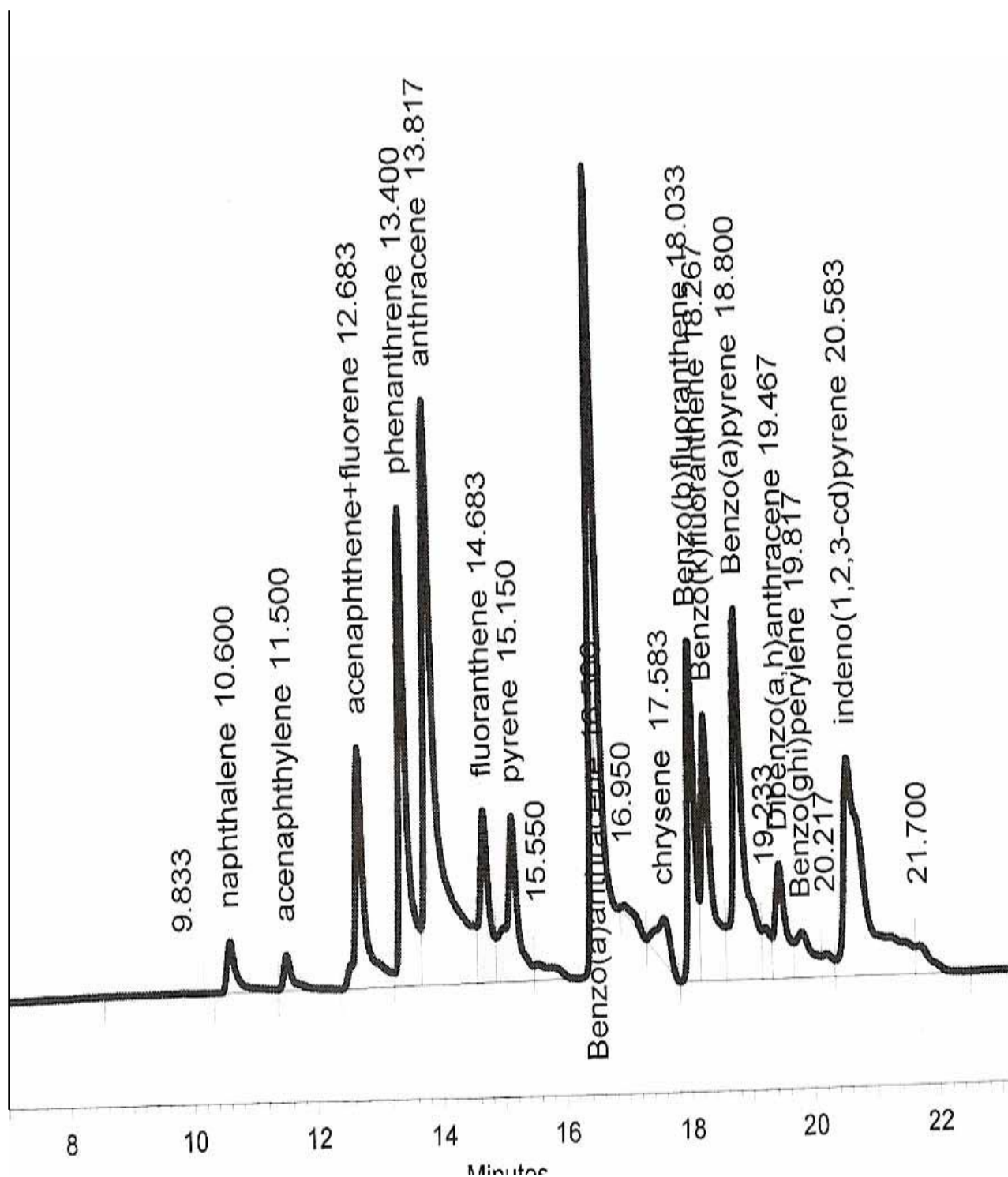


Figure (22): Seasonal changes in the concentrations of Pyrene, Benzo(a) Anthracene, Chrycene, Benzo(b)Fluoranthene, Benzo(k)Fluoranthene and Benzo(a)pyrene in the water samples of Euphrates river sites (1-5) during the study period (Jul. 2005 – Jun. 2006).



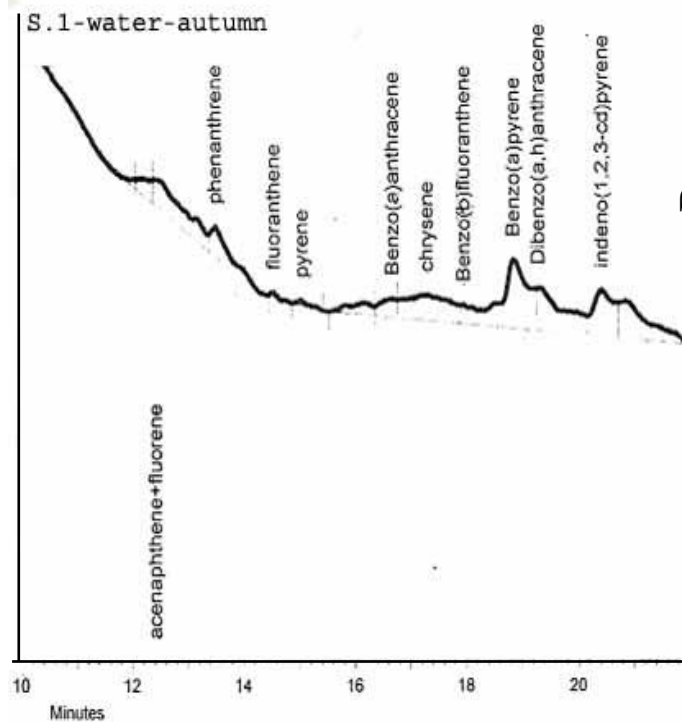
Figure(23):Seasonal change in the Dibenzo(a,h)Anthracene, Benzo(ghi)Perylene and Indeno(1,2,3-cd)Pyrene concentration in the water samples of Euphrates river sites during the study period (Jul. 2005 – Jun.2006).



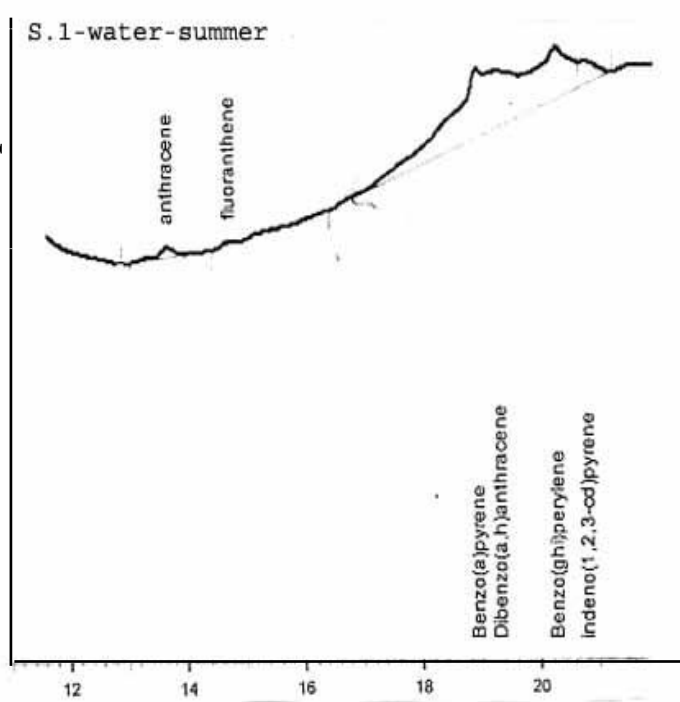
Figure(24):Chromatograms of PAHs mixture standard containing sixteen PAHs listed by USEPA as priority pollutants

Responses

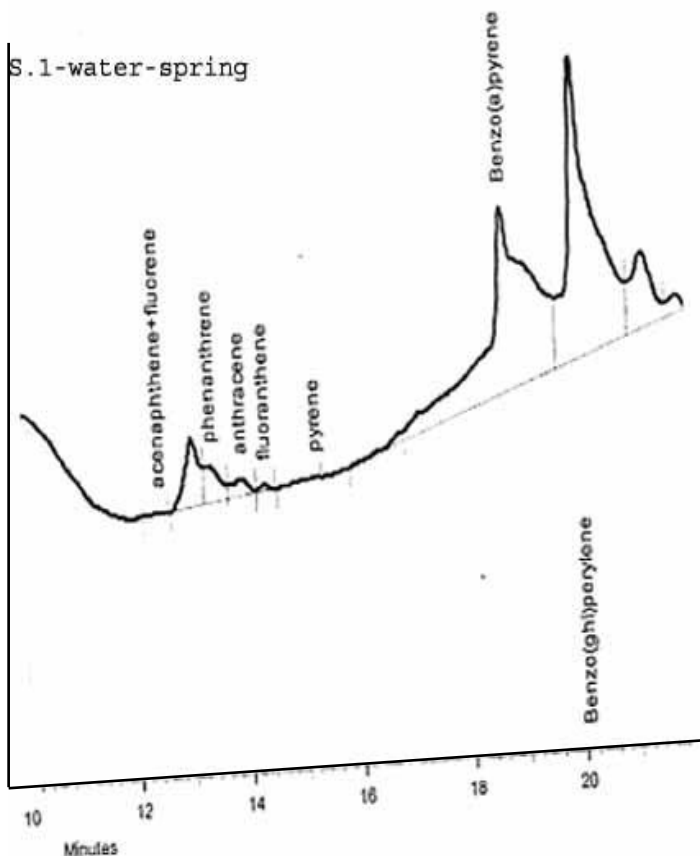
Responses



Responses

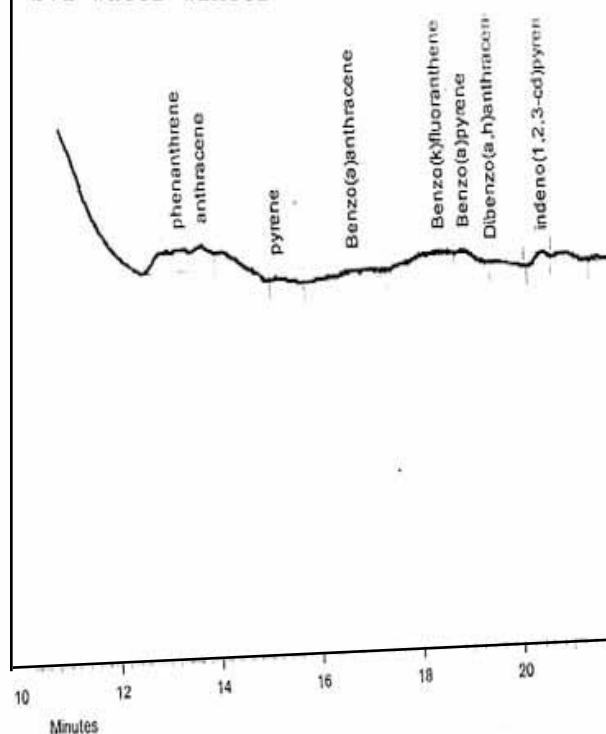


S.1-water-spring



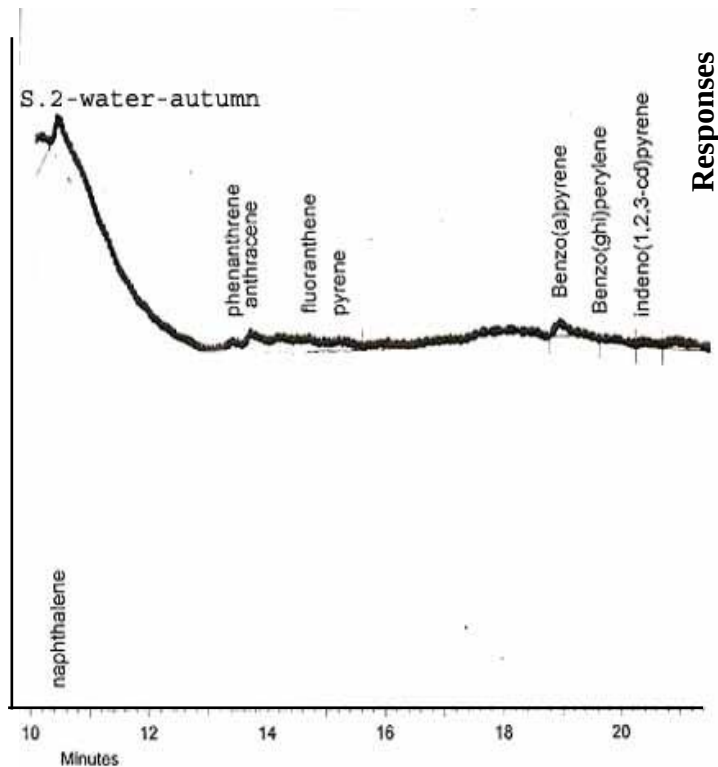
Responses

S.1-water-winter

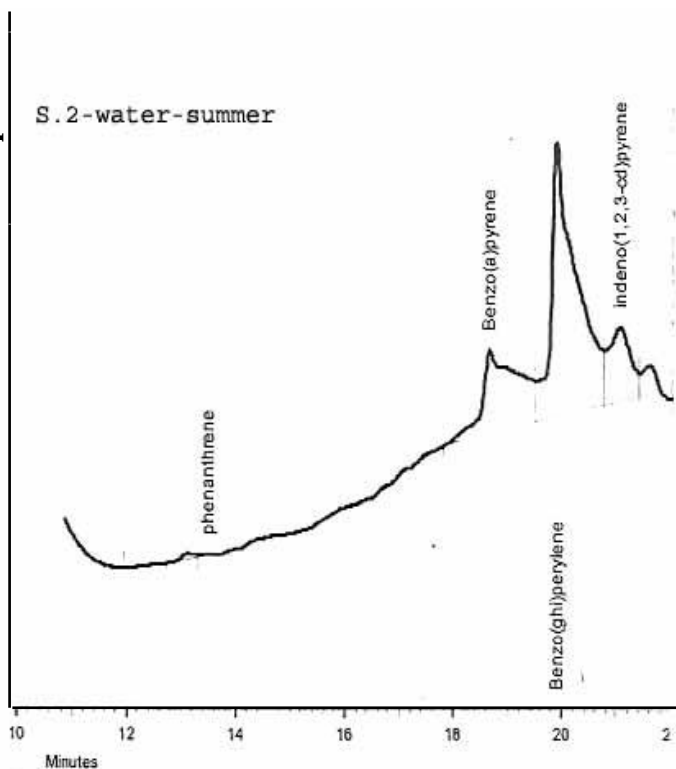


Figure(25): PAHs chromatogram for water sample collected at site 1 during the study period

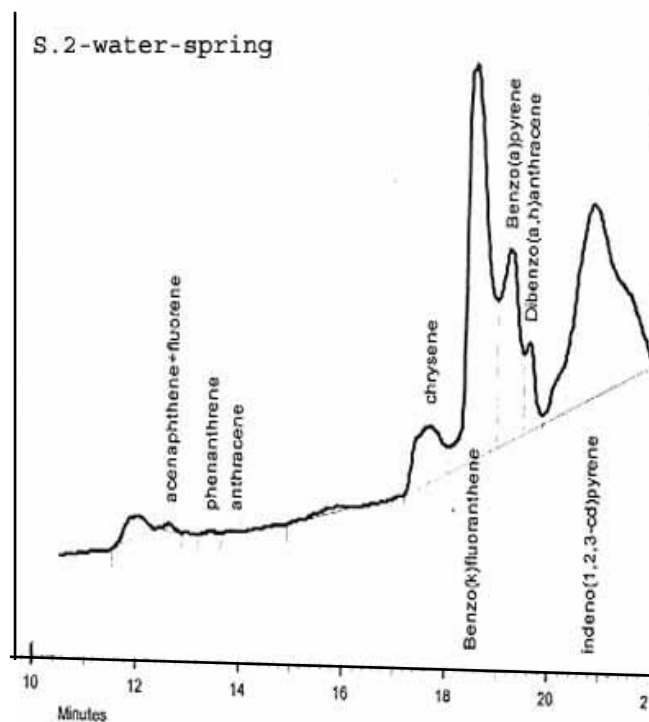
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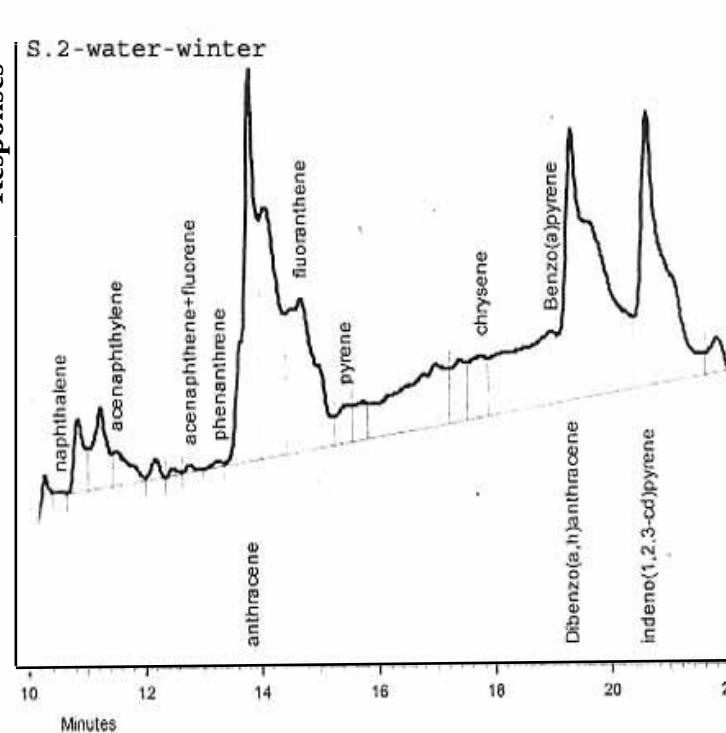
Responses



Responses

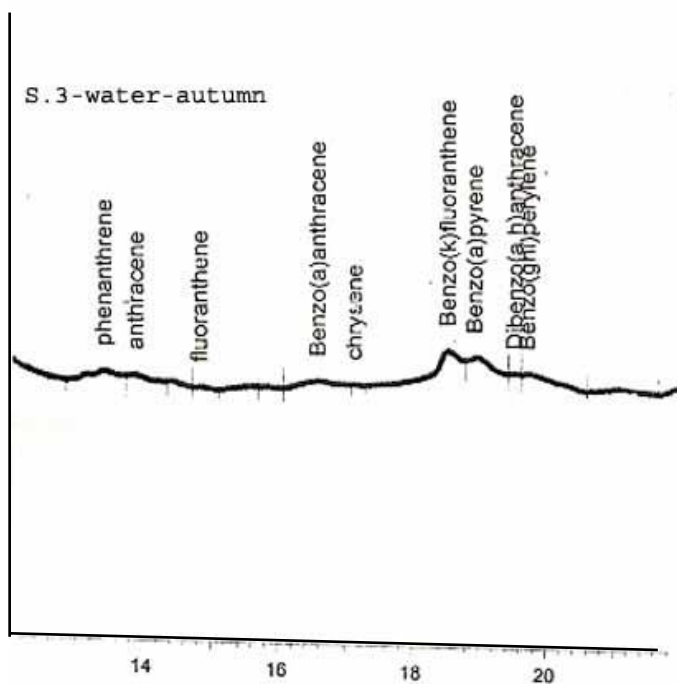


Responses

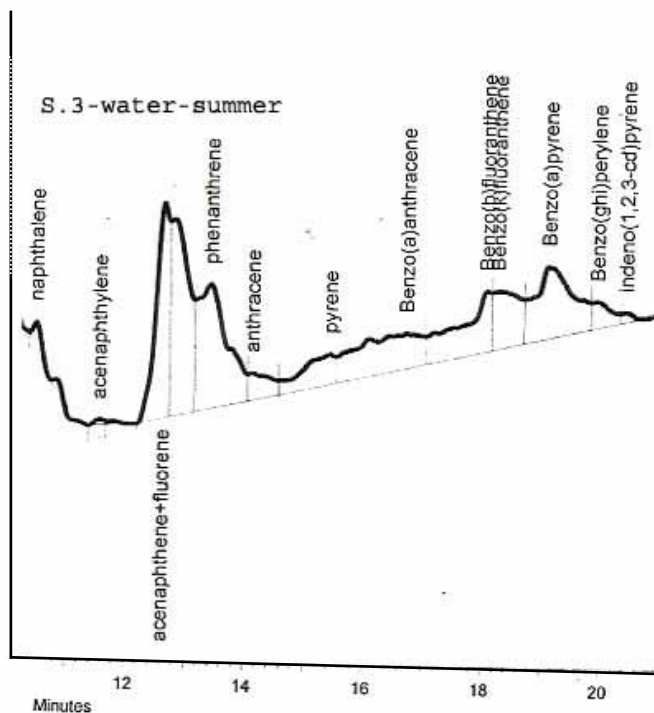


Figure(26): PAHs chromatogram for water sample collected at site 2 during the study period

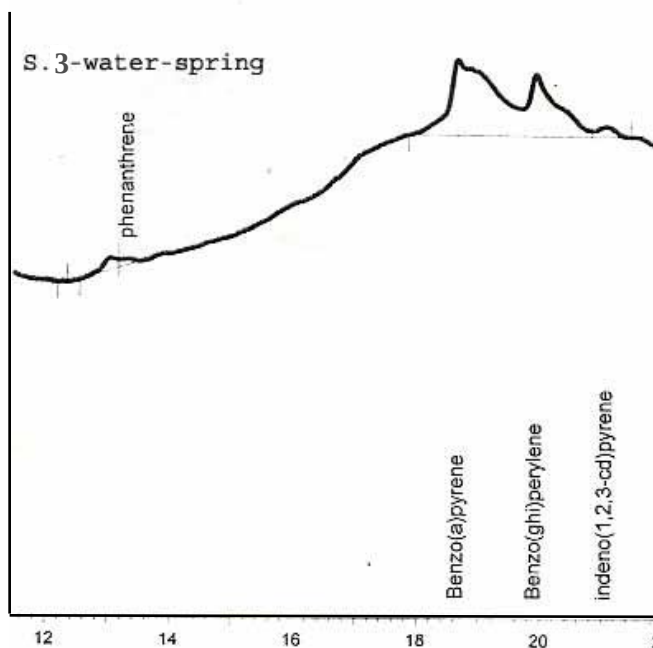
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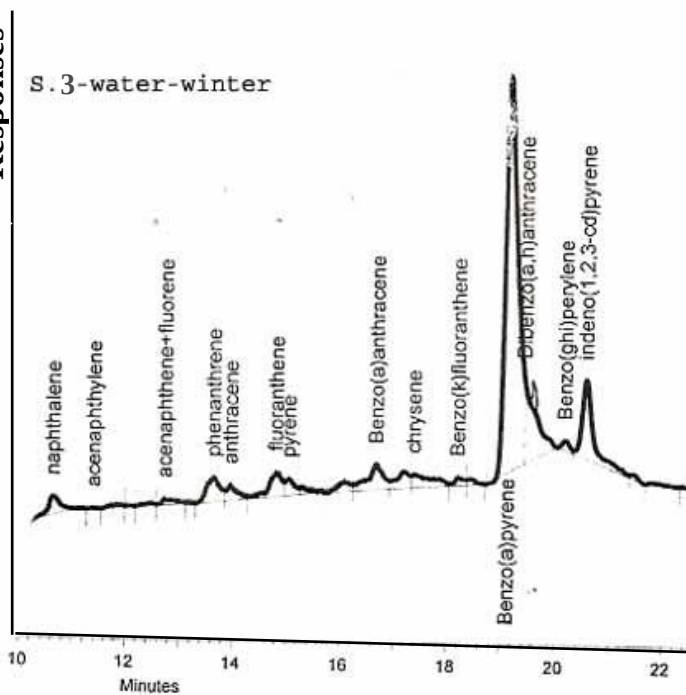
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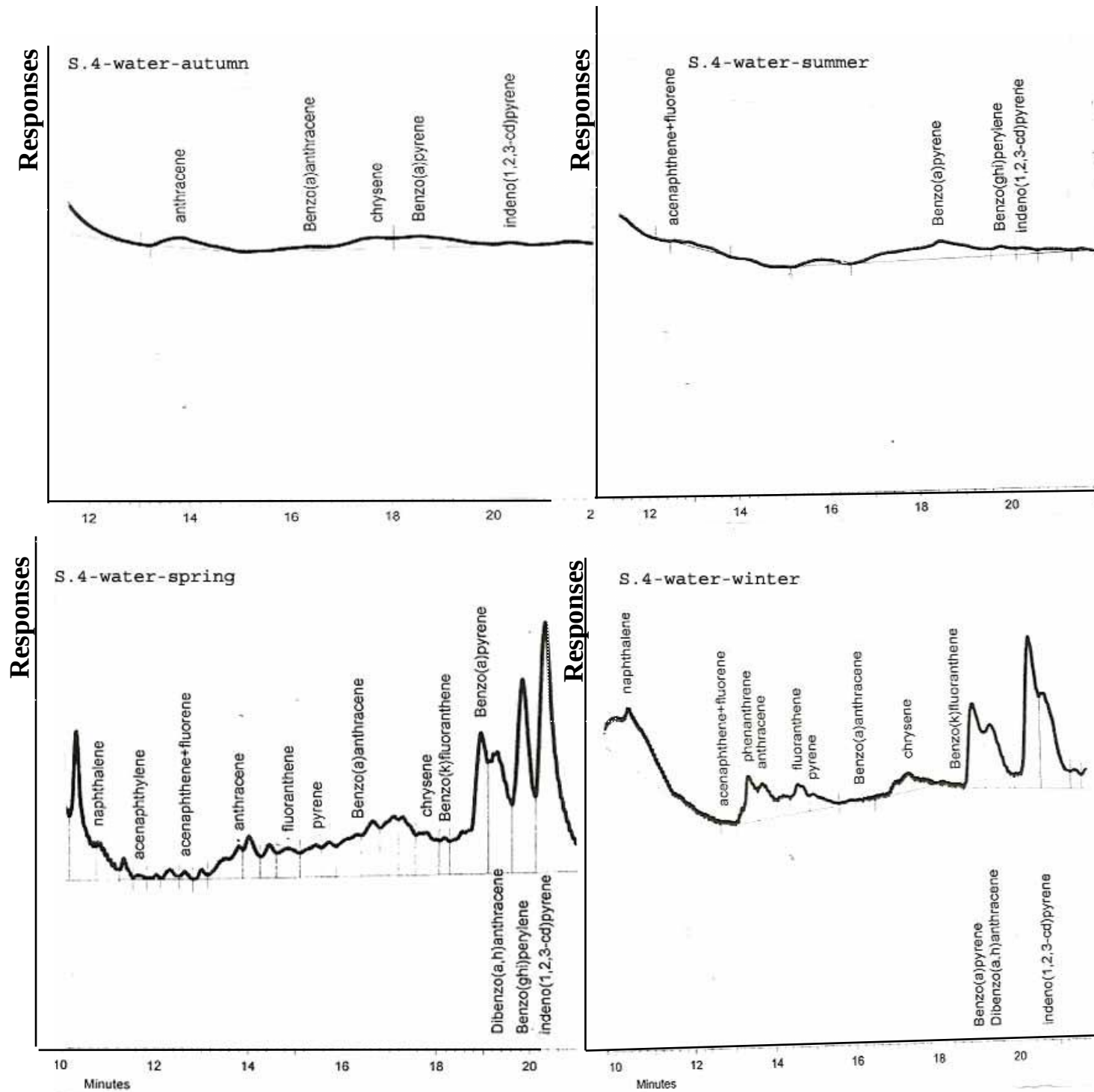
Responses



Responses

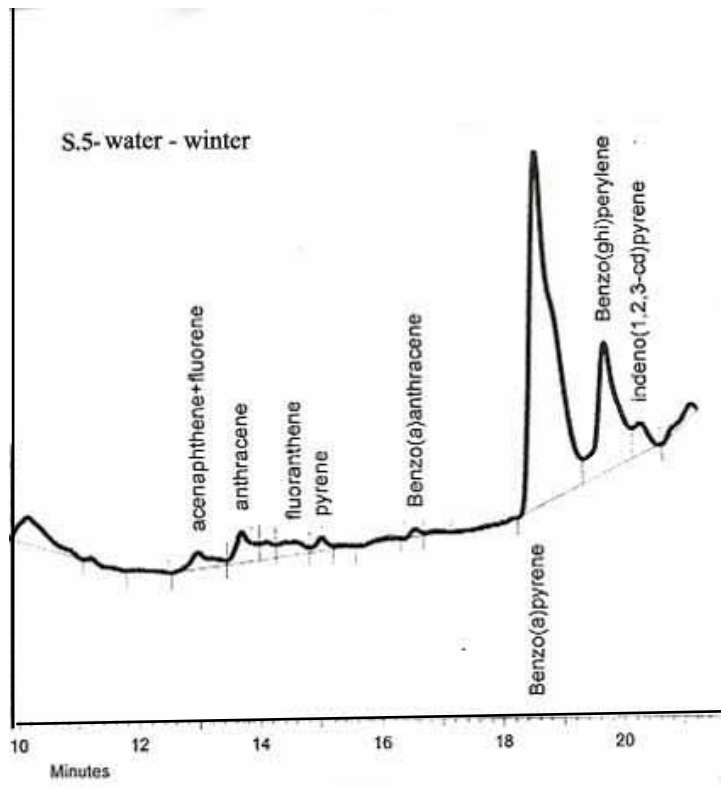


Figure(27): PAHs chromatogram for water sample collected at site 3 during the study period

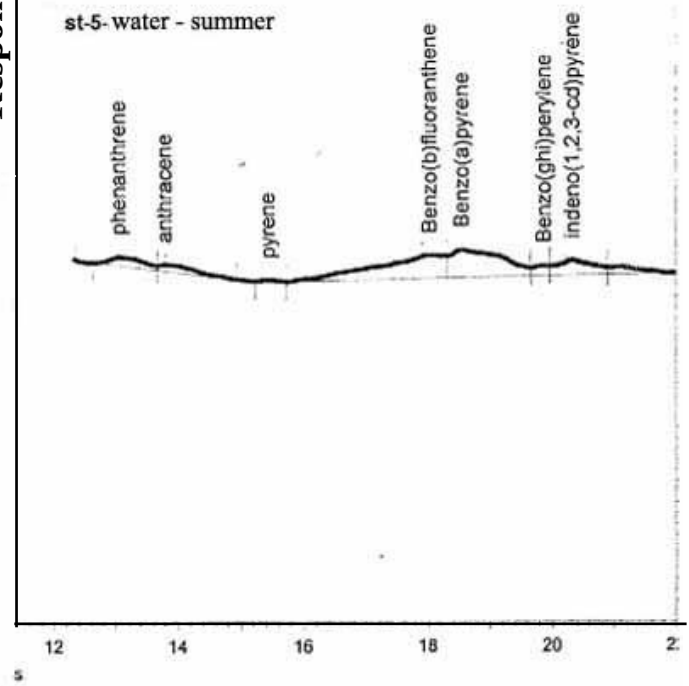


Figure(28): PAHs chromatogram for water sample collected at site 4 during the study period

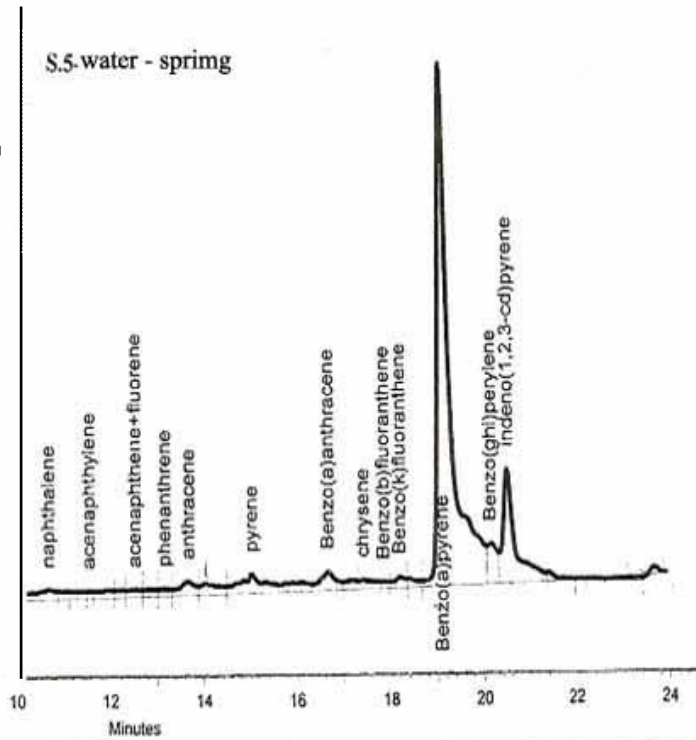
Responses



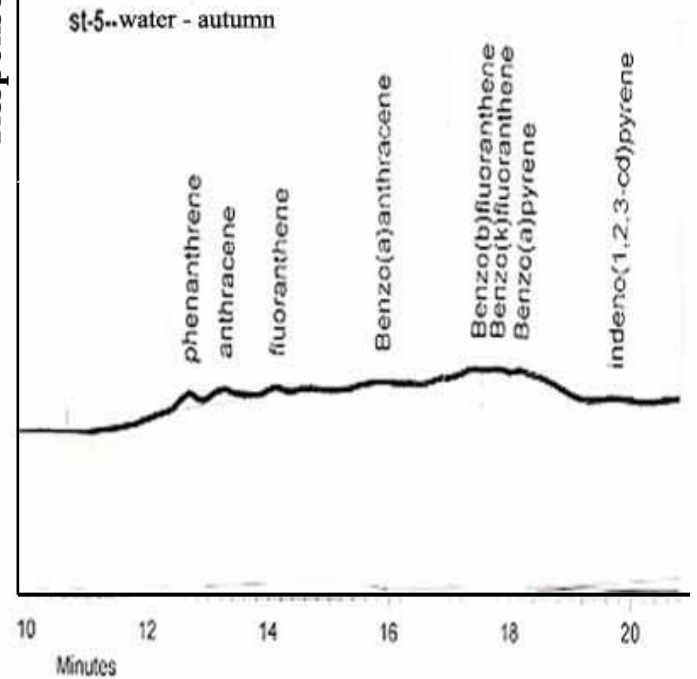
Responses



Responses



Responses



Figure(29): PAHs chromatogram for water sample collected at site 5 during the study period

3-3-1-2: Compositional pattern of PAHs in water

The figures(30, 31 and 32) show the seasonal changes and mean concentration of PAHs in water samples by ring numbers and molecular weight, while the figure 33 represents the mean percentage of PAHs by ring number.

The highest concentration of 2 ring-PAHs, Naphthalene(1.65µg/l) was recorded at site 2 during autumn, but no concentration were detected at site 1 in all seasons, site(2) in summer and autumn, site 3 in autumn and spring, site 4 during summer and autumn and site 5 during summer and winter. Statistical analysis referred to significant differences of 2 ring-PAHs concentration among sites and seasons.

The concentration of 3-ring PAHs (Acenaphthene, fluorene, phenanthrene and anthracene) ranged between (0.25µg/l- 3.87µg/l) recorded at site 2 and 3 during summer respectively with annual mean concentration of(0.79µg/l). The concentrations of 3-ring PAHs were significant among sites and seasons.

The concentration between(ND–2.92µg/l) were observed for 4-ring PAHs (Fluoranthene, Pyrene, Benzo(a)Anhracene and chrycene)at site 2 during summer and site 5 during spring with annual mean concentration of(1.13µg/l). Statistically, significant differences were recorded for 4ring-PAHs among sites and seasons($P < 0.01$). The detected concentration of 5-ring PAHs(BbF, BkF, BaP and DbA) were ranged between(0.37-7.68µg/L) recorded at site 1 during winter and site 5 during spring with annual mean concentration of (2.75µg/l). The statistical analysis referred to significant differences for 5-ring PAHs concentrations among sites and seasons ($P < 0.01$).

The concentrations of 6-ring PAHs [BghiP and IND] ranged between (0.03 µg/l-5.16µg/l) recorded at site 1 during winter and spring respectively with the annual mean concentration of (1.60µg/l). Statistical analysis

referred to significant differences among seasons, and sites ($P < 0.01$). Significant positive correlation was recorded for 6-ring PAHs with 5-ring PAHs ($r = 0.743$, $P < 0.01$). The compositional pattern of PAHs by molecular weight was also assessed. The concentration of Low Molecular Weight (2 and 3 ring-PAHs) were between ($0.06 \mu\text{g/l}$) recorded at site 2 during the summer and ($1.153 \mu\text{g/l}$) observed at site 3 during winter with annual mean concentration of ($1.09 \mu\text{g/l}$). The detected concentration of High Molecular Weight PAHs (4, 5, and 6-ring PAHs) ranged from $0.42 \mu\text{g/l}$ at site 1 during winter to $14.44 \mu\text{g/l}$ at site 5 during spring with annual mean concentration of $5.36 \mu\text{g/l}$. The mean percentage was 16.94% was observed for Low Molecular Weight PAHs and 83.06% for High Molecular Weight PAHs.

In general the mean concentration of total PAHs ranged between $4.75 \mu\text{g/l}$ recorded at site 4 to $7.73 \mu\text{g/l}$ at site 2 with mean annual concentration of ($6.453 \mu\text{g/l}$). Statistically, concentration of total PAHs were significant among seasons, but not significant among sites. Significant positive correlation was obtained of total PAHs with the water flow ($r = 0.579$, $P < 0.01$). The correlation coefficient among PAHs compounds in water samples were explained in (index 3/table 2).

3-3-1-3: Sources of PAHs in the water

The possible sources (Pyrogenic or Petrogenic origin) in water samples may be assessed by the ratio of individual PAHs compounds (table, 6 and figure 34). The ratio of Flur/Py greater than one and Phen/Ant less than one referred to the Pyrogenic sources (Sirece *et al.*, 1987; Sanders *et al.*, 2002 and Zhu *et al.*, 2004).

The ratio of BaP/BghiP (0.48-7.25), (1.2-5) and (1-3) were recorded for urban air, woodburning and coal burning (pyrolytic processes) respectively (Maher & Aislabie, 1992). LMW-PAHs/HMW-PAHs < 1 referred to pyrogenic processes (Doon and Lin, 2004)

The ratio (Phen/Ant) within 3ring-PAHs group, (Flur/Py) within 4-ring PAHs, (BaP/BghiP) and (LMW-PAHs/HMW-PAHs) were used to predict the possible sources.

The Phen/Ant ratio for water samples was in the range of (0.47-45.07) recorded at site 4 and site 1 respectively. The ratio of Flur/Py was in the range of (0.14-2.69) with mean concentration of (1.39). The ratios of (0.76-1.95) were recorded for BaP/BghiP at site (1 and 2) respectively with the annual mean concentration of (1.31). The results of the referred to the ratios of (0.13- 0.36) for LMW-PAHs/HMW- PAHS at site 5 and 3 respectively with a mean concentration of 0.20.

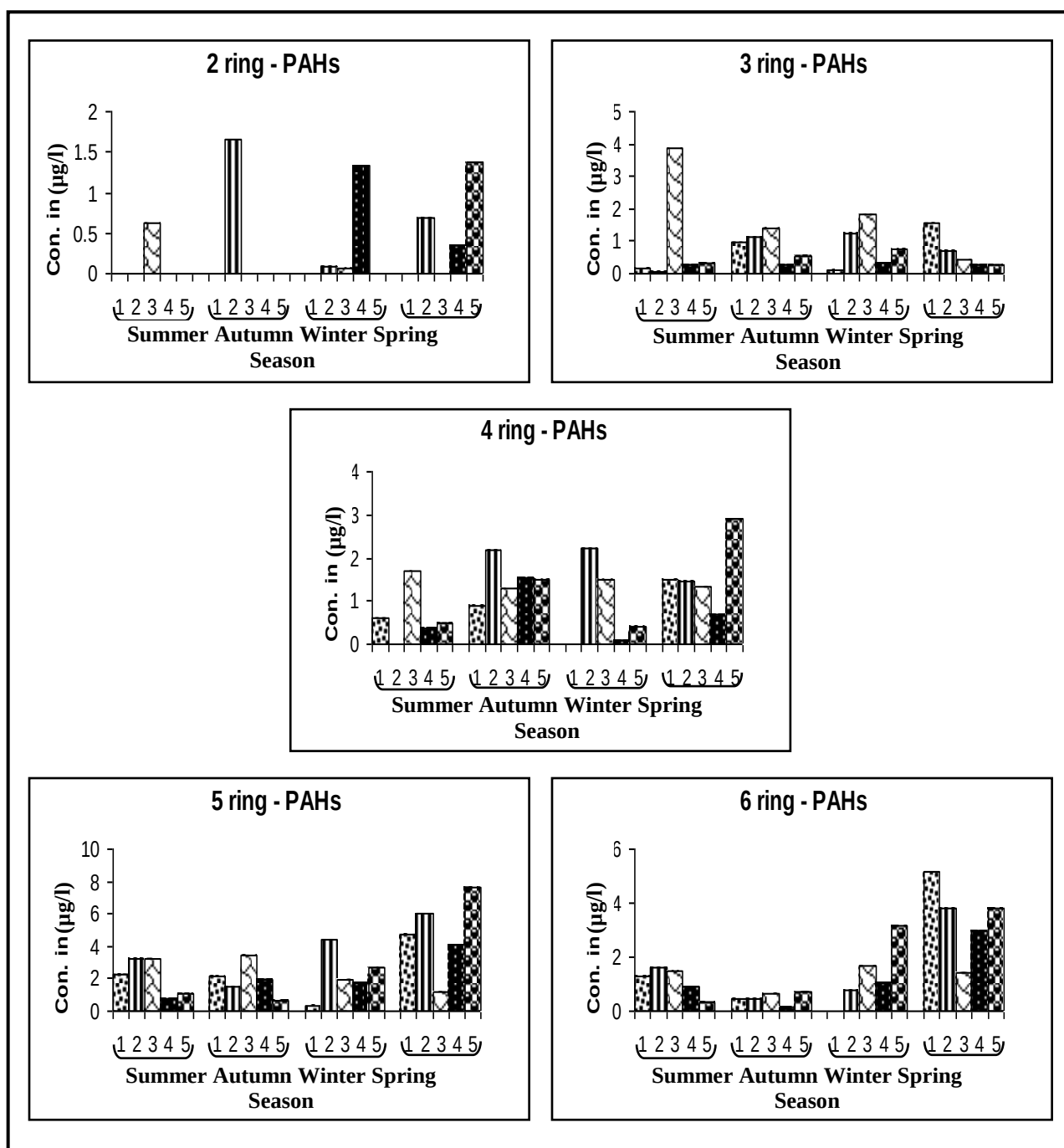


Figure (30): Seasonal changes in the concentrations of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs compounds in the water samples of Euphrates river sites during the study period (Jul. 2005 – June 2006).

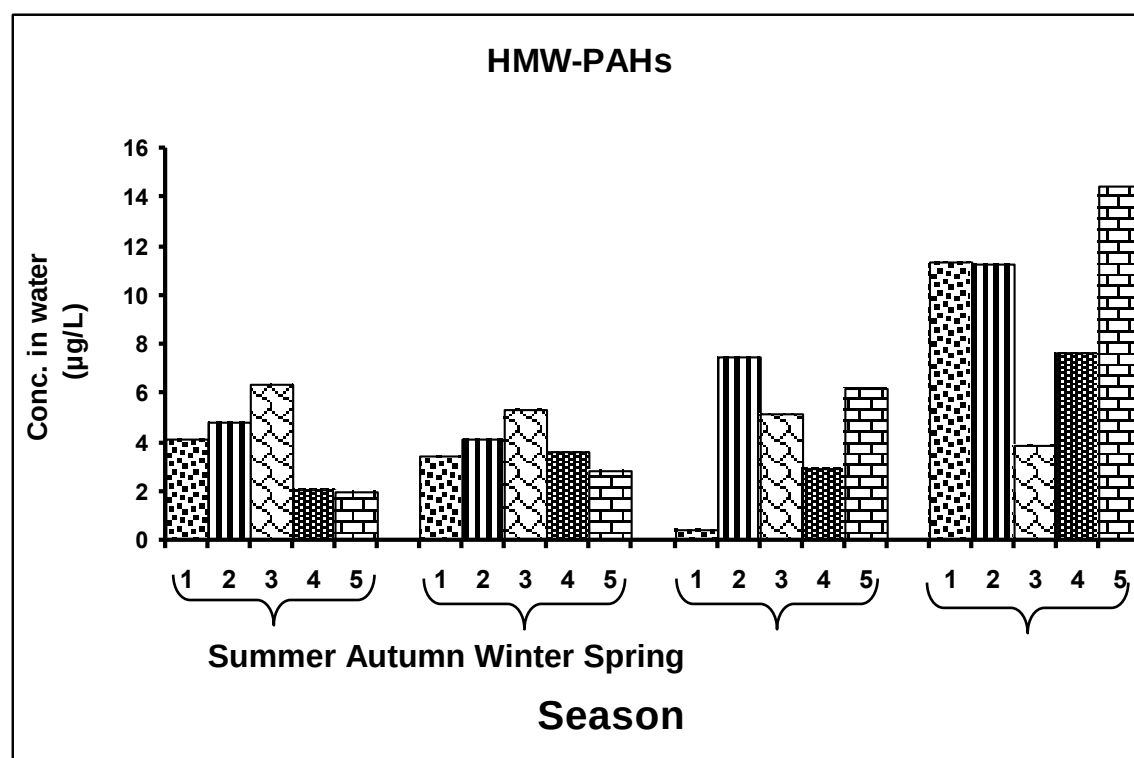
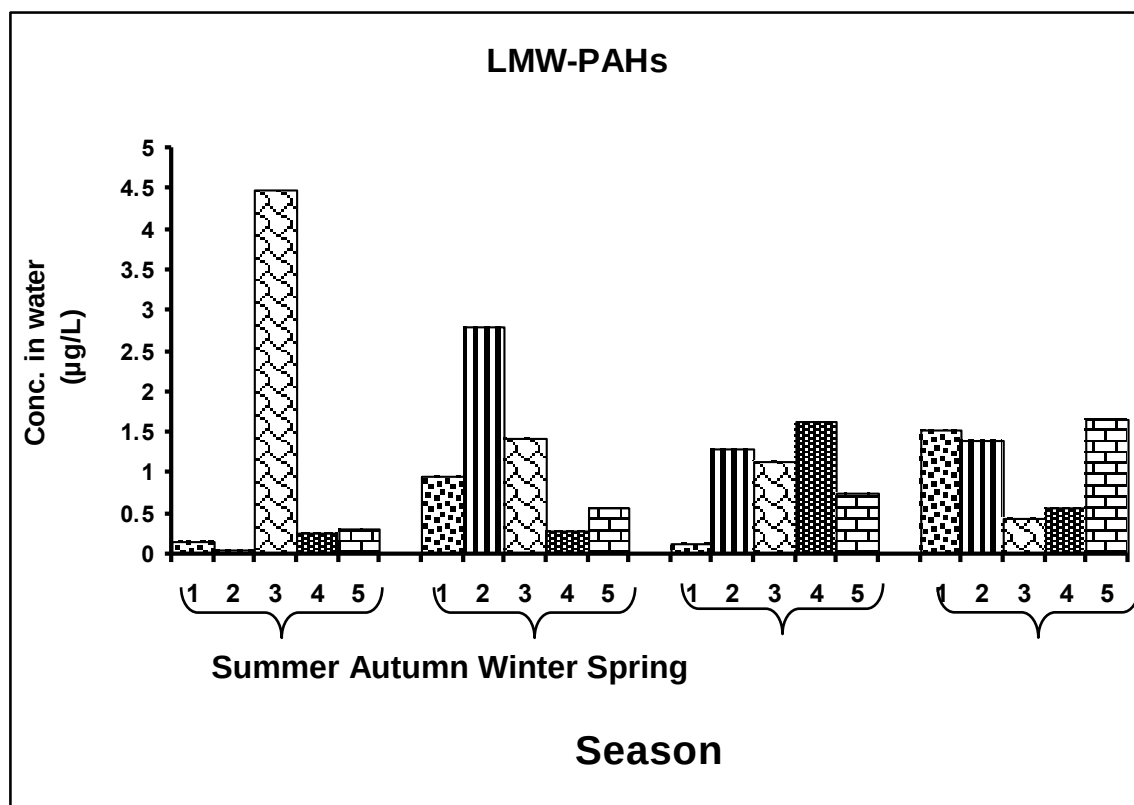


Figure (31) :Seasonal change in the concentration of Low molecular weight PAHs (LMW PAHs), High molecular weight PAHs (HMW PAHs) in water samples of Euphrates river sites during the study period.

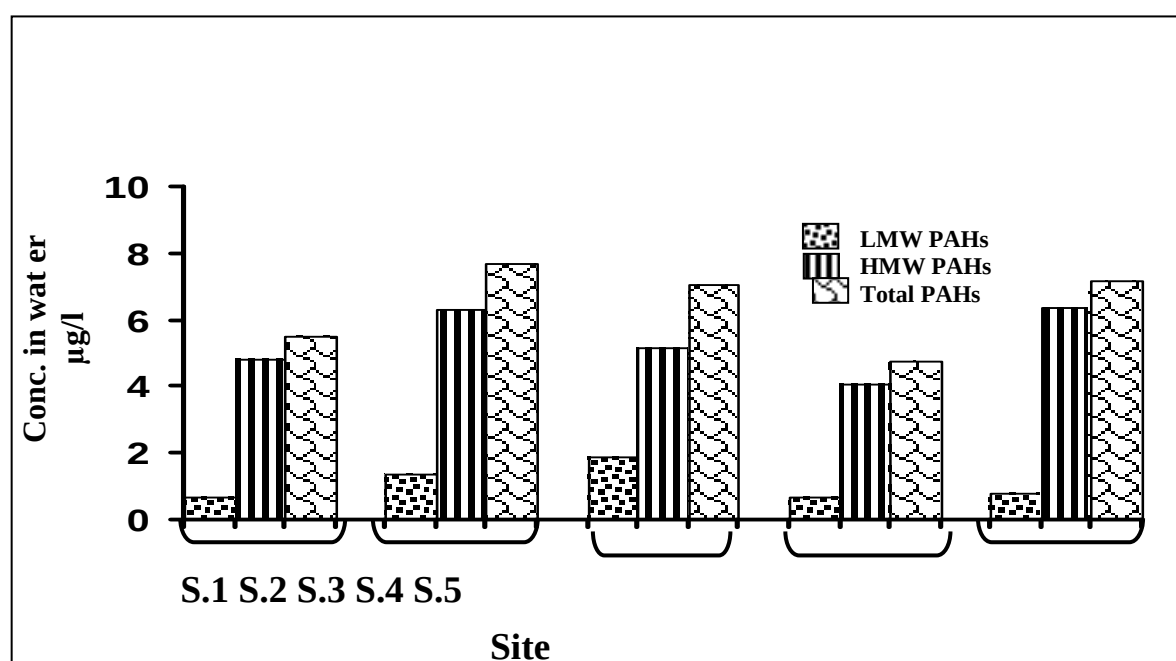
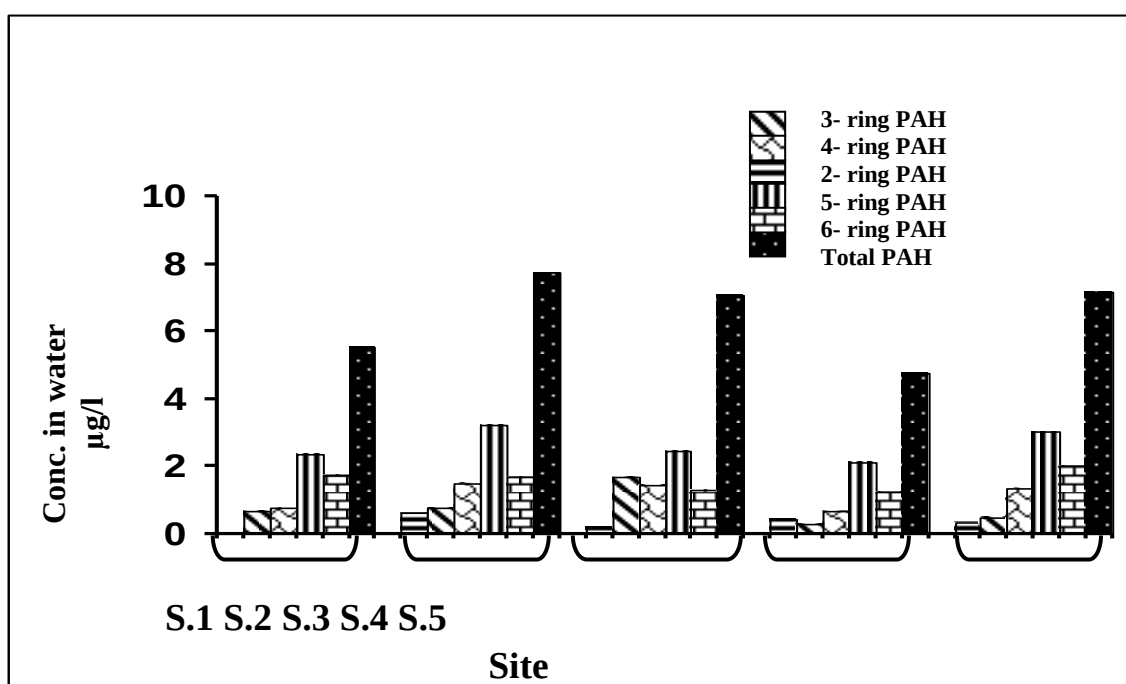
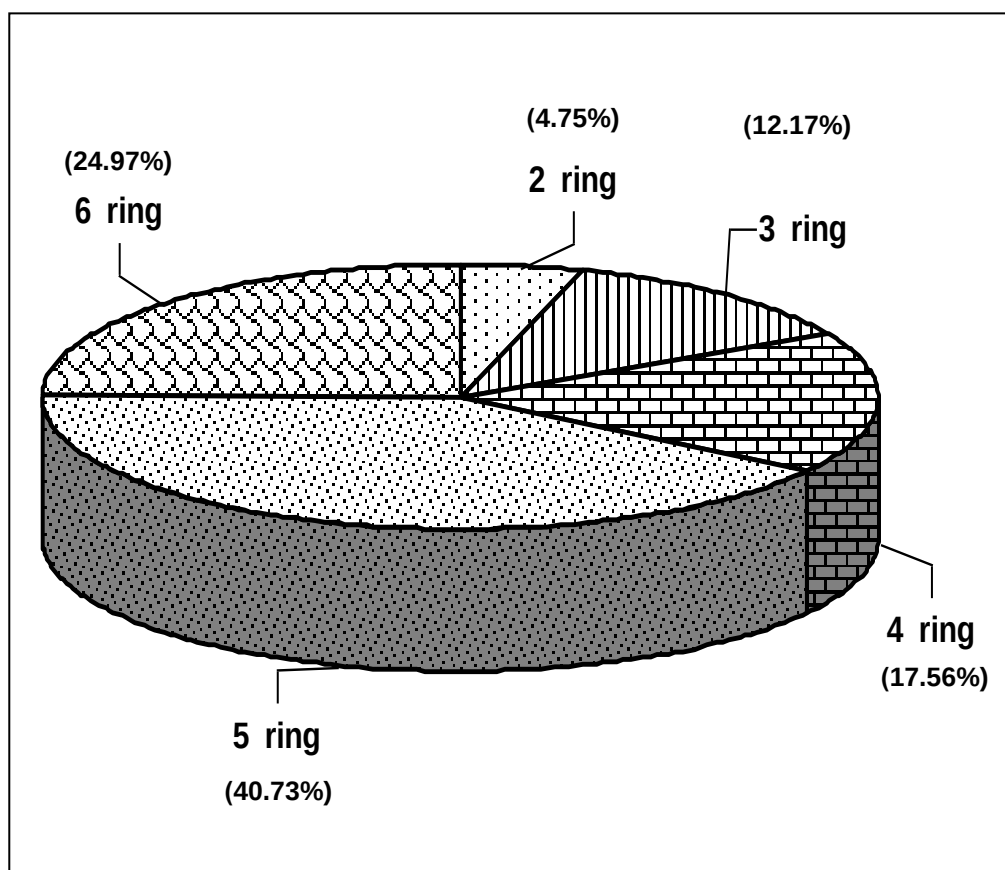


Figure (32) :Composition pattern of PAHs by ring number and molecular weight and Total PAHs in water samples of Euphrates river sites during study period (Jul.2005-Jun.2006).



Figure(33): Mean percentage of 2-ring, 3-ring, 4-ring, 5-ring and 6-ring PAHs in the water samples of Euphrates river site during the study period (Jul. 2005 – June 2006).

Table (6) :Mean ratios of individual PAHs compounds in water samples of Euphrates river sites during the study period(Jul.2005-Jun.2006).

Ratio Site	Phen/Ant	Flur/Py	Bap/BghiP	LMW-PAHs/HMW-PAHs	Sources
S.1	45.07	0.17	0.76	0.14	Pyrogenic,petrogenic and urban air
S.2	31.4	2.69	1.95	0.22	Pyrogenic,petrogenic and urban air
S.3	4.95	0.14	0.77	0.36	Pyrogenic,petrogenic and urban air
S.4	0.47	1.68	1.39	0.17	Pyrogenic and urban air
S.5	2.21	2.30	1.69	0.13	Pyrogenic and urban air

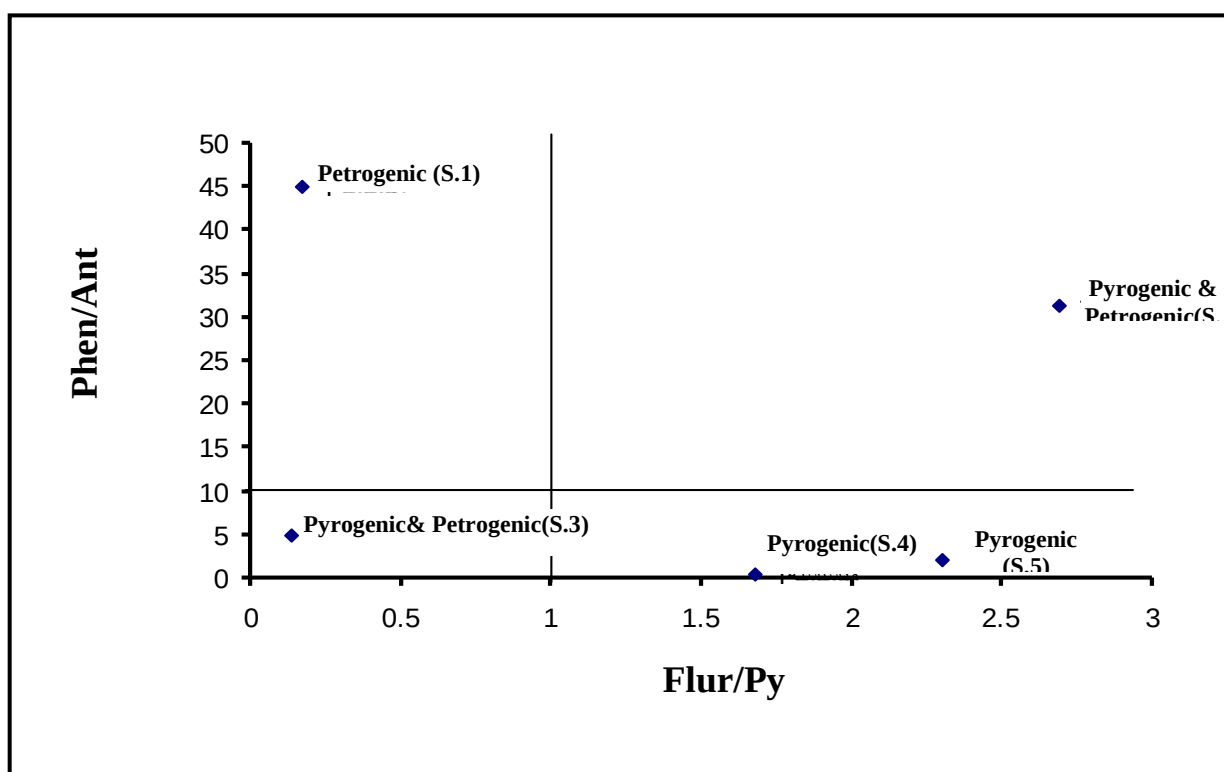


Figure (34) :The ratios of Phen/Ant and Flur/Py For water samples of Euphrates river sites.

Table(7):The range and Mean ($\mu\text{g/L}$) $\pm$ S.D. of PAHs in water samples of Euphrates river sites during the study period(Jul.2005–Jun.2006

Compound	Site(1)	Site(2)	Site(3)	Site(4)	Site(5)
Naphthalene	ND-1.38 0.35 $\pm$ 0.55	ND-1.65 0.61 $\pm$ 0.61	ND-0.62 0.17 $\pm$ 0.39	ND-1.33 0.42 $\pm$ 0.78	ND-ND ND
Acenaphthalene	ND-0.07 0.02 $\pm$ 0.06	ND-0.74 0.28 $\pm$ 0.45	ND-0.09 0.02 $\pm$ 0.08	ND-0.07 0.02 $\pm$ 0.04	ND-0.01 0.003 $\pm$ 0.01
Acenaphthene & Flurene	ND-0.64 0.19 $\pm$ 0.1	ND-0.19 0.08 $\pm$ 0.09	ND-1.7 0.61 $\pm$ 1.5	ND-0.23 0.09 $\pm$ 0.04	ND-0.142 0.05 $\pm$ 0.123
Phenanthrene	0.023-0.41 0.18 $\pm$ 0.23	0.01-1.13 0.31 $\pm$ 0.63	0.01-2.03 0.9 $\pm$ 0.96	ND-0.133 0.054 $\pm$ 0.097	ND-1.51 0.63 $\pm$ 0.91
Anthracene	0.03-0.15 0.08 $\pm$ 0.094	ND-0.35 0.102 $\pm$ 0.198	0.05-0.18 0.18 $\pm$ 0.29	ND-0.24 0.12 $\pm$ 0.16	0.001-0.03 0.025 $\pm$ 0.02
Flouranthene	ND-0.78 0.37 $\pm$ 0.11	ND-1.37 0.39 $\pm$ 0.8	ND-0.26 0.10 $\pm$ 0.17	0.01-0.14 0.07 $\pm$ 0.07	ND-0.15 0.04 $\pm$ 0.64
Pyrene	0.01-0.47 0.16 $\pm$ 0.16	ND-0.22 0.15 $\pm$ 0.15	0.0-1.22 0.76 $\pm$ 0.71	0.01-0.13 0.04 $\pm$ 0.07	ND-0.99 0.25 $\pm$ 0.6
Benzo(a)anthracene	0.024-0.21 0.09 $\pm$ 0.18	ND-0.04 0.012 $\pm$ 0.02	ND-0.17 0.11 $\pm$ 0.17	ND-0.12 0.06 $\pm$ 0.07	ND-0.08 0.022 $\pm$ 0.03
Chrycene	ND-2.24 0.70 $\pm$ 1.23	ND-1.93 0.92 $\pm$ 1.25	0.19-0.89 0.48 $\pm$ 0.45	0.29-1.38 0.69 $\pm$ 1.29	ND-0.65 0.44 $\pm$ 0.55
Benzo(b)Flouranthene	ND-0.5 0.17 $\pm$ 0.49	ND-ND ND	ND-0.6 0.15 $\pm$ 0.63	ND-0.5 0.13 $\pm$ 0.52	ND-1.7 0.51 $\pm$ 0.31
Benzo(k)Flouranthene	ND-3.31 0.85 $\pm$ 1.89	0.0-1.38 0.35 $\pm$ 1.15	0.16-2.26 0.82 $\pm$ 1.68	ND-1.58 0.49 $\pm$ 1.32	ND-1.7 0.51 $\pm$ 1.44
Benzo (a) Pyrene	0.25-4.35 1.80 $\pm$ 1.95	0.87-2.15 1.28 $\pm$ 0.85	0.3-1.27 0.8 $\pm$ 0.61	0.32-1.6 0.88 $\pm$ 0.91	0.04-3.98 1.25 $\pm$ 1.71
Dibenzo(a,h)Anthracene	ND-0.48 0.21 $\pm$ 0.44	ND-3.32 1.59 $\pm$ 1.85	0.15-1.26 0.44 $\pm$ 0.94	ND-2.16 0.61 $\pm$ 1.43	ND-1.48 0.47 $\pm$ 0.92
Benzo(ghi)Perylene	0.22-2.81 1.07 $\pm$ 1.59	0.01-1.64 0.66 $\pm$ 0.95	0.36-1.43 1.0 $\pm$ 1.25	ND-1.72 0.64 $\pm$ 0.99	ND-5.16 1.66 $\pm$ 2.25
Indeno(1,2,3-cd)Pyrene	0.12-3.42 0.94 $\pm$ 1.77	0.45-2.14 1.01 $\pm$ 1.1	0.25-0.41 0.31 $\pm$ 0.29	0.06-1.23 0.63 $\pm$ 1.01	ND-0.26 0.09 $\pm$ 0.19

3-3-2:PAHs in sediment

The sediment quality of Euphrates river sites was assessed by determination of PAHs concentration con. (determined in dry weight DW). Figure (35,36,37) show the seasonal change in the concentration of PAHs in sediment samples. The significance of PAHs concentration con. were demonstrated in(Index 3/table 1).

3-3-2-1:Individual PAHs in sediment

Sixteen PAHs compounds listed by USEPA as priority pollutant were detected and chromatogram peak of both Acenaphthene and Flourene were appeared as one. The figures (38-42) represent the chromatograms of sediment samples collected from Euphrates river sites

3-3-2-1-1:Naphthalene(NaP)

The concentration of low molecular weight PAHs, Nap was fluctuated between not detected concentration at sites(2,3,4 and 5) during summer, site(3)during autumn and winter to(14.75ng/g DW) recorded at site 4 during spring with the annual mean concentration of (2.19ng/gDW). Nap represents (1.41%) of the total PAHs in the sediment. Statistical analysis showed significant differences in the concentration of Nap among sites and seasons ($p<0.01$).

3-3-2-1-2: Acenaphthalene (AcpY)

The highest concentration of AcpY(15.16 ng/gDW)was recorded at site 5 during autumn, while no detected concentration were observed at sites (2,3,4 and 5) during summer, site(1,4))during spring and site 3 during winter with the annual mean (2.39ng/gDW). The mean percentage 0f AcpY to the total PAHs was(1.46%). Statistical analysis showed to significant differences in the concentration of AcpY among sites and seasons($P<0.01$).

3-3-2-1-3:Acenaphthene and Fluorene(Acp&Flu)

The results referred to highest concentration of Acp & Flu in sediment(30.55ng/gDW) at site 3 during spring, while no concentration were observed at sites(2,4 and 5) during summer, site 5 during autumn, site 3 during winter and site 4 during spring with the annual mean concentration of(3.37ng/gDW). The mean percentage of Acp & Flu to the total PAHs was (2.06%). Statistically,the concentrations of Acp & Flu were not significant among sites, while significant among seasons($P<0.01$).

3-3-2-1-4:Phenanthrene(Phen)

The concentration of Phen in the sediment samples was ranged between(0.66ng/gDW) at site 5 during winter to (31.59ng/gDW) at site 4 during spring. Phen represents (7.08%)of the total PAHs. Statistically, the concentration of Phen were not significant among sites and seasons ($P<0.01$).

3-3-2-1-5:Anthracene (Ant)

The con. of Ant in the sediment samples ranged between (ND-9.08ng/gDW).The highest concentration was observed at site 2 during winter, while no concentration were recorded at sites(1,3 and 4)during autumn, summer and winter respectively. The annual mean concentration of Ant was(3.48ng/gDW) and represent as(2.12%) of the total PAHs in the sediment. Statistical analysis referred to non significant differences of Ant concentration among sites and not among seasons.

3-3-2-1-6:Fluoranthene(Flur)

The results showed that the highest can. of Flur (25.5ng/gDW) was recorded at site 2 during summer, while the lowest con. (0.05ng/gDW) was observed at site 5 during summer. The results referred to annual mean con. of (9.48ng/gDW) and represent about (5.79%) of the total PAHs. The concentrations of Flur were not significant among sites and seasons ($P<0.01$).

3-3-2-1-7:Pyrene(Py)

The concentration of Py in the sediment samples ranged between ND concentration at sites(1,2 and 4) during summer to(33.88 ng/gDW) recorded at site 4 during spring with the annual mean concentration of (6.95ng/gDW). The mean percentage of Py recorded during the study was (4.24%) of the total PAHs. Statistical analysis referred to significant difference was recorded for Py among seasons($P<0.01$) and not significant among sites. Significant positive correlation was recorded for Py with Nap ($r=0.426, P<0.01$).

3-3-2-1-8: Benzo(A)Anthracene (BaA)

No concentration were detected at site 3 during summer, autumn and winter and at site 5 during summer, while high value(18.25ng/gDW) was recorded at site 4 during winter with annual mean concentration of 3.36ng/gDW. The mean percentage of PAHs in the sediment was 2.05% of the total PAHs. Statistically, the concentration of BaA in the sediment samples were not significant among sites and seasons($P<0.01$).

3-3-2-1-9:Chrycene (Chry)

The concentration of Chry in the sediment samples ranged from no detected concentration at site 1 and 2 during spring and summer to (69.04ng/gDW) recorded at site 3 during autumn with annual mean concentration of (20.017ng/gDW). The Chry represents 12.237% of the total PAHs in the sediment. Significant differences were recorded for Chry concentrations among sites and seasons($P<0.01$).

3-3-2-1-10:Benzo(b)Fluranthene(BbF)

The results idicated that no concentration was detected at sites 3,4 and 5during summer, at sites 1,3 and 4 during autumn and sites 1,2 and 3 during winter, while the highest value(32.484ng/gDW) was recorded at site 5 during autumn and site 1,2 and 3 in winter with annual mean concentration of (5.99ng /gDW). The mean percentage of(3.66%) of the total PAHs was

recorded for BbF. Statistical analysis referred to significant difference for BbF concentrations among sites and seasons ($P<0.01$). Significant positive correlation was recorded for BbF with py ($r=0.514$, $P<0.01$).

3-3-2-1-11: Benzo(k) Fluranthene(BkF)

The results indicated that no concentration were recorded at most river sites during the most time of the year, while the highest value(25.17ng/gDW) was recorded at site 3 during the winter with the annual mean concentration of (4.94ng/gDW). The BkF represents about 3.02% of the total PAHs. Significant differences were recorded for BkF concentration among sites and seasons ($P<0.01$). Significant positive correlation was recorded for BkF with Acenaphthalene ($r= 0.496$, $P<0.01$).

3-3-2-1-12: Benzo(a) Pyrene(BaP)

The concentration of BaP in the sediment samples ranged between(4.74-121.95ng/gDW) at site 4 during summer and site 5 during autumn with annual mean concentration of (36.55ng/gDW). BaP represents (22.34%) of the total PAHs. Statistically, the concentration of BaP not significant among sites, while significant among seasons ($P<0.01$). significant positive correlation was recorded for BaP with Naphthalene ($r=0.426$, $P<0.01$).

3-3-2-1-13: Dibenzo(a,h)Anthracene (DbA)

Con. of DbA was recorded at site 1 during winter and spring, at site 2 during summer, autumn and spring, at site 3 during summer and autumn and at site 5 during autumn. The highest value(44.2ng/gDW) was recorded at site 4 during the winter. A annual mean concentration of DbA was(8.12ng/gDW) and represents (4.97%) of the total PAHs. Statistically, significant relationships were recorded for DbA concentrations among sites and seasons($P<0.01$) and positive correlation was found for Acenaphthene with Fluorene ($r=0.509$, $P<0.01$).

3-3-2-1-14: Benzo(ghi) Pyrene (BghiP)

The concentration of BghiP fluctuated between (ND– 146.262 ng/gDW) recorded at site 5 and site 3 during autumn respectively with the annual mean concentration of (28.77ng/gDW) and represents as (23.66%) of the total PAHs. The statistical analysis referred to significant differences were for BghiP among sites ($P < 0.01$), but not among seasons and positive correlation was observed for BghiP with BbF ($r = 0.438, P < 0.01$).

3-3-2-1-15: Indeno(1,2,3-cd)Pyrene (IND)

The mean concentration of IND ranged between (ND-57.06 ng/gDW) at site 4 during summer and autumn respectively with annual mean concentration of (15.55ng/gDW). The IND represents about (8.29%) of the total PAHs. Statistically, significant difference was recorded for IND concentration among sites and seasons ($P < 0.01$).

Statistical analysis recorded significant correlations for individual PAHs in the sediment among them ($P < 0.0$) as demonstrated in (index3/table3). Also positive significant correlations were recorded for PAHs in water with those in sediment ($P < 0.01$) as explained in (index 3/table 4).

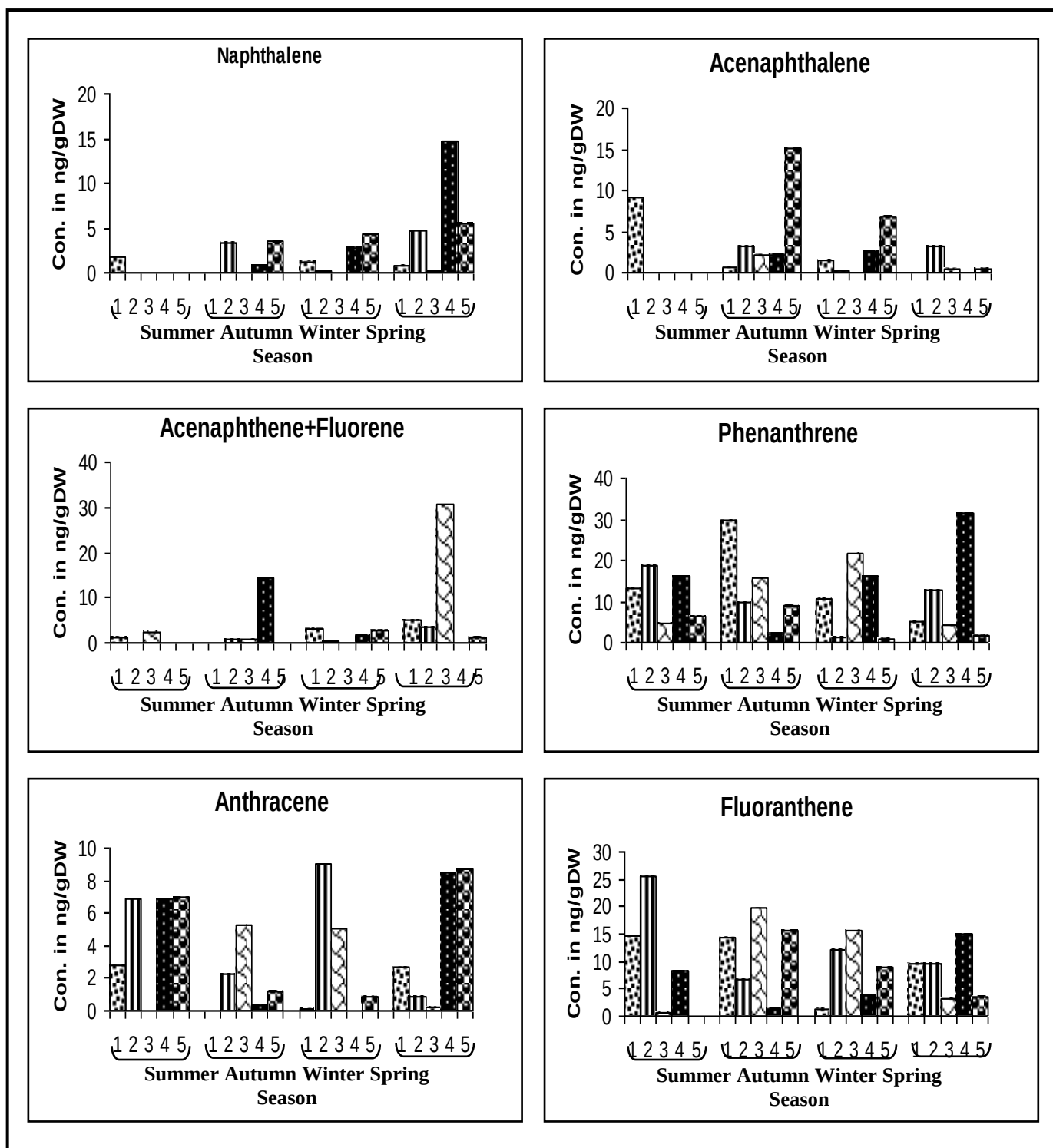


Figure (35): Seasonal changes in the concentrations of Naphthalene, Acenaphthalene, Acenaphthene+Fluorene, Phenanthrene, Anthracene and Fluoranthene in the sediment samples of Euphrates river sites (1-5) from (Jul. 2005 – June 2006).

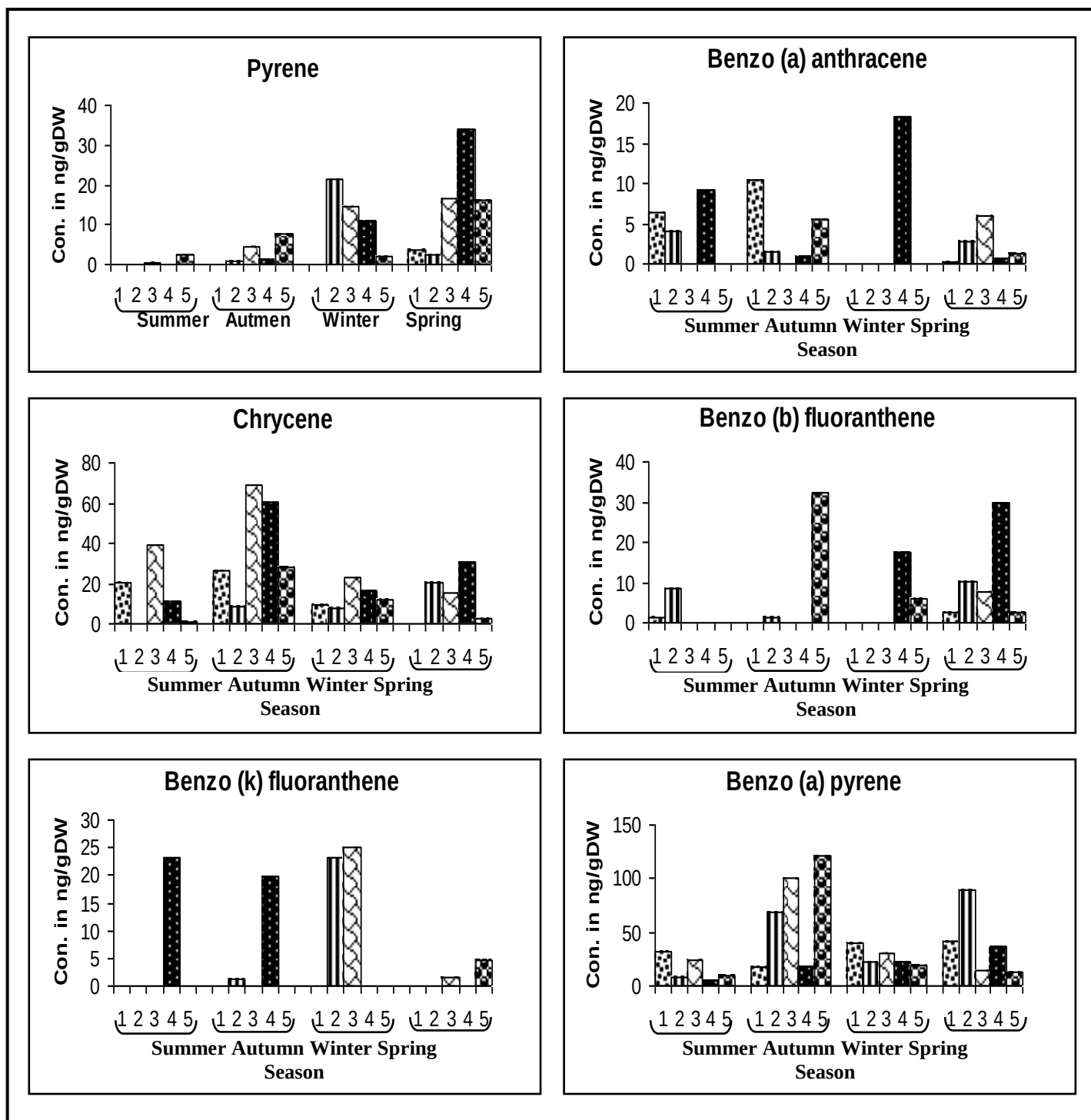


Figure (36): Seasonal changes in the concentrations of PAHs compounds in the sediment samples of Euphrates river sites(1-5) during the study period (Jul. 2005 – June 2006).

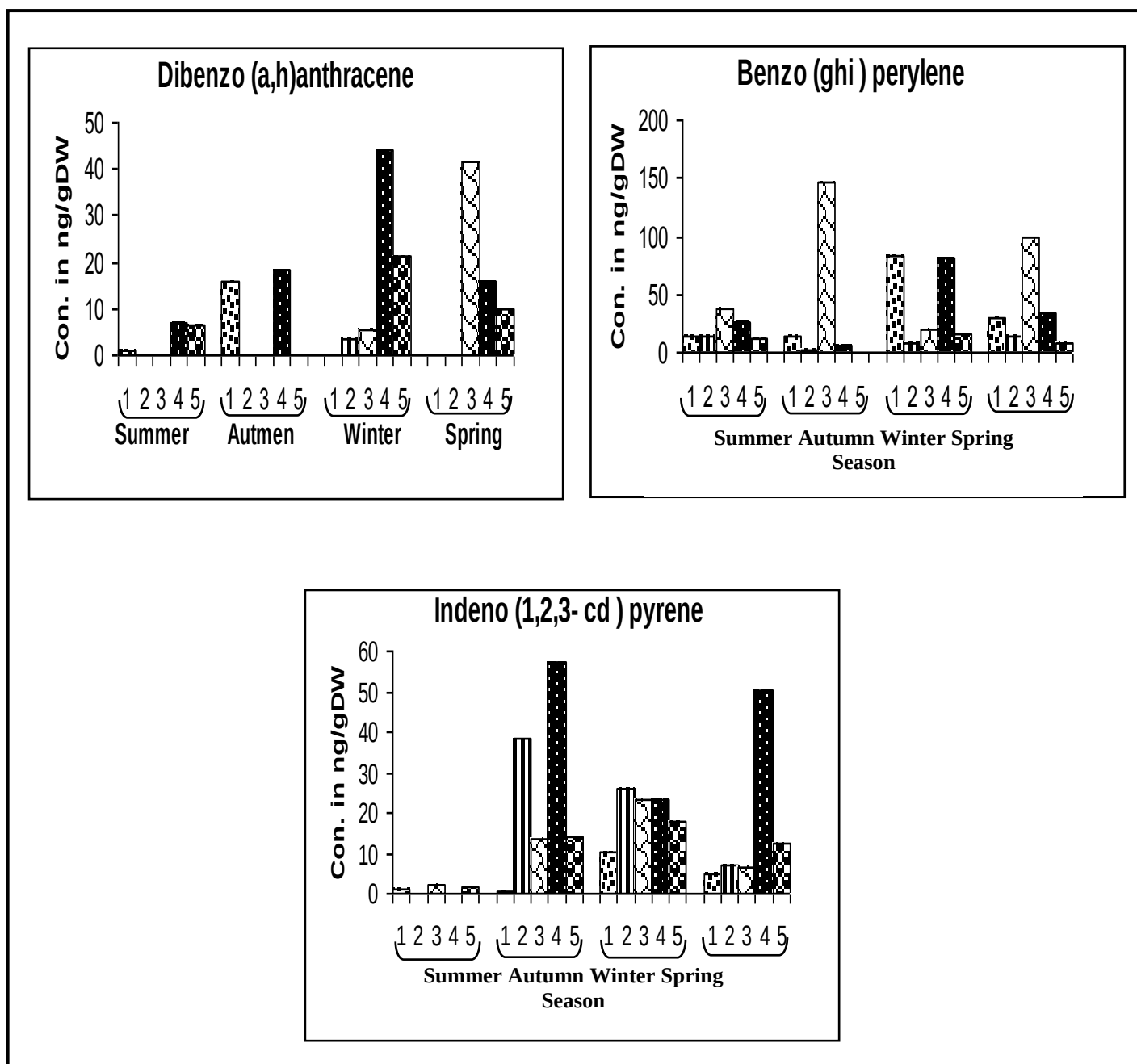
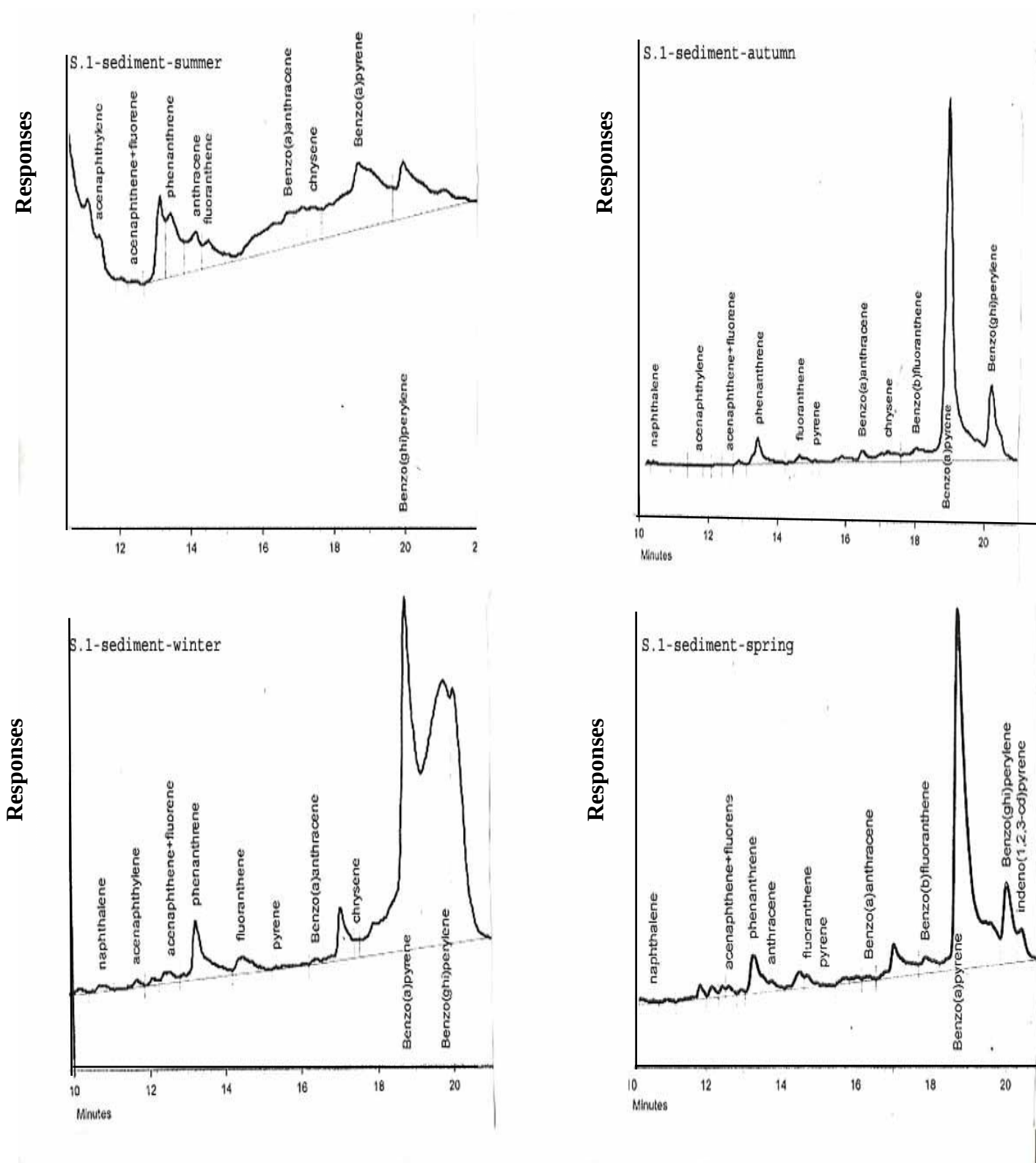
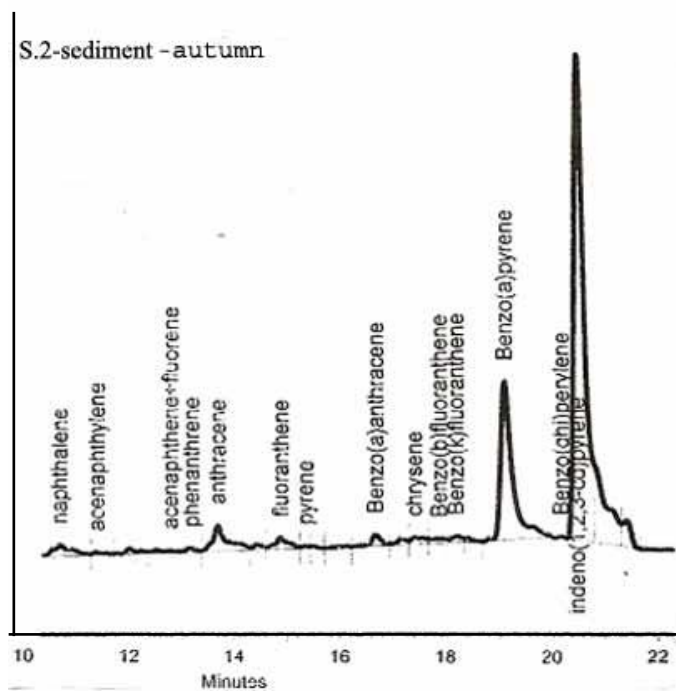


Figure (37): Seasonal changes in the concentrations of PAHs compounds in the sediment samples of Euphrates river site during the study period (Jul. 2005 – June 2006).

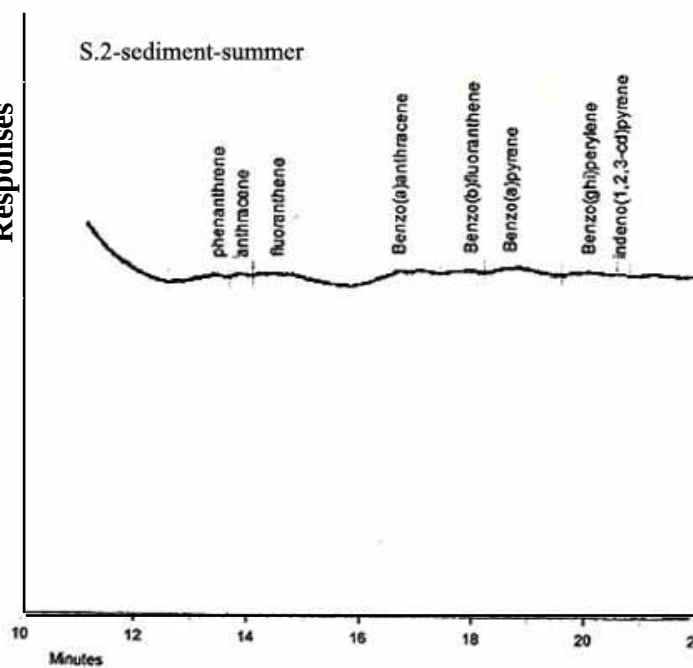


Figure(38): PAHs chromatogram for sediment sample collected at site 1 during the study period

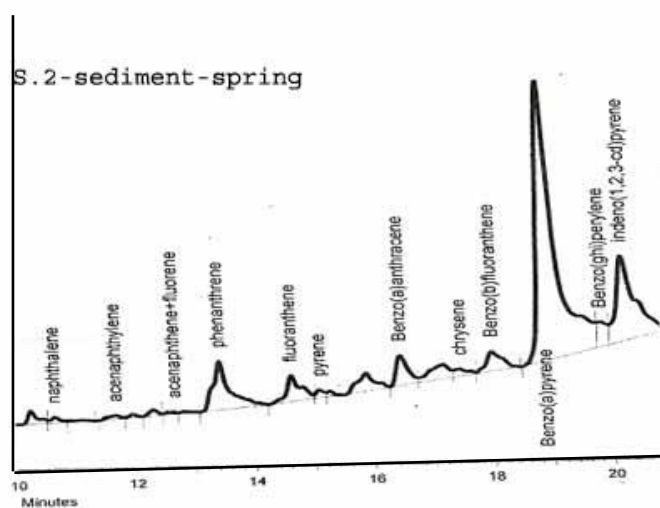
Responses



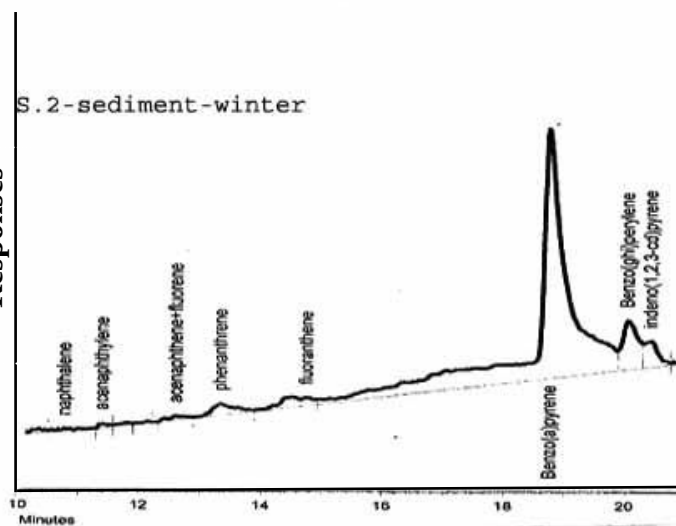
Responses



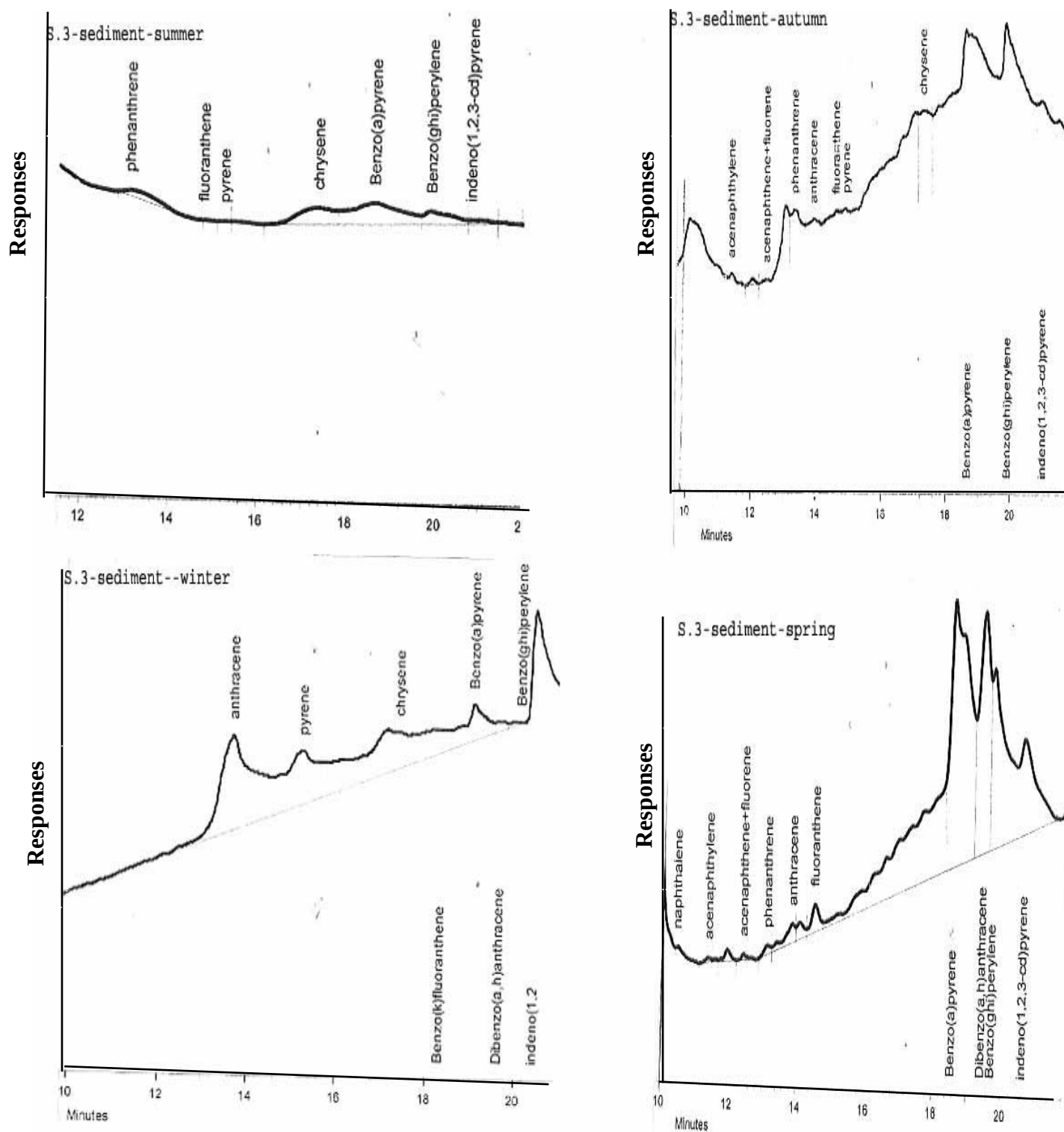
Responses



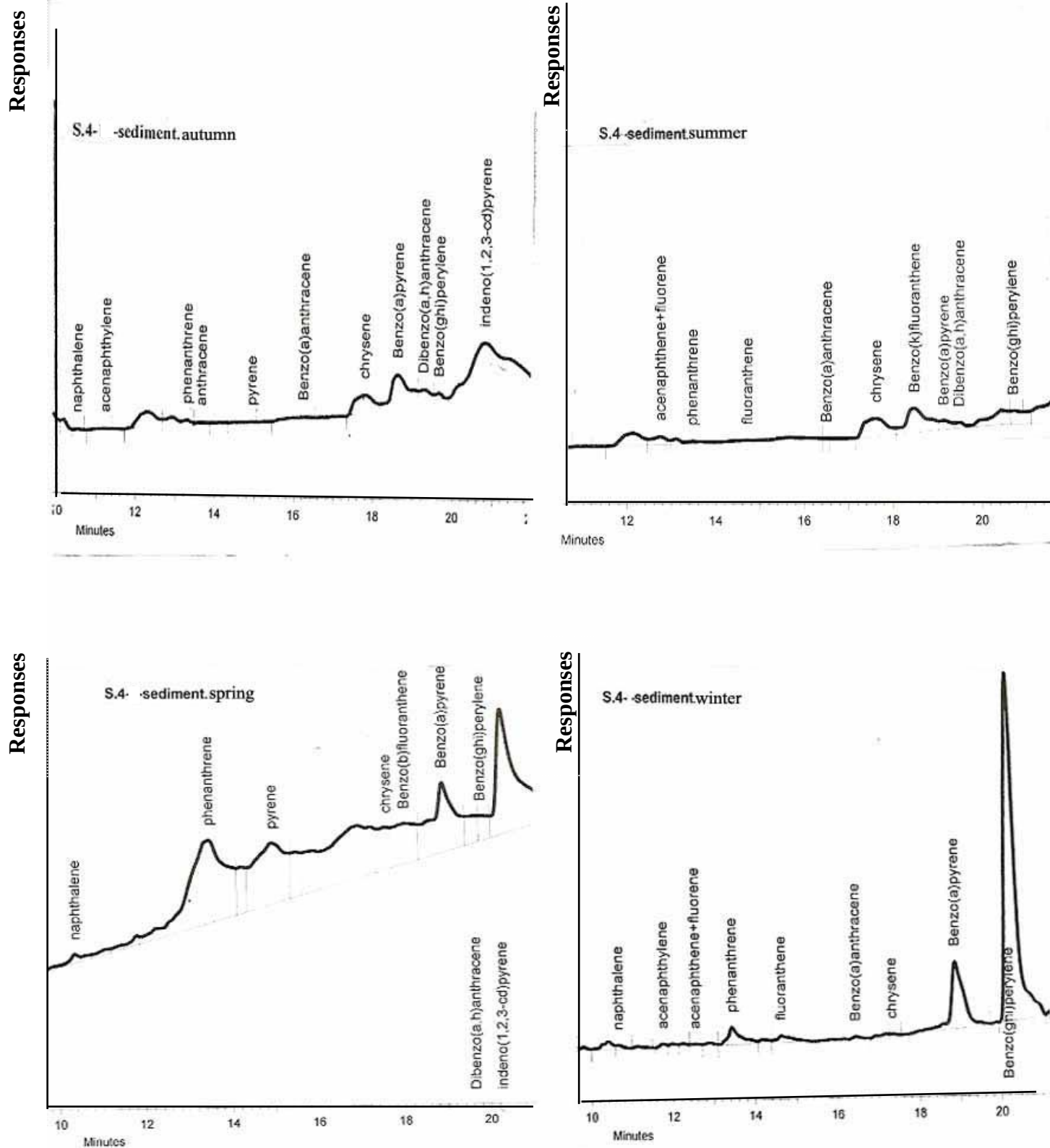
Responses



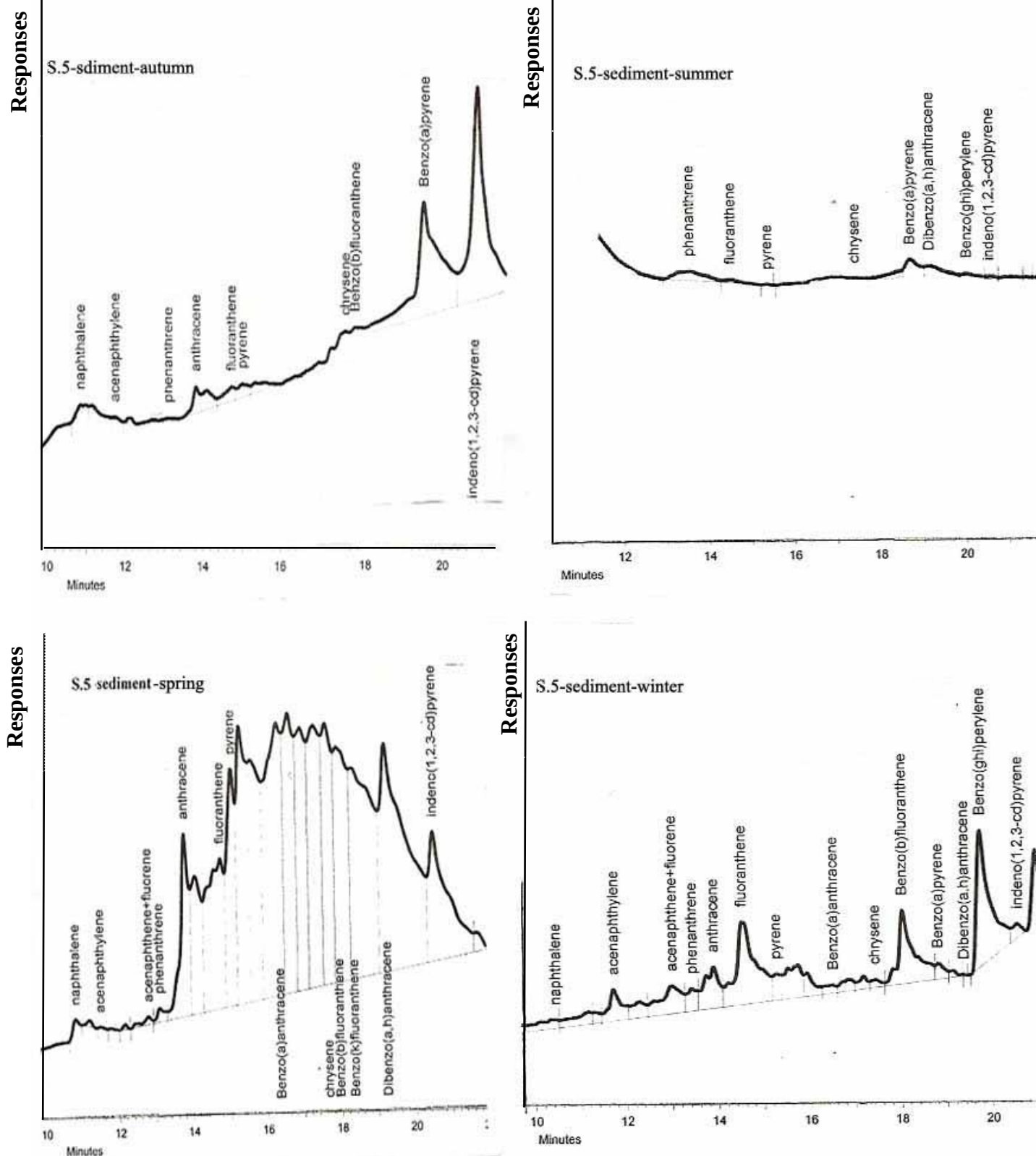
Figure(39): PAHs chromatogram for sediment sample collected at site2 during the study period



Figure(40): PAHs chromatogram for sediment sample collected at site 3 during the study period



Figure(41): PAHs chromatogram for sediment sample collected at site 4 during the study period



Figure(42): PAHs chromatogram for sediment sample collected at site 5 during the study period

3-3-2-2: Compositional pattern of PAHs in the sediment

The compositional pattern of PAHs in sediment samples was studied by ring number and molecular weight of PAHs compounds. The figure(43, 44 and 45) show the seasonal changes and mean concentrations of PAHs by ring number and molecular weight in the sediment samples, while figure 46 shows the mean percentage of PAHs by ring number.

The concentrations of 2 ring-PAHs, Nap were fluctuated between no detected concentration at sites(2, 3, 4 and 5) during summer, site 3 during autumn and winter and (14.75ng/g DW) recorded at site 4 during spring with the annual mean concentration of(2.19ng/gDW). Nap represents (1.31%) of the total PAHs in the sediment. The concentration of 3-ring PAHs were ranged between(6.83-40.08ng/gDW) at site 3 during the summer and at site 4 during spring with the annual mean concentration of 20.85ng/gDW and represents about (12.47%) of total PAHs. The concentration between(2.98-93.43ng/gDW) were recorded for 4-ring PAHs at site 5 during the summer and site 3 during autumn respectively, with annual mean concentration of (39.80 ng/gDW).4-ring PAHs represents (23.81%) of the total PAHs. The lowest concentration of 5-ringPAHs (16.13ng/gDW) was recorded at site 5 during the summer, while the highest concentration of(144.43ng/gDW) was at site 5 during autumn.

The annual mean concentration of 5-ring PAHs was 56.92ng/gDW and represents (34.04%) of the total PAHs. The concentration between (12.88-159.74ng/gDW) were recorded for 6-ring PAH at site 5 and 3 during summer and autumn respectively with annual mean of (47.41ng/gDW) and represents (28.36%) of the total PAHs. Statistical analysis indicated that there were significant differences for 2, 4,5 and 6 ring- PAHs concentration among sites($P < 0.01$). Positive correlation was recorded for 4-ring PAHs with 5-ring PAHs ($r = 0.583$, $P < 0.01$) and 6-ring PAHs($r = 0.582$, $P < 0.01$). Also positive correlation was recorded for 4-ring PAHs in the sediment with

6-ring PAHs in the water ($r=0.558$, $P<0.01$). It is clear from the results that the high mean percentage of (34.211%) was recorded for 5-ring PAHs to the total PAHs in the sediment that referred to the abundance of 5-ring PAHs in the sediment. The compositional pattern of PAHs by molecular weight was also assessed. The concentration of low molecular weight-PAHs(LMW-PAHs) ranged between(6.83-54.83ng/gDW) at site 3 during summer and site 4 during spring respectively with the annual mean concentration of(23.04ng/gDW) and represents (13.78%) of the total PAHs. As related to High MolecularWeight-PAHs(HMW-PAHs), the concentrations ranged between (31.99-354.02ng/gDW) at site 5 during summer and site 3 during spring respectively. The mean concentration of of (144.13ng/gDW) was obtained and represents (86.22%) of the total PAHs.

In general, the total PAHs concentration recorded in the sediment samples ranged between(45.35-378.17ng/gDW) at site 5 during summer and site 3 during autumn respectively, with annual mean concentration of(167ng/gDW). The statistical analysis referred to significant differences for total PAHs among seasons($P<0.01$) and not significant among sites.

3-3-2-3: Sources of PAHs in the sediment

Table(8) and Figure(48) show the sources of PAHs in the sediment of Euphrates river sites by the ratios of individual PAHs compound (Phen/Ant,Flur/Py, BaP/B(ghi)Pery and LMW-PAH/HMW-PAH) in the similar manner in water samples.

The ratio of Phen/Ant ranged between(1.01-10.593) at site 5 and site 1 respectively with mean concentration of(4.5). The ratios between(0.61 - 10.91) were recorded for Flur/Py at site 4 and 1 respectively with mean concentration of(3.2).The ratio of BaP/BghiP were fluctuated between(0.55- 5.08) at site 3 and 2 respectively, with mean ratio of(2.5). The ratio of LMW-PAH /HMW-PAH were ranged between(0.11-0.22) at site 3 and 1 respectively with the mean concentration of (0.17).

3-3-2-4: Total Organic Carbon in the sediment(TOC %)

Table(9) shows the seasonal change in TOC % concentration in the sediment samples. The concentration between (0.16% -1.60%) were recorded at site 4 during spring and site autumn respectively with the annual mean percentage of(0.99%). The statistical analysis referred to significant relationships of TOC % concentration among sites and seasons ($P < 0.01$). Figure(49) shows positive correlation between TOC % with the total PAHs in the sediment($r = 0.739$, $P < 0.01$).

3-3-2-5: Grain size analysis of sediment samples

The percentage of sand, silt and clay of sediment samples collected from Euphrates river sites were(38.04,22.15,39.81%), (52.75, 18.44, 28.81 %), (33.16, 21.71, 45.13 %), (36.47, 31.15, 32.38 %) and(22.41, 31.68, 45.91 %) for sites(1-5) respectively as explain in table (10).

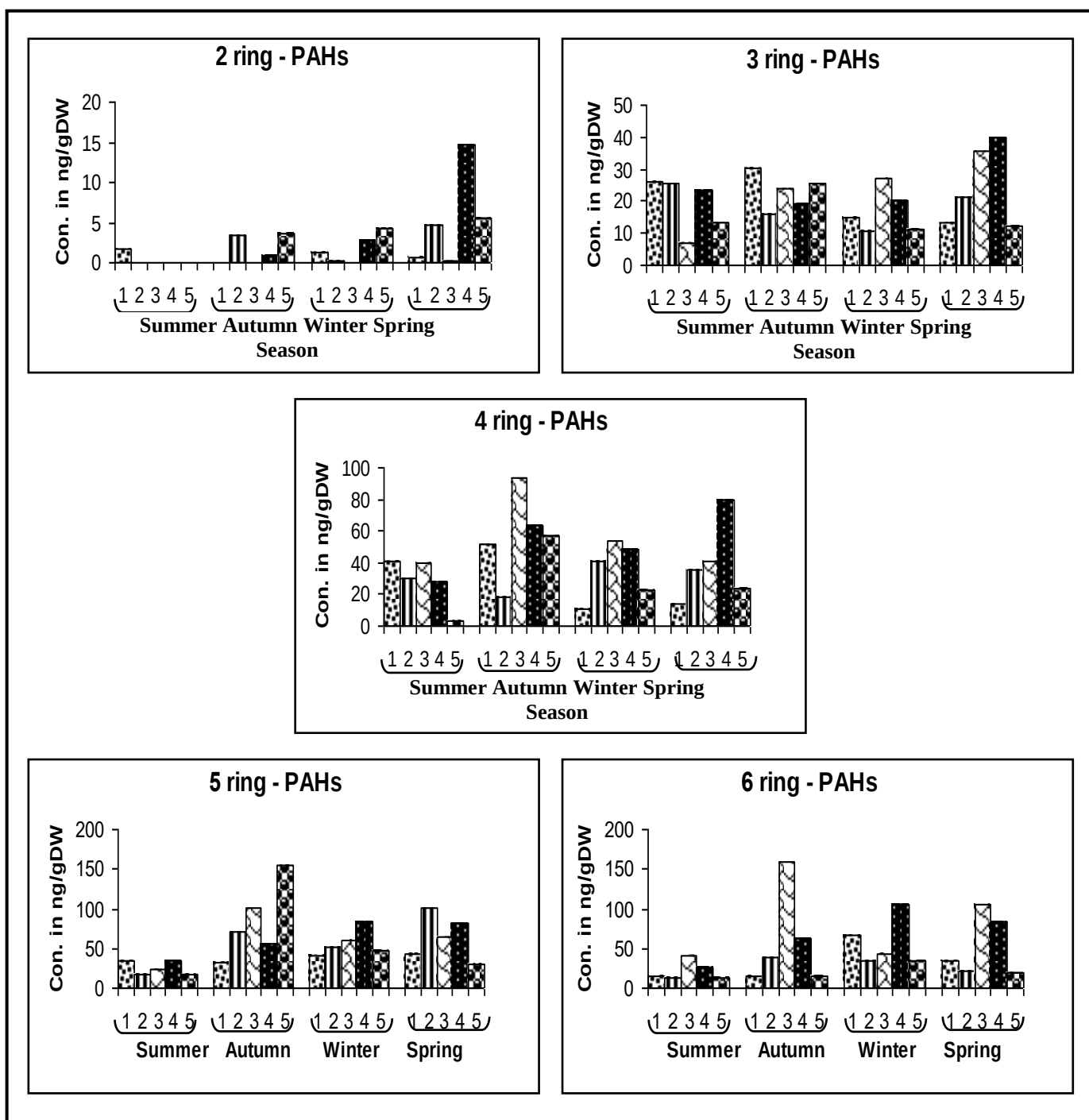


Figure (43): Seasonal changes in the concentrations of 2-ring, 3ring, 4ring, 5ring and 6ring-PAHs compounds in the sediment samples of Euphrates river site during the study period (Jul. 2005 – June 2006).

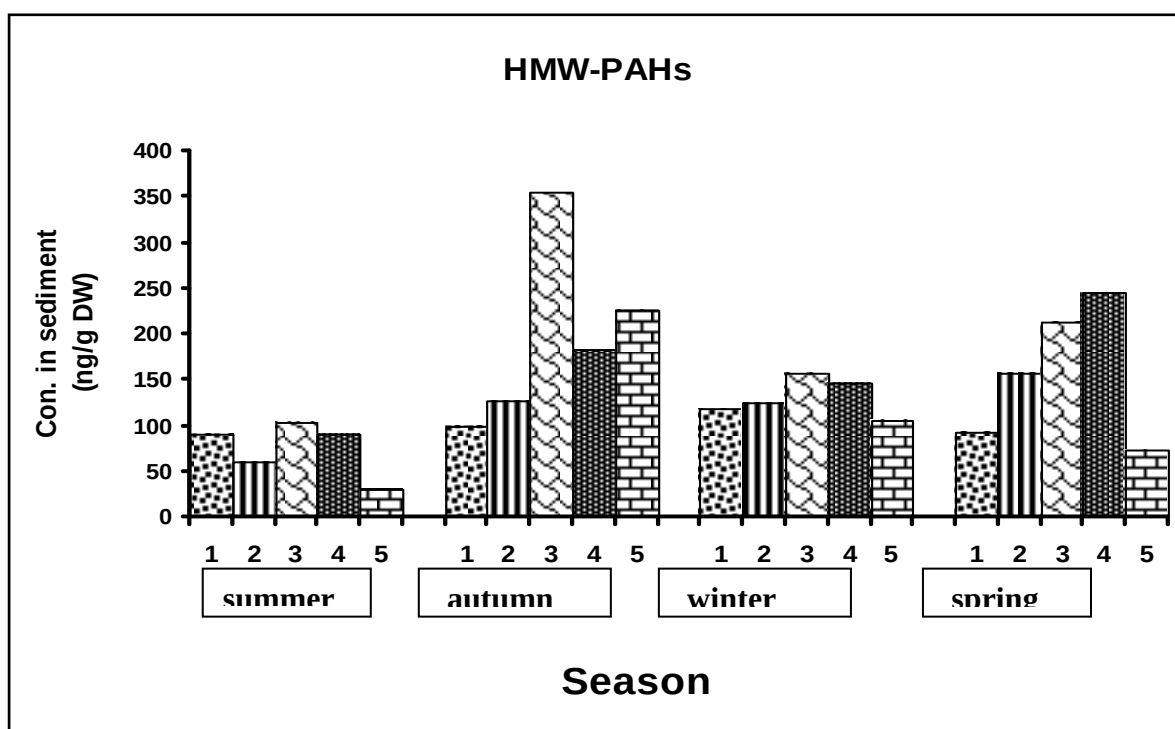
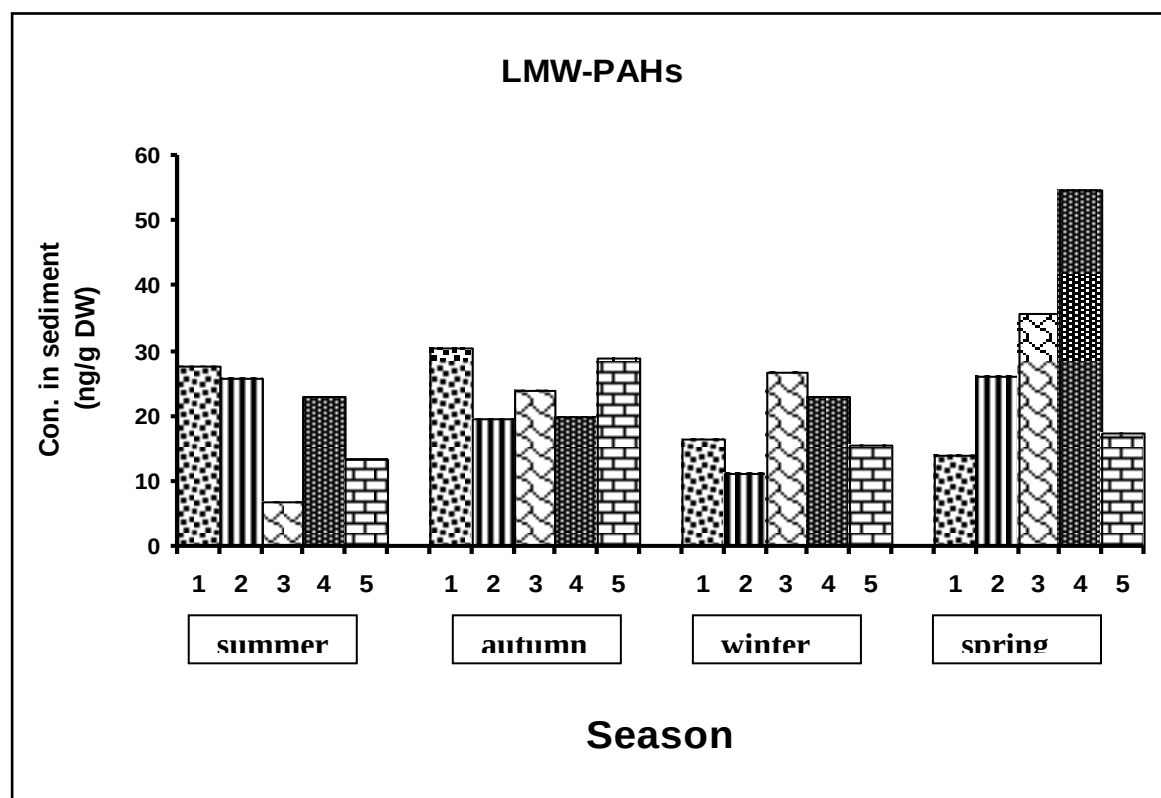


Figure (44) :Seasonal change in the concentration of Low molecular weight PAHs (LMW PAHs) and High molecular weight PAHs (HMW PAHs) in the sediment samples of Euphrates river sites (1-5) during the study period(Jul.2005-Jun.2006).

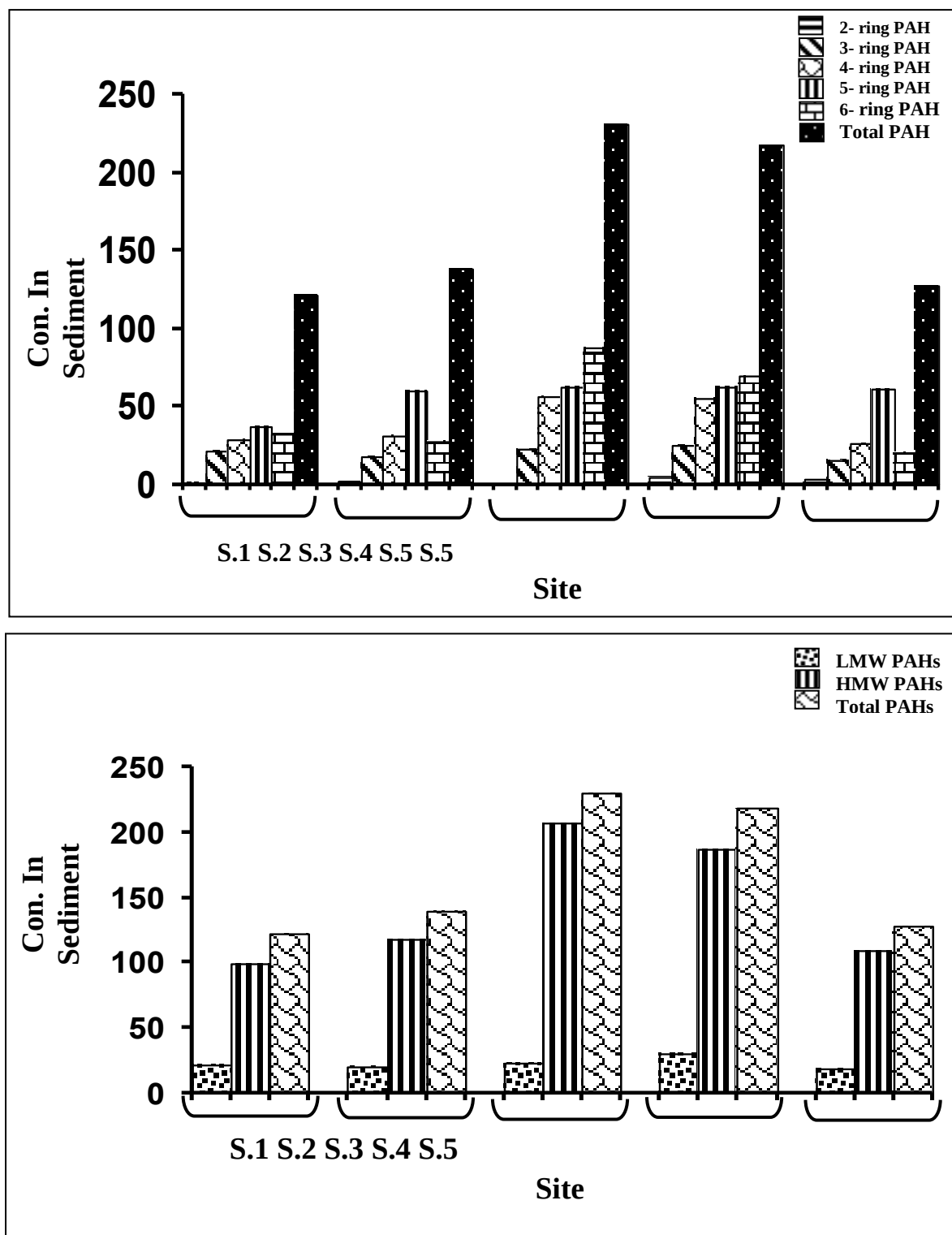


Figure (45) :Composition pattern of PAHs by ring numbers and molecular weight of sediment collected from Euphrates river sites(1-5) during the study period from(Jul.2005-Jun.2006)

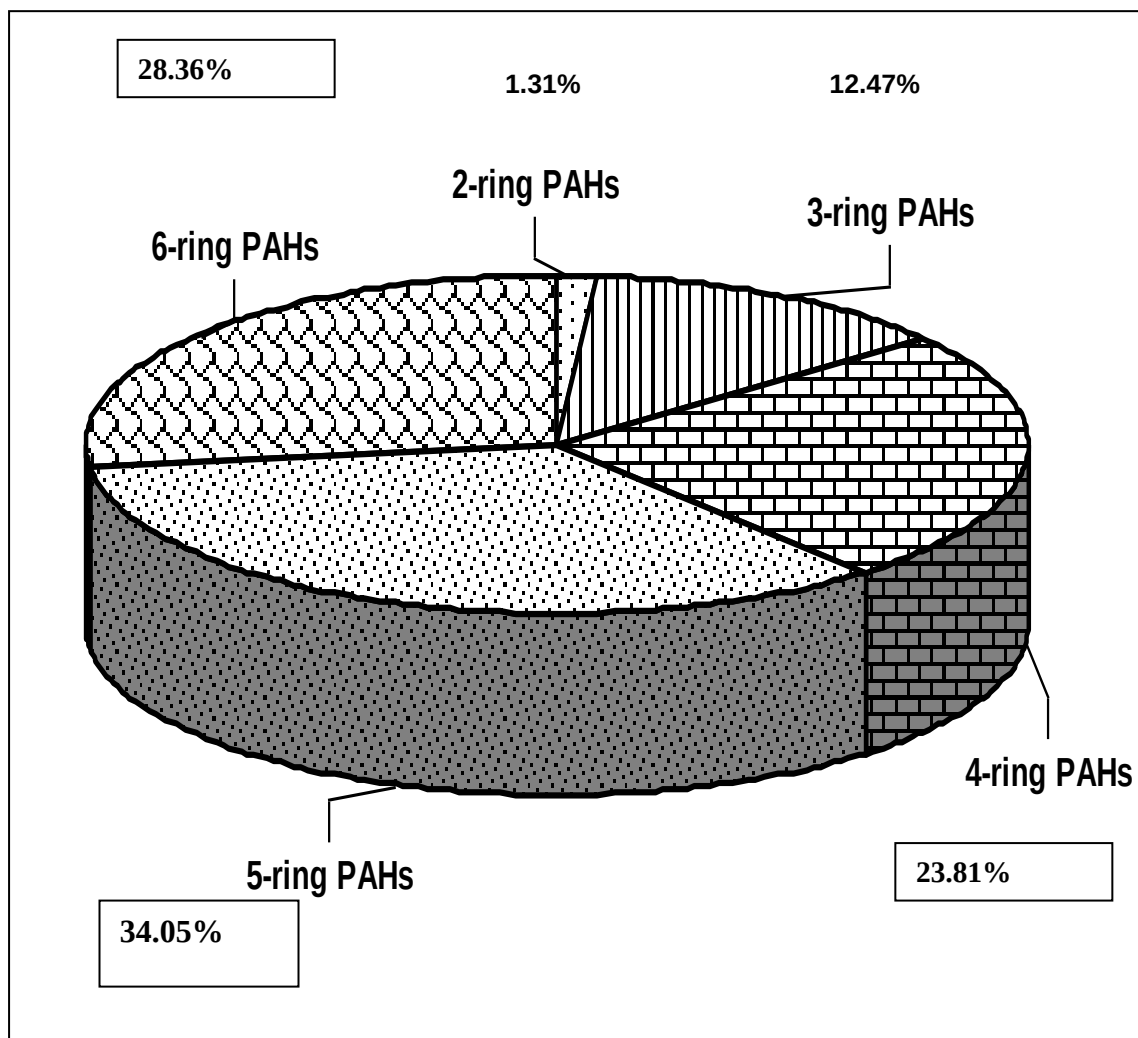


Figure (46): Mean percentage of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs in the sediment samples of Euphrates river site during the study period (Jul. 2005 – June 2006).

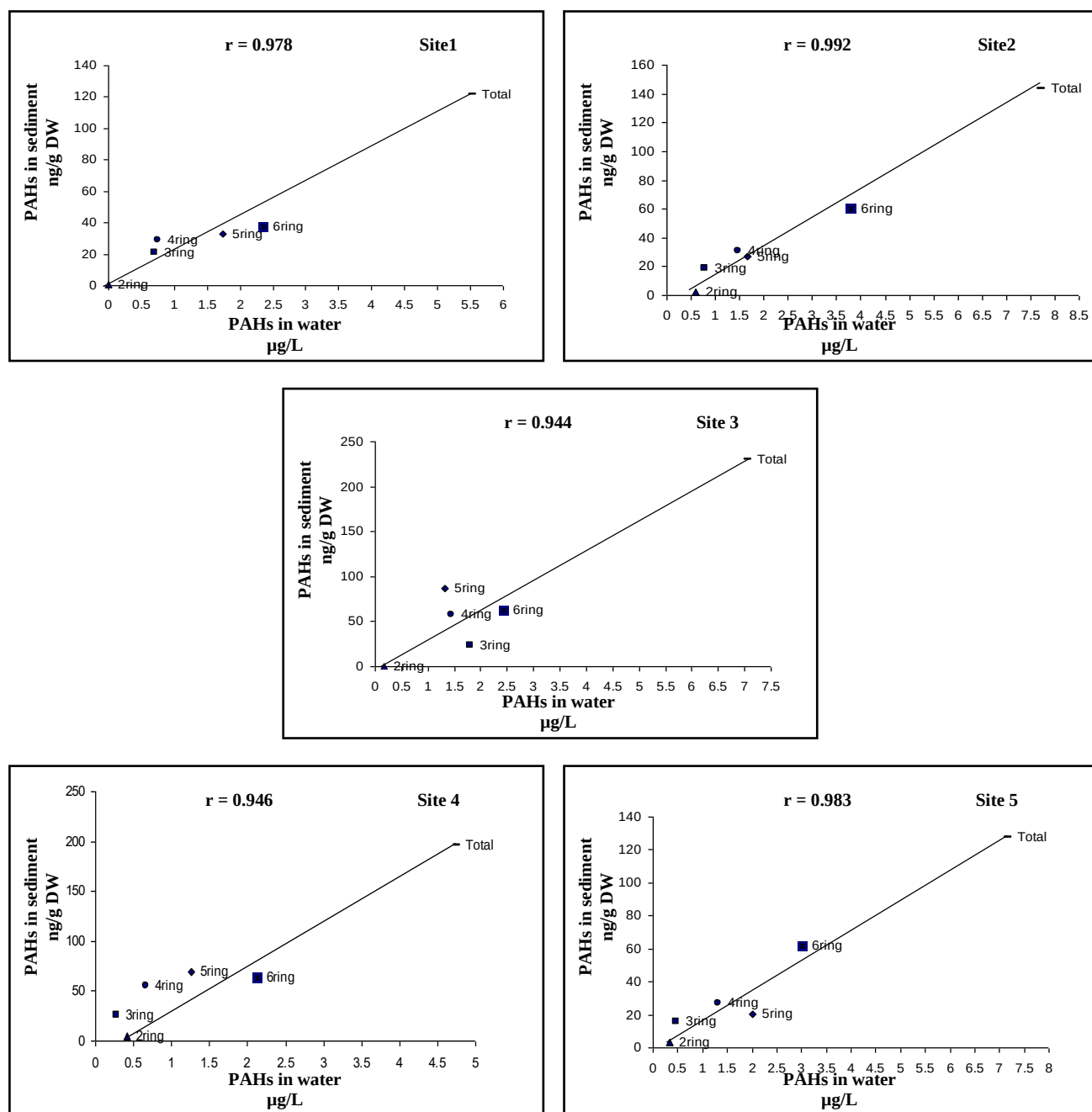


Figure (47): Relationship between the concentrations of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs and Total PAHs in the sediment with those in water from Euphrates river sites.

Table (8) :Mean ratios of individual PAHs compounds in sediment samples of Euphrates river sites during the study period(Jul.2005-Jun.2006).

Ratio Site	Phen/Ant	Flur/Py	Bap/BghiP	LMW-PAHs/HMW-PAHs	sources
S.1	10.59	10.91	1.15	0.22	Pyrogenic,petrogenic and urban air
S.2	2.12	2.18	5.08	0.17	Pyrogenic and urban air
S.3	4.42	1.18	0.55	0.11	Pyrogenic and urban air
S.4	4.33	0.61	0.94	0.16	Pyrogenic,petrogenic and urban air
S.5	1.01	1.03	4.64	0.17	Pyrogenic and urban air

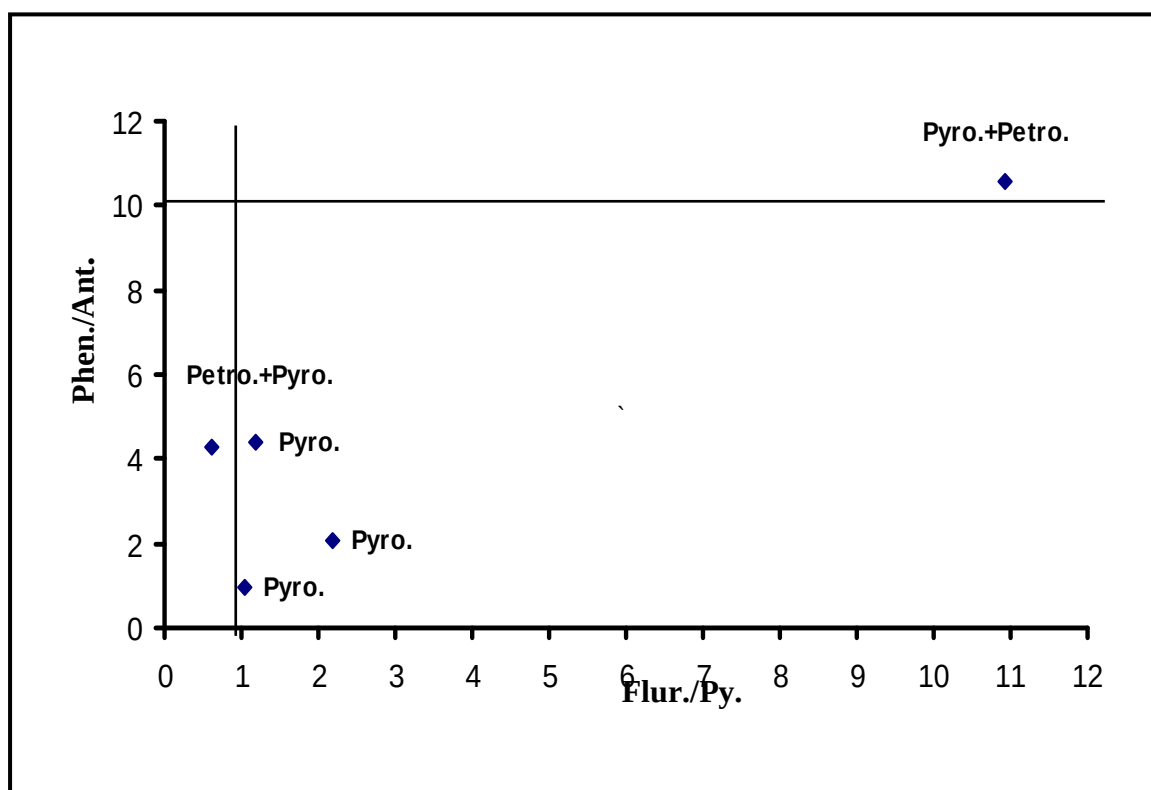
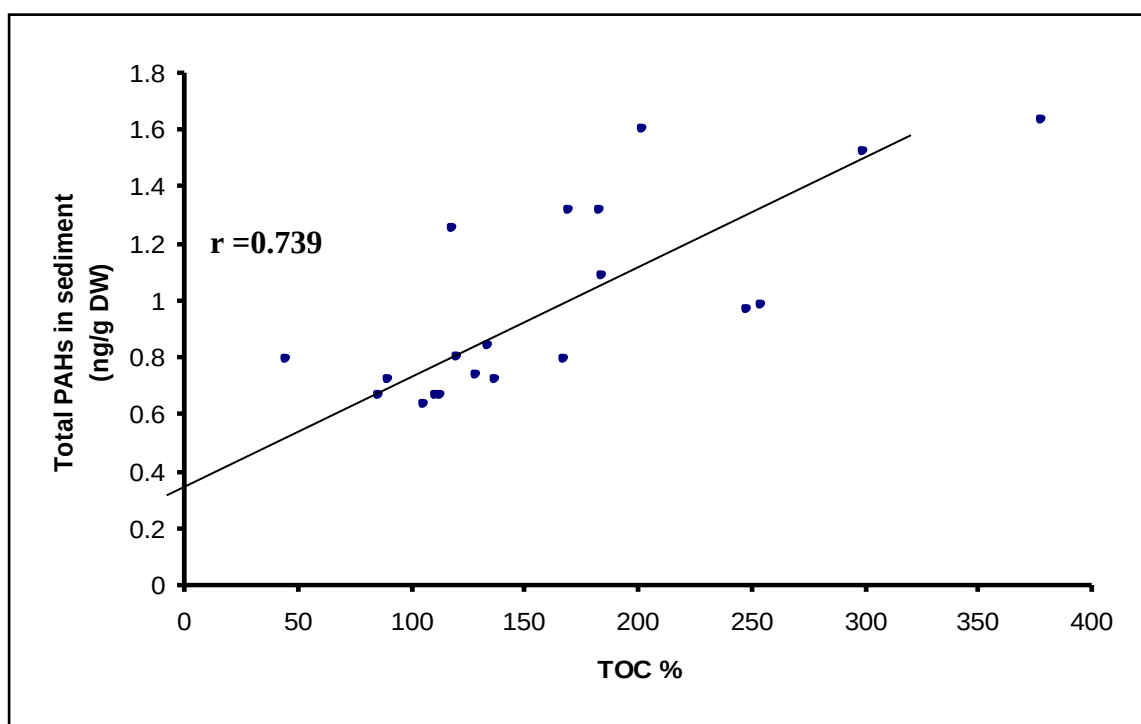


Figure (48) :The ratios of Phen/Ant and Flur/Py for sediment samples of Euphrates river sites.

Table(9):Seasonal changes in the percentage of Total Organic Carbon (TOC%) in the sediment samples of Euphrates river.

Season Site	Summer	Autumn	Winter	Spring
S.1	1.25	0.74	0.84	0.64
S.2	0.66	0.79	0.72	1.32
S.3	0.67	0.81	1.09	1.52
S.4	0.67	1.60	1.32	0.16
S.5	0.79	0.97	0.80	0.72



Figure(49): Relationship between PAHs in sediment with mean percentage of Total Organic Carbon(TOC%) recorded during the study period from(Jul,2005-Jun.2006)

Table (10) :Mean percentage of sediment components of Euphrates river sites during the study period(Jul.2005-Jun.2006).

component Site	% Clay	% Silt	% Sand	Texture
S.1	39.81	22.15	38.04	Clay-Sand-Silt
S.2	28.81	18.44	52.75	Sand-Clay-Silt
S.3	45.13	21.71	33.16	Clay-Sand-Silt
S.4	32.38	31.15	36.47	Sand-Clay-Silt
S.5	45.91	31.68	22.41	Clay-Silt-Sand

Table (11):The range and Mean(ng/g DW) $\pm$ S.D. of PAHs in sediment samples of Euphrates river sites during the study period(Jul.2005 –Jun.2006).

Compound	Site(1)	Site(2)	Site(3)	Site(4)	Site(5)
Naphthalene	ND-1.67 0.91 $\pm$ 0.72	ND-4.77 2.10 $\pm$ 2.35	ND-0.14 0.04 $\pm$ 0.06	ND-14.75 4.55 $\pm$ 3.46	ND-5.54 3.34 $\pm$ 2.35
Acenaphthalene	ND-9.14 2.82 $\pm$ 4.37	ND-3.26 1.69 $\pm$ 2.72	ND-2.19 0.66 $\pm$ 1.33	ND-2.16 1.21 $\pm$ 2.45	ND-15.16 5.59 $\pm$ 7.05
Acenaphthene & Flurene	0.05-5.23 2.33 $\pm$ 2.64	ND-3.62 1.18 $\pm$ 1.84	ND-30.55 8.43 $\pm$ 17.4	ND-14.48 3.98 $\pm$ 6.80	ND-2.87 1.04 $\pm$ 2.25
Phenanthrene	5.28-29.73 14.68 $\pm$ 13.19	1.15-18.82 10.63 $\pm$ 9.05	4.38-21.78 11.62 $\pm$ 18.45	2.18-31.59 16.57 $\pm$ 18.93	0.66-8.96 4.46 $\pm$ 4.15
Anthracene	ND-2.77 1.39 $\pm$ 2.25	1.84-9.08 5.01 $\pm$ 9.71	ND-5.23 2.63 $\pm$ 3.45	ND-8.49 3.93 $\pm$ 5.38	0.87-8.7 4.42 $\pm$ 7.57
Flouranthene	1.40-14.69 10.05 $\pm$ 7.83	6.58-25.5 13.42 $\pm$ 17.16	0.72-19.76 9.81 $\pm$ 11.26	1.33-14.85 7.02 $\pm$ 8.8	0.05-15.74 5.31 $\pm$ 6.51
Pyrene	ND-3.56 0.92 $\pm$ 2.99	ND-21.28 6.17 $\pm$ 13.85	0.39-16.69 9.09 $\pm$ 14.45	ND-33.83 11.47 $\pm$ 16.34	1.87-16.36 7.08 $\pm$ 12.58
Benzo(a)anthracene	0.04-10.43 4.27 $\pm$ 5.17	0.05-4.13 2.15 $\pm$ 1.99	0.0-5.96 1.49 $\pm$ 3.82	0.0-18.25 7.20 $\pm$ 15.51	0.0-5.45 1.68 $\pm$ 2.46
Chrycene	ND-26.38 13.92 $\pm$ 13.1	ND-20.13 9.21 $\pm$ 11.45	15.5-69.04 36.68 $\pm$ 23.41	11.15-60.06 29.40 $\pm$ 20.85	0.58-28.50 10.88 $\pm$ 12.5
Benzo(b)Flouranthene	ND-2.6 0.98 $\pm$ 1.83	ND-10.29 5.02 $\pm$ 5.15	ND-7.6 1.9 $\pm$ 5.76	ND-29.76 11.78 $\pm$ 18.35	ND-41.18 10.3 $\pm$ 13.78
Benzo(k)Flouranthene	ND	ND-23.3 6.14 $\pm$ 14.28	ND-25.17 6.64 $\pm$ 11.60	ND-23.33 10.75 $\pm$ 11.31	ND-4.70 1.18 $\pm$ 2.20
Benzo (a) Pyrene	16.91-41.07 32.57 $\pm$ 14.42	8.38-89.34 47.37 $\pm$ 39.39	14.31-100.9 41.99 $\pm$ 38.27	4.74-36.5 19.98 $\pm$ 14.96	9.9-121.95 40.82 $\pm$ 49.8
Dibenzo(a,h)Anthracene	ND-15.86 4.20 $\pm$ 7.56	ND-3.3 0.83 $\pm$ 18.38	ND-41.74 11.83 $\pm$ 18.38	7.08-44.2 21.36 $\pm$ 8.29	ND-21.4 9.42 $\pm$ 14.4
Benzo(ghi)Perylene	13.11-56.63 28.3 $\pm$ 19.33	1.23-14.24 9.33 $\pm$ 6.41	20.35-146.3 76.06 $\pm$ 56.93	6.35-81.52 65.47 $\pm$ 11.4	ND-16.74 8.8 $\pm$ 7.05
Indeno(1,2,3-cd)Pyrene	0.79-10.23 4.29 $\pm$ 8.24	0.06-38.4 17.9 $\pm$ 25.54	2.37-23.09 11.37 $\pm$ 11.45	ND-57.07 32.66 $\pm$ 26.5	1.6-17.77 11.54 $\pm$ 9.7

3-3-3: PAHs in Clams

3-3-3-1 :Individual PAHs in Clam

The seasonal changes in the concentration of PAHs(ng/g dry weight DW) in two species of clams (*Unio tigridis* and *Pseudodontopsis euphraticus*) were studied are shown in table(12) and Figure(50), while figure(51,52)show the chromatogram for clams collected in Euphrates river.

3-3-3-1-1:Naphthalene (Nap)

The highest concentration of NaP(0.2ng/g DW) was recorded in *U. tigridis* during winter with no concentration recorded in other seasons, NaP represents only(0.01%) of the total PAHs. In clam *P. euphraticus*, NaP concentrations ranged between (ND-12.2ng/g DW) during autumn and winter respectively with the mean concentration of(5.3 ng/g DW)and represents only (0.46%) of the total PAHs.

3-3-3-1-2:Acenaphthalene (AcpY)

The mean concentration of AcpY in the clam *U. tigridis* was (35.68ng/g DW) and represents(3.31%) of the total PAHs. The highest value(50 ng/g DW) was recorded during autumn, while the lowest value(24.0 ng/gDW) was during winter. In *P. euphraticus*, the highest and lowest values(29 ng/g dw and 3.3 ng/g DW) were recorded during autumn and spring respectively with the mean concentration of(13.33 ng/g DW) and represents (1.13%) of the total PAHs in clam.

3-3-3-1-3:Acenaphthene& Fluorene (Acp & Flu)

The results of the study referred to concentration between(7.2-36.4 ng/g DW) for Acp & Flu in clam *U. tigridis* during winter and spring respectively with the mean concentration of(18.43 ng/g DW) and represents (0.76 %) of the total PAHs. In the clam *P. euphraticus*, no concentration were recorded during autumn and winter and the highest concentration of

30.9ng/gDW was recorded during summer with annual mean concentration of 9.08ng/gDW.

3-3-3-1-4:Phenanthrene(Phen)

The concentration of Phen in the clam *U. tigridis* ranged between (5.5-58.2 ng/g DW) during autumn and spring respectively with the annual mean concentration of (20.02ng/g DW) and mean percentage (1.9%) of the total PAHs. In *P. euphraticus*, the concentration of Phen were between (4.5-28.1 ng/g DW) in spring and winter respectively with the mean concentration of (14.1 ng/g DW) and represent (1.19%) of the total PAHs

3-3-3-1-5 :Anthracene (Ant)

The concentration of (Ant) in clam *U. tigridis* fluctuated between (4.6-12.4ng/g DW) in autumn and spring respectively with the mean concentration of (7.85 ng/g dw) and mean percentage (0.73 %) of the total PAHs. The highest concentration for Ant (7.5 ng/g DW) was recorded in *P. euphraticus* during summer, while the lowest value (4.8 ng/g DW) was observed during autumn. The mean concentration of Ant was (6.5 ng/g DW) and represent (0.6%) of the total PAHs.

3-3-3-1-6 :Fluoranthene(Flur)

No detected concentration of Flur in clam *U. tigridis* during spring, but the concentration (86.5 ng/g DW) was observed during autumn with the annual mean concentration of 45.1 ng/g DW that represents (4.59 %) of the total PAHs. The concentration between (24.8- 83 ng/g dw) for Flur were recorded in *P. euphraticus* during summer and spring respectively. The mean concentration of Flur was (54.2 ng/g DW) that represents (4.59%) of the total PAHs.

3-3-3-1-7 :Pyrene (Py)

The concentration of Py in clam *U. tigridis* ranged between (ND-120.2 ng/g Dw) during summer and spring respectively, with the mean concentration of (57.7 ng/g DW) and represent (5.75%) of the total PAHs.

In *P. euphraticus*, the concentration of Pyrene were ranged between(13.4-57.9 ng/g DW) during summer and autumn respectively with the mean concentration (40.0 ng/g DW) and mean percentage (3.39 %) of the total PAHs

3-3-3-1-8 :Benzo(a) Anthracene(BaA)

The high concentration of BaA(46.2 ng/g DW) was recorded in clam *Unio tigridis* during autumn, while the lowest value(4.0 ng/g DW) was recorded in summer, with the annual mean concentration of(32.95 ng/g DW) and mean percentage of(3.05%). The concentration of BaA in *P. euphraticus* ranged(21.0 -81.5 ng/g DW) during summer and spring respectively with the mean concentration of(53.5 ng/g DW) and represents(4.53 %) of the totala PAHs.

3-3-3-1-9 : Chrycene (Chry)

The concentration of Chry in the clam *U. tigridis* were fluctuated between(43.7-255.9 ng/g DW) during summer and autumn with the annual mean concentration of(171.83 ng/g DW) and represents (15.94 %) of the total PAHs. In *P. euphraticus*, the concentration of Chry were between(110-25 ng/g DW) in summer and spring respectively with mean concentration of(188.33 ng/g DW) and mean percentage (15.95 %) of the total PAHs.

3-3-3-1-10 : Benzo(b)Fluoranthene(BbF)

The lowest and highest concentration of BbF in clam *U. tigridis* were (5.4 ng/g DW and 114.5 ng/g DW) recorded during summer and autumn respectively, with the mean concentration of (69.15 ng/g DW) and mean percentage (6.42 %). The concentration of BbF in *P. euphraticus* ranged from (ND to 112.9 ng/gdw) in summer and spring respectively, with the annual mean concentration of(65.78 ng/gDw) that represents (9.56%) of the total PAHs.

3-3-3-1-11: Benzo(k)Fluoranthene(BkF)

The concentration of BkF in clam *U. tigris* ranged (ND-83.6ng/g dw) in autumn and spring respectively, with the annual mean concentration of (36.23ng/g DW) and mean percentage (3.36%) of the total PAHs. In *P. euphraticus*, the concentration of BkF were (ND-239ng/g DW) in autumn and summer respectively, with annual mean concentration of (93.87 ng/g DW) and represents (7.39%) of the total PAHs.

3-3-3-1-12: Benzo(a)Pyrene(BaP)

The mean concentration of BaP in clam *U. tigris* was (101.75 ng/g dw) and represents (9.44%) of the total PAHs. The highest concentration was (168.3ng/gdw) recorded in autumn, while the lowest concentration (49.5ng/g dw) was recorded during winter. The concentration of BaP in *P. euphraticus* fluctuated between (ND-138ng/gDw) during summer and autumn respectively, the annual mean concentration of (86.2ng/gdw).

3-3-3-1-13: Dibenzo(a,h)Anthracene(DbA)

The concentration of DbA ranged between (ND-314ng/g dw) in clam *U. tigris* during spring and summer respectively, with the annual mean concentration of (159.85ng/gDW) and represents (14.83%) of the total PAHs. In *P. euphraticus*, the concentration of (317.6ng/g DW) was recorded as a maximum concentration during summer while no concentration in spring. The mean concentration of DbA was (181.43ng/g dw) and represents (15.28%) of the total PAHs.

3-3-3-1-14: Benzo(ghi)Perylene(BghiP)

The concentration of BghiP in the clam *U. tigris* were ranged (75.5-425.1ng/g DW) during summer and winter respectively with the mean concentration of (264.45 ng/g dw) and represents (24.5%) of the total PAHs. The highest concentration of BghiP 533.3ng/g DW in *P. euphraticus* was observed in winter, while the lowest concentration (41.0ng/g DW) in

summer with the mean concentration of (325.5ng/g DW) and represents (27.57%) of the total PAHs.

3-3-3-1-15: Indeno(1,2,3-cd)Pyrene(IND)

The concentration of IND were ranged (36.7-78.6ng/g DW) in clam *U. tigridis* during autumn and summer with the mean concentration of (56.63ng/g Dw) and represent about (5.25%) of the total PAHs. The mean concentration of IND (43.45ng/g dw) was recorded in clam *P. euphraticus* that represents (3.68%) of the total PAHs. The highest concentration and lowest concentration of IND was (10ng/g DW and 94.2ng/g DW) recorded in summer and winter respectively.

3-3-3-2 : Composition pattern of PAHs in clam

The composition pattern of PAHs in both species of clams by ring numbers as explained in Figure(53,54).

The mean concentration of 2ring-PAHs in clam *U. tigridis* and *P. euphraticus* were (0.05ng/gDW and 5.35ng/g DW respectively) and represents (0.01% and 0.45% respectively). The results of the study referred to the mean concentration of (47.56ng/gDW-150.7ng/g DW) for 3 ring-PAHs in clam *U. tigridis* during winter and spring respectively with the annual mean concentration of (81.97ng/g DW) and represent, (7.61%) of the total PAHs. In clam *P. euphraticus*, the concentration of 3 ring-PAHs ranged from 20.2 to 65.9ng/g DW during spring and summer respectively with mean percentage of (3.64%) of the total PAHs and mean concentration of (43.0 ng/gDW).

As related with the 4 ring PAHs in clam *U. tigridis*, the concentration (80.5-463.9ng/g DW) were recorded during summer and autumn respectively with the mean concentration of (307.58ng/g dw) and represents (28.54%) of the total PAHs. In clam *P. euphraticus*, the lowest and highest concentration of 4 ring-PAHs were (169.2ng/g DW and 469.3ng/g DW)

recorded during spring and summer respectively with mean concentration of(336.03ng/g DW) and mean percentage of (28.46%).

The concentration of 5 ring- of the total PAHs in clam *U. tigridis* were ranged from 289.1ng/gDW to 487.4ng/gDW in winter and autumn respectively with the mean concentration of(366.98 ng/g DW) and represents about(34.05%) of the total PAHs. In clam *P. euphraticus*, the concentration of(330 ng/gDW and 556.6ng/gDW) were recorded as minimum and maximum concentration of 5 ring –PAHs during spring and summer respectively with the annual mean concentration of (427.28ng/g DW) and represents (36.19%) of the total PAHs. As related the 6 ring-PAHs in clam *Unio tigridis*, the concentration were ranged from 154.1 to 464.3ng/g DW during summer and winter respectively with the annual mean value(321.1ng/g DW) that represents (29.79%) of the total PAHs. In the clam *P. euphraticus*, the highest mean concentration of 6 ring-PAHs was(627.5 ng/g DW) recorded during winter, while the lowest concentration of(51.1 ng/g Dw) was during summer with the annual mean concentration of(368.95 ng/g DW) and mean percentage (31.25%) of the total PAHs. In general the mean concentration of total PAHs in *U. tigridis* was(1077.68 ng/g dw) and the Low Molecular Weight PAHs(LMW-PAHs) represent(7.61%) of the total PAHs, while high molecular weight–PAHs (HMW-PAHs) represent (92.39%) of the total PAHs.

The mean concentration of total PAHs was(1180.61ng/gDw), the mean percentage of LMW-PAHs(8.19%) and HMW-PAHs(91.81%) in *P. euphraticus*. Statistical analysis referred to significant positive correlations were recorded for PAHs in both species of clam with those in water and sediment as demonstrated in figure(55).

The mean ratio of Phen/Anth, Flur/Py. BaP/BghiP and LMW-PAHs /HMW-PAHs were (2.17, 1.36, 0.26 and 0.09 respectively) recorded for

clam *U. tigridis* and (2.55, 0.78, 0.38 and 0.08 respectively) for *P. euphraticus*.

The results of statistical analysis explain that the concentration of PAHs detected in both species of clams were not significant clams, while significant differences were recorded for both species among seasons with the exception of non significant differences in the concentration of naphthalene($P < 0.01$).

In clam *U. tigridis*, Significant positive correlation were recorded for 3 ring-PAHs and 4 ring-PAHs among them indicating the homogeneity of PAHs. Also negative correlations were observed for some individual pAHs (Index3/Table5).

In clam *P. euphraticus*, positive correlation was recorded among 4 ring-PAHs. Also negative correlations were observed for LMW-PAHs with HMW-PAHs and 4 ring-PAHs with most of 3 ring-PAHs(Index3/Table6).

3-3-3-3:BioConcentration and BioSediment Accumulation Factors of PAHs in clam

The BioConcentration Factor(BCF) and BioSediment Accumulation Factor (BSAF) were assessed for individual PAHS in both types of clams(table, 14). BCF concentration were ranged from 0.12 to 1784 for naphthalene and Acenaphthalene respectively in clam *U. tigridis* and(12.83-1000) for naphthalene and pyrene respectively in clam *P. euphraticus*. The BSAF in clam *U. tigridis* was fluctuated between(0.12 and 320) recorded for naphthalene and Acenaphthalene respectively, while in clam *P. euphraticus* ranged from 8.51 to 152.3 for phenanthrene and BghlP respectively.

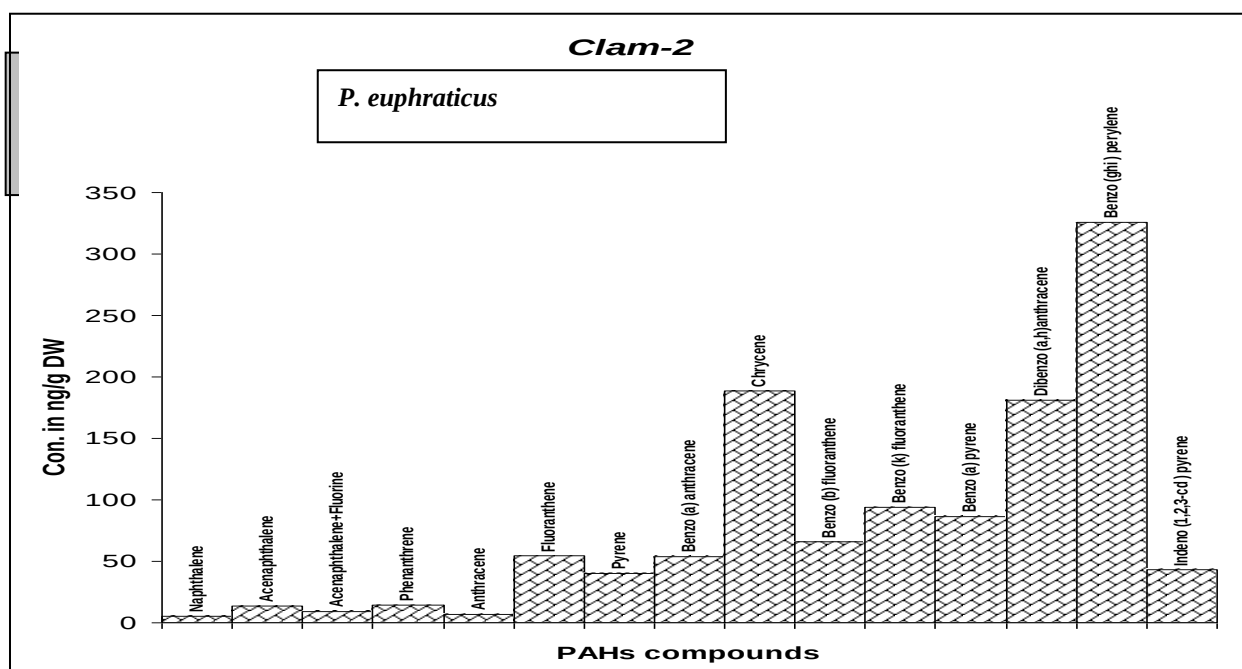
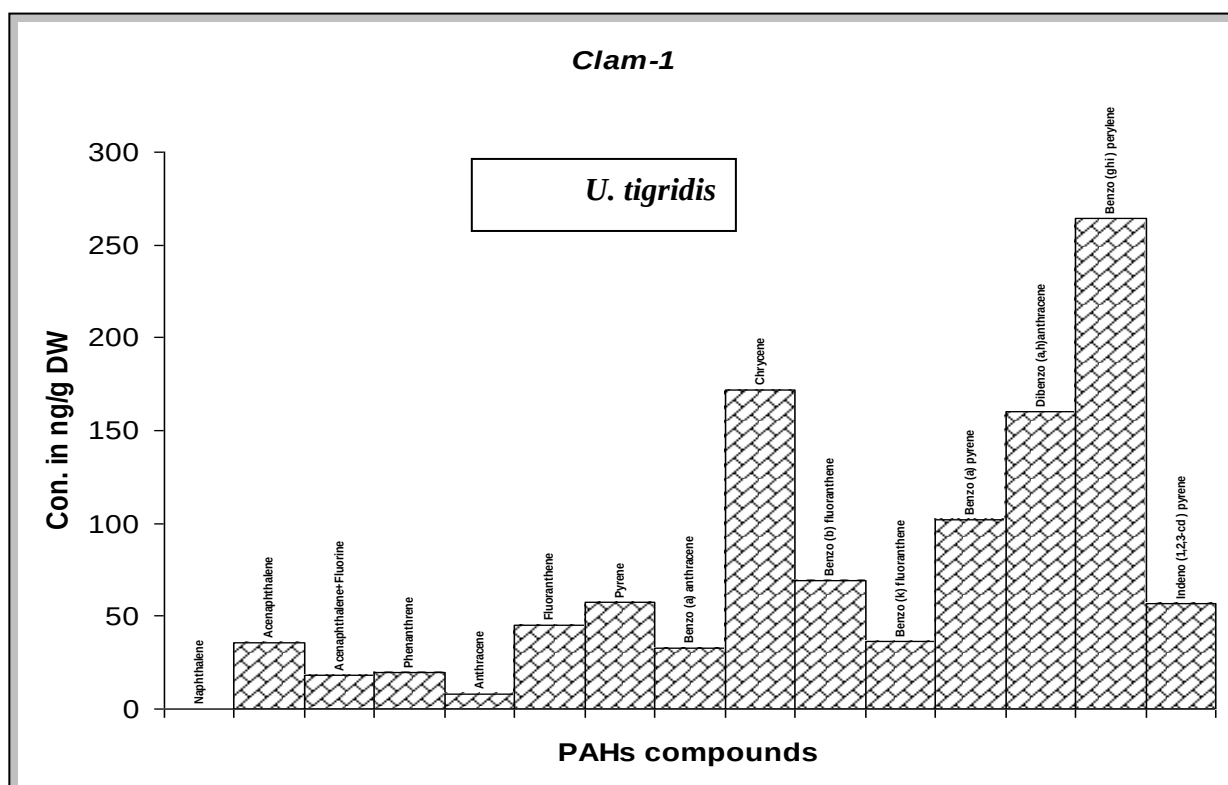
3-3-3-4:Lipid content in the clam

The concentrations of lipid in clam *U. tigridis* were ranged between (0.8 and 1.28 mg/gDW) recorded during summer and autumn respectively, while the range between (0.98 and 1.5 mg/gDw) was in clam *P. euphraticus*

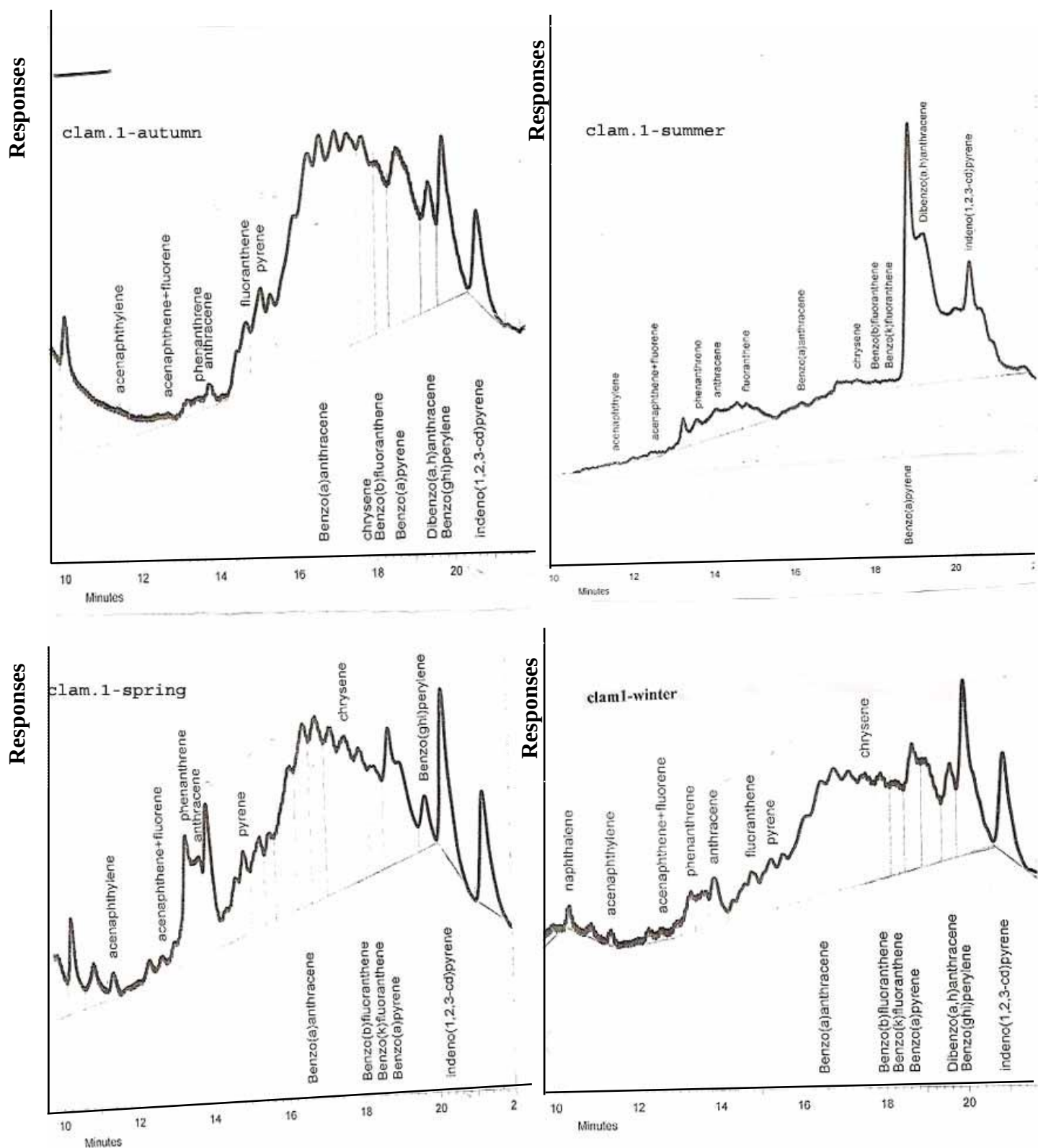
during summer and autumn respectively. Positive correlation was recorded for PAHs concentration in clam with lipid content ($r=0.964, P<0.01$ and $r=0.972, P<0.01$) in *U. tigris* and *P. euphraticus* respectively.

Table(12) :seasonal changes in the concentration of PAHs (ng/gDry Weight) in two species of clams (*Unio tigris* and *Pseudodontopsis euphraticus*) collected from Euphrates river.

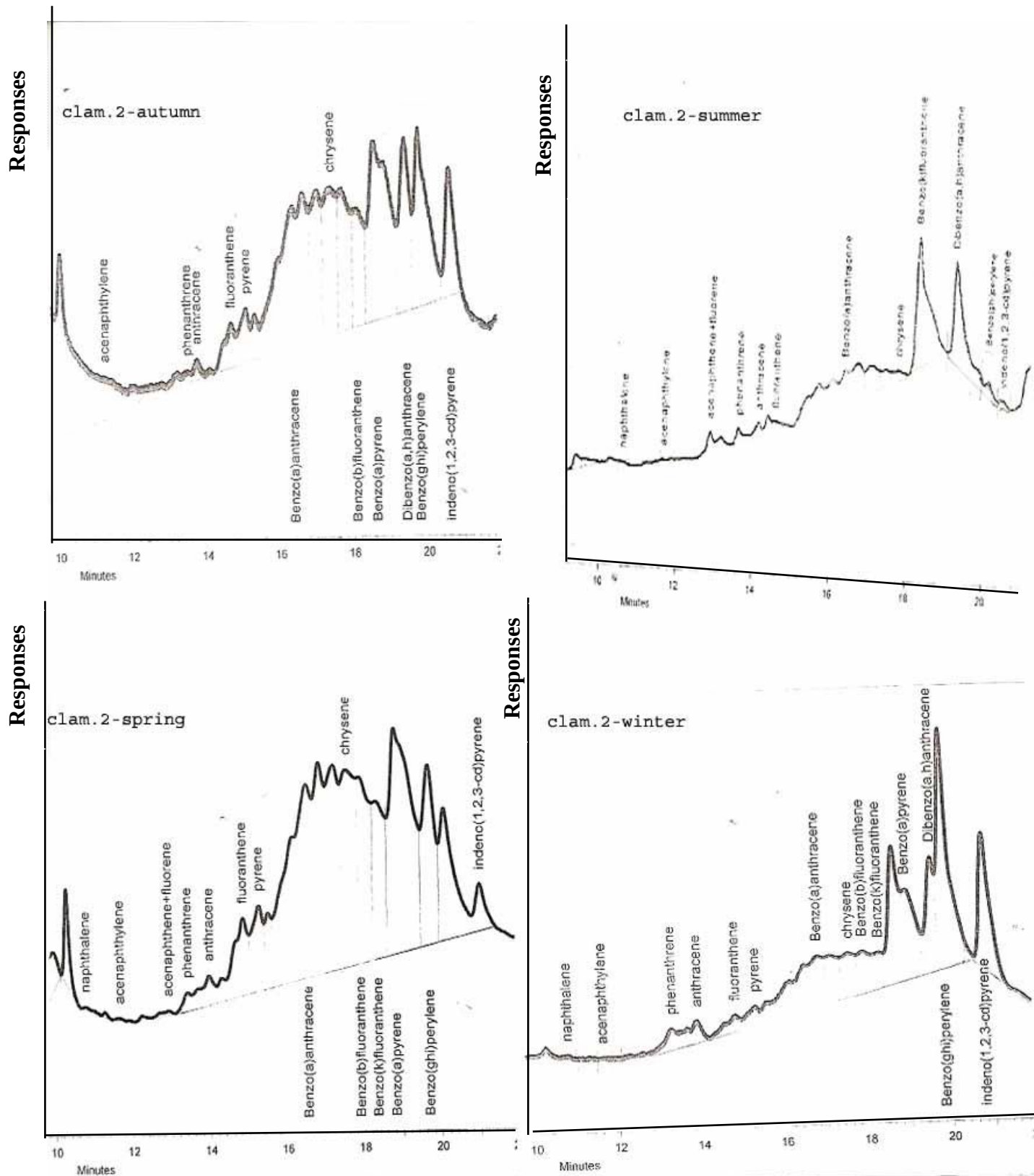
Compound	<i>U. tigris</i>				<i>P. euphraticus</i>			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Naphthalene	ND	ND	0.2	ND	3.6	ND	12.2	5.6
Acenaphthalene	25	50	24.0	43.7	11.3	29.0	9.7	3.3
Acenaphthalene and Fluorene	11.6	18.5	7.2	36.4	30.9	ND	ND	5.4
Phenanthrene	7.6	5.5	8.76	58.2	16.2	7.6	28.1	4.5
Anthracene	6.8	4.6	7.6	12.4	7.5	4.8	6.7	7.0
Fluoranthene	32.8	86.5	61.1	ND	24.8	50.7	58.3	83
Pyrene	ND	75.3	35.3	120.2	13.4	57.9	36.2	52.5
Benzo (a) anthracene	4.0	46.2	44.2	37.4	21.0	67	44.5	81.5
Chrycene	43.7	255.9	147.3	240.4	110	241.7	149.3	252.3
Benzo (b) fluoranthene	5.4	114.5	65.5	91.2	ND	85.1	65.1	112.9
Benzo (k) fluoranthene	7.5	ND	53.8	83.6	239	ND	49.3	87.2
Benzo (a) pyrene	69.2	168.3	49.5	120	ND	138	76.8	130
Dibenzo (a,h)anthracene	314	204.6	120.8	ND	317.6	216.1	192	ND
Benzo (ghi) perylene	75.5	324	425.1	233.2	41	432.1	533.3	295.6
Indeno (1,2,3-cd) pyrene	78.6	36.7	39.2	72	10.1	45.7	94.2	23.8
Total PAHs	681.7	1390.6	1089.6	1148.7	846.4	1375.7	1355.7	1144.6



Figure(50) : Mean concentration of PAHs compounds in the clam *Unio tigridis* and *Pseudodontopsis euphraticus* (clam1 and clam 2 respectively) collected from Euphrates river (site 4)during the study period (Jul.2005-Jun.2006)



Figure(51):PAHs chromatogram for clam *Unio tigridis*(Clam 1) collected from Euphrates river at site 4 during the study period



Figure(52): PAHs chromatogram for clam *Pseudodontopsis euphraticus* (Clam 2) collected from Euphrates river at site 4 during the study period

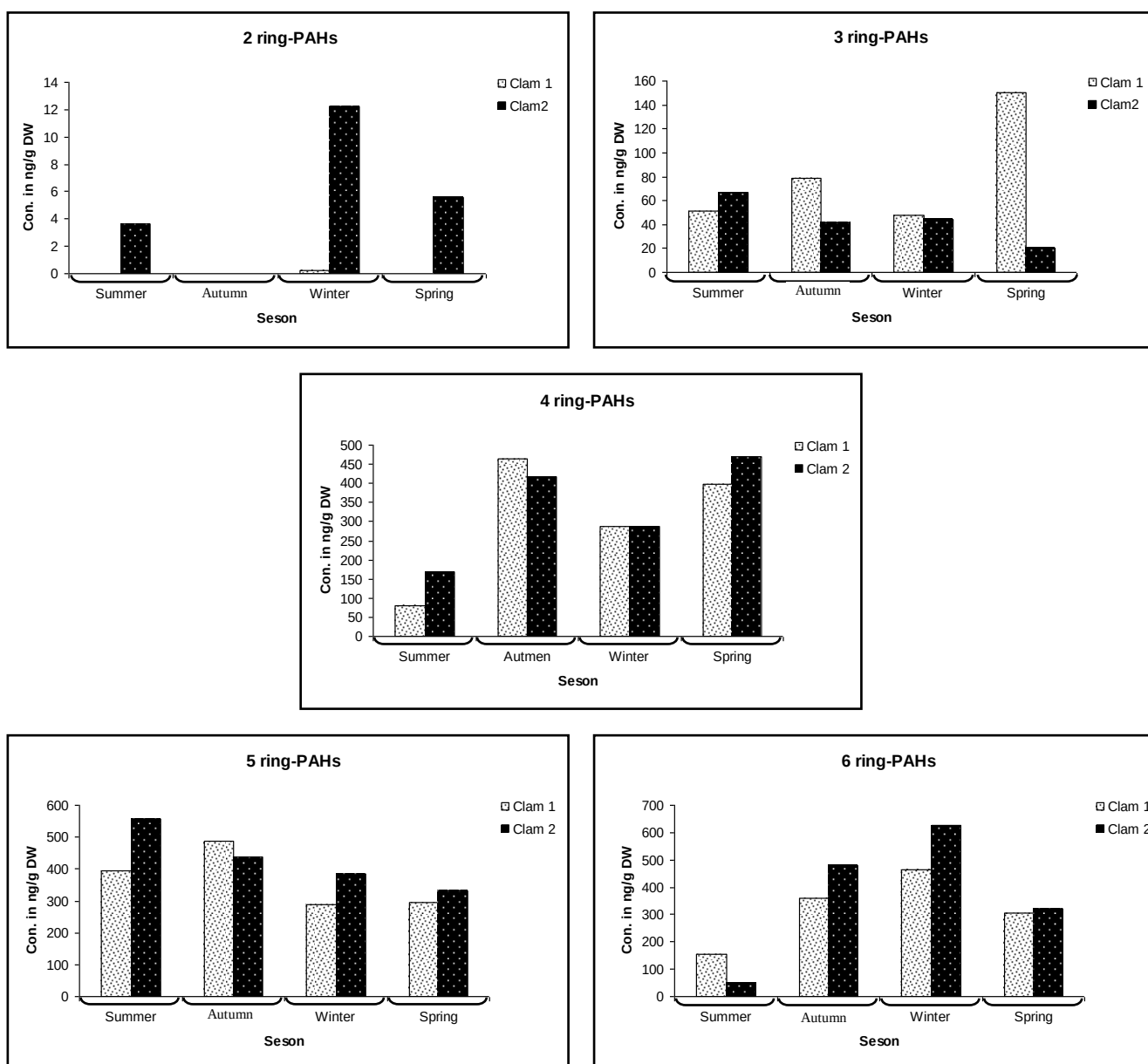
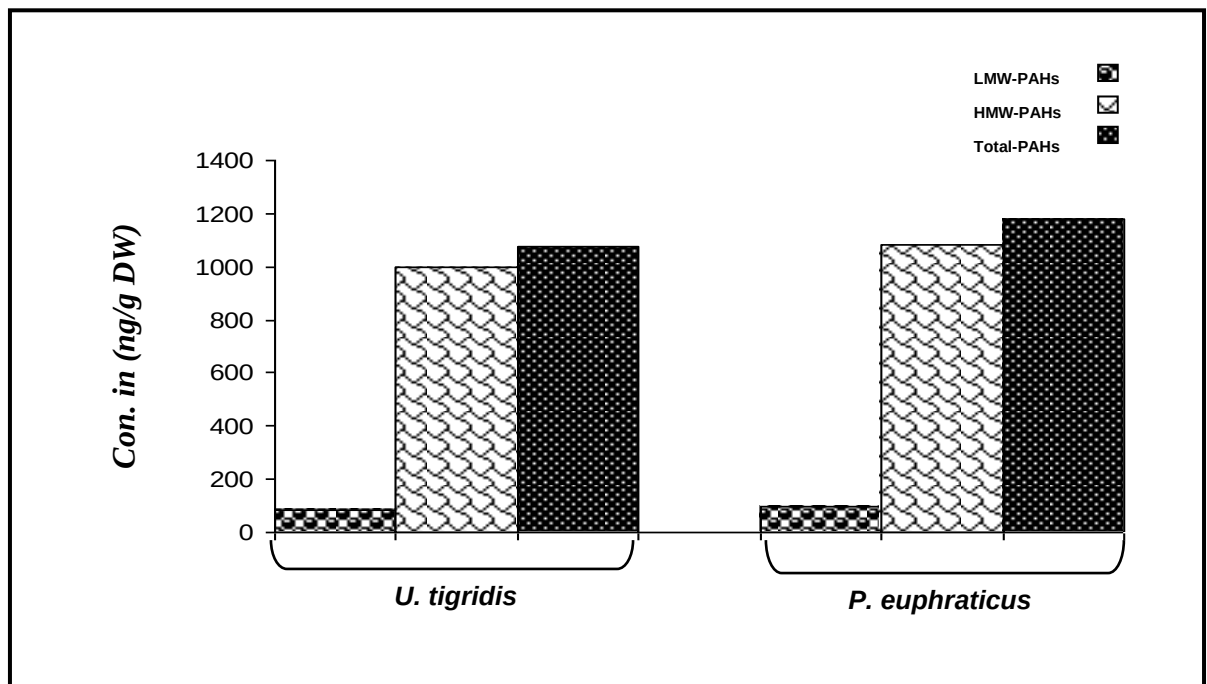
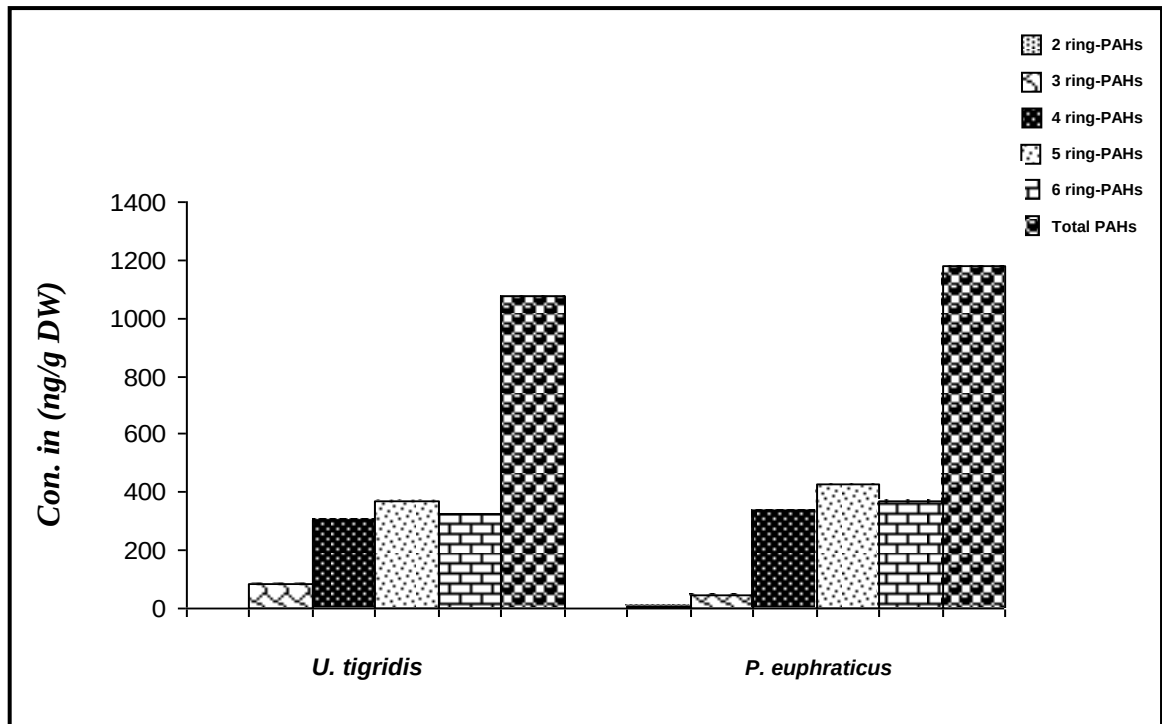


Figure (53): Seasonal changes in the mean concentrations of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs compounds in the both types of clams *Unio tigridis* and *Pseudodontopsis euphraticus* (clam1 and 2 respectively) collected from Euphrates river site during the study period (Jul. 2005 – June 2006).



Figure(54) :Composition pattern of PAHs in clams *Unio tigridis* and *Pseudodontopsis euphraticus* collected from Euphrates river during the study period(Jul.2005-Jun.2006)

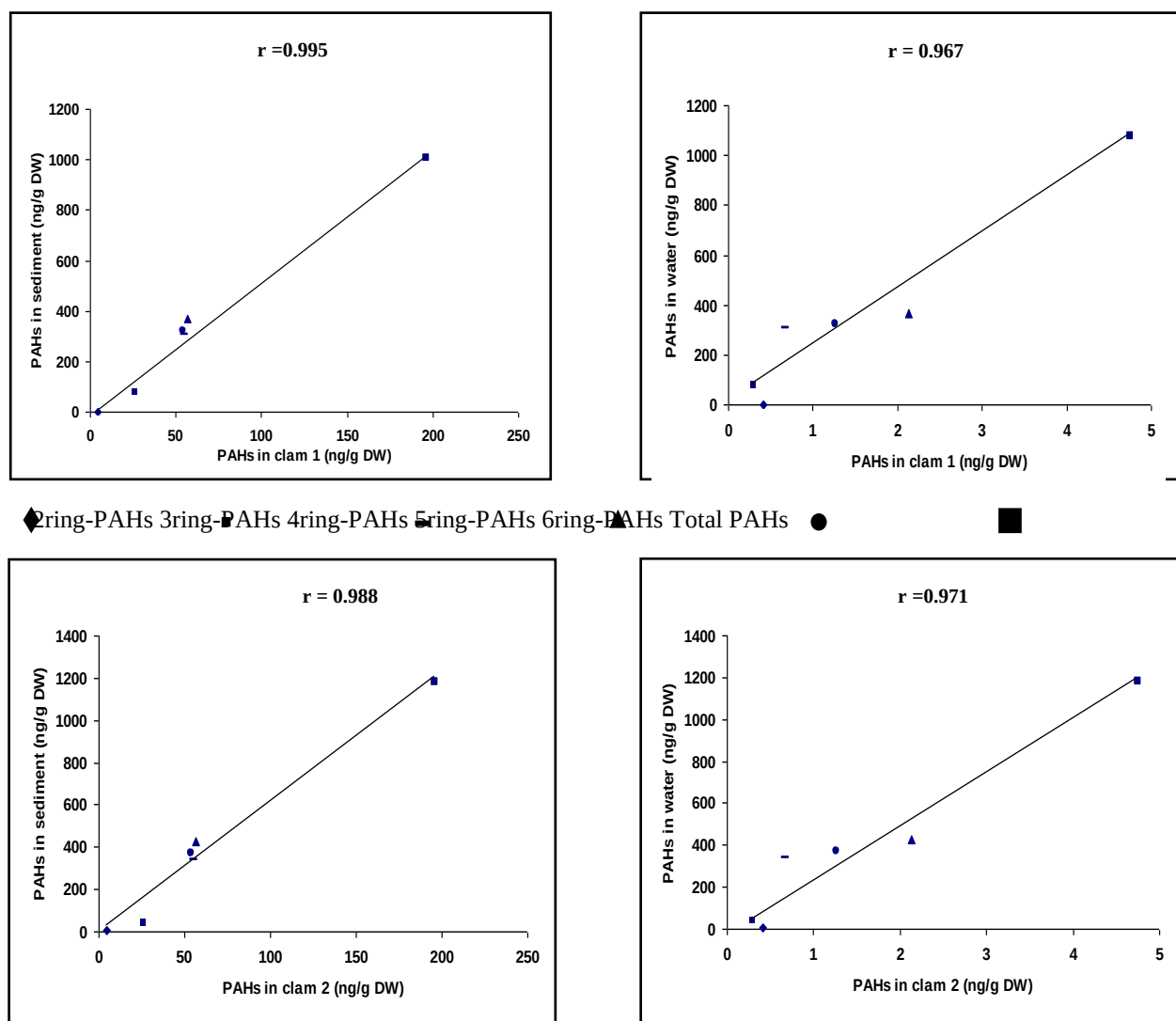


Figure (55): Relationship between the concentrations of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs and total PAHs in the both types of clams *tigridis* and *Pseudodontopsis euphraticus* (clam1 and2 respectively)with those in water and sediment of Euphrates river.

Table(13):BioConcentration Factors and BioSediment Accumulation Factors for PAHs in clams *tigridis* and *Pseudodontopsis euphraticus* (clam 1 & clam 2 respectively)

compound	Con.in water (µg/L).	Con. in sediment (ng/gDW)	Con. in clam1 (ng/gDW)	BCF	BSAF	Con. in clam2 (ng/gDW)	BCF	BSAF
Naphthalene	0.42	4.55	0.05	0.12	0.12	5.35	12.83	11.76
Acenaphthalene	0.02	1.21	35.68	1784	320	13.33	666.5	110.16
Acenaphthene&Fluorene	0.09	3.98	18.43	204.8	50.16	1.98	22	22.81
Phenanthrene	0.05	16.57	20.02	400.4	13.1	14.1	282	8.51
Anthracene	0.12	3.93	7.85	65.42	1.98	6.5	54.17	16.39
Fluoranthene	0.07	7.02	45.1	644.3	69.56	54.2	774.28	77.21
Pyrene	0.04	11.47	57.7	1442.5	54.48	40.0	1000	34.87
Benzo(a)Anthracene	0.06	7.20	49.61	826.3	49.61	53.5	891.67	74.31
Chrycene	0.69	29.40	171.83	249.02	63.32	188.33	272.54	64.06
Benzo(b)Fluoranthene	0.15	11.78	69.15	531.9	63.59	65.78	506	55.84
Benzo(k)Fluoranthene	0.49	10.75	36.23	73.94	36.53	93.87	191.19	89.31
Benzo(a)pyrene	0.88	19.98	101.75	115.6	55.17	86.2	97.95	43.14
Dibenzo(a,h)Anthracene	0.61	21.36	159.85	262.1	120.85	181.43	297.43	126.61
Benzo(ghi)Perylene	0.64	65.47	264.45	413.2	134.25	325.21	508.14	152.3
Indeno(1,2,3-cd)Pyrene	0.63	32.66	56.63	89.88	18.78	43.45	68.97	13.3

3-3-4:PAHs in plants

3-3-4-1:Individual PAHs in plants

Seasonal changes in the concentration of PAHs in two species of plant (*Ceratophyllum demersum* and *Typha domingensis*) were studied as demonstrated in table(14) and figure(56), while figure (57,58) represent the chromatogram for plant collected from site 4.

3-3-4-1-1:Naphthalene (Nap)

In plant *C. demersum*, the highest concentration of Nap (0.7ng/gDw) was recorded during spring and no concentration in summer and winter with the annual mean concentration of 0.33ng/g Dw).

As related to Nap in plant *T. domingensis*, the range between(ND-19.0ng/gDW) was recorded during winter and summer respectively with the annual mean concentration of(8.9 ng/gDW). Nap represents (0.05% and 1.3%) of the total PAHs in both plants respectively.

3-3-4-1-2:Acenaphthalene (AcpY)

The mean concentration of acenaphthalene in *C. demersum* was(5.25ng/gDW) with the highest concentration of(9.8ng/g DW) recorded in spring and no concentration in winter. The mean percentage of AcPY was(0.82%) of the total pAHs.

In plant *T. domingensis*, AcpY concentrations were ranged between(ND and 21.7 ng/g DW) during winter and summer respectively with the annual mean concentration of(13.0 ng/g DW). AcpY represents (1.9%) of the total PAHs in *T. domingensis*.

3-3-4-1-3:Acenaphthene and Fluorene (Acp& Flu)

The concentration of AcP & Flu in plant *C. demersum* were ranged(ND-62.3ng/gDW) during summer and autumn respectively with the annual mean concentration of(17.73 ng/g DW) and represent(2.77%) of the total PAHs in the plant.

The concentration of AcP and Flu in plant *T. domingensis* ranged between (5.5 and 58.1 ng/g DW) during summer and autumn, with the mean concentration of (22.15 ng/g DW) and mean percentage of (3.22%) of the total PAHs.

3-3-4-1-4: Phenanthrene(Phen)

The results of the study referred to fluctuation of Phen concentration in the plant *C. demersum* between (1.4-31.3 ng/g DW) during spring and autumn respectively with the mean concentration of (10.85 ng/g Dw) and mean percentage of (1.7%) of the total PAHs. In plant *T. domingensis*, the concentration of Phen ranged between (3.3-18 ng/g DW) in spring and winter respectively with mean concentration of (9.63 ng/g DW) and represents (1.4%) of the total PAHs in plant.

3-3-4-1-5: Anthracene(Ant)

The concentration of Anth in plant *C. demersum* fluctuated between (1.5 and 9.2 ng/g DW) during summer and spring respectively with the mean concentration of (5.73 ng/g DW) and represent (1.4%) of the total PAHs.

As related to Ant concentration in plant *T. domingensis*, the concentration ranged between (3.1-14.3 ng/g DW) during summer and spring respectively, with mean concentration of (9.38 ng/g Dw) and represents (1.37%) of the total PAHs.

3-3-4-6: Fluoranthene(Flur)

The results referred to the highest concentration of Flur in *C. demersum* (37.1 ng/g DW) that was recorded during spring and lowest concentration of (6.6 ng/g DW) in summer. The mean concentration of Flur was (22.08 ng/g Dw) and represents as (3.45%) of the total PAHs. In plant *T. domingensis*, the concentration of Flur was ranged between (28.3-56.0 ng/g DW) in autumn and spring respectively, with the mean

concentration of (39.45 ng/g DW) and mean percentage of(5.74%) of the total PAHs.

3-3-4-1-7:Pyrene(Py)

The concentration of Py in plant *C. demersum* were ranged between(ND-28.2 ng/g DW) during autumn and spring respectively with the mean concentration of(8.08 ng/g DW) and mean percentage of (1.26%). It appears from the results that the concentration of Py in plant *T. domingensis* fluctuates between (6.4 - 98 ng/g dw) in winter and autumn respectively with mean concentration of (40.88 ng/g DW) and represents(5.95%) of the total PAHs.

3-3-4-8: Benzo(a)Anthracene(BaA)

The concentration of BaA in *C. demersum* ranged between(ND and 27.1 ng/g Dw) during winter and spring with mean concentration of(12.08 ng/g DW) and mean percentage of(1.89%). The concentration of BaA in plant *T. domingensis* ranged between(ND-40.6ng/g DW) in winter and spring respectively, with mean concentration of (19.0ng/gDw) that represents (2.77%) of the total PAHs.

3-3-4-1-9:Chrycene(Chry)

The concentrations of Chry in plant *C. demersum* were fluctuated between (0.8-161.8 ng/g DW) during summer and spring respectively with mean concentration of (99.08 ng/g DW) that represents (15.5%) of the total PAHs in plant. The concentration between(19.2-181.1ng/gDW) were recorded for *T. domingensis* during summer and spring with mean concentration of (107.73 ng/g Dw) and mean percentage of(15.69%) of the total PAHs.

3-3-4-1-10 : Benzo(b)Fluoranthene(BbF)

The highest concentration of BbF (59.3 ng/g Dw) was recorded for plant *C. demersum* during spring and no concentration were detected in summer. The annual mean concentration of BbF was(26.68 ng/g DW) that

represents (4.17%) of the total PAHs. In plant *T. domingensis*, the concentrations of BbF were ranged between and concentrations during summer and autumn to(71.1 ng/g DW) during spring with mean concentration of(26.48 ng/g DW) and mean percentage of(3.86%).

3-3-4-1-11:Benzo(k) Fluoranthene (BkF)

In plant *C. demersum* the concentration of BkF was between(2.8-199.2 ng/g Dw) recorded during summer and autumn with mean concentration of(81.83 ng/g Dw) and represents (12.79%) of the total PAHs in plant. No concentration for BKF were recorded in plant *T. domingensis* during summer, while the concentration of (210ng/g Dw) was recorded during autumn with the mean concentration of (88 ng/g DW) and represents (12.81%) of the total PAHs.

3-3-4-1-12:Benzo(a)Pyrene(BaP)

The highest concentration of BaP(128.6 ng/g DW) in plant *C. demersum* was recorded during spring and no concentration were detected in autumn with the mean concentration of(54.85 ng/g DW)and mean percentage of(8.58%). The concentration of BaP in plant *T. domingensis* ranged between(ND-142.2 ng/g Dw) during autumn and spring respectively with mean concentration of(60.43 ng/g DW) and represents (8.8%) of the total PAHs.

3-3-4-1-13:Dibenzo(a,h)anthracene(DbA)

The concentration of DbA anthracene in plant *C. demersum* ranged between (ND-383.8 ng/g Dw) in spring and autumn respectively with mean concentration of (225.5 ng/g DW) and mean percentage of(35.27%). In plant *T. domingensis*, the concentration of DbA Anthracene fluctuated between ND concentration during summer and spring and 348.6 ng/g DW in autumn with mean concentration of(173.45 ng/g Dw) and represents about(25.27%) of the total PAHs.

3-3-1-14: Benzo(ghi)Perylene(BghiP)

The results of the study referred to no concentration recorded for BghiP in plant *C. demersum* during most seasons, while the highest concentration of (37.7 ng/gDw) was recorded during the autumn. BghiP represents (1.47%) of the total PAHs and the mean concentration was (0.43ng/gDW). The concentrations of BghiP in *T. domingensis* were ranged between no concentration during spring and winter and 21.38 ng/gDw in autumn with mean concentration of (78.4 ng/g Dw) and mean percentage of (3.11%) of the total PAHs.

3-3-4-1-15: Indeno(1,2,3-cd)Pyrene (IND)

The concentration of IND in plant *C. demersum* were ranged between (4.4ng/gDw and 90.0 ng/g DW) during summer and autumn with mean concentration of (59.8 ng/g DW) and mean percentage of (9.35%). In plant *T. domingensis*, the concentration of Indeno(1,2,3-cd)Pyrene ranged between (8.1 and 83.0 ng/g Dw) during autumn and spring respectively, with mean concentration of (46.9 ng/g dw) and mean percentage of (6.83%) of the total PAHs.

The results of the statistical analysis referred to no significant differences of PAHs concentrations in both species of plants, while significant differences were recorded among seasons for both species of plants with exception in the concentration of Naphthalene among seasons ($P < 0.01$).

3-3-4-2: Composition Pattern and sources of PAHs in plants

The composition pattern of PAHs by ring number and molecular weight was studied as shown in figure 59 and 60.

The mean concentration of 2 ring-PAHs in plant *C. demersum* and *T. domingensis* were (0.33 ng/g DW and 8.75 ng/gDw) respectively. As related to 3 ring-PAHs in *C. demersum*, the range between (10.6-107.2 ng/g Dw) were recorded during summer and autumn respectively with the mean

concentration of(39.55ng/g Dw) and mean percentage of(6.12%) of the total PAH. In plant *T. domingensis*, the concentrations ranged(35.0-100.3 ng/gDW) during spring and autumn respectively with mean concentration of(54.15 ng/g Dw) that represent about(7.88%) of the total PAHs.

The concentrations of 4 ring-PAHs in plant *C. demersum* ranged between(10.6 and 220.4 ng/gDW) during summer and spring respectively, with mean concentration of(141.3ng/g dw) and mean percentage of(21.94%) of the total PAHs. In plant *T. domingensis*, the concentrations of 4 ring-PAHs ranged between (83.8-238.7 ng/gDW) during summer and autumn respectively, with the mean concentration of (207.1 ng/g Dw) and represents (30.14%) of the total PAHs. As related with the concentration of 5 ring-PAHs in plant *C. demersum*, the concentrations ranged between(212.5ng/g dw-611.5 ng/g Dw) during summer and autumn respectively with the mean concentration of(388.93 ng/g DW) and mean percentage of (60.83%). In *T. domingensis*, the 5 ring-PAHs concentration ranged between(34.6ng/g Dw and 558.6 ng/g DW) during summer and winter respectively with mean concentration of(348.8 ng/gDW) and represents (50.76%) of the total PAHs.

The concentration of 6 ring-PAHs in *C. demersum* ranged between(4.4 ng/g DW and121.7 ng/g DW) during summer and autumn respectively, with mean concentration of(69.23 ng/g DW) and mean percentage of(10.83%) of total PAHs. The results of the study for 6 ring-PAHs in plant *T. domingensis* referred to high concentration of(86.5 ng/g DW) during the autumn, while the low concentration (36.1 ng/g DW) was recorded during summer with mean concentration of(68.28 ng/g DW) and mean percentage of(9.94%) of the total PAH.

Statistically, there is no significant differences in the concentrations of (3,4,5,and 6 ring-PAHs) between both species of plants, while significant differences were recorded for both plants among seasons ($P<0.01$).

In general, the mean concentration of total PAHs in *C. demersum* was (639.34ng/g Dw) and HMW-PAHs represents (93.76%, 599.64 ng/gDW), while LMW-PAHs recorded only (6.24% and 39.88ng/gDW).

As related to plant *T. domingensis*, the mean concentration of PAHs was (687.08 ng/g DW) and mean percentage of (90.84 % and 9.15%) and mean concentration of (62.9 ng/gDW and 624ng/gDW) was recorded for HMW-PAHs and LMW-PAHs respectively.

The sources of PAHs in both plants were explained by the ratio of individual PAHs. The mean ratio of Phen/Ant, Flur/Py, BaP/BghiP and LMW-PAHs/HMW-PAHs (92.17, 1.36, 0.26 and 0.09) respectively were recorded for plant *C. demersum* and the concentration of (2.55, 0.78, 0.38 and 0.08) for *T. domingensis*.

Statistical analysis referred to significant positive correlation recorded for 3 ring-PAHs and 4 ring-PAHs in *C. demersum* among them the homogenous PAHs ($P < 0.01$) were indicated. Also positive correlation were recorded for 3 ring-PAHs with 4 and 5 ring-PAHs ($P < 0.01$). Negative correlation also was recorded for some individual PAHs (Index 3/ Table 7). In plant *T. domingensis*, significant positive correlation was recorded for 3 ring-PAHs with most of 4 and 5 ring-PAHs ($P < 0.01$). Also negative correlation was recorded for LMW-PAHs with HMW-PAHs (Index 3/ Table 8) As related to concentration of PAHs in both plant species with those in water and sediment, Positive correlation was recorded for PAHs in plants with those in water and sediment (Figure 61).

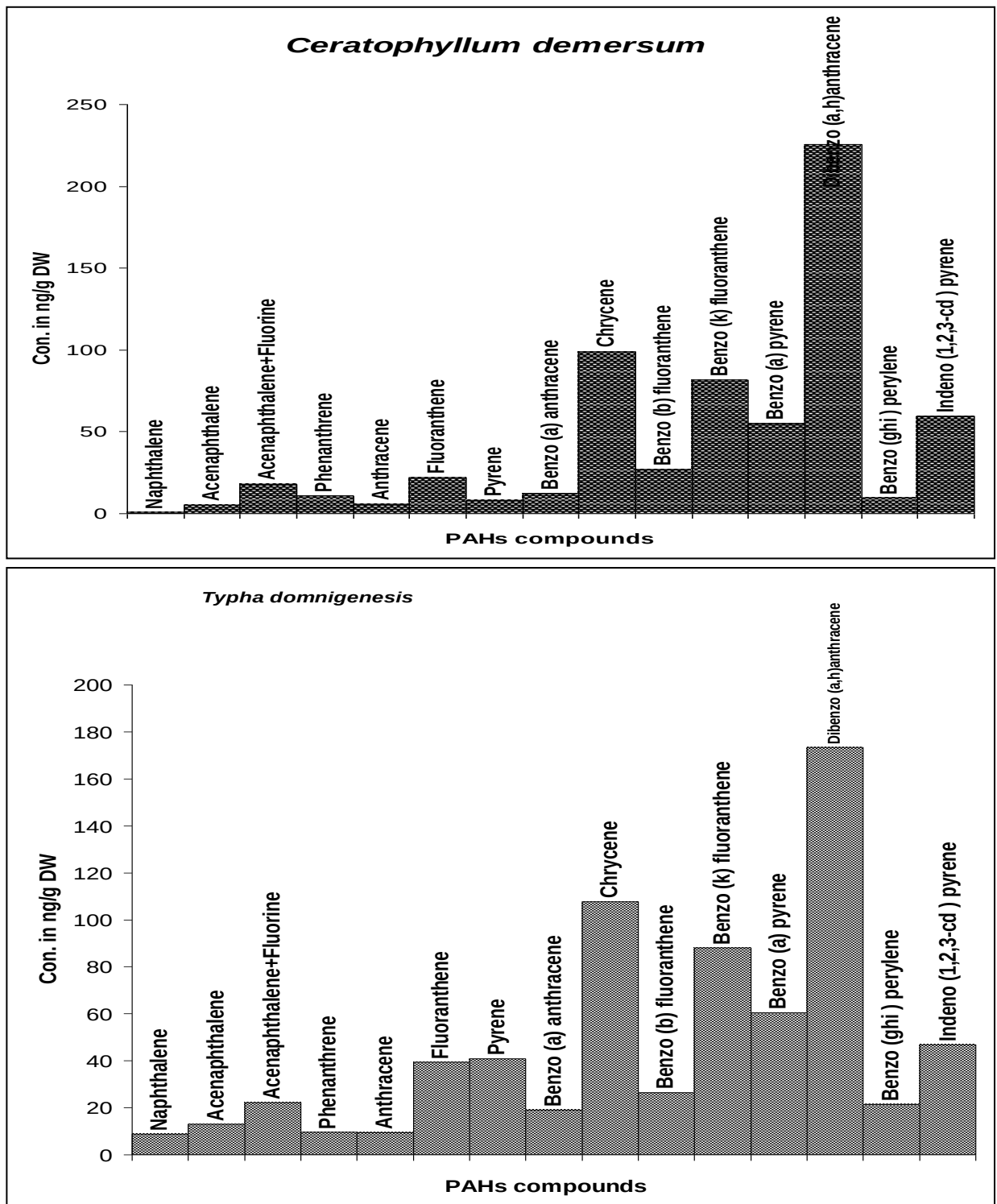
3-3-4-3: Bioconcentration and Biosediment accumulation factor of PAHs in plant

The efficiency of plant to accumulate PAHs from water and sediment was investigated by determining BCF and BSAF (table, 15). As related to the concentration of PAHs from water, the BCF in plant *C. demersum* ranged between (0.78-369.67) for naphthalene and Dibenzo (a,h) anthracene

respectively and(21.34-1022) in plant *Typha domingensis* for naphthalene and Pyrene respectively. BSAF in plant *C. demersum* were(0.07-10.56) for naphthalene and dibenzo(a,h)Anthracene, while the concentration of(0.33-10.54) were recorded for BghiP and Acenaphthene respectively in plant *T. domingensis*.

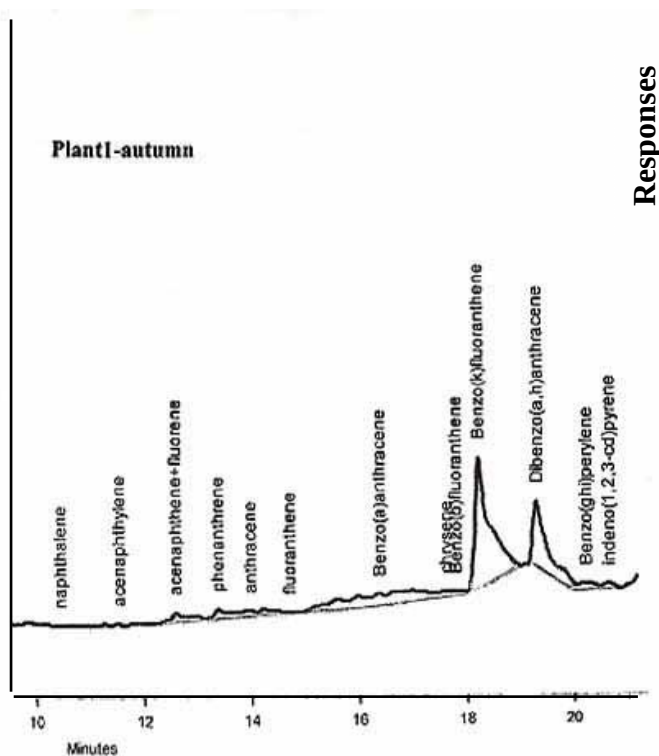
Table (14): Seasonal change in the concentration of PAHs(ng/gDW) recorded in plant *Ceratophyllum demersum* and *Typha domingensis* collected from Euphrates river(site 4)during the study period (Jul.2005-Jun.2006)

compound	<i>Ceratophyllum demersum</i>				<i>Typha domingensis</i>			
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Naphthalene	ND	0.6	ND	0.7	19.0	16.0	ND	0.6
Acenaphthalene	6.2	5.0	ND	9.8	21.4	19.1	ND	10.0
Acenaphthalene and Fluorene	ND	62.3	3.7	4.9	5.5	58.1	17.6	7.4
Phenanthrene	2.9	31.3	7.8	1.4	6.3	11.9	18.0	3.3
Anthracene	1.5	8.6	3.6	9.2	3.1	11.0	9.1	14.3
Fluoranthene	6.6	10	34.6	37.1	39.4	28.3	34.1	56.0
Pyrene	1.5	ND	2.6	28.2	20.1	98.0	6.4	39
Benzo (a) anthracene	1.7	19.5	ND	27.1	5.1	30.3	ND	40.6
Chrycene	0.8	105.7	161.8	128.0	19.2	82.1	148.5	181.1
Benzo (b) fluoranthene	ND	28.5	18.9	59.3	ND	ND	34.8	71.1
Benzo (k) fluoranthene	2.8	199.2	29.3	96.0	ND	210.0	30.0	112.0
Benzo (a) pyrene	11.8	ND	79.0	128.6	34.6	ND	64.9	142.2
Dibenzo (a,h)anthracene	197.9	383.8	320.6	ND	ND	348.6	345.2	ND
Benzo (ghi) perylene	ND	37.7	ND	ND	7.1	78.4	ND	ND
Indeno (1,2,3-cd) pyrene	4.4	90.0	85.7	59.1	29.0	8.1	67.5	83
Total PAHs	238.1	982.2	747.6	589.4	210.1	1000.1	776.1	760.6

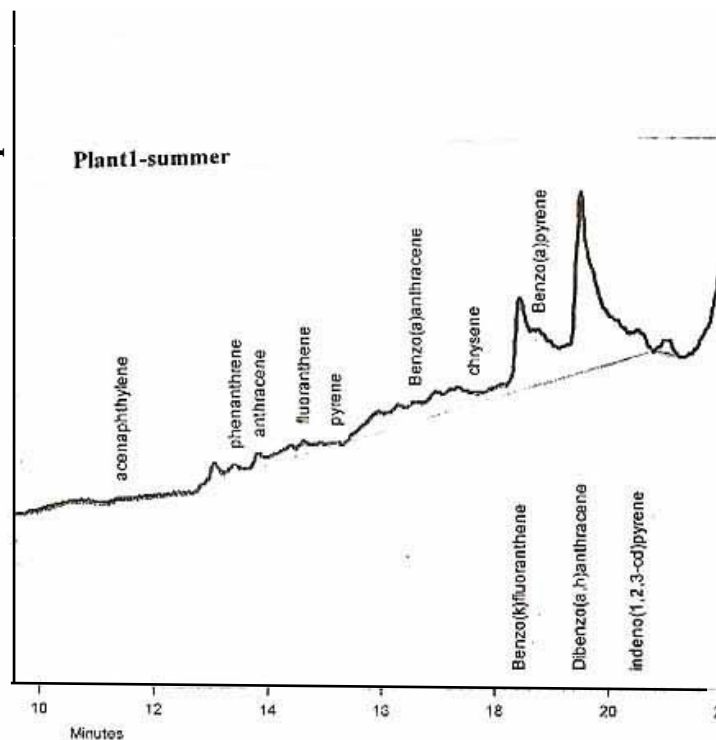


Figure(56):Mean concentration of PAHs in plant *Ceratophyllum demersum* and *Typha domingensis* collected from Euphrates river site during the study period (Jul.2005-Jun.2006)

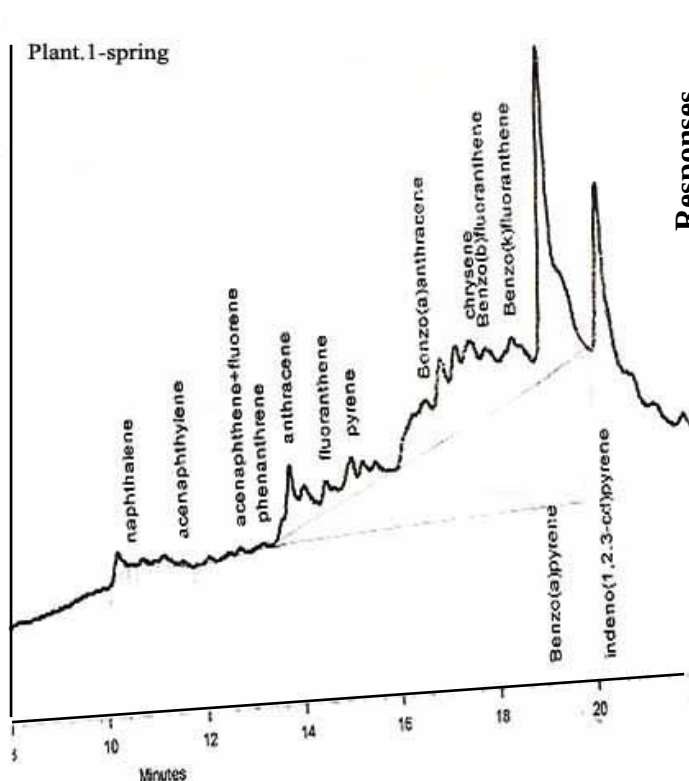
Responses



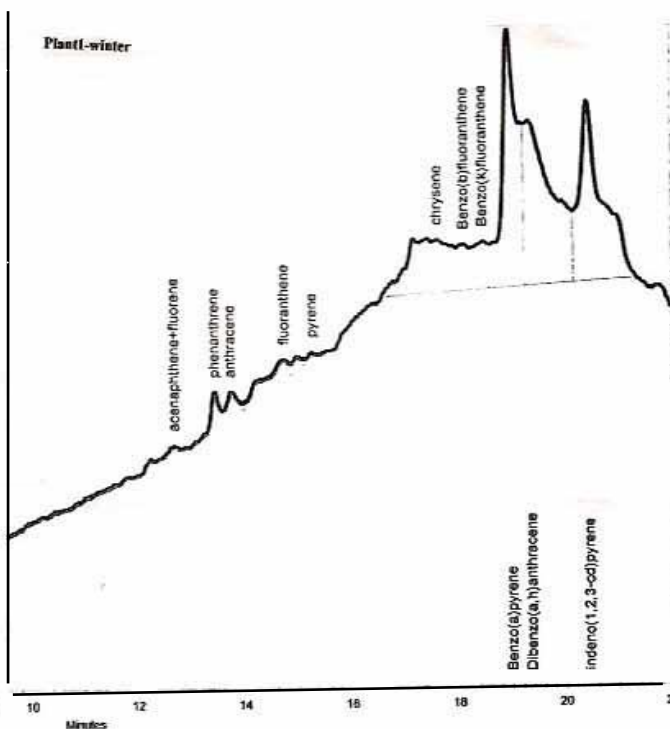
Responses



Responses

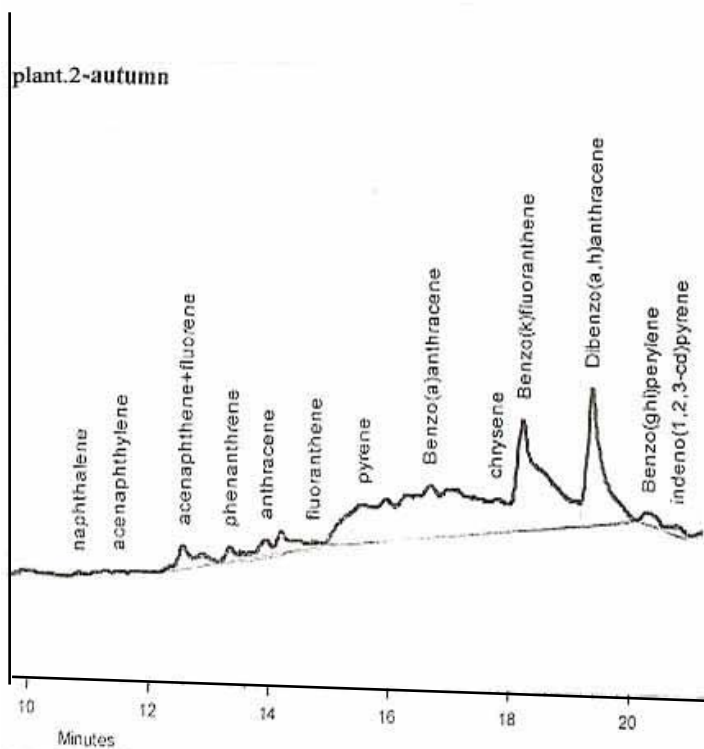


Responses

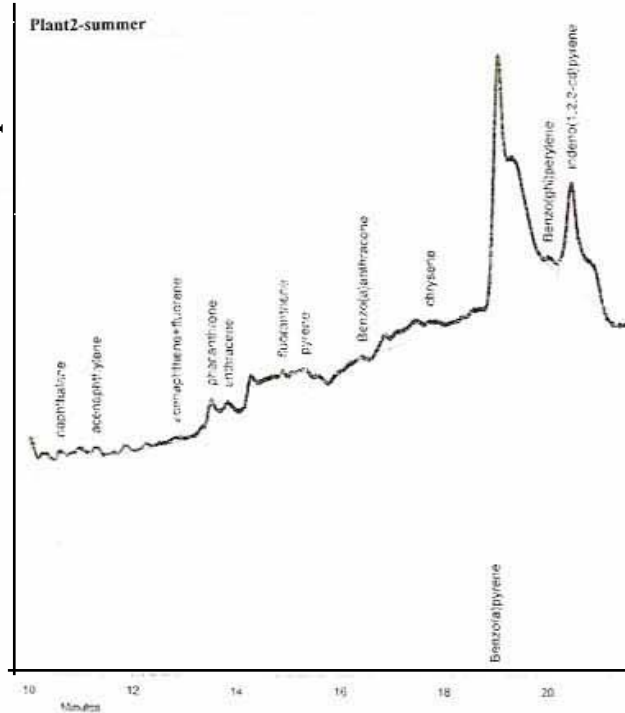


Figure(57): PAHs chromatogram for clam (plant 1) *C. demersum* (plant 1) collected from Euphrates river at site 4 during the study period

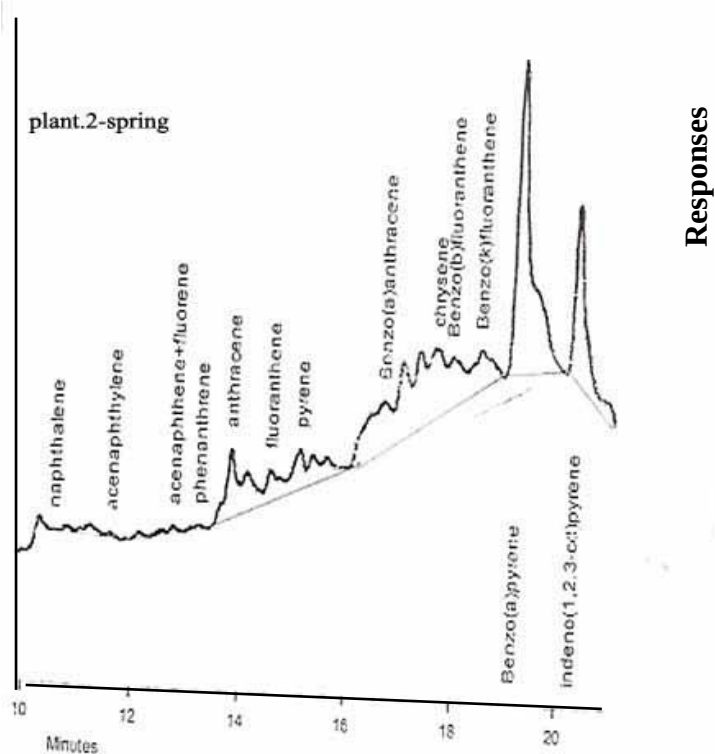
Responses



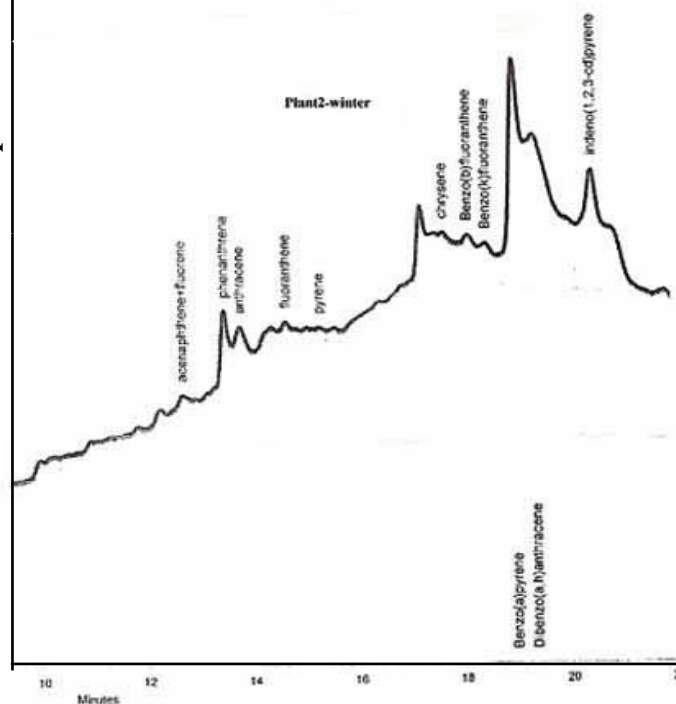
Responses



Responses



Responses



Figure(58): PAHs chromatogram for plant *Typha domingensis* (plant 2) collected from Euphrates river at site 4 during the study period

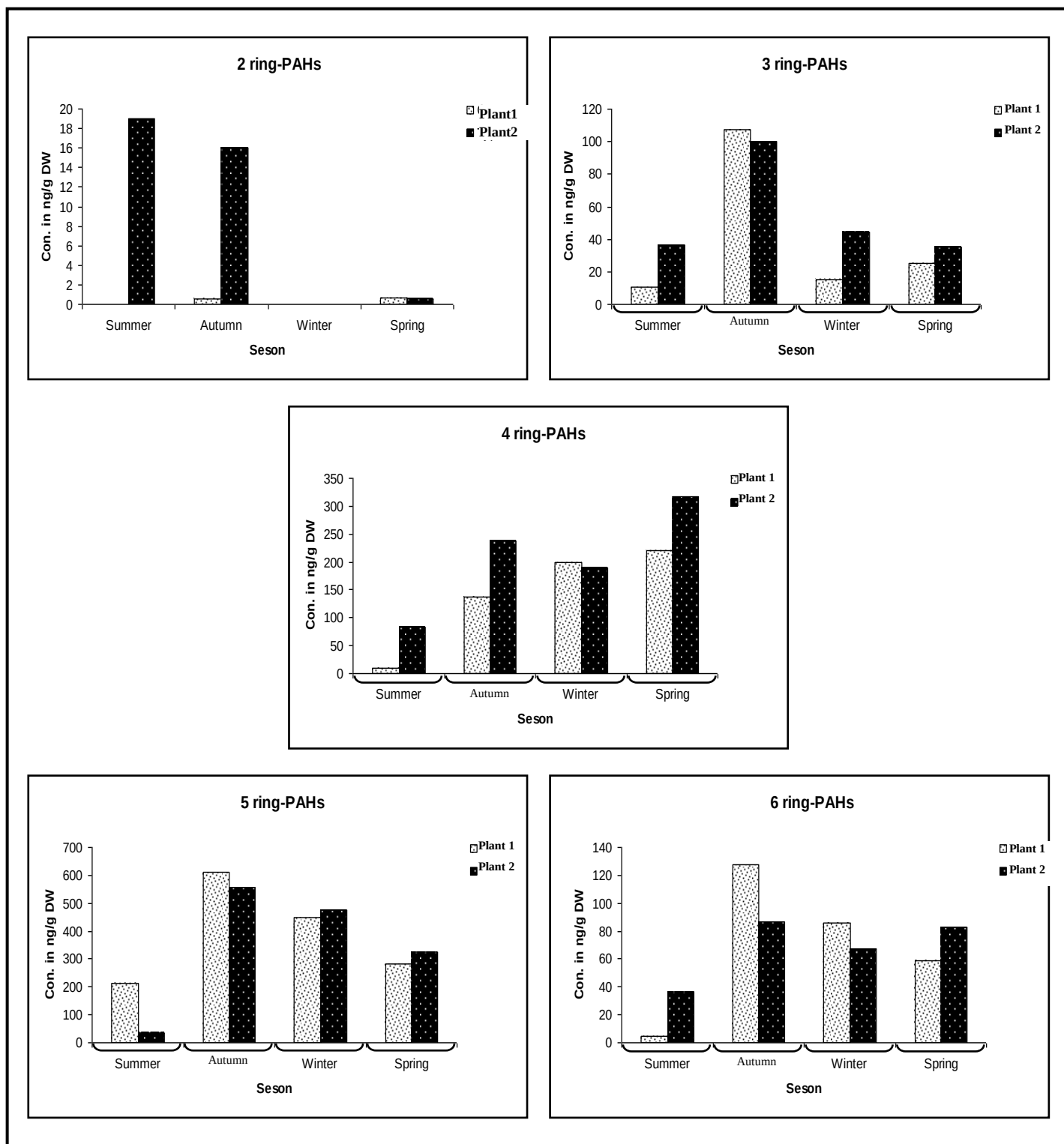
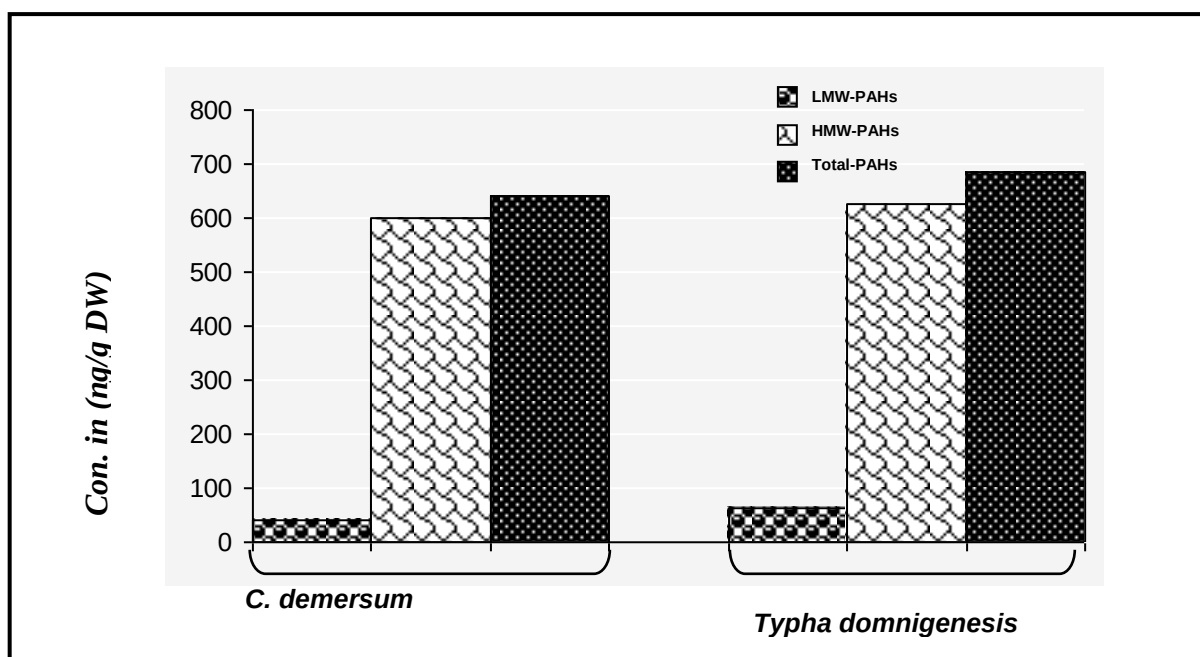
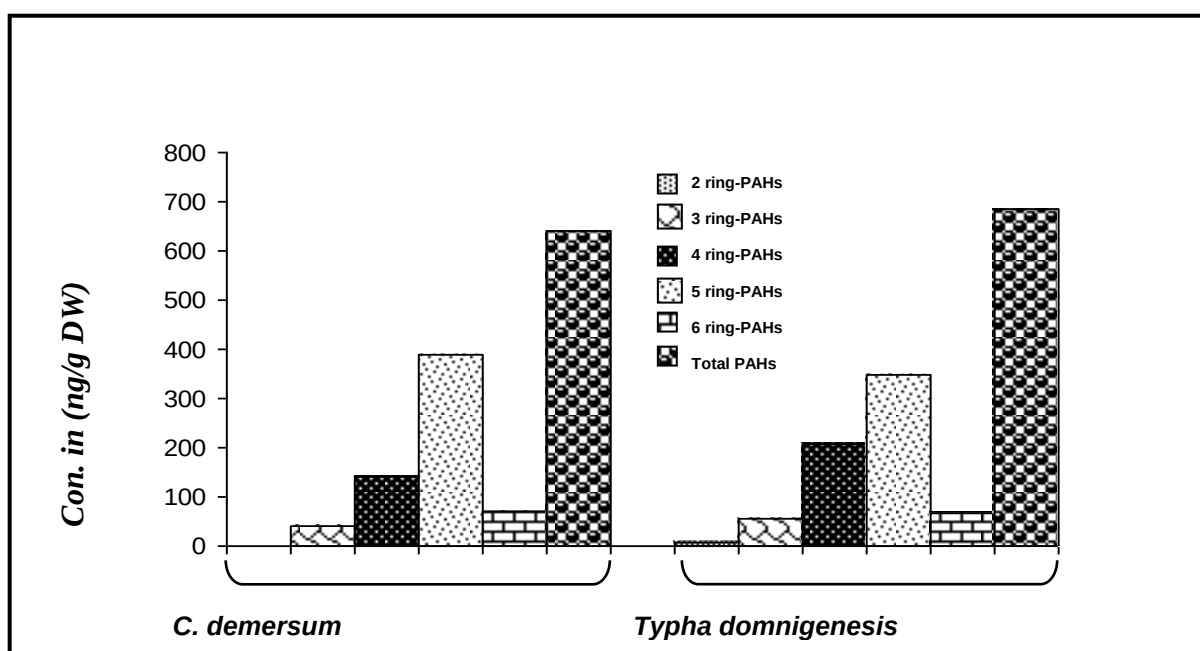
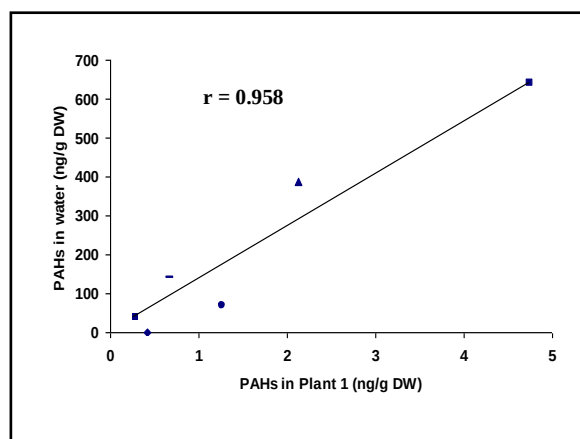
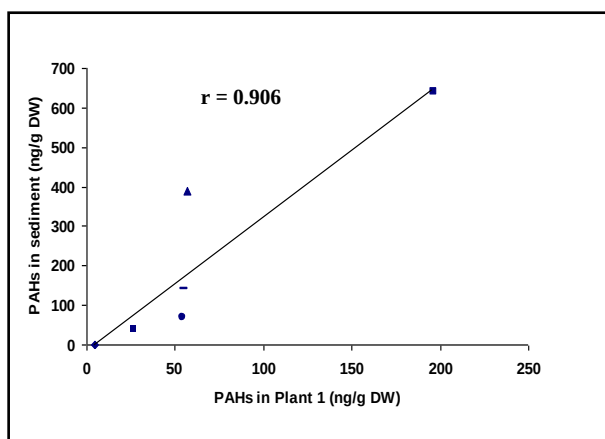


Figure (59): Seasonal changes in the concentrations of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs compounds in *Ceratophyllum demersum* and *Typha domingensis* (plant 1 and 2 respectively) collected from Euphrates river site during the study period (Jul. 2005 – June 2006).



Figure(60) :Composition pattern of PAHs in plant *Ceratophyllum demersum* and *Typha domingensis* collected from Euphrates river during the study period(Jul.2005-Jun.2006)



2ring-PAHs 3ring-PAHs 4ring-PAHs 5ring-PAHs 6ring-PAHs Total PAHs

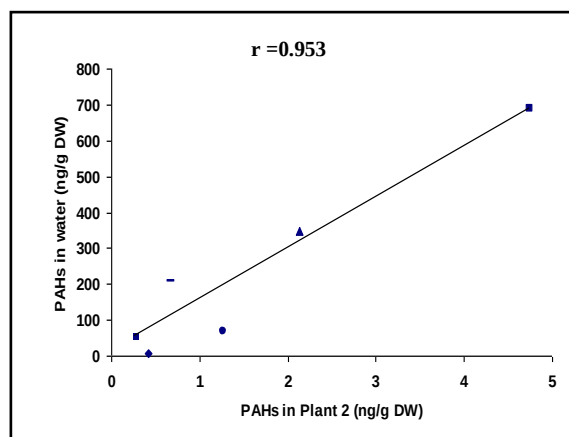
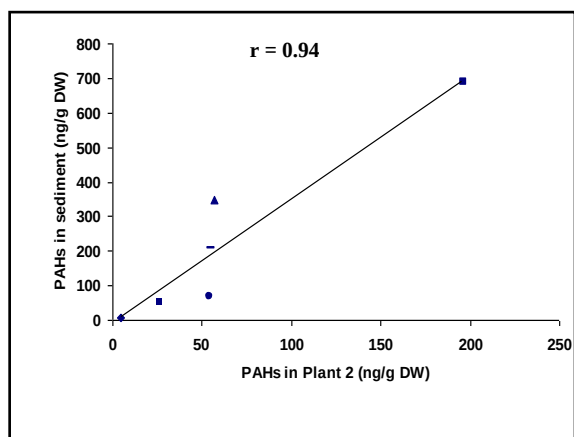


Figure (61): Relationship between the concentrations of 2ring, 3ring, 4ring, 5ring and 6ring-PAHs, total PAHs in *Ceratophyllum demersum* and *Typha domingensis* (plant 1 and plant 2 respectively) with those in water and

Table(15):Bioconcentration factors and Biosediment accumulation factors for PAHs in plants *Ceratophyllum demersum* and *Typha domingensis* (plant 1 &plant 2)

compound	Con.in water (µg/L).	Con. in sediment (ng/gDW)	Con. in plant 1 (ng/gDW)	BCF	BSAF	Con. in plant 2 (ng/gDW)	BCF	BSAF
Naphthalene	0.42	4.55	0.33	0.78	0.07	8.9	21.34	1.95
Acenaphthalene	0.02	1.21	5.25	262.5	4.35	12.75	650	10.54
Acenaphthene&Fluorene	0.09	3.98	17.73	197	4.45	22.15	246.1	5.57
Phenanthrene	0.05	16.57	10.85	217	0.65	9.63	192.6	0.89
Anthracene	0.12	3.93	5.73	47.75	1.46	9.88	78.17	2.51
Fluoranthene	0.07	7.02	22.08	315.43	3.14	39.45	563.57	5.62
Pyrene	0.04	11.47	8.08	202.0	0.7	40.88	1022	3.56
Benzo(a)Anthracene	0.06	7.20	12.08	201.3	1.68	19.0	316.67	2.64
Chrycene	0.69	29.40	99.08	143.59	3.37	107.73	156.1	3.66
Benzo(b)Fluoranthene	0.15	11.78	26.68	177.86	2.26	26.48	176.5	2.25
Benzo(k)Fluoranthene	0.49	10.75	81.83	167.34	7.61	88.0	179.59	8.19
Benzo(a)pyrene	0.88	19.98	54.85	62.33	2.75	60.43	68.67	3.02
Dibenzo(a,h)Anthracene	0.61	21.36	225.5	369.67	10.56	173.45	284.34	12.10
Benzo(ghi)Perylene	0.64	65.47	9.43	14.73	0.14	21.38	33.4	0.33
Indeno(1,2,3-cd)Pyrene	0.63	32.66	59.8	94.92	1.83	46.9	74.44	1.44

Table (16):The range and Mean $\pm$ S.D.(ng/gDW) of PAHs in aquatic organisms collected from Euphrates river during the study period(Jul.2005 –Jun.2006).

Compound	clam		plant	
	<i>U. tigridis</i>	<i>P. euphraticus</i>	<i>C. demersum</i>	<i>Typha domnigenis</i>
Naphthalene	0.0-0.2 0.05 $\pm$ 0.1	0.0-12.2 5.35 $\pm$ 5.1	0.0-0.7 0.33 $\pm$ 0.091	0.0-19.0 8.9 $\pm$ 8.0
Acenaphthalene	24.0-50.0 35.68 $\pm$ 13.16	3.3-29.0 13.33 $\pm$ 11.01	0.0-9.8 5.25 $\pm$ 11.907	0.0-21.7 13.0 $\pm$ 8.08
Acenaphthene + Flurene	7.2-36.4 18.43 $\pm$ 12.85	0.0-30.9 9.08 $\pm$ 14.77	0.0-62.3 17.73 $\pm$ 11.627	5.5-58.1 22.15 $\pm$ 25.38
Phenanthrene	5.5-58.2 20.02 $\pm$ 25.49	4.5-28.1 14.1 $\pm$ 10.56	1.4-31.3 10.85 $\pm$ 23.06	2.3-18 9.63 $\pm$ 10.16
Anthracene	4.6-12.4 7.85 $\pm$ 3.29	4.8-7.5 6.5 $\pm$ 1.18	1.5-9.2 5.73 $\pm$ 2.97	3.1-14.3 19.38 $\pm$ 4.403
Flouranthene	0.0-86.5 45.1 $\pm$ 37.37	24.8-83.0 54.2 $\pm$ 23.85	6.6-37.1 22.08 $\pm$ 33.66	28.3-56.0 39.45 $\pm$ 16.03
Pyrene	0.0-120.2 57.7 $\pm$ 51.72	13.4-57.9 40.0 $\pm$ 20.31	0.0-28.2 8.08 $\pm$ 46.85	6.4-98.0 40.88 $\pm$ 32.91
Benzo(a)anthracene	4.0-46.2 32.95 $\pm$ 19.59	21.0-81.5 53.5 $\pm$ 26.6	0.0-27.1 12.08 $\pm$ 17.79	0.0-40.6 19.0 $\pm$ 15.94
Chrycene	43.7-255.9 171.83 $\pm$ 97.79	110.0-252.3 188.33 $\pm$ 92.07	0.8-161.8 99.08 $\pm$ 88.608	19.2-181.1 107.73 $\pm$ 65.64
Benzo(b)Flouranthene	5.4-114.5 69.15 $\pm$ 47.09	0.0-112.9 65.78 $\pm$ 48.05	0.0-59.3 26.68 $\pm$ 42.49	0.0-71.1 26.48 $\pm$ 27.52
Benzo(k)Flouranthene	0.0-83.6 36.23 $\pm$ 39.73	0.0-239 93.87 $\pm$ 103.17	2.8-199.2 81.83 $\pm$ 35.77	0.0-210.0 88.0 $\pm$ 84.19
Benzo (a) Pyrene	49.5-168.3 101.75 $\pm$ 53.14	0.0-138.0 86.2 $\pm$ 63.55	0.0-128.6 54.85 $\pm$ 48.29	0.0-142.2 60.43 $\pm$ 56.05
Dibenzo(a,h)Anthracene	0.0-204.6 159.85 $\pm$ 132.74	0.0-317.6 181.43 $\pm$ 132.76	0.0-383.8 225.5 $\pm$ 120.047	0.0-348.6 173.45 $\pm$ 173.69
Benzo(ghi)Perylene	75.5-425.1 264.45 $\pm$ 148.13	41.0-533.3 325 $\pm$ 213.13	0.0-37.7 9.43 $\pm$ 134.04	0.0-78.4 21.38 $\pm$ 28.62
Indeno(1,2,3-cd)Pyrene	36.7-78.6 56.63 $\pm$ 21.85	10.1-94.2 43.45 $\pm$ 36.78	4.4-90.0 59.8 $\pm$ 19.68	8.1-83.0 46.9 $\pm$ 34.99

Chapter Four

4- Discussion

4- 1- : Physico-chemical properties of water

Rivers that flow through agricultural & urban industrial area carry a great number and variety of pollutants, therefore the examination of different properties is quite essential (Morgan *et al.* , 1993) .

The results of present study referred that the lowest concentration of air temperature was recorded during December 2005, while the highest concentration was recorded in July 2005 .This is related with Iraqi climatic nature (Hassan, 1997; Ganjo, 1997; Ganjo & Aziz, 2002; Al –Lami, 2002; Al–Lami *et al.*, 2002; Hassan, 2004 & Al–Fatlawi , 2005).

Surface water temperature was highly coincided with the surrounded air temperature as confirmed by positive correlation between air and water temperature ($r = 0.9783$, $p < 0.01$) so variation in water temperature related to many environmental factors as water flow, water depth, bottom material, temperature of inlet water and exposure to direct sun light and degree of shading (Welch, 1952, Al Saadi *et al.*, 1986 and Bartram & Balance, 1996).

Local variation of water temperature due to difference in the time of measurement. Similar conclusion was made by other authors (Hassan, 1997; Al Lami *et al.*, 2002; Hassan, 2004 & Salman, 2006).

The water flow is the rate at which water flows past a reference point .The variation of water flow has important implication on the biota (Smith, 2004). The maximum current velocity (133.3 cm/sec.) was recorded during spring at site 2, while minimum concentration (4 cm/sec.) was recorded during winter at site 5 .This is probably related to climatic condition (Al – Saadi *et al.*, 1986) .The variation in the period of precipitation which could produce the variation in the runoff rates affect the rate of water flow (Witton,

1975). Also the construction of barrage and discharge rate may affected the water flow behind the barrage (Morgan *et al.*, 1993).

The river content of calcium carbonate is a major ecosystem which regulate the pH –concentration in natural water (Witton, 1975).The increase in Dissolved oxygen and density of phytoplankton and aquatic plants cause the increase in pH concentrations(Golterman, 1975). Because a strong correlation occurred between pH and concentration of CO₂ in water(Weiner, 2000), the consumption of CO₂ in photosynthetic processes leads to increase pH concentration (Sabri *etal.*, 1989).

The pH concentrations recorded in the present study were within the narrow range and tend to be alkaline as it is common in Iraqi inland water. This is due to buffering capacity of Iraqi natural waters which it is relatively high content of calcium bicarbonate(Al –Lami, 2002 ; Hassan, 2004 & Salman, 2006).

Electrical conductivity in water referred to dissolved salts,so high correlation occurred between EC & TDS(APHA, 1999 & Watzel, 2001). The Electrical conductivity concentrations were ranged between 423.66–998.6 µs/cm. The highest concentration was recorded during cold season probably related to high precipitation and soil leaching processes (Hutchinson, 1957) or due to effluent loaded by salts and dissolved material (Al–Lami, 2002). Also increase in the concentrations of total hardness causes increase in EC concentrations (Hutchinson, 1957).This is confirmed by positive correlation between EC and total hardness ($r = 0.394$, $p < 0.01$).

The results agreed with other studies(Hassan, 1997; Al –Lami *et al.*, 1999; Al –Lami *etal.*, 2002; Al–Fatlawi, 2005 and Salman, 2006). Similar trends were obtained in salinity concentrations(0.257-0.619 %).

The concentrations of Electrical conductivity and salinity recorded were slightly lower than those obtained for the same river before (Al–

Fatlawi, 2005 & Salman, 2006) which may be related to dilution factor and climatic condition during the study period .

Oxygen is one of the most important limiting factors enters the aquatic ecosystem through the air–water interface and by the photosynthetic activities of aquatic plants. Thus the amount of dissolved oxygen in aquatic ecosystem depends on the rate at which these processes occur (Morgan *et al.*, 1993).

The solubility of oxygen in the running water is influenced by several factors such as temperature, dissolved salts and partial pressure of gas as well as inputs of organic matter(Witton, 1975; Morgan *et al.*, 1993 and Wetzel and likens, 2000).

The results referred to high concentrations of Dissolved Oxygen recorded in some sites due to aerated, high water concentration, well mixing and density of phytoplankton.Similar conclusions were made by other authores (Al-Lami *et al.*, 2001; Al-Lami *et al.*, 2002 and Salman, 2006) .The lower concentration may be due to low water concentration and degradation of organic matter (Al–saadi *et al.* ,1998). Similar statement was recorded by other authores (Hassan, 1997;Al Lami *et al.*, 1999 and Al –Lami *et al.*, 2001).

In the running ecosystem as river and streams, because of the relatively shallow nature and dense microbial life in addition to self purification of river, the amount of organic matter decreases resulting in the lowering BOD (Witton, 1975).The low BOD concentrations were recorded in different Iraqi water (Ganjo, 1997, Ganjo and Aziz, 2002, Mashkur, 2002 ; Hassan & Hassan, 2004).

The results of the present study referred to high concentrations of BOD₅ in some sites that exceed permissible limits (5mg/l) recommended by WHO, (1996) .This is probably related to organic matter loads discharge into river from the area near sewage effluent and agricultural land .Comparable

results were obtained by other authores (Al –Musawi *etal.*, 1995; Hassan & Hassan, 2004; Al –Fatlawi, 2005; Salman, 2006).

Alkalinity is a measure of pH–buffering capacity of water (Smith, 2004) . The geologic formation of an area is closely related to the alkalinity. In Iraq the total alkalinity is mainly due to bicarbonate ions which are abundant in Iraqi inland water (Al –Saadi *etal.*, 1998; Al –Lami *etal.*, 1999; Al–Lami *etal.*, 2002).

The total alkalinity concentrations recorded in the present study were within the range of natural inland water which is 20-200 mg/l. and agreement with other studies (Rasheed, 1994; Ganjo, 1997; Hassan, 1997; Al Saadi *et al.*, 2001; Al –Lami *et al.*, 2002).

High concentration of alkalinity recorded were probably related to phytoplankton activity as photosynthesis (Golterman, 1975) or due to the organic matter degradation like calcium carbonate to bicarbonate (Weiner, 2000). In the present study high water concentration and high water discharge rate related to high total alkalinity .The lower concentration of total alkalinity recorded in cold season probably was related to dilution.

The result of the present study referred to high concentration of total hardness as it is common in iraqi inland water (Hassan *et al.*, 1995; Hassan, 1997; Saeed, 1997; Al–Lami *et al.*, 1999; Al- Lami *et al.*, 2001). Because of higher concentration of total hardness that exceed the concentration of total alkalinity at all sites, the other ions as sulphate and chloride ions contribute to total hardness in addition to calcium and magnecium (Lind, 1979).

The higher concentration of total hardness were possibly related to high water concentration and discharge rate (Salih, 1982, Al-Zubaidy, 1985; Al –Fatlawi, 2005) or related to evaporation which increase and concentrate the available cations (Goldman and Horne, 1983 and Toma, 2002) or due to high precipitation and thus high soil leaching and high current velocities (Al–Musawi *etal.*, 1994; Saeed , 1997; salman, 2006), while the lower

concentrations related to dilution factor due to precipitation or high water concentration (Salih, 1982; Toma, 2002).

In the present study, fluctuation in the concentration of total hardness was possibly related to change in water discharge rate which is controlled by Al-Hindiya barrage, sewage and domestic effluent loads and rate of precipitation .

The major cations calcium and magnesium in addition to sodium and potassium usually are required in very low quantities, but their concentrations in fresh water can influence the osmoregulation of organisms(Wetzel and likens, 2000).The present results indicated that concentrations of calcium were higher than magnesium concentration in most months which may due to solubility of CO₂ by calcium which was higher than magnesium, so magnesium tend to precipitate (Goldman & Horne, 1983) or may be due to high concentration of sulphate ions that precipitate magnesium as magnesium sulphate(Al-Musawi *et al.*, 1994).In some months, the concentration of magnesium exceeds calcium.This may be due to consumption of calcium by organisms(Al-Saadi *etal.* ,1998 & Wetzel, 2001)or may be due to additional amounts of magnesium coming from agricultural area on river sides(Al-Lami *etal*, 2002 & Salman, 2006) .

The sulphate concentrations in Euphrates river were ranged between 66.88-682 mg/l. .This range was comparable to results recorded by different authors (Ganjo, 1997 in Ruwandiz river;Al –Lami *etal.*, 1999 in Tigris river, Al-Fatlawi, 2005 & Salman, 2006 in Euphrates river).

The concentrations of sulphate showed variation among the study months and higher concentrations were recorded at some sites .This is possibly due to the lithology of area which common in gybsum nature (Taliq, 2004) and anthropogenic release of sulphate into atmosphere followed by deposition in to surface water(Dobson & Frid, 1998 & Wetzel, 2001). Also climatic condition and erosion processes in addition to sewage

and domestic effluent may contribute in high concentration (Lind, 1979; Bartram & Ballance, 1996).

Goldman and Horne(1983) indicated that higher concentrations of chloride are related to the evaporation in the hottest months, while the lower concentration related to precipitation and high water concentration .Also the nature of area and the increase of dissolved substances are closely related to the chloride concentrations (Bartram & Ballance, 1996).

Different mean concentrations of chloride ion were recooded by authors in different Iraqi inland waters, 0.03mg/l. in Ruwandiz river (Aziz, 1997),478mg/l. in Thar–Thar arm, 128 mg/l. in Tigris river , 123mg/l. in Euphrates river(Al–Lami *et al.*, 2002) and 123mg/l. and 145mg/l. in Tigris river before and after Baghdad(Al–Lami , 2002).The mean concentration of chloride ions in the present study was 100mg/l. with higher concentration recorded at site 5 in April 2006 due to soil leaching and additional inputs from agricultural land nearby , while the low concentration related to precipitation and dilution factor (Goldman & Horne, 1983).

The results of the present study referred to high concentration of total suspended solids TSS and Total Dissolved Solids TDS in autumn and summer, while low concentrations were observed at site 5 in the winter and end of autumn.This is probably related to low water concentration with high evaporation during autumn and summer and shallow depth, while the precipitation rate and dilution factor in winter and end of autumn cause the decrease in TSS and TDS rate. This agreement with the other studies (Al – Mussawi *et al.*, 1995; Al- Saadi *et al.*, 2001), while the opposite results obtained by other authores(Al-Mousawi, 1995; Salman, 2006) who obtained high concentration in winter and low concentration during the summer .

Phosphorous occurs in number of inorganic and organic compounds in both particulate and dissolved form .The particulate phase is in the living biota primary algae and higher aquatic plants (Smith, 2004), while dissolved

phase is in the form of orthophosphate, polyphosphate and organic colloidal. Orthophosphate may be assimilated rapidly by the biota. Therefore the concentration at any given time is very low (Wetzel and Likens, 2000).

Different factors may affect the concentration of total phosphorous in aquatic ecosystem these include pH, water flow, adsorption on particulate matter (Weiner, 2000) and the role of aquatic plants in cycling of phosphorous (Wetzel, 2001).

There is fluctuation in the concentration of total phosphorous and affected by the number of phytoplankton (Al-Mousawi *et al.*, 1994). Our results referred to high concentration of total phosphorous recorded in the end of summer at site 4, while the low concentrations were recorded in the end of autumn at site 5. This is possibly due to additional input from agricultural land nearby (Foy and Whithers, 1995) or due to the activity of phytoplankton (Hassan, 1997 and Al-Mousawi *et al.*, 1995).

A large fraction of total nitrogen in fresh water may occur as organic nitrogen in the form of particulate and dissolved organic detritus and generally are not available for photosynthetic. They represent a major reservoir of nitrogen in aquatic ecosystem (Wetzel and Likens, 2000).

Unlike phosphorous, nitrogen occurs in a number of very distinct inorganic forms in aquatic ecosystem, N_2 , NH_4^+ , NO_2^- and NO_3^- . Also occurs in a variety of organic forms in aquatic plants (Wetzel, 2001). The high concentration of total nitrogen was recorded during winter, while the low concentration obtained during autumn. This is possibly related to the change in water temperature and degradation process (Al-Mousawi *et al.*, 1995). Also the fluctuation in the concentration of total nitrogen depends on the amount of uptake of nitrogen compounds by phytoplankton and autochemotrophic bacteria (Al-Mousawi *et al.*, 1994).

The ratio of N:P seem to be the suitable indicator of a limiting factor to phytoplankton growth (Wetzel, 2001). Different ratios were recorded by

other authors. The theoretical ratio was 15:1 that optimizes the growth of phytoplankton (Polat & Isik, 2002).

The ratios recorded in some study periods referred to phosphorous as limiting factor. Also ratios less than 9:1 were recorded that indicate nitrogen as limiting factor. The average ratio 17.6:1 was recorded in Tigris river that indicated the phosphorous as limiting factor for primary productivity in the river (Al-Lami *et al.*, 1999).

4-2: Qualitative and Quantitative studies of phytoplankton

Algae are important and dominant primary producers in aquatic ecosystems. Their presence may be affected by many different factors including water volume and chemistry of water (Bartram & Ballance, 1996). The high number of cells and taxa were recorded at site (4) which located nearby Al-Hindiya city center and may be affected by sewage and domestic effluent in addition to the receive nutrients from agricultural area nearby. Also the speciality of environmental condition of this site that is characterized by the density of aquatic plants which providing suitable habitat for algae growth and release them during flooding period. This situation agreed with other authores (Al-Zubaidi, 1985; Hassan & Al-Saadi, 1995 and Al-Fatlawi, 2005).

The fluctuation of phytoplankton population dependent on different factors as temperature and the amount of nutrient such as nitrogen, phosphorous and silicate (Polat & Isik, 2002), current, discharge rate, construction of barrage and zooplankton population competition (Huntchinson, 1967; Morgan *et al.*, 1993).

In general, two peaks of the total numbers of phytoplankton were obtained in the Euphrates river at all sites, one during Autumn and the second during spring. A similar pattern was obtained by other authores (Hassan & Al-Saadi, 1995 in Hilla river and Al-Fatlawi, 2005 in Euphrates river). Bimodal distribution of phytoplankton was noted in many studies

(Al-Zubaidi ,1985 ; Hassan, 1997, Polat & Sarihan, 2000 and polat & Isik, 2002).

The higher phytoplankton numbers recorded during autumn and spring may be related to optimum temperature and light, low turbidity (Welch, 1952; Huntchinson, 1967). Similar conclusion was made by (Al – Lami *et al.*, 2001 & Al-Lami and Salman, 2003). Also removing of phytoplankton attached to the surface due to high water flow causes an increase in the number of phytoplankton (Kolyli and Buysal, 1998).

Among the algae groups recorded in the present study, diatoms seem to be the most abundant groups. Similar finding was reported in different Iraqi inland waters (Al-Mousawi *et al.*, 1994; Al-Mousawi *et al.*, 1995 in Al –Hammar Marshes; Hassan and Al–Saadi, 1995; Hassa, 1997 in Hilla river; Aziz, 1997; Ganjo, 1997 in Ruwandiz river; Al–Lami *et al.*, 1999 in Tigris river and Al–Fatlawi, 2005 in Euphrates river) and in other parts of the world (Polat & Sarihan, 2000; Polat and Isik, 2002). The dominance of diatoms may be related to their tolerance range to different environmental condition and the availability of silica. Also the physico-chemical properties as pH, EC, dissolved ions , Oxygen, turbidity may affect directly the growth and distribution of Diatoms (Bartram & Ballance, 1996; Wetzel, 2001).

There is a seasonal fluctuation in the number of Chlorophyceae and cyanophyceae recorded during the study period due to the change in the environmental condition and seem to occur during the warm months with some exception. It seem that among diatom species, *Cyclotella ocellata* was the most common taxa in the all Euphrates river sites. This may be related to high silicate concentrations present in high concentrations in most Iraqi inland water (Hassan & Al Saadi ,1995 in Hilla river, Al-Fatlawi, 2005 and Salman, 2006 in Euphrates river).

Synedra sp highly abundant in site 4 which is located nearby Al–Hindiya city center and some species belong to this genus indicated the

pollution (Hassan & Al-Saadi, 1995). Site 4 also was distinguished by the high numbers of *Nitzschia sp.*, *Navicula sp.*, *Cymbella sp.* Results referred to the presence of some genera at all sites including *Chlamydomonas sp.*, *Chlorella sp.*, *Oscillatoria sp.*, *Scenedesmus sp.*, *Euglena sp.* and *Phacus sp.* Some species of these genera seem to bloom in polluted water (Al-Saadi *et al.* 1986).

4-3: Polycyclic Aromatic Hydrocarbons (PAHs)

4-3-1: PAHs in water

Due to the urbanization and industrialization, different types of pollutants find their way into all parts of the environment (Morgan *et al.*, 1993; Gale and MacCarthy, 1999; Hsue, 2004). Water pollution by PAHs compounds may be associated with the anthropogenic activities that represent the major source of PAHs in addition to natural source (Simpson *et al.*, 1996; EHC-202, 1998; Zakaria *et al.*, 2002).

PAHs are of special interest due to their potential hazard to human and natural life (Pham *et al.*, 1999; Wong, 1999; Dahle *et al.*, 2003). Therefore, the determination of PAHs in the aquatic ecosystem is quite essential and provides important information on the anthropogenic input into the river.

The concentration of low molecular weight PAHs, Naphthalene and acenaphthalene (0.31 and 0.07 µg/l) were lower than those found in different aquatic ecosystems (0.60, 1.33, 729, 35, and 153 µg/l) in Jiulong river estuary, Western Xiamen sea in China, in the surface runoff in the Lagos, 11e-1fe, Osogbo area, Nigeria and Gao-Ping river, Taiwan respectively (Maskaoui *et al.*, 2002; Ogunfowokan *et al.*, 2003; Doong and Lin, 2004).

The concentrations of Acenaphthene and Fluorene (0.20 µg/l) were close to the concentration recorded by Doong and Lin, 2004 in Gao-Ping river, but lower than those recorded in other parts of the world (5.64, 1.64, 1.55 µg/l) in Giantang river, Hongzhou canal and inland river in China by

Zhu *et al.*, 2004. The concentration of Phenanthrene and Anthracene, Fluranthene, Pyrene, Benzo(a)Anthracene and Chrycene were lower than those found in other parts in the world (El-Nemr and Abd-Allah, 2003 and Zhu *et al.*, 2004), but close to the concentration obtained by Maskaoui *et al.*, 2002 and Doong and Lin, 2004. Similar results were obtained for other individual PAHs in the present study. The five ring-PAHs represent (40.73%) of the total PAHs in the Euphrates river sites, while low percentage (4.78%) was recorded for 2-ring PAHs indicated that 5-ring PAHs were the most abundant than the others (5-ring PAHs >6-ring PAHs >4-ring PAHs >3-ring PAHs >2-ring PAHs). The present results referred to the dominancy of High Molecular Weight PAHs (83.06%) in comparisons with Low Molecular Weight PAHs (16.93%). This may be related to low water solubility of HMW-PAHs and high partition coefficient concentration (K_{ow}) and high volatility of LMW-PAHs and affinity to organic particles in water. Similar explanation was made by Al-Timari, 2000a who detected lower concentrations of HMW-PAHs with no concentrations recorded for LMW-PAH in the Shatt Al-Arab river. Opposite results were obtained by Doong and Lin, 2004 .In other study, it was indicated that the major PAHs compounds in Shatt Al-Arab river and north Arabian Gulf were Bghi, AcP and An .Also concentrations of NaP were recorded at some sites (Al-Saad, 1995).

Table(17) shows that the total concentration of PAHs in different water bodies. The mean concentration of total PAHs in the water samples in the present study (6.45 µg/L) was lower than those recorded in other aquatic ecosystem in the world, suggesting that Euphrates river sites was not heavily polluted. The concentration of total PAHs in water exceeding 10 µg/l was considered as heavily contaminated (WHO, 1998). The current study results referred to mean concentrations which ranged from (4.75 to 7.73 µg/L). However, the concentration above 10 µg/l was recorded at some sites during

some periods .In comparing the concentrations of total PAHs in the present study with those found in Shatt Al-Arab river and North West Arabian Gulf(Al-Saad, 1995; Al-saad *et al.*, 1998 and Al-Timari, 2000a), high concentrations were recorded . This may be due to the nature of the aquatic ecosystem of Shatt Al-Arab and North West Arabian Gulf that characterized by high water concentration and role of dilution factor, specialty of location, urban development after the 2003 war in Iraq ,emission from industries nearby that release concentrations of PAHs in to atmosphere and finally fall into water ,direct domestic and industrial discharge in to river, burning of wood for different domestic purposes because of the shortage energy sources especially in undeveloped area in addition to uncontrolled explosions from time to time.

The nature of area, environmental condition, nature of aquatic ecosystem, method and condition of analysis should be taken in significant where making the comparison. It is also important to explain that the numbers of individual PAHs analyzed in different studies were varying from (7-16) .

In general, the concentrations of PAHs in water depend on several factors including properties of PAHs as hydrophobic nature with low solubility (Brooks, 1997 and Vrana *et al.*, 2001), interaction of several processes such as volatilization, bioconcentration, sedimentation, solubilization and biodegradation (Narbone *et al.*, 1995; EHC-202, 1998), Proximity of water body to the source, and source type and seasons(Moor and Ramammorthy, 1984). Also the fluctuation in the concentration of PAHs in water may be associated with the non-point sources as direct discharge from industrial and domestic sewage effluent. However, the urban surface runoff, application of chemicals in agriculture, and soil erosion nearby may be contributed in the concentrations of PAHs in water (Mai *et al.*, 2001) .

The results of the study referred to non significant variation in the concentration of PAHs in water samples among sites with exception of significant differences in the concentration of some individual PAHs at some sites ($P < 0.01$). This may be due to exposure to similar anthropogenic activity at sites. However the variation of PAHs concentration among sites may be attributed to the proximity of source, type of source, and anthropogenic activity at site (Moor and Ramammorthy, 1984; Crunkilton and Devital, 1997; EHC-202, 1998; Maskaoui *et al.*, 2002; Doong and Lin, 2004), water concentration and role of dilution factor may be associated with concentration of PAHs in water. The low concentration of PAHs ($4.75 \mu\text{g/L}$) was recorded at site 4 which may be related to low water concentration and large river area that increase sedimentation process and photo degradation. Also the density of plants in the site play important role in removing PAHs from water by adsorption and accumulation (Hsu, 2004). High concentration of total PAHs ($7.73 \mu\text{g/L}$) was recorded at site 2 may due to close of site from agricultural area nearby and burning of wood for domestic purposes.

The results of the present study referred to the fluctuation in the concentrations of PAHs among seasons. The statistical analysis shows significant differences among seasons at ($P < 0.01$). The high concentrations were recorded during spring and autumn, while lower concentrations observed during the summer with the exception of high concentrations of some individuals PAHs recorded during the hot season. This may be related to the climate condition of Iraq which characterized by high temperature in summer that causes volatilization of Low Molecular weight PAHs and rapid assimilation by aquatic organisms or may be due to loss of LMW-PAHs during extraction. Similar explanation was made by some authors (Al-Saad *et al.*, 1995; Al-Timari, 2000a; Al-Timari, 2001). Statistical analysis referred to positive correlation of total PAHs in water with air temperature and water temperature ($r = 0.273$, $P < 0.05$ & $r = 0.281$, $P < 0.05$ respectively).

Photodegradation and microbial degradation play an essential role in removing of PAHs from water (Monson *et al.*, 1995; ATDSR, 1996; AL-Timari *et al.*, 2002). Seasonal variation in PAHs in Gao-Ping river was concluded by the change in the discharge of river (Doong and Lin, 2004).

Zhu *et al.* (2004) found a higher concentration of PAHs in summer than in winter which may be contributed to the sorption of PAHs on to the suspended particles and atmospheric deposition which increase during the hot seasons. Mitra and Bianchi (2003) found a higher concentrations of PAHs in autumn than in winter suggesting that the compositional difference in PAHs particle–water distribution were function of seasonal discharge across year.

The present study referred to high concentrations of some individual PAHs (AcP, Flu, Phen, Py and BbF) recorded in summer at site 3 may be due to affected of site by agricultural area nearby or increase of atmospheric deposition during summer as a result of high urban vehicle traffic that release individual PAHs in to atmosphere (EHC-202, 1998) or may be due to the combustion processes as wood burning (Mitra and Bianchi, 2003). As related with concentration of PAHs and water flow, High concentration (11.48 µg/l) was recorded during high water flow (103.32 cm/second) and positive correlation ($r=0.287$, $P<0.05$) was observed during the study which may be due to increase suspended particles and re-distribution of PAHs between water and sediment. Similar explanation was made by Crunkilton and Devita (1997). Opposite results were obtained by MacCarthy and Gale (1999) and Doong and Lin (2004) who suggested that concentration of PAHs may be reduced or diluted during the period of high flow of water.

The sources of PAHs in water can be assessed by the ratios of individual PAHs from different seasons (Yunker *et al.*, 1996; Vrana *et al.*, 2001; Zakaria *et al.*, 2002). The crude petroleum oil contains the compounds such as Naphthalene, Flurene, Phenanthrene and Anthracene, while

Fluoranthene and Pyrene are usually most abundant compounds of Pyrogenic processes. Ratio of Fluoranthene/Pyrene (Flur/Py) greater than one and Phenanthrene Anthracene(Phen/Ant) less than ten referred to pyrolytic processes (Sirece *et al.*, 1987; Sanders *et al.*, 2002; Dahle *et al.*, 2003; Doong and Lin, 2004). Also the ratio of Benzo(a)Pyrene /Benzo(ghi)Perylene (BaP/BghiP) was used to expect the possible sources of PAHs ratios of(0.48-7.25) were recorded for air urban, (1.2-5) for wood burning and (1-3) for coal burning (Maher and Aislabie, 1992).

The present study referred and the ratio of Phen/Ant to be between 0.47 at site 4 and 45.07 at site 1 which indicated both petrogenic and pyrogenic sources. The petrogenic sources of PAHs at site 1 may be associated with the leakage of oil refined products from boat(oil droplets appear on the surface of water during the sampling) ,waste water from domestic and industrial effluent and Vehicles movement in the area in addition to atmospheric deposition(Carras, 1997 ; Doong and Lin, 2004) .

The mean ratio of (1.39) was recorded for Flu/Py indicating pyrogenic input .The mean ratio of (1.31) was recorded for BaP/BghiP. This concentration is close to ratio obtained by Maskaoui *et al.*, 2002 (1.37) in the Jiulong river estuary and Western Xiamen sea ,China and within the range obtained by Maher and Aislabie ,1992 in Sweden and Norway indicating both wood and coal burning and urban air as the main sources.

The mean ratio of(LMW-PAHs /HMW-PAHs)was 0.20 indicating the pyrogenic source of PAHs. Opposite result was obtained by Doong and Lin (2004) (1.12-2.69) suggesting petrogenic input .

It is clear from the results that the distribution of PAHs in the Euphrates river sites may have the origin from different sources (petrogenic, pyrogenic and urban air).

Table(17):Comparison of PAHs concentrations in water samples of Euphrates river with those in other studies in the world

Location	Date of sampling	Number of PAHs	Range (µg/L.)	Mean ((µg/L.)	Reference
Seine river and Estuary, France	Oct. 1993	11	0.004-0.036	0.02	Fernandes <i>et al.</i> , 1997
Sea water around England and Wales	Jun.1993-Jul.1995	15	0.001-2.48	1.002	Law <i>et al.</i> ,1997
ST.Lawrence river (Canada)	1993-1994	14	-	326	Pham <i>et al.</i> ,1998
Shatt Al-Arab river	1993-1994	7	5.1-21×10 ³	-	Al Saad <i>et al.</i> ,1998
Shatt Al-Arab river estuary	1993-1994	7	6.1-7.2×10 ³	-	Al Saad <i>et al.</i> ,1998
NW-Arabian Gulf	1993-1994	7	3.1-4×10 ³	-	Al Saad <i>et al.</i> ,1998
Shatt Al-Arab river	1997-1998	7	21-55×0 ³	-	Al-Timari,2000a
Western Xiamen sea ,China	Jul. 1998	16	0.11-0.95	0.355	Zhu <i>et al.</i> ,2000
Jiulong river estuary and Xiamen Sea ,China	Jun. ,1999	16	6.96-26.9	16.114	Maskaoui <i>et al.</i> ,2002
Surface runoff of Lagos iie-ife and Osogbo area	1994-1995	13	2,030-110,020	42,495	Ogunffowkan <i>et al.</i> ,2003
Subsurface water along Alexandria coast ,Egypt	2002	7	13.2-119.9	47.0	El-Nemr and Abd-Allah,2003
Gao-Ping river	Nov.1999-Jul.2000	16	0.01-9.4	0.43	Doong and lin,2004
Qiantang river	1999-2002	10	25.9-60.24	41.51	Zhu <i>et al.</i> (2004)
Hangzhou canal	1999-2002	10	11.21-41.8	26.4	
Inland river	1999-2002	10	8.6-33.6	21.63	
Euphrates river Before Al-Hindiya dam to Al-Kifil city	Jul.2005-Jun.2006	16	4.75-7.73	6.6	Present study

Note: Total PAHs in Al-Saad *etal*,1998 and Al-Timari,2000a are in dissolved phase only

4-3-2 :PAHs in sediment

Sediments are a good indicator of water pollution and major repository of pollutants introduced into surface water (Ingersoll *et al.*, 1997a). The concentrations of PAHs in the sediment were studied widely by authors and the toxic effect of these pollutants was also evaluated (Narbone *et al.*, 1999; Tay *et al.*, 2003; Geffard *et al.*, 2003; Thorsen, 2004). The sources of PAHs to aquatic sediments is pyrogenic from combustion processes and small contribution of petrogenic source and enter the sediments from urban runoff and atmospheric deposition (Chen, 2001; Sanders *et al.*, 2002). Due to high hydrophobicity and low water solubility, PAHs have the affinity to accumulate in the sediment where they are distributed between available and non-available fraction (Chen, 2001). The evolution of PAHs in the sediment of Euphrates river provides the baseline informations of sediment quality. Therefore seasonal changes of PAHs concentrations were assessed. The concentration of Low Molecular Weight PAHs, Naphthalene (2.19 ng/gDW) was lower than those found in other aquatic ecosystem the world (11.33 and 15.1 ng/gDW) in Jiulong river & Western Xiamen sea and Gao-ping river respectively (Maskaoui *et al.* 2002; Doong & Lin, 2004). As related to concentration of Phenanthrene and Anthracene (11.59, 3.48 ng/gDW), the concentrations were lower than those found by Maskaoui *et al.*, (2002) Zhu *et al.*, (2004) and Doong and Lin, 2004, but higher than concentrations obtained by Dahle, (2003) and Mitra *et al.*, 2003. The concentration of high molecular weight PAHs (Fluoranthene to Indeno (1,2,3-cd) Perylene) showed wide fluctuation in comparison with those found in other studies (Al-Hamdi, 1989; Maskaoui *et al.*, 2002; Mitra *et al.*, 2003; Sanders *et al.*, 2003; Zhu *et al.*, 2004; Rhea *et al.*, 2005).

In general, the concentrations of PAHs in the sediment are usually found to be several order of magnitude higher than concentrations in the water column (Ingersoll *et al.*, 1997a; Geismar, 2002; Rhea *et al.*, 2005). Also

the distribution of that in the sediment is very similar to PAHs in water (maskaoui *et al.*, 2002). The present study results referred to high concentrations of PAHs in sediment as compared with in the water column and dominated by high molecular weight PAHs especially 5 ring-PAHs followed by 4 ring and 6 ring-PAHs. Similar results was obtained in water. This result was confirmed by strong correlation obtained for PAHs in sediment with those in the water ($r=0.978$, $P<0.01$ for 2 ring-PAHs; $r=0.992$, $P<0.01$ for 3 ring-PAHs; $r=0.994$, $P<0.01$ for 4 ring-PAHs; $r=0.946$, $P<0.01$ for 5 ring-PAHs and $r=0.983$, $P<0.01$ for 6 ring-PAHs). Similar results were obtained in Little Sciote river, Marion that dominated by HMW-PAHs especially 4 ring-PAHs (Ohio EPA , 1992). The high concentration of High Molecular Weight-PAHs may be due to the lower solubility of these compounds and resistant relative to photo and microbial degradation. Therefore, they tend to adsorb on the surface of organic particulate materials and accumulated in the sediment (Juhnsen, 1985; Zhou *et al.*, 2000). Sediment with high TOTAL Organic Carbon (TOC)% silt and clay have the higher concentration of PAHs than sediments with sand and low TOC (SFEI, 1998).

The percentage of Total Organic Carbon (TOC %) in sediment samples ranged between (0.636 and 1.602%) with the mean concentration of (1.0 %). This concentration is comparable to those found by Al-Taei (2002) in Hilla river (1.09 %) and Al-Timari *et al.* (2002) in Khor Alzubair (0.531%) and relatively higher than that observed by Salman (2006) in Euphrates river (1.44 %); (0.82-10.44%) in Elizabeth river, Virginia recorded by Stout *et al.*, 2003; (0.179 %) obtained by Doong and Lin (2004) in Gao-Ping river and (0.65-13.5%) recorded by Rhea *et al.* (2005) in the lakes from Grand Teton National Park .

The concentration of TOC % (1.602 %) was recorded at site 4 which located near Al-Hindiya city center therefore affected by domestic sewage

effluent and dominated by dense aquatic plants that may be the sources of organic materials after their death. Similar explanation was made by Salman (2006).

The present results referred to significant positive correlation between TOC% and total PAHs in the sediment ($r= 0.739$, $P<0.01$) which may be due to hydrophobicity nature of PAHs and their affinity to organic material or may be the fraction of TOC in the sediment. The results agree with those obtained by other researchers (Dahle *et al*, 2002 and Mitra *et al*, 2003) . Positive correlation was recorded for total hydrocarbons and TOC% by (Al-Saad, 1983 and Al-Saad *et al.*, 2000) in the north west Arabian Gulf and between PAHs and TOC% obtained by Al-Hamdi, 1989 in Khour Al-Zubair in Iraq . The current study results referred to negative correlation between PAHs and the grain size of sediment (sand ,silt and clay).This may be agreed with the results obtained by Al-Hamdi, 1989 in Khour Al-Zubair due to homogeneity of grain size distribution or may be related with other factors rather than the grain size affected the distribution of PAHs or due to heterogeneity deposition of PAHs in the sediment .Opposite results were obtained by Papadopouliou & Samara (2002) and Dahle *et al.* (2003) and explained by strong adsorption of PAHs to fine fraction($<63\mu\text{m}$) and large surface area of fine fraction to the weight.

The total concentration of PAHs in the sediment did not show significant relationships among sites which may be due to the similar nature of the sediment of sites and the exposure to the similar anthropogenic activity. However, some individual PAHs showed significant differences among sites. It was found that variation in the concentrations of PAHs among sites may be due to additional input source (Maskaoui *et al.*, 2002) and the proximity of site from the source (Sanders *et al.*, 2002). The present results referred to significant differences in the concentrations of PAHs among seasons during the study. The highest concentrations were obtained

in autumn and spring, while the lowest concentration recorded in summer. This may be related with the climatic condition of Iraq and the effect of photo oxidation, volatilization and high degradation during the hot season(Al-Saad, 1987; Al –Hamdi, 1989; Al-Saad and Al–Timari, 1989; Al – Timari, 2000b; Al–Timari *et al*, 2002 ; Sanders *et al.*, 2002; Doong and Lin , 2004 and Nasir, 2004) .

In comparisons of the total PAHs in the present study with those found in other parts of the world (table 18), it is clear that the middle concentrations were obtained and the variation in the concentrations in different studies may be due to nature of the area, environmental condition, nature of the sediment component, water concentrations during the times of year, anthropogenic activity in the area near the water bodies, different in the numbers of individual PAHs detected ,sampling method and analysis condition .

Mitra *et al.* (2003) explained that many physical, chemical and biological factors as temperature, photo-oxidation, transport mechanisms, weathering, dilution factors, solubility, biodegradation, sampling method and natural formation of PAHs may be attributed to variation in the concentrations of PAHs in the sediment .

In Iraq, several studies were done to determine the total PAHs in the sediments and restricted to the south aquatic ecosystem of Iraq. The range of(3.8-76ng/g DW) recorded in Shatt Al-Arab river by Al-saad ,1987; (6.0-40.0ng/gDw) in Kowr Al-Zubair by Al-Hamdi,1989;(0.5-2.1ng/gDw) in Hor Al–Hammar by Al-Saad and Al-Timari, 1989 ; (8.4-70.56ng/gDw) in Shatt Al-Arab and NW-Arabian gulf by Al-Saad, 1995)

The ratios of Phen/Ant, Flur/Py, BaP/BghiP and LMW-PAHs/HMW-PAHs can provide a useful informations for explanation of the origin of PAHs in the sediment in the manner similar to ratios in the water (Yunker *et*

al., 1996; Vrana *et al.*, 2001; Zakaria *et al.*, 2002; Maskaoui *et al.*, 2002; Doong and Lin, 2004).

In the present study, the mean ratio of Phen/Ant (4.50), Flur/Py (3.2) and LMW-PAHs/HMW-PAHs(0.17) indicated pyrogenic input of PAHs in to sediment(Phen/Ant<10, Flur/Py >1, LMW-PAHs/HMW-PAHs<1 refer to pyrogenic input of PAHs. However, the ratio of Phen/Ant (10.60)at site 1 and Flur/Py(0.61) at site 4 refer to the petrogenic input which may be due to leakage of petroleum and refined products as gasoline, diesel and fuel oil from boat and vehicle traffic. The mean ratio of BaP/BghlP(2.5) referred to the pyrogenic source and urban air(1.2-5 for wood burning, 1-3 for coal burning and 0.48-7.25 for urban air as described by Maher and Aislabie (1992).The ratio of Phen/Ant and Flur/Py (0.01- 0.5 and 0.81-2.01 respectively) were obtained by Doong and Lin (2004) in the Gao-ping river, Taiwan.

Table(18):Comparisons of PAHs concentrations in sediment samples of Euphrates river with those in other studies world wide

Location	Date of sampling	Number of PAHs	Range (ng/gDW)	Mean (ng/gDW)	Reference
Khor Al-Zubair Basrah, Iraq	1989	-	6.0 -40.0	17.34	Al-Hamdi (1989)
Shatt Al-Arab river	1979-1980	-	3.8-76	-	Al-Saad (1987)
Shatt Al-Arab river estuary	1979-1980	-	3.4-19	-	Al-Saad (1987)
Kowr Al-Zubair	1979-1980	-	1.6-19	-	Al-Saad (1987)
NW-Arabian Gulf	1979-1980	-	0.2-15	-	Al-Saad (1987)
Hor Al-Hammar	1986	-	0.5-2.1	-	Al-Saad & Al-Timari (1989)
Little Scioto river ,Marion -Ohio	1988-1991	15	0.43×10^3 - 550×10^3		Ohio EPA(1992)
Kitimat Harbour,Canada	1996	15	310- 528000	66700	Simpson <i>et al</i> . (1996)
Kuwait Saudi Arabia Bahrain	1991 1991 1991	-	- 36-751 46-93	30 - -	Fowler <i>et al</i> . (1993)
Kuwait	1990-1989	-	7.3-16.9	-	Al-Timari (2000a)
South China sea	1999	21	24.7 -275.4	146	Yang <i>et al</i> (1999)
Western Xiamen sea ,China	July 1998	16	247 -480	367	Zhou <i>et al</i> (2000)
Malaysia riverine	2002	-	4 -924	187	Zakaria <i>et al</i> (2002)
Jiulong river estuary and Western Xiamen sea	June 1999	16	59 -1177	334	Maskaoui <i>et al</i> . , (2002)
Savannah river	June –July 1994	24	29 -5375	1217	Sanders <i>et al</i> (2002)
Kara sea shelf Gulf of Ob Yenisei bay	Aug. 1993 – Sept. 1994	27 27 27	0.3 -71 0.0 -66 0.2 -224	6.15 8.59 19.9	Dahle <i>et al</i> . (2003)
Elizabeth river ,Norflk, Virginia	2003	53	7.743×10^3 - $7,0843 \times 10^3$	58043×10^3	Stout <i>et al</i> .(2003)

Continued

Mississippi river and Gulf of Mexico	1999 1999	15 16	- -	2521.8 135.04	Mitra <i>et al</i> . (2003)
Gao-Ping river	Nov.1999- Jul.2000	16	8.0-356	80.6	Doong and Lin(2004)
Qiantang river Hangzhou canal Inland river West lake	2002 2002 2002 2002	10 10 10 10	343-2342 139.9-308 141.4-1561 1560.6	224 4221 674.2	Zhu <i>et al</i> (2004)
Lakes from Ingrand Teton National Park ,Wyoming	2001-2002	16	-	3,110	Rhea <i>et al</i> (2005)
Euphrates river Before Al- Hindiya dam to Al-Kifil city	Jul.2005- Jun.2006	16	45.35- 378.17	!67.17	Present study

4-3-3:PAHs in clams

Among the most aquatic organisms, molluscs are of special interest and used in different environmental studies. They play an important role in the trophic level and nutrient dynamic of aquatic ecosystems since as a main source of nutrients for different aquatic organisms(Helfrich and Noves, 2003).

Clams have the ability to live in polluted environment and can be the useful indicators of pollution (Graczyk *et al.*, 1998 and Phelps, 2002). Bivalves tend to accumulate high concentrations of PAHs rather than detoxify or modify them. This may be related to the lack or inefficient cytochrome P450 ecosystem responsible for detoxification of organic pollutants. Therefore, they have been recommended for water contamination and bioaccumulation studies (SFEI, 1998; Phelps, 2002). In the present study, we observed the community of clams in the Euphrates river during the sampling period which may be due to several environmental factors that are suitable for their growth. Among these are temperature, salinity, pH and the presence of calcium important for shell formation. Therefore these factors may influence the uptake, retention and translocation of PAHs in their bodies .

Several PAHs accumulated in clam tissues several orders of magnitude higher than those in the water and sediments and the main routes for taking PAHs are through filtration of water for some times and ingestion of sediments (Roper and cherry, 1996). Therefore, the patterns of PAHs distribution are similar to those in water and sediments. The results referred to positive correlation between PAHs in both species of clams and those in water and sediments which dominated by high molecular weight PAHs. This may be related to the low solubility of these compounds and resistance to microbial and photodegradation and biota metabolism. Therefore they tend to accumulate in the sediment and biota (Eisler, 1987; EHC-202, 1998 and

EPA, 2000). Similar results were obtained by Roper *et al.*(1997) whom recorded the accumulation of Pyrene, Chrycene and Benzo(a) Anthracene. The present results referred to significant differences for PAHs in both types of clams with seasons which may be to the change in different environmental factors as temperature, water concentrations that may influence the rate of different physiological processes in the clams. Therefore the concentrations of PAHs were expected to change(Helfrich and Noves, 2004). High concentrations of PAHs in clams were recorded during the cold seasons rather than the hot seasons. This may be related with the mechanisms as volatilization, photolysis, sedimentation and hydrological processes that may cause the variation in the concentrations of PAHs in water and sediments and thus the concentrations of PAHs in clams (Irwin, 1997).

In general wide range of physical(rate of mixing, rate of sedimentation, diffusion of pollutant between sediment pore water and water column and resuspension), Chemical(pH, sediment organic content, organic matter characteristics) and biological (Biotransformation, lipid content, organism size or age, organism behavior, diet as sediment ingestion, feeding mechanism and organism response to physicochemical conditions) factors that have the potential to affect the bioavailability of PAHs in the clam (Eisler, 1987).

Some individual PAHs showed high concentrations during summer which may be related to the recent input from atmosphere or the loads of sewage effluents close to the site where the clams were collected. Also the procedures of extraction, clean-up, storage and condition of analysis, efficiency of HPLC were all the factors that affected the concentrations recorded. However the blanks of all reagents, glassware's and samples were done and recorded no contamination but few exception. In these cases the concentrations were almost corrected.

The present results referred to high concentration for HMW-PAHs as Chrycene, Benzo(a)pyrene, Dibenzo(ah)anthracene and Benzo(ghi)Perylene in both species of clams. These results leads to the suggestion of pyrogenic input of PAHs. Also the lack of detoxifying enzymes as mixed function oxidase(MFO) and resistant of HMW-PAHs to microbial, photodegradation and metabolisms lead to their accumulation in the tissues (Kisro, 1998; Narbone *et al.*, 1999 and Phelps, 2002). The lipid content of tissues is an important factor affecting the concentrations of PAHs in the organisms (Eisler ,1987; EHC-202,1998 NOAA, 2000). Because of the lipophilic properties of PAHs, they tend to accumulate in the lipid. Therefore there is a positive correlation between PAHs concentrations and lipid content (Al-Saad ,1983 ; Kayal and Connel ,1995) .Similar correlation was recorded in present study($r=0.964$, $P<0.01$) for *Unio tigridis* and($r=0.972$, $P<0.01$)for *Pseudodontopsis euphraticus*. Crosby (1998)was suggested that the accumulation of pollutants in fat body never reach the toxic concentrations which may be related to slow accumulation rate and the loss of fat by organisms that does not provide the toxic level.

One way to assess the bioavailability of PAHs in the environment is to compare individual PAH concentration in the organisms to PAHS concentrations in water ($BCF = \text{concentrations of PAHs in organism} / \text{Concentrations in the water}$) and sediment ($BSAF = \text{concentrations of PAHs in organisms} / \text{concentrations in the sediment}$) as demonstrated by other researchers (McFarland , 1995; Brookes, 1997; EPA, 2000; Thorsen, 2004).

The present results referred to BCF that ranged between(0.12-1784) in *Unio tigridis* for Naphthalene and acenaphthalene respectively and (12.83-1000) in *Pseudodontopsis euphraticus* for Naphthalene and Pyrene respectively suggested that HMW-PAHs were rapidly accumulated in tissues than LMW-PAHs .This may be related to the linear relation between BCF

and water partition coefficient(K_{ow}).The high number, the more tendency to bioaccumulation and may be greater for HMW-PAHs. Eisler (1987) reported that the BCF concentrations from (6-236) were recorded for clam *Rangia cuneata* and Irwin(1997) cited the concentration of (1000) for 3 ring-PAHs in Oyster .

The present study results referred to the concentration of BSAF range between(0.12-320) recorded for Naphthalene and acenaphthalene respectively .Brooks (1997) cited that the concentration of BSAF for PAHs was 0.2 or less indicating no significant bioconcentration of PAHs from sediment. However the BSAF of PAHs from sea water were 10.3 to 1349 indicating low to moderate potential for accumulation of PAHs from sediment . The concentration of BSAF less than 1 referred to lowered bioavailability of PAHs for organisms(McFarland, 1995) . However several factors should be explained the decreased BSAF concentrations of some individual PAHs .These include differences in hydrophobic character between mussel lipid and sediment organic carbon, lack of steady state condition for clam, the sediment phase and the capacity of clam to assimilate some PAHs(Thorsen, 2004). In comparison of PAHs in both species of clams recorded in the present study with those recorded in the other parts of the world, it is clear that concentrations were within the range recorded for other studies world wide (table 19). The variation in the concentrations recorded may be related with differences in Molluscs species, time of sampling, environmental condition, size, adaptation and life cycles of each species, procedures of extraction, storage, clean up and analysis condition and number of PAHs detected. Therefore all these factors should be taken into consideration when making the comparisons .

Table (19):Comparisons Of PAHs concentrations in clams collected from Euphrates river (site 4) with those in other studies world wide.

Location	Type of Molluscs	Mean (ng/gDW)	Reference
Palmetto Bay ,south Carolina	<i>Crassostrea virginica</i>	520(FW)*	Marcus and Stokes,1985
Times Beach,Buffalo,New York	<i>Dreissena polymorpha</i>	5,640	Roper and Cherry,1997
Potomac river (control site)	<i>Corbicula flumnea</i>	421-456	Phelps,2002.
Tributaries (Anacostia river)	<i>Corbicula flumnea</i>	637-1442	Phelps,2002.
Estuary(Anacostia river)	<i>Corbicula flumnea</i>	1366-2350	Phelps,2002.
Potomac river (control)	<i>Corbicula flumnea</i>	60.0	Phelps,2005
Lower Baeverdam Creek	<i>Corbicula flumnea</i>	0.0-260	Phelps,2005
Northeast Branch near industrial park area in PrinceGeorges county	<i>Corbicula flumnea</i>	2196	Phelps,2005
Watts Branch	<i>Corbicula flumnea</i>	1088	Phelps,2005
Euphrates river Before Al-Hindiya dam to Al-Kifil city	<i>Unio tigridis</i>	1077.68	Present study
Euphrates river Before Al-Hindiya dam to Al-Kifil city	<i>Pseudodontopsis euphraticus</i>	1180.61	Present study

* FW=Fresh Weight

4-3-4:PAHs in plant

Because of their wide distribution, low cost and the efficiency to accumulate pollutants in their tissues, aquatic plants can be used to remove PAHs from contamination area (Colins and Willey, 2004; Hsu, 2004). PAHs compounds are detected in different parts of plants including root, leaves and the concentration may be greater on plant surface than internal tissues, broad leaves than narrow leaves (Eisler, 1987; Irwin, 1997; Colins and Willey, 2004).

Several experimental researches and field were done to assess the accumulation potential of plants (McGlynn and Livingston, 1997; Hsu, 2004; Alfani *et al.*, 2005) .

The present results referred to non-significant differences in the concentration of PAHs in the two plants studied. This may be related to the grow of both species under the same environmental condition and exposed to the same pollution sources. The present study referred to significant differences in the concentrations of PAHs among seasons in both species of plants. This may be related with the fluctuation of different climatic conditions that affected the efficiency of plant to concentrate pollutants in their bodies. High concentrations were recorded during the cold season than the hot season with some exception. This may be attributed to the elevated PAHs photo degradation in summer caused by strong sun light and high temperature (Alfani, 2005) .However, some individual PAHs showed high concentrations during the summer which may be due to recent input of PAHs from atmosphere in addition to different factors related with extraction, cleanup and analysis condition. It is also related to the properties of individual PAHs as molecular weight since it is known some high molecular weight are resistant to photo and microbial degradation so its expected to detect some HMW-PAHs during the hot season (EHC-202, 1998; Eisler, 1987; and Irwin, 1997). The concentration of PAHs in both species of plants

were higher than those recorded in water and sediment. Irwin (1997) cited that the concentrations of PAHs in plant can be many times higher than those in water due to bioconcentration. High concentrations of 5 ring-PAHs were recorded in comparisons with the other PAHs as in water and sediment due to their low solubility in water and tend to accumulate in the sediment and biota (Roper *et al.*, 1997).

There are fluctuations in the possibility of plants to accumulate PAHs from water and sediment. This is confirmed by the concentrations of BCF(0.78-369.67) and BSAF (0.07-10.56) for naphthalene and Dibenzo(a,h)anthracene in *Ceratophyllum demersum*. In *Typha domingensis*, the range between(0.33-10.7) was recorded for Dibenzo(a,h) anthracene and anenaphthalene respectively which referred to high affinity of plants to accumulate HMW-PAHs that represent 93.76% of total PAHs in *Ceratophyllum demersum* and 98.73% of PAHs in *Typha domingensis* .

According to the ratio of Phen/Ant., Flur/Py,BaP/BghiP and LMW-PAHs /HMW-PAHs, the sources of PAHs in plants may be pyrogenic, petrogenic and urban air. Alfani(2005) suggested that the sources of emission, the distance from the source and physical-chemical properties of PAHs may be affected the concentration of PAHs in the plant .

Because the plants were collected from urban site near an urban area with high traffic movement and close to the domestic sewage effluent in addition to emissions from small industries nearby, we expected the high concentration of PAHs in plant. There are just few data present about the concentrations of PAHs in aquatic plants and most recent studies were experimental and interested in the efficiency of some orders of plants used in phytoremediation technology to remove PAHs from contaminated area (Huang *et al.*, 1997; Marwood *et al.*, 2001; Colins and Wielley, 2004; Hsu, 2004).

Conclusions

1. The water quality of Euphrates river under the study was considered to be :
 - A- Slightly alkaline, very hard, well oxygenated and concentrations of BOD₅ were recorded in some months that exceed the permissible limits.
 - B- There was a fluctuation in the concentration of total phosphorous and total nitrogen and the ratio of TN/TP referred to phosphorous as limiting factor for phytoplankton growth. However, the ratios less than 9:1 were recorded indicating nitrogen as limiting factor .
2. Among the algae groups, diatoms seem to be the most abundant in the term of cell numbers and taxa. The high number of cells and taxa was recorded at site 2 near agriculture area and site 4 which located near Al-Hindiya city center and may affected by domestic sewage effluent.
3. The concentrations of PAHs in water samples were low due to hydrophobic nature of PAHs and interactions of several processes such as volatilization, photooxidation and sedimentation.
4. In sediments, PAHs compounds were found in concentrations several times higher than those in water .Moreover, strong correlation was recorded for PAHs in sediment with TOC% due to affinity to organic materials .
5. The grain size analysis of sediment samples indicated that the distribution of PAHs in sediment was not correlated with texture.
6. The concentrations of PAHs in both species of clams and plant under the study were several times higher than those in water and sediment due to low solubility and resistance to photo and microbial degradation.

7. Positive correlation was recorded for PAHs in both species of clams with lipid content due to lipophilic nature and tend to accumulate in the lipid.
8. The concentration of PAHs was significant among seasons in both species of clams and plants with the exception of Naphthalene.
9. The composition pattern of PAHs in all samples of water, sediment and aquatic organisms was dominated by 5 ring-PAHs and higher concentration was recorded for HMW-PAHs .
10. According to the ratios of (Flouranthene /Pyrene, Phenanthrene/ Anthracene, Benzo(a)Pyrene/Benzo(ghi)Perylene and LMW-PAHs/HMW-PAHs), the PAHs in all aquatic samples have the origin from different sources including pyrogenic, petrogenic and urban air .
11. According to the concentrations of BCF and BSAF, both species of clams and plants can accumulate low and high molecular weight-PAHs.

Recommendations

1. Domestic and industrial waste water near and around the river suggested to be directly treated before discharged in to the river .
2. Because the concentrations of BOD recorded in some months were exceeded the permissible limits, more attention should be paid in future studies.
3. Because of the importance of algae, further studies should be investigated especially the isolation of species recorded more abundancy during the study and the possibility to use these in bioremediation technology for removing of PAHs from water.
4. An abundance of High Molecular Weight-PAHs especially of carcinogenic group (BbF, BkF, BaP and DbA) in the river, it is suggested that the discharge from domestic and industrial waste water, emissions from industries and vehicular exhaust in addition to wood burning and explosions might be the main sources of PAHs in the river. Therefore, the monitoring programme should be made .
5. In order to determine the non-point sources of PAHs in river, it is recommended for future studies the investigation of PAHs in atmosphere, surface run off and soil .
6. Because the known toxicity of PAHs compounds, it is recommended to be assessed in future toxicological studies and determine the health impacts to human and aquatic life
7. The BioConcentration Factor(BCF) and BioSediment Accumulation Factor(BSAF) recorded in the study provided good estimates of bioaccumulation potential .Therefore, it is recommended to use aquatic organisms in pollution monitoring programme.

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Index (1)/Table(1): Values of F calculated from ANOVA table for different properties of Euphrates river. Differences among site (first line) and among seasons (second line).

Variable	F	Variable	F
Air temperature	1.682 26.556**	Total Hardness	2.964** 38.824**
Water temperature	1.050 25.346**	Calcium ion	3.335** 48.551**
Water flow	0.927 1.661**	Magnesium ion	0.583 37.012**
Water pH	0.370 23.111**	Sulphate ion	0.231 219.608**
Electrical conductivity	0.156 79.805**	Chloride ion	3.063** 0.850
Salinity	0.149 80.356**	TSS	4.854** 7.676**
Dissolved Oxygen	0.888 7.917**	TDS	0.745 0.828
BOD5	0.253 13.043**	Total phosphorous	0.866 10.795**
Total alkalinity	5.419** 21.067**	Total nitrogen	0.300 164.18**

**** Significant at 0.01 level**

Index(1)/Table(2): Correlation coefficient among some water properties of Euphrates river during the study period

	Do	Air temp.	water temp.	water flow	water pH	EC	BOD	alkalinity	hardness	calcium	magnesium	TSS	TDS	sulphate	total phosphorus	total nitrogen	ratio	total algae	total PAHs in water	Nap in water
DO	1	-.297*	-.265*	-.166	-.077	.338**	-.075	-.342**	.141	.048	.021	.061	.020	.305*	-.001	.106	.017	-.026	-.202	.094
Air temperature	-.297*	1	.973**	.089	-.391**	-.412**	.266*	-.036	.308*	.492**	-.007	.482**	-.038	-.229	.004	-.211	-.157	-.016	-.273*	.001
water	-.265*	.973**	1	.098	-.424**	-.376**	.332**	.028	.294*	.573**	-.057	.459**	.018	-.260*	.002	-.246	-.140	.016	-.281*	.016
water flow	-.166	.089	.098	1	.111	-.444**	.176	.401**	-.211	-.104	-.116	-.062	-.058	-.080	-.024	.340**	.096	.240	.287*	.058
water pH	-.077	-.391**	-.424**	.111	1	.045	.109	.243	.060	-.286*	.235	-.114	-.007	-.015	.136	-.007	-.034	.148	.169	.201
EC	.338**	-.412**	-.376**	-.444**	.045	1	-.069	-.399**	.315*	.043	.287*	-.057	.176	.048	-.137	-.344**	.248	-.117	-.200	.004
BOD	-.075	.266*	.332**	.176	.109	-.069	1	.178	.276*	.163	.186	.274*	.046	.030	-.064	-.034	-.073	.025	.046	.126
alkalinity	-.342**	-.036	-.028	.401**	.243	-.399**	.178	1	-.187	-.144	-.095	-.199	-.075	-.007	.006	.329*	.214	.086	.147	.036
Chloride	.234**	-.167	-.215	.462**	.168	-.052	.008	-.346**	-.126	-.154	-.057	-.069	-.091	-.272**	.293**	.085	.321	.325	-.139	-.241
hardness	.141	.308*	.294*	-.211	.060	.315*	.276*	-.187	1	.375**	.664**	.281*	.088	-.066	-.042	-.376**	.087	.225	-.306*	.053
calcium	.048	.492**	.573**	-.104	-.286*	.043	.163	-.144	.375**	1	-.246	.137	.285*	-.171	.144	-.352**	.043	-.002	-.346**	.103
magnesium	.021	-.007	-.057	-.116	.235	.287*	.186	-.095	.664**	-.246	1	.243	.043	-.099	-.149	-.206	-.144	.220	-.124	-.030
TSS	.061	.482**	.459**	-.062	-.114	-.057	.274*	-.199	.281*	.137	.243	1	-.228	-.112	.057	-.238	-.175	.204	-.287*	-.147
TDS	.020	-.038	.018	-.058	-.007	.176	.046	-.075	.088	.285*	.043	-.228	1	-.068	.015	-.184	-.028	-.042	-.184	-.026
sulphate	.305*	-.229	-.260*	-.080	-.015	.048	.030	-.007	-.066	-.171	-.099	-.112	-.068	1	-.093	.457**	.010	-.244	.132	-.002
Total phosph.	-.001	.004	.002	-.024	.136	-.137	-.064	.006	-.042	.144	-.149	.057	.015	-.093	1	-.170	-.033	.166	.010	-.046
total nitrogen	.106	-.211	-.246	.340**	-.007	-.344**	-.034	.329*	-.376**	-.352**	-.206	-.238	-.184	.457**	-.170	1	.378**	-.120	.428**	-.009
ratio	.017	-.157	-.140	.096	-.034	-.248	-.073	.214	-.087	.043	-.144	-.175	-.028	.010	-.033	.378**	1	.236	.069	-.075
	-.026		.016	.240	.148	-.117	.025	.086	.225	-.002	.220	.204	-.042	-.244	.166	-.120	.236	1	.084	-.109
total PAH water	-.202	-.273*	-.281*	.287*	.169	-.200	.046	.147	-.306*	-.346**	-.124	-.287*	-.184	.132	.010	.428**	.069	.084	1	.081
Nap in water	.094	.001	.016	.058	.201	.004	.126	.036	.053	.103	-.030	-.147	-.026	-.002	-.046	-.009	-.075	-.109	.081	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Index (2)/Table(1): Values of F calculated from ANOVA table for phytoplankton taxa number among sites and seasons.

compound	F value(among sites)	F value(among saesons)
Cyanophyceae	0.407	3.087**
Chlorophyceae	2.637**	2.171**
Bacillariophyceae	1.561**	6.805**
Xanthophyceae	4.196**	0.756
Chrysophyceae	0.830	0.686
Euglenophyceae	0.718	2.273**
Total algae	1.683**	7.156**

**** Significant at 0.01 level**

Index(2)/Table(2): List of phytoplankton and cell number (Cell×10³/l) in the Euphrates River at site (1) during the study period.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Cyanophyceae													
<i>Ocillatoria</i> sp. (Vaucher)	-	58	45	200	-	-	18	-	-	9	14	125	469
<i>Microcystis aeruginosa</i> (Kütz)	27	18	-	41	4	-	50	0	18	4	14		176
<i>Nostoc</i> sp. (Vaucher)	-	18	-	-	-	-	27	-	-	-	-	27	49
<i>Merismopedia elegans</i> (Smith)	-	-	-	-	-	-	-	-	-	9	18	13	40
<i>Merismopedia tenissima</i> (Lemm)	-	-	-	49	9	4	-	-	-	-	-	40	93
<i>Gleocapsa aeruginosa</i> (Garm) Kütz	-	27	-	-	9	-	-	-	27	-	27	-	81
<i>Aphanothca</i> sp. (Naegeli)	-	9	-	-	-	4	-	-	-	-	9	-	22
<i>Chrococcus minutus</i> (Kütz) Naegeli	4	4	-	-	-	-	-	-	-	-	-	-	4
<i>Chrococcus limneticus</i> (Lemm)	-	4	-	-	-	-	-	-	-	-	-	-	4
<i>Aphanocapsa endophytica</i> (Smith)					9	9			9	9			36
<i>Aphanocapsa elachista</i> (West & West)		45			18								63
Chlorophyceae													
<i>Chlamydomonas</i> sp. (Ehrenberg)	9	40	134	40	196	223	36	267	4	18	40	58	1065
<i>Chlorella</i> sp. (Beyerinck)	9	13	14	45	86	-	9	31	27	9	9	45	297
<i>Chlorococcum humicola</i> (Naeg.)	89	67	50	-	-	-	94	67	13	18	67	45	510
<i>Ulothrix</i> sp. (Kützting)	18	4	-	-	9	-	-	36	-	36	-	-	103
<i>Ankistrodesmus falcatus</i> (Corda)	27	-	-	18	4	-	-	27	18	31	-	-	125
<i>Scendesmus dimorphus</i> (Turp) Kützting	-	-	-	-	-	-	-	-	-	-	45		45
<i>Scendesmus acuminatus</i> var <i>minor</i> (Smith)		18										62	80
<i>Scendesmus</i> sp. (Meyean)		62									27		89
<i>Pediastrum duplex</i> (Meyean)									4				4
<i>Pediastrum simplex</i> (Meyean)		36									13	27	76
<i>Eudorina elegans</i> (Ehrenberg)	9	13		94	9		9				4	13	151
<i>Cosmarium</i> sp. (Corda)	4		4				9			13		4	34
Baicalariophyceae													
<i>Cyclotella ocellata</i> (Pantocsek)	220		138	286	639	264	220	471	306	603	797	170	4114
<i>Cyclotella meneghiniana</i> (Kützting)	66	220	-	66	207		220	-	41	113	132	19	1084
<i>Cyclotella comta</i> (Ehr) Kützting				22				13				19	54

Followed index(2)/Table(2)

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Cyclotella stelligera</i> (Cleve) VanHeurek					69		22					38	242
<i>Cyclotella glomerata</i> (Bachmann)	44						22			38	22		126
<i>Stephanodiscus hantzschii</i> (Grun.)			69	88									157
<i>Stephanodiscus</i> sp. (Ehrenberg)			69	66									135
<i>Aulacoseria granulate</i> (Ehr)	44	440	69	22	17	38	22	38	20	19		376	1105
<i>Melosira ambigua</i> (Grun.) Muller	22			44	52			38					156
<i>Diatoma elongatum</i> (Leyngby) Agardh	44		52	242	35						132		505
<i>Diatoma vulgare</i> (Bory)									41				41
<i>Amphora ovalis</i> (Kütz)							66			57	132		255
<i>Amphora holastica</i> (Hustt)			17										17
<i>Achnanthes delicatula</i> (Kütz) Grun.		4			52								56
<i>Gyrosigma acuminatus</i> (Kütz) Rabenn.			86										86
<i>Gomphonema intrcatum</i> (Kütz)		113									22		135
<i>Gomphonema fanesis</i> (Maillard)						94			61	57			212
<i>Gomphonema parvulum</i> (Kütz) Kützing		132	138	176		75			41	38			600
<i>Gomphonema consrictum</i> (Ehr)	22		52	242									316
<i>Gomphonies olivacea</i> (Lyngbye) Dawson	22			22									44
<i>Fragilaria capusina</i> (Demazi eres)	66		17				44				22		168
<i>Fragilaria intermedia</i> (Grun.)			17	88									105
<i>Fragilaria brevisriata</i> (Grun.)	22												22
<i>Fragilaria critonesis</i> (Kitton)		132	17						41	38			228
<i>Cocconies plcentula</i> (Ehr)	264	66	363	330		150	151		306	151	264		2459
<i>Cocconies pediculus</i> (Ehr)	220	44		264		19	22		367	38	242		1273
<i>Navicula radisa</i> (Kütz)	22				17								61
<i>Navicula halophila</i> (Grun.) Cleve	22										22		44
<i>Navicula cincta</i> (Kütz)										19			19
<i>Navicula enigmatica</i> (Germain)			17					75					92
<i>Navicula phyllepta</i> (Kütz)			17	22		19							58

Followed index(2)/Table(2)

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Navicula cryptocephala</i> (Kütz)			35										35
<i>Navicula cupidata</i> (Ehr)			17		36								53
<i>Navicula dicephala</i> (Ehr)				44				38					82
<i>Navicula bervisriata</i> (Smith)			19										19
<i>Navicula pupula</i>									20				20
<i>Nitzschia hungarica</i> (Grun.)				22									22
<i>Nitzschia amphibia</i> (Grun.)	66		17							19			102
<i>Nitzschia gracilis</i> (Hantzsch)	22						27						44
<i>Nitzschia palacea</i> (Grun.)										38			38
<i>Nitzschia palea</i> (Kütz)	154	66	35	66	17		44			38	176		596
<i>Nitzschia acicularis</i> (Smith)				22						19			41
<i>Nitzschia hantzschiana</i> (Rabh)	44										22		66
<i>Nitzschia romana</i> (Grun.)				22									22
<i>Nitzschia dissipata</i> (Grun.)		17		22									39
<i>Cymatoplinea solea</i> (Breb.) Smith		22	17		69								108
<i>Synedra acus</i> (Kütz)	110			65	17	18					66		276
<i>Synedra tabulata</i> (Agardh) Kütz			35	44									79
<i>Synedra ulna</i> (Nitzsche) Ehr.		44		44		18	22				22		150
<i>Synedra pulchella</i> (Ralfs) Kütz			52		52				41	19			164
<i>Synedra parasitica</i> (Smith) Hustedt				88					20				108
<i>Synedra rumpens</i> (Kütz)										19			19
<i>Cymbella prostate</i> (Berkeley) Cleve		19				38							57
<i>Cymbella affinis</i> (Kütz)	176		17	22	35	19			41				310
<i>Cymbella leptoceros</i> (Ehr) Grun.				132						19			189
<i>Cymbella ventricosa</i> (Kütz)						22							22
<i>Cymbella parva</i> (Smith) Kitehn			17						20	19			56
<i>Cymbella amphicephala</i> (Grun.)					52								52
<i>Cymbella helvetica</i> (Kütz)	22												22
<i>Diplonies ovalis</i> (Hilse) Cleve		22	35	22									7922
Euglenophyceae													
<i>Euglena</i> sp (Ehrenberg)		4	18	9	9		4			13			57
<i>Phacus</i> sp (Dujardin)				4	13	22		22				4	65

Followed index(2)/Table(2)

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Xanthophyceae													
<i>Meringosphaera spinosa</i>	9	18		18	89						147	94	375
Chrysophyceae													
<i>Dinobryon sp</i> (Ehrenberg)				4		9							13
<i>Mallomonas acaroides</i> (Perty)		4			9								13

Index(2)/Table3: List of phytoplankton and cell number (Cell×10³/l) in the Euphrates River at site (2) during the study period.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Cyanophyceae													
<i>Ocillatoria</i> sp. (Vaucher)		36		4					14	71	9	9	143
<i>Microcystis aeruginosa</i> (Kütz)	13			9						13			35
<i>Haematococcus</i> sp (Agardh)							27						27
<i>Spirulina</i> sp. (Turpin)		4											4
<i>Nostoc</i> sp. (Vaucher)								9		45			54
<i>Merismopedia elegans</i> (Smith)	18				9			9		45			81
<i>Merismopedi tenuissima</i> (Lermm.)		9								36			45
<i>Gomphosphaeria aponina</i> (Kütz)				4						4			8
<i>Gleocapsa aeruginosa</i> (Garm) Kütz										4			4
<i>Aphanotheca</i> sp (Naeg.)						4							4
<i>Dactylococcopsis acicularis</i> (Lermm.)													44
<i>Aphanocapsa endophytica</i> (Smith)		4		40	49								93
<i>Aphanocapsa elachista</i> (West & West)					4								4
Chlorophyceae													
<i>Chlamydomonas</i> sp. (Ehrenberg)	4	13	71	13	62	22	45		45	27	80	9	391
<i>Chlorella</i> sp. (Beyerinck)	22	45		89	13	22	22	45	36		36	18	348
<i>Chlorococcum humicola</i> (Naeg.)	9			27	67						36	4	143
<i>Asterococcus limneticus</i> (Smith)						9	4					4	17
<i>Ulothrix</i> sp (Kütz)		9	45	67	4					89			214
<i>Ankistrodesmus falcatus</i> (Corda)	4					13			13	22			61
<i>Kirchneriella contorta</i> (Schmidle)	9					9		4					22
<i>Scendesmus quadricauda</i> (Turp.)				4	4								8
<i>Scendesmus ecornis</i> (Turp.)								4				13	17
<i>Scendesmus dimorphus</i> (Turp.) Kütz											9		9
<i>Scendesmus</i> sp (Meyae)	4		9					4		4			21
<i>Closteriopsis longissima</i> (Lermm.)					4	4	4	4					16
<i>Tetraedron enorme</i> (Ralfs)		4											4
<i>Tetraedron muticum</i> (Brnun)			13										13
<i>Tetraedron minimum</i> (Brnun)								4		4			8

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Pediastrum simplex</i> (Meyeam)			9		22					31			62
<i>Eudorina elegans</i> (Ehrenberg)						13		13		31	9		66
<i>Selanastrum gracile</i> (Reinsch)							4	13		13			30
<i>Cosmarium</i> sp. (Corda)	9							4			9	13	35
Bacillariophyceae													
<i>Cyclotella ocellata</i> (Pantocsek)	188		121	641	1187	38	75	308	88	113	150		3060
<i>Cyclotella meneghiniana</i> (Kützinger)	113		35	19					88	113	38	86	492
<i>Cyclotella stelligera</i> (Cleve) VanHeurek			52		57				44	38			210
<i>Cyclotella glomerata</i> (Bachmann)												35	35
<i>Stephanodiscus hantzchi</i> (Grun.)				132	38								170
<i>Stephanodiscus</i> sp. (Ehrenberg)					38	19			22	19	19		117
<i>Aulacoseria granulate</i> (Ehr)	94		173	433	188		19			113	57	17	1056
<i>Melosira mbigua</i> (Grun.) Muller	38			57	19					57			228
<i>Diatoma elongatum</i> (Lyngby) Agardh				19	57	38	19		145		19	17	323
<i>Diatoma vulgare</i> (Bory)									22			17	39
<i>Amphora veneta</i> (Kütz)				38	19								57
<i>Amphora ovalis</i> (Kütz)					19					19			38
<i>Achnanthes delicatula</i> (Kütz) Grun.											19		19
<i>Achnanthes minutissima</i> (Kütz)	57												57
<i>Gyrosigma acuminatus</i> (Kütz) Rabenn.											19		19
<i>Gyrosigma peisonis</i> (Grun.)												17	17
<i>Gomphonema intricatum</i> (Kütz)				75					66		19		160
<i>Gomphonema fanesii</i> (Maillard)	38		35			38			44		75		324
<i>Gomphonema parvulum</i> (Kütz) Kützinger									88				88
<i>Gomphonema accuminatum</i> (Ehr)													
<i>Gomphonema constrictum</i> (Ehr)										19			19
<i>Gomphonema exigua</i> (Ehr) Hustedt						19					75		94
<i>Gomphonema olivacea</i> (Lyngbye) Dawson			35	57		19							92
<i>Suirella ovata</i> (Kütz)										19			19

Followed Index(2)/Table(3):

<i>Taxa</i>	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Suirella robusta</i> (Ehr)											19		19
<i>Fragilaria capusina</i> (Demazieres)					38	19				19		35	111
<i>Fragilaria intermedia</i> (Grun.)				19					44	19	38		139
<i>Fragilaria brevisriata</i> (Grun.)	19										57		76
<i>Fragilaria virescens</i> (Ralfs)			17										17
<i>Fragilaria crotonesis</i> (Kitton)					38					75			113
<i>Cocconies placentula</i> (Ehr)	151		121	207	358	38	38		264	132	339	52	1907
<i>Cocconies pediculus</i> (Ehr)			94	94			19						207
<i>Neidium binode</i> (Kütz)				19						19			19
<i>Navicula radiosa</i> (Smith) Kütz									22			35	57
<i>Navicula grimmei</i> (Krasske)											38		38
<i>Navicula halophila</i> (Grun.) Cleve	19	19								57			95
<i>Navicula cincta</i> (Kütz)					38	12			22			17	96
<i>Navicula enigmatica</i> (Kütz) Germain			52	19						19			90
<i>Navicula phyllepta</i> (Germain) Kütz				76	38					76			114
<i>Navicula cryptocephala</i> (Kütz)											19		19
<i>Navicula placentula</i> (Kütz)											38		38
<i>Navicula digitoradiata</i> (Gregory)											52		52
<i>Navicula dicephala</i> (Ehr)					94	19			44		19		157
<i>Navicula crucicula</i> (Ehr)					19								19
<i>Nitzschia amphibia</i> (Grun.)	19												19
<i>Nitzschia gracilis</i> (Hantzsch)	19			17									36
<i>Nitzschia fruticosa</i> (Hantzsch)			19	17									36
<i>Nitzschia Paleacea</i> (Grun.)												17	17
<i>Nitzschia Palea</i> (Kütz)		19								38	38	17	112
<i>Nitzschia acicularis</i> (Smith)					38		19						57
<i>Nitzschia hantzchiana</i> (Rabh)	38			19					22				79
<i>Nitzschia romana</i> (Grun.)		52			52	19	19		44	19	38		243
<i>Nitzschia dissipata</i> (Grun.)											38		38

Followed Index(2)/Table(3):

<i>Taxa</i>	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Nitzschia intermedia</i> (Kütz)												35	35
<i>Nitzschia pusila</i> (Smith)					94	19					19		113
<i>Rhoicosphenia marina</i> (Kütz)	20			19	19	75				19	75		133
<i>Cymatoplua solea</i> (Breb.) Smith				38									38
<i>Synedra acus</i> (Kütz)	38			19					22	19			79
<i>Synedra tabulata</i> (Agardh) Kütz					19					75			94
<i>Synedra ulna</i> (Nitzsch) Ehr	38		38		52	19			22	19			188
<i>Synedra pulchella</i> (Ralfs) Kütz				52						52	57		161
<i>Synedra parasitica</i> (Smith) Hustedt									22	38			60
<i>Synedra rumpens</i> (Kütz)										19	57		76
<i>Cymbella prostata</i> (Smith) Hustedt										19			19
<i>Cymbella affinis</i> (Kütz)	15		17		38				154		75	35	338
<i>Cymbella gracilis</i> (Berkeley) Cleve	57			19									76
<i>Cymbella leptoceros</i> (Ehr) Grun.	19	75	19	75					22	17		17	244
<i>Cymbella ventricosa</i> (Kütz)								20					20
<i>Peroni fibula</i> (Greibson et Arnott) Ross	38		36		192				88		188	35	615
<i>Diploneis ovalis</i> (Hilse) Cleve	19			38									57
Euglenophyceae													
<i>Euglena sp</i> (Ehrenberg)		9							13				22
<i>Phacus sp</i> (Dujardin)			4	18	18	4	22		18	13	36		133
Xanthophyceae													
<i>Meringosphaerea spinosa</i>	8		25	42	10	10	15		4	10			134
Chrysophyceae													
<i>Dinobryon sp</i> (Ehrenberg)			9										9
<i>Mallomonas acaroides</i> (Perty)		27		36					4	9	9		85
<i>Mallomonas alpine</i> (Pascher & Ruttner)		4		4						9			17

Index(2)/Table(4): List of phytoplankton and cell number (Cell×10³/l) in the Euphrates River at site (3) during the study period.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Cyanophyceae													
<i>Ocillatoria sp.</i> (Vaucher)	18	143	134	4	4	89	4		18	13		22	449
<i>Microcystis aeruginosa</i> (Kütz)		54				27				22			103
<i>Haematococcus sp</i> (Agardh)									94				94
<i>Nostoc sp.</i> (Vaucher)													
<i>Merismopedia elegans</i> (Smith)	4	62			9								75
<i>Merismopedi tenuissima</i> (Lermm.)		27	4		4								35
<i>Gomphosphaeria aponina</i> (Kützing)		4				4							8
<i>Gleocapsa aeruginosa</i> (Garm) Kütz		4							4				8
<i>Aphanotheca sp</i> (Naeg.)											9		9
<i>Dactylococcopsis acicularis</i> (Lermm.)								4					4
<i>Aphanocapsa endophytica</i> (Smith)	9		27			4						9	49
<i>Lyngbya nordgaardii</i> (Wille)		4	13										17
<i>Gleocapsa raphidoides</i>	18		18			18							54
Chlorophyceae													
<i>Chlamydomonas sp.</i> (Ehrenberg)	13	4	98	201	281	27	49	4	85	192	62	36	1052
<i>Chlorella sp.</i> (Beyerinck)			13	49	36	9	40	18	31	18	9	45	268
<i>Chlorococcum humicola</i> (Naeg.)	27			13	67	13	13			54	31	27	245
<i>Asterococcus limneticus</i> (Smith)			9			9		4				9	31
<i>Ulothrix sp</i> (Kützing)			22	80	27							36	165
<i>Ankistrodesmus falcatus</i> (Corda)		9	9				13	13			18		62
<i>Ankistrodesmus convolutus</i> (Corda)		13											13
<i>Kirchneriella contorta</i> (Schmidte)	18	13											31
<i>Scendesmus quadricauda</i> (Turp.)						9							9
<i>Scendesmus ecoris</i> (Turp)								4					4
<i>Cerasteria staurostroides</i> (Wset & West)		4											4
<i>Closteriopsis longissima</i> (Lermm)		9			4				13		58	13	97
<i>Closteriopsis sp</i> (Lermm)	18		45			18			13			9	103
<i>Tetraedron enorme</i> (Ralfs)								4				9	13
<i>Tetraedron trigonum</i> (Naeg)			4										4
<i>Tetraedron minimum</i> (Braun)		4				9		4					17
<i>Pediastrum simplex</i> (Meyeam)		9	9			13							31

Followed Index(2)/Table(4):

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Eudorina elegans</i> (Ehrenberg)	13	49	9	4	4			13		4	4	13	113
<i>Selanastrum sp.</i> (Reinch)		13				4							17
<i>Cosmarium sp.</i> (Corda)	4	4	13	9	18			4	9		4		69
Bacillariophyceae													
<i>Cyclotella ocellata</i> (Pantocsek)	113	138	501	639	812	61	138	104	82	173	220	510	3491
<i>Cyclotella meneghiniana</i> (Kützting)	57	69	17	173	173	41		138		17			685
<i>Cyclotella comta</i> (Ehr) Kützting	57		35	173	104								369
<i>Cyclotella stelligera</i> (Cleve)		69	35		17								121
<i>Cyclotella glomerata</i> (Bachmann)	19		35		17	61		17	20				152
<i>Stephanodiscus intermedia</i>				17									17
<i>Stephanodiscus sp</i> (Ehrenberg)			86										86
<i>Melosira ambigua</i> (Crun.) Muller	38	69		69		20							196
<i>Diatoma elongatum</i> (Lyngby) Agardh		17	17		17		52		20	138	22		283
<i>Achnanthes delicatula</i> (Kütz)			17										17
<i>Achnanthes minutissima</i> (Kütz)					17								17
<i>Gyrosigma acuminatus</i> (Kütz) Rabenn.					17						22		39
<i>Gyrosigma peionis</i> (Grun.)					35								35
<i>Gomphonema intricatum</i> (Kütz)										17			17
<i>Gomphonema fanesis</i> (Maillard)			17			20	35	17	20	52	44		205
<i>Gomphonema abbreviatum</i> (Ehr)												20	20
<i>Gomphonema exigua</i> (Ehr) Hustedt					17					52			69
<i>Gomphoneis olivacea</i> (Lyngbye) Dawson							17			17			34
<i>Fragilaria intermedia</i> (Grun.)	19		17										36
<i>Fragilaria brevisriata</i> (Grun.)		17	17				52			35			121
<i>Cocconies placentula</i> (Ehr)	57	121	35	121	190	61	69	121	102	190	286	286	1639
<i>Cocconies pediculus</i> (Ehr)	38				17	41	35		82			20	233
<i>Navicula halophila</i> (Grun.) Cleve	19		35					22		17			93
<i>Navicula cincta</i> (Kütz)		17	17										34
<i>Navicula sohrensii</i> (Kütz)	19				104						22		145

Followed Index(2)/Table(4):

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Navicula cryptocephala</i> (Kütz)				52	35					35			122
<i>Nitzschia amphibia</i> (Grun.)		17						17					34
<i>Nitzschia fruticosa</i> (Hantzsch)		35			17								52
<i>Nitzschia Paleacea</i> (Grun.)					52								52
<i>Nitzschia Palea</i> (Kütz)	17				69								86
<i>Nitzschia acicularis</i> (Smith)						151							151
<i>Nitzschia hantzchiana</i> (Rabh)		52					86						138
<i>Nitzschia incnspicua</i> (Gregory) Grun.	17			35							66		118
<i>Nitzschia apiculata</i> (Grun.)				35	17			17		35	44		148
<i>Nitzschia romana</i> (Grun.)		17								69			86
<i>Nitzschia minuscula</i> (Grun.)					52								52
<i>Nitzschia hungarica</i> (Grun.)											44		44
<i>Nitzschia pusila</i> (Smith)	19												19
<i>Nitzschia linearis</i> (Kütz) Grun.		17											17
<i>Rhoicosphenia curvata</i> (Kütz)							17	17	20		88		142
<i>Synedra acus</i> (Kütz)	19	138	17		17					17			208
<i>Synedra tabulata</i> (Agardh) Kütz		35	17							69	22	17	160
<i>Synedra ulna</i> (Nitzsch) Ehr	57	69		35	52			52		17	22		304
<i>Synedra parasitica</i> (Smith) Hustedt	19									35			54
<i>Cymbella prostata</i> (Berkely) Cleve										17			17
<i>Cymbella affinis</i> (Kütz)			35				17					35	87
<i>Cymbella leptoceros</i> (Ehr) Grun.			17										17
<i>Cymbella ventricosa</i> (Kütz)	19	35	35				17			35	66		207
<i>Cymbella helvetica</i> (Kütz)									20				20
<i>Cymbella cistula</i> (Henprie) Grun.									41	17			58
<i>Peroni fibula</i> (Brebisson et Arnott) Ross					207					35	22		264
<i>Diploneis ovalis</i> (Hilse) Cleve										17			17
Euglenophyceae													
<i>Euglena</i> sp (Ehrenberg)				9			22			4	4		39
<i>Phacus</i> sp. (Dujardin)	4			22					18	18	4	9	75
Xanthophyceae													
<i>Meringosphaera spinosa</i>	45	18	250	67		89		9	58		67	80	683

Followed Index(2)/Table(4):

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Chrysophyceae													
<i>Dinobryon</i> sp. (Ehrenberg)										4		9	13
<i>Mallomonas acaroides</i> (Perty)			4		18				4			4	30
<i>Mallomonas alpina</i> (Pascher & Ruttner)										4	4		8

Index(2)/Table(5): List of phytoplankton and cell number (Cell×10³/l) in the Euphrates River at site (4) during the study period.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Cyanophyceae													
<i>Ocillatoria</i> sp. (Vaucher)		112	13					4	4	134		80	347
<i>Microcystis aeruginosa</i> (Kütz)							9	4		4	9		26
<i>Haematococcus</i> sp (Agardh)								13					13
<i>Spirulina</i> sp. (Turpin)								13					13
<i>Nostoc</i> sp. (Vaucher)												80	80
<i>Merismopedia elegans</i> (Smith)		13											13
<i>Merismopedi tenuissima</i> (Lermm.)						9						22	31
<i>Gomphospheria aponina</i> (Küetzing)		4											4
<i>Aphanotheca</i> sp. (Naegeli)							4						4
<i>Chroococcus minutus</i> (Kütz)										4			4
<i>Chroococcus minor</i> (Kütz)								13					13
<i>Aphanocapsa elachista</i> (West & West)		89											89
<i>Gloeocapsa punctata</i> (Naegeli)						4				13			17
<i>Dactylococcopsis smithii</i> (Lermm.)	13			22		4	27					67	133
<i>Lyngbya nordardii</i> (Wille)		4											4
Chlorophyceae													
<i>Chlamydomonas</i> sp (Ehrenbreg)	143	9		36	227	112	22		36	31	125	80	821
<i>Chlorella</i> sp. (Beysrinck)	71	76				54	36		107	134	58	27	563
<i>Chlorococcum humicola</i> (Naeg.)				27	62				45	45	19		197
<i>Asterococcus limneticus</i> (Smith)	18	13		4		4				4			43
<i>Ulothrix</i> sp (Küetzing)									8	4			12
<i>Ankistrdesmus falcatus</i> (Corda)					4				9	18		22	53
<i>Ankistrdesmus convolutes</i> (Corda)			27							36			63
<i>Kirchneriella contorta</i> (Schmidte)			13	22			45						80
<i>Scendesmus quadrucauda</i> (Turp.)										4		4	8
<i>Scendesmus eornis</i> (Turp.)						9				18			27
<i>Scendesmus dimorphus</i> (Turp.) Küetzing							36						36
<i>Scendesmus acuminatus</i> var. <i>minor</i> (Smith)								9					9
<i>Scendesmus</i> sp. (Meyean)		27	40		18	18						45	148
<i>Tetraedron muticum</i> (Braun)			4										4
<i>Tetraedron minimum</i> (Braun)			4										4
<i>Pediastrum simplex</i> (Meyean)			4									4	8

Index(2)/Table(5):

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Eudorina elegans</i> (Ehrenbreg)		13	13	18				4			4		52
<i>Arthrodesmus</i> sp.		9											9
<i>Cosmarium</i> sp (Corda)	4	9	13	4	18			9		18			75
Bacillariophyceae													
<i>Cyclotella ocellata</i> (Pantocsek) Kützing	452	19	1183	449	1432	207	44	286	132	734	52	138	5128
<i>Cyclotella meneghiniana</i> (Kützing)	75	75	245	204	75			88	44	102	69		977
<i>Cyclotella comta</i> (Ehr) Kützing	113							22				155	290
<i>Cyclotella stelligera</i> (Cleve)		57			283	41						17	396
<i>Stephanodiscus dubius</i>	19				38								57
<i>Stephanodiscu</i> sp. (Ehrenbreg)		19	20							20			59
<i>Aulacoseria granulate</i> (Ehr)		94				20	44				35		158
<i>Melosira ambigua</i> (Grun.) Muller	57	57									52	86	200
<i>Diatoma elongatum</i> (Lyngbey) Agardh				20	19				176				250
<i>Diatoma vulgare</i> (Bory)	17		20	20				22		20			153
<i>Amphora ovalis</i> (Kütz)					19								19
<i>Calonies placentula</i>		94											94
<i>Achnanthes delicatula</i> (Kütz) Grun.												17	17
<i>Mastigloia elilptica</i> (Agardh)	38												38
<i>Gyrosigma acuminatus</i> ((Kütz) Rabh												35	35
<i>Gomphonema fanesis</i> (Maillard)	75				57		22			20	35		209
<i>Gomphonema parvulum</i> (Kütz) Kützing	75					61	22	22	66				246
<i>Gomphonema constrictum</i> Ehr		19		20									39
<i>Gomphonema gracile</i> (Ehr)			45	61									106
<i>Gomphoneis olivacea</i> (Lyngbye) Dowson					38								38
<i>Suirella robusta</i> (Ehr)					57								57
<i>Fragilaria capusina</i> (Demazieres)	38		61	20				22	154	45	35		375
<i>Fragilaria intermedia</i> (Grun.)	19	38	20	45							52		212
<i>Fragilaria brevisriata</i> (Grun.)				45									45
<i>Fragilaria crotonesis</i> (Kitton)					19								19
<i>Fragilaria consruens</i> (Ehr) Grun.								66		20			86
<i>Cocconies placentula</i> (Ehr)	245	207	163	102	339	245	110	44	330	102	121	135	2146

Index(2)/Table(5):

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Cocconies pediculus</i> (Ehr)				469									469
<i>Navicula radiosa</i> (Kütz)	57			45					88				190
<i>Navicula grimmei</i> (Krasske)	57				57		44						158
<i>Navicula halophila</i> (Grun.) Cleve			45	45		20		22			35		167
<i>Navicula cincta</i> (Kütz)					38					20			58
<i>Navicula phylepta</i> (Kütz)			61					22			17		100
<i>Navicula cryptocephala</i> (Kütz)				61					88		35		184
<i>Navicula digitoradiata</i> (Gregory)				20	19								39
<i>Navicula dicephala</i> (Ehr)									44		35		79
<i>Navicula crucicula</i> (Grun.) Smith				20				22					42
<i>Nitzschia amphibia</i> (Grun.)		19											19
<i>Nitzschia gracilis</i> (Hantzsch)	19												19
<i>Nitzschia Paleacea</i> (Grun.)												17	17
<i>Nitzschia palea</i> (Kütz)			102	82	38			66	88		35	36	446
<i>Nitzschia acicularis</i> (Rabh) Smith					19							17	36
<i>Nitzschia hantzchiana</i> (Rabh)									66			17	83
<i>Nitzschia apiculata</i> (Gregory) Grun.	19								88		86		193
<i>Nitzschia romana</i> (Grun.)	19		20	61				22	88		17		227
<i>Nitzschia dissipata</i> (Grun.)									88		86		174
<i>Nitzschia rostellata</i> (Hantzsch)		94											94
<i>Nitzschia intermedia</i> (Grun.)											17		17
<i>Nitzschia hungarica</i> (Grun.)				45									45
<i>Nitzschia pusila</i> (Smith)				22	113								155
<i>Nitzschia linearis</i> (Smith) Schmidt		57	20					44					121
<i>Rhoicosphenia marina</i> (Kütz)			45	22	188			22					277
<i>Cymatoplinea solea</i> (Breb) Smith	19		20	45									84
<i>Synedra acus</i> (Kütz)		75	102	102					44		17	69	409
<i>Synedra ulna</i> (Nitzsche) Ehr	94	75		45	170		22				35	69	510
<i>Synedra pulchella</i> (Ralfs) Kütz	38												38
<i>Synedra parasitica</i> (Smith) Hustedt	57												57
<i>Synedra rumpens</i> (Kütz)					57		22						79
<i>Cymbella prostate</i> (Berkeley) Cleve				20									20
<i>Cymbella affinis</i> (Kütz)		19							110	45	35		209

Index(2)/Table(5):

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Cymbella gracilis</i> (Raben.) Cleve		19	20	45	19								103
<i>Cymbella leptoceros</i> (Ehr) Grun.		19	45				22				17	52	155
<i>Cymbella ventricosa</i> (Kütz)							22					17	39
<i>Cymbella parva</i> (Smith) Kitehn	38	38		45									121
<i>Cymbella helvetica</i> (Kütz)				20			22		66		17		125
<i>Cymbella abtusiuscula</i>		38											38
<i>Cymbella cistula</i> (Hemprien)													
<i>Peroni fibula</i> (Brebisson) Ross		113				61	22					69	265
<i>Diploneis ovalis</i> (Hilse) Cleve		38	20					44		20			122
<i>Diploneis simithii</i>		38		45									83
Euglenophyceae													
<i>Euglena sp.</i> (Ehrenberg)		13					4	4	13	9	18		61
<i>Phacus sp.</i> (Dujardin)					27	13					4		44
Xanthophyceae													
<i>Meringosphaera spinosa</i>		18				36		9	4			22	89
Chrysophyceae													
<i>Mallomonas acaroides</i> (Perty)		4	4		4			4				4	20
<i>Mallomonas alpina</i> (Pascher & Ruttner)		4					4			4			12

Index(2)/Table(6): List of phytoplankton and cell number (Cell×10³/l) in the Euphrates River at site (5) during the study period.

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Cyanophyceae													
<i>Ocillatoria sp</i> (Vaucher)		98					9	9		62		36	214
<i>Microcystis aeruginosa</i> (Kütz)		18						18					36
<i>Haematococcus sp.</i> (Agardh)								85					85
<i>Nostoc sp.</i> (Vaucher)		54						4					58
<i>Merismopedia elegans</i> (Smith)		18		4					4	4		13	43
<i>Merismopedi tenuissima</i> (Lermm.)		40		4		9						18	71
<i>Gomphosphaera aponina</i> (Kützing)		4			4								8
<i>Crococcus limneticus</i> (Lermm.)								18					18
<i>Aphanocapsa endophytica</i> (Smith)				80								27	107
<i>Aphanocapsa elachista</i> (West & West)		16								4			165
<i>Gloeocapsa punctata</i> (Naegeli)						4							4
<i>Dactylocopsis smithii</i> (Lermm.)	22			67	45								134
<i>Lyngbya nordardii</i> (Wille)	58												58
Chlorophyceae													
<i>Chlamydomonas sp</i> (Ehrenberg)		22	9		161	98		152	67		58		567
<i>Chlorella sp.</i> (Beyerinck)	67	71	13		13		13		27	40	40		284
<i>Ulothrix sp.</i> ((Kützing)				125	62	18							205
<i>Ankistrdesmus falcatus</i> (Corda)			45				13	13		13			84
<i>Kirchneriella contorta</i> (Schmidte)		13	4			30							30
<i>Scendesmus quadrucauda</i> (Turp.)	4	4										9	17
<i>Scendesmus sp.</i> (Meyean)				4									4
<i>Tetraedron enorme</i> (Ralfs)	18	9		13						36			76
<i>Pediastrum duplex</i> (Meyean)												4	4
<i>Pediastrum simplex</i> (Meyean)						9	4			36			49
<i>Eudorina elegans</i> (Ehrenberg)	9	27		4	18			4	4	13	9	27	115
<i>Arthrodesmus sp</i> (Turp.)		4			18								22
<i>Cosmarium sp.</i> (Corda)	9	9	4		4	4				4		13	47
Bacillariophyceae													
<i>Cyclotella ocellata</i> (Pantocsek)	41	19	714	678	433	151	283		52	509			2880
<i>Cyclotella meneghiniana</i> (Kützing)	104	38	143	151	75		19		104	38	104		672

Index(2)/Table(6)

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Cyclotella comta</i> (Ehr) Kützing											34		34
<i>Cyclotella stelligera</i> (Cleve)			20	75	38						35		168
<i>Cyclotella glomerata</i> (Bachmann)							19						19
<i>Stephanodiscus dubius</i> (Grun.)				19									19
<i>Aulacoseria granulata</i> (Ehr)	20	38		19	38	38				170			323
<i>Melosira ambigua</i> (Grun.) Muller		38		57									95
<i>Diatoma elongatum</i> (Lyngby)					19		94		17				130
<i>Diatoma vulgare</i> (Bory)		38	41			38	38		17		69		241
<i>Amphora ovalis</i> (Kütz)				19							17		36
<i>Amphora holastica</i> (Hustt)		19											19
<i>Calonies ladogensis</i> (Cleve)		19											19
<i>Achnanthes delicatula</i> (Kütz) Grun.				57									57
<i>Gyrosigma peionis</i> (Grun.)									17				17
<i>Gomphonema intricatums</i> (Kütz)			20										20
<i>Gomphonema fanesis</i> (Maillard)	138					57		184	17	19	104		519
<i>Gomphonema parvulum</i> (Kütz) Kützing				38	57	19					17		131
<i>Gomphonema angustratum</i> (Kütz) Rabh									86				86
<i>Gomphoneis olivacea</i> (Lyngpye) Dawson									17		86		103
<i>Suirella ovata</i> (Kütz)								41					41
<i>Fragilaria capusina</i> (Demazieres)		19	41							38	17		115
<i>Fragilaria intermedia</i> (Grun.)			41						17		86		144
<i>Fragilaria brevisriata</i> (Grun.)			20	19					52				91
<i>Fragilaria crotonesis</i> (Kitton)									17	57			74
<i>Cocconies placentula</i> (Ehr)	143	132	102	188	245	170	94		294	94	259		1721
<i>Cocconies pediculus</i> (Ehr)	61		41	57	38	19	19	163	17	19		41	475
<i>Navicula radiosa</i> (Kütz)	20		20	19									59
<i>Navicula halophila</i> (Grun.) Cleve			41	19	19								79
<i>Navicula sohrensii</i> (Krasske)		19							35				54

Index(2)/Table(6)

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
<i>Navicula cryptocephala</i> (Kütz)											52		52
<i>Navicula placentula</i> (Ehr) Grun.			20			19							39
<i>Navicula digitoradiata</i> (Gregory)		38					19						57
<i>Navicula crucicula</i> (Grun.) Smith		19									52		71
<i>Navicula brevisriata</i> (Smith)					94								94
<i>Navicula pupula</i> (Kütz) Grun.							19		17				36
<i>Nitzschia amphibia</i> (Grun.)	41	19											36
<i>Nitzschia gracilis</i> (Hantzsch)									35				35
<i>Nitzschia Palea</i> (Kütz)			61						104		69		234
<i>Nitzschia hantzschiana</i> (Rabh)		19							17				36
<i>Nitzschia apiculata</i> (Gregory) Grun.											17		17
<i>Nitzschia romana</i> (Grun.)			20						17				37
<i>Nitzschia rostellata</i> (Hustedt)		38							35				73
<i>Nitzschia intermedia</i> (Grun.)											104		104
<i>Nitzschia hungarica</i> (Grun.)	41		20						35		113		113
<i>Nitzschia recta</i> (Hantzsch)									35				35
<i>Synedra acus</i> (Kütz)			20						17	57	27		111
<i>Synedra tabulata</i> (Agardh) Kütz		19				19				19			57
<i>Synedra ulna</i> (Nitzsch) Ehr		38	61	57	38		19						213
<i>Synedra pulchella</i> (Ralfs) Kütz	41												41
<i>Synedra parasitica</i> (Smith) Hustedt											138		138
<i>Synedra rumpens</i> (Kütz)									17				17
<i>Cymbella affinis</i> (Kütz)			20				75		35		69		199
<i>Cymbella gracilis</i> (Raben.) Cleve			20										20
<i>Cymbellaleptoceros</i> (Ehr) Grun.	20	19				38			17	19	121		234
<i>Cymbella cymbiform</i> (Kütz) VanHeurck									17	19			36
<i>Cymbella perpusilla</i> (Agardh Kütz) VanHeurck										19			19
<i>Cymbella parva</i> (Smith) Kitehn		19	20							35			74
<i>Cymbella microcephala</i> (Grun.)		19											19
<i>Peroni fibula</i> (Brebisson et Arnott) Ross		19	20								35		74

Index(2)/Table(6)

Taxa	Jul.	Aug.	Sep.	Oct.	Nov.	Des.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total
Euglenophyceae		19											19
<i>Euglena</i> sp. (Ehrenberg)	20	38		19		38			69	57	69		310
<i>Phacus</i> sp (Dujardin)	4			4			13		36				57
Xanthophyceae													
<i>Meringosphaera spinosa</i>				4	36	27				36	31		143
Chrysophyceae													
<i>Mallomonas acaroides</i> (Perty)						4					4		8
<i>Mallomonas alpina</i> (Pascher & Ruttner)	4				4								8

Index (3)/Table(1): Values of F calculated from ANOVA table for PAHs compounds in water and sample sediment. Differences among site(first line) and among seasons(second line).

compound	F value(PAHs in water)	F value(PAHs in sediment)
Naphthalene	0.396 0.415	3.096** 5.416**
Acenaphthalene	3.93** 1.586	2.730** 2.358**
Acenaphthene & Fluorene	1.36 1.07	1.56 2.215**
Phenanthrene	2.785** 2.256**	1.465 0.714
Anthracene	1.39 1.33	1.865 0.221
Fluoranthene	1.543 1.23	1.515 0.51
Pyrene	5.347** 2.000**	1.106 4.362**
Benzo(a)Anthracene	1.026 1.50	0.702 0.157
Chrycene	0.519 2.786**	6.225** 7.54**
Benzo(b)Fluoranthene	1.356 1.616	2.418** 1.873**
Benzo(k)Fluoranthene	0.256 3.179**	2.442** 1.873**
Benzo(a)Pyrene	1.16 5.967**	1.123 7.108**
Dibenz(a, h)Anthracene	2.323** 4.095**	2.689** 2.025**
Benzo(ghi)Pyrene	0.969 3.208**	11.845** 0.615
Indeno(1, 2, 3-cd)Pyrene	1.984** 4.716**	4.153** 4.689**
2 ring-PAHs	2.396** 2.415**	3.096** 5.416**
3 ring-PAHs	1.997** 1.986**	0.783 0.785
4 ring-PAHs	0.926 2.165	2.410** 1.987**
5 ring-PAHs	3.348** 3.336**	3.3320** 3.76**
6 ring-PAHs	3.015** 8.950**	3.142** 1.956**

**** Significant at 0.01 level**

Index(3)/table(2):Correlations of PAHs compounds in water sample

	Nap	AcPY	AcP&Flu	Phe n	Ant	Flur	Py	BaA	Chry	BbF	BkF	BaP	Db A	BghiP	IND
Nap	1	,016	,062	,190	,002	-,053	,081	-,046	,442**	-,014	,161	,322*	.0	-,076	,224
AcPY	,016	1	-,017	-,154	,063	,667**	-,017	-,033	,029	-,117	,019	,065	.0	-,014	,000
AcP&Flu	,062	-,017	1	,132	-,067	-,004	,184	,159	-,024	,229	,035	,068	,080	,053	-,034
Phen	,190	-,154	,132	1	-,144	-,026	,500**	,000	,164	,340**	,036	,202	-,1	,197	-,146
Ant	,002	,063	-,067	-,144	1	,119	,116	-,017	-,037	-,069	-,006	-,054	,173	,015	,002
Flur	-,053	,667**	-,004	-,026	,119	1	-,044	,009	,115	-,026	-,096	-,028	-,1	-,049	-,079
Py	,081	-,017	,184	,500**	,116	-,044	1	,046	-,054	,342**	,105	,236	,083	,365**	,081
BaA	-,046	-,033	,159	,000	-,017	,009	,046	1	-,020	,039	,126	-,088	,165	,138	-,064
Chry	,442**	,029	-,024	,164	-,037	,115	-,054	-,020	1	-,105	,216	,417**	.0	-,209	,374**
BbF	-,014	-,117	,229	,340**	-,069	-,026	,342**	,039	-,105	1	-,070	,033	-,1	,180	-,165
BkF	,161	,019	,035	,036	-,006	-,096	,105	,126	,216	-,070	1	,360**	,106	-,098	,549**
BaP	,322*	,065	,068	,202	-,054	-,028	,236	-,088	,417**	,033	,360**	1	-,1	,350**	,432**
DbA	-,025	-,026	,080	-,119	,173	-,089	,083	,165	-,002	-,109	,106	-,071	1	,003	,136
BghiP	-,076	-,014	,053	,197	,015	-,049	,365**	,138	-,209	,180	-,098	,350**	,003	1	-,182
IND	,224	,000	-,034	-,146	,002	-,079	,081	-,064	,374**	-,165	,549**	,432**	,136	-,182	1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Index(3)/Table(3):Correlation coefficient among PAHs compounds in sediment samples of Euphrates river

	Nap	AcPY	Acp & Flu	phen	Ant	Flur	Py	BaA	Chry	BbF	BkF	BbP	DbA	BghiP	IND
Nap	1	,175	-,105	-,027	,253	,040	,426**	-,130	,426**	,003	,624**	-,218	-,032	,071	-,145
AcPY	,175	1	-,028	-,091	-,158	,084	-,079	,061	-,079	,178	,437**	-,214	,496**	-,091	-,154
Acp&Flu	-,105	-,028	1	-,073	-,187	-,196	,188	,099	,188	,156	,031	,017	-,040	,509**	,381**
phen	-,027	-,091	-,073	1	-,081	-,091	,002	-,028	,002	,021	-,021	,154	-,114	-,095	,020
Ant	,253	-,158	-,187	-,081	1	,317*	,226	-,125	,226	-,181	-,045	-,020	-,122	-,098	-,054
Flur	,040	,084	-,196	-,091	,317*	1	,137	-,003	,137	,015	,208	-,075	,130	-,129	,037
Py	,426**	-,079	,188	,002	,226	,137	1	-,053	1,000**	-,058	,514**	-,007	-,058	,336**	,038
BaA	-,130	,061	,099	-,028	-,125	-,003	-,053	1	-,053	,017	-,002	-,124	-,112	,164	-,049
Chry	,426**	-,079	,188	,002	,226	,137	1,000**	-,053	1	-,058	,514**	-,007	-,058	,336**	,038
BbF	,003	,178	,156	,021	-,181	,015	-,058	,017	-,058	1	,033	,086	,221	,058	,438**
BkF	,624**	,437**	,031	-,021	-,045	,208	,514**	-,002	,514**	,033	1	-,250	,221	,104	-,105
BbP	-,218	-,214	,017	,154	-,020	-,075	-,007	-,124	-,007	,086	-,250	1	-,218	,002	-,165
DbA	-,032	,496**	-,040	-,114	-,122	,130	-,058	-,112	-,058	,221	,221	-,218	1	-,207	,257*
BghiP	,071	-,091	,509**	-,095	-,098	-,129	,336**	,164	,336**	,058	,104	,002	-,207	1	,199
IND	-,145	-,154	,381**	,020	-,054	,037	,038	-,049	,038	,438**	-,105	-,165	,257*	,199	1

**, Correlation is significant at the 0.01 level (2-tailed).

*, Correlation is significant at the 0.05 level (2-tailed).

Index(3)/Table(4):Correlation coefficient of PAHs compounds in sediment samples(columns) with those in water samples(Rows) of Euphrates river

	Nap	AcP Y	AcP& Flu	Phen	Ant	Flur	Py	BaA	chry	BbF	BkF	BaP	DbA	BghiP	IND
Nap	-,095	,817**	-,233	,175	-,107	,277	,526	,615	-,150	,776**	-,379	,480	,037	,000	-,037
AcP Y	,793**	-,251	-,298	,785**	,792**	,840**	,696	,970**	,034	,499	-,483	,358	-,294	,302	,544
AcP&Flu	,160	-,250	-,296	-,127	,073	,052	,108	-,169	-,243	,038	,088	,048	,039	,503	-,318
Phen	-,298**	-,127	-,007	,068	-,291	-,321	-,379	-,184	-,044	-,355	-,180	-,380	,108	-,124	-,090
Ant	-,271	,318	,676*	-,175	-,354	-,178	,008	,331	,587*	,139	-,053	-,141	-,013	-,665*	,258
Flur	,753**	,276	-,308	,869**	,756**	,795**	,587*	-,184	-,057	,408	-,508	,405	-,300	,237	,482
Py	,474	,325	,072	,631*	,339	,506	,627*	,178	,253	,551	-,335	,459	,220	,063	,571
BaA	,432	,319	-,034	,060	-,100	,088	,557	,116	,315	,481	-,298	,727**	,542	,263	,487
chry	-,212	,631*	,217*	-,130	-,208	-,069	,069	,351	,277	,165	,077	,066	,318	-,320	,285
BbF	-,180	,257	,306	-,249	-,180	-,108	-,195	-,090	,390	-,202	,249	,149	,259	-,291	,381
BkF	,416	,089	-,156	-,329	-,305	-,225	,488	,075	,069	,442	-,314	,598*	,584*	,519	,058
BaP	-,406	,296	,019	,009	-,258	-,164	-,167	,182	,067	-,058	-,172	-,362	,132	-,233	,016
DbA	,614*	-,116	-,234	-,102	-,157	-,136	,584*	-,071	,029	,446	-,398	,599*	,563	,655*	,056
BghiP	,635*	-,312	-,318	,873**	,876**	,865**	,541	-,209	-,055	,367	-,285	,233	-,447	,276	,362
IND	,306*	-,270	-,247	,005*	-,213	-,237	,246	-,188	-,052	,146	-,541	,084	,38	,451	-,042

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Index(3)/Table(5): Correlation coefficient among PAHs compounds in clam *Unio tigridis*

	Nap	AcPy	AcP&Flu	Phen	Ant	Flur	Py	BaA	Chry	BbF	BkF	BaP	DbA	BghiP	IND
Nap	1	-.591*	-.582*	-.294	-.051	.287	-.288	.381	-.167	-.052	.296	-.657*	-.196	.722**	-.532
AcPy	-.591*	1	.688*	.360	.031	.119	.797**	.519	.881**	.835**	-.024	.979**	-.349	.127	-.226
AcP&Flu	-.582*	.688*	1	.912**	.722**	-.629*	.886**	.201	.632*	.483	.556	.576*	-.681*	-.187	.381
Phen	-.294	.360	.912**	1	.942**	-.826**	.783**	.140	.436	.283	.825**	.204	-.811**	-.134	.480
Ant	-.051	.031	.722**	.942**	1	-.901**	.574	.025	.186	.045	.921**	-.136	-.783**	-.121	.541
Flur	.287	.119	-.629*	-.826**	-.901**	1	-.301	.403	.144	.307	-.680*	.227	.441	.529	-.852**
Py	-.288	.797**	.886**	.783**	.574	-.301	1	.632*	.901**	.813**	.584*	.664*	-.835**	.278	-.080
BaA	.381	.519	.201	.140	.025	.403	.632*	1	.840**	.903**	.326	.419	-.641*	.906**	-.801**
Chry	-.167	.881**	.632*	.436	.186	.144	.901**	.840**	1	.984**	.297	.791**	-.666*	.531	-.472
BbF	-.052	.835**	.483	.283	.045	.307	.813**	.903**	.984**	1	.210	.759**	-.598*	.644*	-.621*
BkF	.296	-.024	.556	.825**	.921**	-.680*	.584*	.326	.297	.210	1	-.217	-.909**	.262	.200
BaP	-.657*	.979**	.576*	.204	-.136	.227	.664*	.419	.791**	.759**	-.217	1	-.159	.044	-.231
DbA	-.196	-.349	-.681*	-.811**	-.783**	.441	-.835**	-.641*	-.666*	-.598*	-.909**	-.159	1	-.470	.083
BghiP	.722**	.127	-.187	-.134	-.121	.529	.278	.906**	.531	.644*	.262	.044	-.470	1	-.889**
IND	-.532	-.226	.381	.480	.541	-.852**	-.080	-.801**	-.472	-.621*	.200	-.231	.083	-.889**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Index(3)/Table(6): Correlation coefficient among PAHs co, pounds in clam *Pseudodontopsis euphraticus*

	Nap	Acp Y	AcP& Flu	Phen	Ant	Flur	Py	BaA	chry	BbF	BkF	BaP	DbA	BghjP	IND
Nap	1	-.637*	-.232	.768**	.487	.286	-.235	-.172	-.373	.026	-.037	-.184	-.195	.410	.687*
Acp Y	-.637*	1	-.239	-.174	-.883**	-.378	.338	.034	.215	-.021	-.451	.277	.468	.255	.095
AcP&Flu	-.232	-.239	1	.028	.642*	-.709**	-.852**	-.727**	-.671*	-.835**	.973**	-.862**	.549	-.948**	-.70*
Phen	.768**	-.174	.028	1	.298	-.340	-.545	-.656*	-.756**	-.477	.109	-.531	.464	.282	.697*
Ant	.487	-.883**	.642*	.298	1	-.097	-.728**	-.461	-.586*	-.442	.801**	-.685*	-.024	-.582*	-.28
Flur	.286	-.378	-.709**	-.340	-.097	1	.740**	.881**	.757**	.933**	-.582*	.783**	-.976**	.521	.232
Py	-.235	.338	-.852**	-.545	-.728**	.740**	1	.939**	.953**	.933**	-.882**	.998**	-.668*	.650*	.221
BaA	-.172	.034	-.727**	-.656*	-.461	.881**	.939**	1	.976**	.976**	-.704*	.953**	-.867**	.471	.037
chry	-.373	.215	-.671*	-.756**	-.586*	.757**	.953**	.976**	1	.918**	-.698*	.954**	-.751**	.402	-.07
BbF	.026	-.021	-.835**	-.477	-.442	.933**	.933**	.976**	.918**	1	-.784**	.954**	-.881**	.626*	.240
BkF	-.037	-.451	.973**	.109	.801**	-.582*	-.882**	-.704*	-.698*	-.784**	1	-.877**	.420	-.915**	-.63*
BaP	-.184	.277	-.862**	-.531	-.685*	.783**	.998**	.953**	.954**	.954**	-.877**	1	-.711**	.659*	.235
DbA	-.195	.468	.549	.464	-.024	-.976**	-.668*	-.867**	-.751**	-.881**	.420	-.711**	1	-.323	-.02
BghjP	.410	.255	-.948**	.282	-.582*	.521	.650*	.471	.402	.626*	-.915**	.009*	.	.305	.939**
IND	.687*	.095	-.696*	.697*	-.282	.232	.221	.037	-.065	.240	-.630*	.235	-.025	.884**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Index(3)Table(7):Correlation coefficient among PAHs compounds in plant *Ceratophyllum demersum*

compound	Variables														
	Nap	Ac pY	Ac p & Flu	Phen	Ant	Flur	Py	BaA	Chry	BbF	BkF	BaP	DbA	BghiP	IND
Nap	1	-,591*	-,582*	-,294	-,051	,287	-,288	,381	-,167	-,052	,296	-,652*	-,196	,722**	-,534
Ac pY	-,591*	1	,688*	,360	,031	,119	,797**	,519	,881**	,835**	-,024	,976**	-,349	,127	-,225
Ac p & Flu	-,582*	,688*	1	,912**	,722**	-,63*	,886**	,201	,632*	,483	,556	,555	-,681*	-,187	,382
Phen	-,294	,360	,912**	1	,942**	-,83**	,783**	,140	,436	,283	,825**	,177	-,811**	-,134	,481
Ant	-,051	,031	,722**	,942**	1	-,90**	,574	,025	,186	,045	,921**	-,163	-,783**	-,121	,541
Flur	,287	,119	-,629*	-,826**	-,901**	1	-,301	,403	,144	,307	-,680*	,251	,441	,529	-,851**
Py	-,288	,797**	,886**	,783**	,574	-,30	1	,632*	,901**	,813**	,584*	,646*	-,835**	,278	-,079
BaA	,381	,519	,201	,140	,025	,403	,632*	1	,840**	,903**	,326	,418	,001*	,382**	,807**
Chry	-,167	,881**	,632*	,436	,186	,144	,901**	,840**	1	,984**	,297	,784**	-,666*	,531	-,471
BbF	-,052	,835**	,483	,283	,045	,307	,813**	,903**	,984**	1	,210	,756**	-,598*	,644*	-,620*
BkF	,296	-,024	,556	,825**	,921**	-,68*	,584*	,326	,297	,210	1	-,241	-,909**	,262	,199
BaP	-,652*	,976**	,555	,177	-,163	,251	,646*	,418	,784**	,756**	-,241	1	-,137	,049	-,244
DbA	-,196	-,349	-,681*	-,811**	-,783**	,441	-,835**	-,641*	-,666*	-,598*	-,909**	-,137	1	-,470	,083
BghiP	,722**	,127	-,187	-,134	-,121	,529	,278	,906**	,531	,644*	,262	,049	-,470	1	-,890**
IND	-,534	-,225	,382	,481	,541	-,85**	-,079	-,801**	-,471	-,620*	,199	-,244	,083	-,890**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Index(3)/Table(8):Correlation coefficient among PAHs compounds in plant *Typha domingensis*

Variables															
compound	Nap	AcP _Y	AcP&Flu	Phen	Ant	Flur	Py	BaA	Chry	BbF	BkF	BaP	DbA	BghiP	IND
Nap	1	,900**	,339	-,152	-,639	-,479	,427	-,120	-,948**	-,882**	,104	-,774**	-,099	,548	-,909**
AcP _Y	,900**	1.00	,235	-,542	-,366	-,10	,531	,268	-,760**	-,596*	,256	-,464	-,389	,495	-,731**
AcP&Flu	,339*	,235	1.00	,412	,264	-,685*	,869**	,281	-,135	-,482	,831**	-,665*	,744**	,961**	-,680
Phen	-,152	-,542	,412	1.00	-,143	-,783**	-,091	-,612	,028	-,329	-,047	-,493	,897**	,198	-,171
Ant	-,639*	-,366	,264	-,143	1.00	,413	,393	,787**	,851**	,710**	,666*	,544	,167	,154	,455
Flur	-,479	-,098	-,685	-,783**	,413	1.00	-,310	,501	,514	,822**	-,164	,926**	-,788**	-,621	,746**
Py	,427	,531	,869**	-,091	,393	-,310	1.00	,654*	-,134	-,324	,944**	-,439	,331	,937**	-,629
BaA	-,120	,268	,281	-,612	,787**	,501	,654*	1.00	,414	,438	,764**	,381	-,223	,351	,098
Chry	-,948**	-,760**	-,135	,028	,851**	,514	-,134	,414	1.00	,905**	,199	,765**	,119	-,321	,816**
BbF	-,882**	-,596	-,482	-,329	,710**	,882**	-,324	,438	,905**	1.00	-,033	,966**	-,311	-,582*	,936**
BkF	,104	,256	,831	-,074	,666*	-,164	,944**	,764**	,199	-,033	1.00	-,198	,398	,830**	-,360
BaP	-,774**	-,464	0,665*	-,493	,544	,926**	-,439	,381	,764**	,996**	-,198	1.00	-,536	-,709**	,935*
DbA	-,099	-,389	,744**	,897**	,167	-,788**	,331	-,223	,119	-,311	,398	-,536	1.00	,545	-,311
BghiP	,548**	,495	,961**	,198	,154	-,621*	,937**	,351	-,321	-,852*	,830**	-,709**	,545	1.00	-,805**
ND	-,909**	-,731**	-,680*	-,171	,455	,746**	-,629*	,098	,813**	,935*	-,360	,935**	-,311	-,805**	1.00

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).



Qualitative and Quantitative Studies of Some Polycyclic Aromatic Hydrocarbons (PAHs) and Limnology of Euphrates river from Al-Hindiya Barrage to Al-Kifil City – Iraq

**A Thesis Submitted By
Awaz Bahroz Mohammed**

*To the Council of College of Science University of Babylon
In Partial Fulfillment of the Requirements for the Degree of Doctor
of philosophy in Biology –Ecology & Pollution*

Supervisors

Dr. Fikrat M. Hassan

Dr. Maysoon M. S. Al-Tae

October – 2007

Shawal – 1428



دراسات نوعية وكمية لبعض المركبات الهيدروكربونية الأروماتية متعددة الحلقات (PAHs) ولمنولوجية نهر الفرات من سدة الهندية إلى مدينة الكفل - العراق

أطروحة مقدمة من قبل
آواز بهروز محمد

إلى مجلس كلية العلوم/ جامعة بابل كجزء من متطلبات نيل درجة الدكتوراه
فلسفة في علوم الحياة - بيئة وتلوث

إشراف

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تشرين الأول - 2007

شوال - 1428

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿وَمَا يَسْتَوِي الْبَحْرَانِ هَذَا عَذْبٌ فُرَاتٌ سَائِغٌ شَرَابُهُ وَهَذَا مِلْحٌ
أُجَاجٌ وَمِنْ كُلٍّ نَأْكُلُوا لَحْمًا طَرِيًّا وَنَسْخَرُ جُودَ حَمَلِهِ نَلْبَسُنَا مِنْهَا وَنَرَى
الْفَلَاحَ فِيهِ مَوْلَا خَيْرٍ لِّبَتَّغُوا مِنْ فَضْلِهِ وَلَعَلَّكُمْ تَشْكُرُونَ﴾

صدق الله العظيم

سورة فاطر (الآية 12)

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Supervisors certification

We certify that the preparation of this thesis entitled"

"

by the PhD student "**Awaz Bahroz Mohammed**" was made under our supervision at the department of Biology, College of Science, University of Babylon for the degree of Doctor of Philosophy in Biology (Ecology & Pollution).

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In view of the available recommendations of the supervisors, I forward this thesis for discussion by the examining committee.

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