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# Polychlorinated Biphenyls (PCB) in sediments of the southern part of Tigris River-Iraq

AL-Hasanayn M. AL-Hasani * Makia M. Al-Hejuje* H. T. Al-saad**
* Department of Ecology, College of Sciences, University of Basrah, Iraq.
** Department of Marine Chemistry, Marine Science College, University of Basrah, Iraq.
E-mail: makia.khalaf@uobasrah.edu.iq

**Abstract**

Polychlorinated Biphenyls (PCB) are persistent, toxic, bioaccumulative, and widely distributed in the environment because of their high stability and tendency to accumulate in the bodies of living organisms, causing serious health effects. Sediment samples were collected from the southern part of the Tigris River from Autumn,2022 to Summer,2023 to investigate their occurrence and determine the concentrations of PCB compounds. Twelve PCB compounds were identified in Tigris River sediments: PCB153, PCB149, PCB141, PCB138, PCB101, PCB52, PCB44, PCB31, PCB28, PCB18, PCB194, and PCB189. A dioxin-like PCB compound was also observed (PCB189). The concentrations of total PCBs in sediment samples ranged from (11.00 ng/g dry weight) during autumn to (38.26 ng/g dry weight) during the summer season, which was highest in the upper station compared to the lower stations, which may be due to human activities, household waste, and neighboring agricultural lands that use fertilizers and pesticides as sources of PCBs compounds.

**Key words:** Polychlorinated Biphenyls, PCB, Tigris River, sediments, pollution

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## Introduction

Polychlorinated Biphenyls (PCBs) are persistent, toxic, bioaccumulative, and are widely distributed in the environment. Discharges into the environment can occur via urban and industrial discharge, seepage, leaching from the soil, urban runoff, and volatilization (Combi *et al.* 2016). POPs have high separation coefficients for organic carbon (Koc), which causes them to be adsorbed into sediments; therefore, they serve as a good matrix to determine the extent of PCBs contamination (Pozo *et al*., 2014), These organic compounds are not only very stable and difficult to degrade or biodegrade, but also have a highly toxic effect (Al-Hejuje *et al.*, 2017).

Although water analysis is useful for assessing river pollution, sediments can also serve as a pollution indicator. Surficial sediments of the studied rivers represent a sink for pollutants, and this accumulation of pollutants in sediments could serve as a source of water pollution in the case of changes in environmental conditions (Al-Hejuje *et al*., 2015).

Organic pollutants enter water from industrial discharge and urban waste into rivers, lakes, and coastal waters, and the concentration of these compounds in the surface microlayer is greater than that in the subsurface. Owing to their low solubility in water, they run with water floods and rivers reaching the sediments (Al-Asadi & Al-Hejuje, 2019).

In addition, these organic pollutants are generally highly hydrophobic and tend to bind to suspended particles carried by rivers, thus accumulating in aquatic systems (Al-Atbee,2018). The transfer of PCBs from terrestrial sources to aquatic environments may result from direct entry points after leakage from the containing systems. PCBs are chemically stable and are only minimally converted during deposition. Owing to their lipophilic nature, PCBs accumulate in soils and sediments by binding to microparticles rich in organic matter (Gardes *et al.*, 2020).

PCBs used on land can enter the aquatic environment through diverse pathways, including wastewater discharged by industries, municipal wastewater, river inputs, air transport, and deposition. However, the distribution and ecotoxicological risks of PCBs in the sediments of different rivers remain unclear (Wang *et al*.,2019). Its potential effects on cancer, its high chemical affinities to fats, and therefore its resulting bioaccumulation have made its study a very important topic in environmental research (Cortazar *et al*., 2002).

To our knowledge, no previous study has investigated the occurrence and distribution of PCB in Tigris sediments. Therefore, this study aimed to determine the concentrations of PCB in Tigris sediments.

**Materials and methods**

The study area is in the southern part of the Tigris River from the borders of the Maysan Governorate to the borders of the Basra Governorate, represented by Qurna City. The Tigris River is one of the most important surface water sources for the governorates of Basra and Maysan. Four stations (Al-Majar, Qal'at Saleh, Al-Uzair and Al-Qurna) were selected to collect sediment samples in the southern part of the Tigris River (Figure 1).

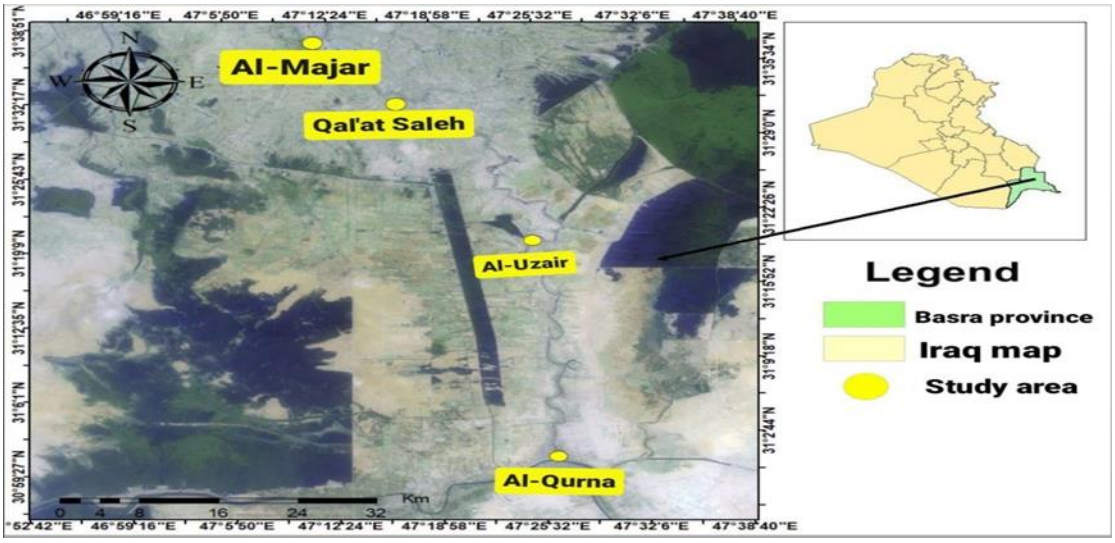


**Fig.1: The study stations**

Sediment samples were collected from four stations along the southern part of the Tigris River seasonally (two months per season) from August 2022 to July 2023) at the beginning of the day using a grab sampler. The water was allowed to flow, come out, and kept in aluminum foil, marked, and placed in a box until it reached the laboratory. In lab. It was air-dried, ground, sieved through a 63 µm mesh sieve, and stored until extraction and analysis of PCB.

The method described by Aganbi *et al.* (2019) was used to extract and analyze the PCBS compounds in the sediment samples as follows:

Twenty grams of dried, grind, and sieved sediment were placed in a thimble and extracted PCBs using the Solet Intermittent Extraction device, by using 100 ml of hexane mixture: Chloride / 1:1) for 48 hours and at a temperature not exceeding (40) ◦C, leave the extract to cool at room temperature, then the process of saponification was performed for two hours with (15) milliliters of potassium hydroxide methanolic standard solution (MOH(KOH (4N), then cool, and transferred to the separation funnel, added 50 ml of homosexual hexane chloride (1:1) to it. Then shake well and leave a period until the solution separated into two layers, the lower layer was removed and disposed of. The top organic layer (unsaponified containing PCBs compounds) was passed through a separation column containing glass wool at the bottom, above 2 g of silica gel, topped with a layer of alumina (2 g) to remove fatty acid residues, and added at the top 2 g of anhydrous sodium sulfate to remove water. The extract was collected in a glass container, marked, allowed to dry, and closed properly until measurement was performed using the GC-MASS device.

**Statistical Analysis**

The statistical program (SPSS) Statistical Package for Social Science was used for the analysis of variance (AVOVA test-one way) at a significance level of 0.05, and the correlation coefficient (r) was extracted to determine the extent of the relationship between the TOC% and sediment texture with the concentrations of PCBs in Sediment.

**Results**

The results of the statistical analysis using one-way ANOVA showed that there were no significant differences between the study stations ($P>0.05$) in most of the PCB compounds, except for three compounds that showed significant differences, which are PCB194, PCB52, and PCB31, as the results of the analysis showed. Statistical analysis showed significant differences between the seasons ($P<0.05$) among most of the PCBs, except for PCB194, PCB138, and PCB31, which did not show significant differences among seasons.

Tables (1-4) show the concentrations of PCB compounds (ng/g dry weight) in the study station sediment samples during the four seasons from autumn 2022 to Summer,2023.

Table (1): PCB concentrations (ng/g dry weight) in the sediments of the study stations during autumn

| Compound | AL-Majar | Qal'at Saleh | Al-Uzair | Al-Qurna |
|---|---|---|---|---|
| PCB18 | 4.13 | 1.38 | 0.57 | 0.23 |
| PCB28 | 1.11 | 3.21 | 1.37 | 3.47 |
| PCB31 | 1.97 | 3.26 | 1.99 | 4.04 |
| PCB44 | 2.74 | 2.94 | 0.73 | 1.7 |
| PCB52 | 0.31 | 0.18 | 0.34 | 0.38 |
| PCB101 | 0.61 | 0.69 | 1 | 1.2 |
| PCB138 | 5.67 | 1.21 | 0.63 | 0.98 |
| PCB141 | 0.21 | 0.4 | 0.32 | 1.19 |
| PCB149 | 0.34 | 0.54 | 0.34 | 0.58 |
| PCB153 | 0.91 | 1.5 | 0.39 | 0.58 |
| PCB189 | 3.42 | 1.66 | 1.03 | 1.9 |
| PCB194 | 1.71 | 1.19 | 2.81 | 0.21 |
| TOTAL PCB | 23.13 | 18.16 | 11.52 | 16.46 |

Table (2): PCB concentrations (ng/g dry weight) in the sediments of the study stations during winter

| Compound | AL-Majar | Qal'at Saleh | Al-Uzair | Al-Qurna |
|---|---|---|---|---|
| PCB18 | 2.58 | 2.28 | 1.81 | 0.5 |
| PCB28 | 1.45 | 0.67 | 0.12 | 1.23 |
| PCB31 | 0.55 | 0.39 | 5.57 | 1.21 |
| PCB44 | 0.46 | 0.34 | 0.19 | 0.13 |
| PCB52 | 1.17 | 0.74 | 0.92 | 5.09 |
| PCB101 | 3.71 | 3.47 | 3.36 | 2.85 |
| PCB138 | 0.4 | 2.3 | 0.53 | 0.16 |
| PCB141 | 1.12 | 0.12 | 0.69 | 0.37 |
| PCB149 | 2.48 | 1.59 | 1.63 | 0.87 |
| PCB153 | 0.39 | 0.17 | 2.13 | 0.58 |
| PCB189 | 1.19 | 2.15 | 0.54 | 0.78 |
| PCB194 | 5.97 | 3.88 | 0.45 | 0.48 |
| TOTAL PCB | 21.47 | 18.1 | 17.94 | 14.25 |

Table 3: PCB concentrations (ng/g dry weight) in the sediments of the study stations during spring.

| Compound | AL-Majar | Qal'at Saleh | Al-Uzair | Al-Qurna |
|---|---|---|---|---|
| PCB18 | 0.44 | 0.35 | 0.35 | 0.36 |
| PCB28 | 1.88 | 2.14 | 2.19 | 1.95 |
| PCB31 | 2.16 | 2.28 | 2.07 | 2.32 |
| PCB44 | 1.16 | 2.15 | 0.59 | 0.78 |
| PCB52 | 3.15 | 4.27 | 0.98 | 2.02 |
| PCB101 | 3.22 | 3.28 | 2.16 | 1.86 |
| PCB138 | 2.72 | 0.22 | 0.99 | 1.52 |
| PCB141 | 0.68 | 1.18 | 0.84 | 1.12 |
| PCB149 | 0.89 | 0.32 | 0.94 | 0.99 |
| PCB153 | 2.7 | 0.57 | 0.49 | 0.46 |
| PCB189 | 1.83 | 1.24 | 1.66 | 1.81 |
| PCB194 | 1.27 | 1.75 | 0.96 | 2.12 |
| TOTAL PCB | 22.1 | 19.75 | 14.22 | 17.31 |

Table 4: PCBs concentrations (ng/g dry weight) in the sediments of the study stations during the summer.

| Compound | AL-Majar | Qal'at Saleh | Al-Uzair | Al-Qurna |
|---|---|---|---|---|
| PCB18 | 0.52 | 2.07 | 2.65 | 4.12 |
| PCB28 | 1.53 | 2.91 | 3.51 | 3.07 |
| PCB31 | 1.53 | 1.39 | 2.71 | 1.92 |
| PCB44 | 2.15 | 2.86 | 6.24 | 4.43 |
| PCB52 | 0.99 | 1.19 | 2.52 | 6.27 |
| PCB101 | 0.84 | 1.19 | 1.74 | 1.82 |
| PCB138 | 0.44 | 1.61 | 0.78 | 2.48 |
| PCB141 | 1.94 | 1.64 | 2.74 | 2.82 |
| PCB149 | 0.27 | 0.68 | 1.21 | 0.46 |
| PCB153 | 2.78 | 1.63 | 4.45 | 5.08 |
| PCB189 | 5.56 | 10.11 | 7.23 | 3.85 |
| PCB194 | 4.59 | 3.6 | 0.41 | 0.18 |
| TOTAL PCB | 23.14 | 30.88 | 36.19 | 36.5 |

The results of this study showed an increase in PCBs during the summer and a decrease during the autumn season at the study stations. The concentrations ranged between (21.47 -23.14) ng / g dry weight in Al Majar station, and in Qalaat Saleh station it ranged between (18.10 -30.88) ng / g dry weight. In Al-Uzayr station, the concentrations ranged between (11.52-36.19) ng/g dry weight, while the values in AL- Qurna station ranged between (14.25-36.5) ng/g dry weight (Fig 2)

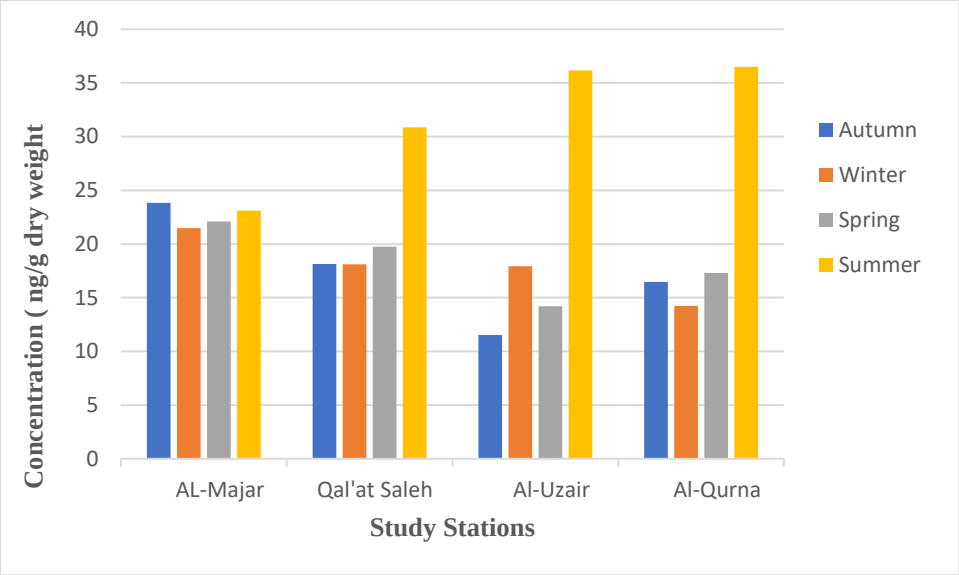


Figure 2: Seasonal and local variations in the total PCBs compounds (ng/g dry weight) in the sediments of the studied stations.

The concentrations of PCBs in sediment samples varied during the seasons, as the lowest value (11.52 ng/g dry weight) was recorded at Al-Uzair station during the autumn season and the highest value ( 36.5 ng/g dry weight )was recorded at Al-Qurna station during the summer season.

Compounds (PCB18, PCB44, PCB52, PCB141, PCB149, PCB153, and PCB189) recorded the highest concentration in the summer, PCB28 recorded the highest concentration in the autumn, PCB101 recorded the highest concentration in the winter, while the compounds (PCB28, PCB44, PCB141, PCB153, and PCB189) recorded the lowest concentration in the winter and the compounds (PCB52, PCB101, and PCB149) recorded the lowest concentration in autumn, while the compound (PCB18) recorded the lowest concentration in the spring season.

**Discussion**:

The properties of PCBs compounds, including heat resistance, low flammability, and high dielectric constant, make them suitable for multiple industrial applications, such as refrigerants and insulation fluids for condensers and electrical transformers. It is also used in the manufacture of PVC wrappers, pesticides, cutting oils, flame retardants, hydraulic fluids, sealants, adhesives, paints, and carbon-free printing paper (Brinkman and Kok, 1980). These sources may supply rivers with high concentrations of PCBs compounds.

PCBs used on land can travel to the aquatic environment through various pathway routes including wastewater discharged by industry, municipal wastewater, river input, air transport and sedimentation (Yang *et al*.,2012), once transported to the aquatic environment, PCBs

can be absorbed by molecules and then incorporated into sediment because they were difficult to dissolve in water, which can lead to pollution (Yang *et al*., 2011), sediments are a clear evidence of aquatic environmental pollution as large quantities of PCBs show that sediment is a reservoir and will be a clear environmental deposit of these pollutants in the aquatic environment.

The study showed high concentrations of PCBs in Qurna station during the summer, and this increase may be attributed to the fact that the sediment texture in the Qurna station was silty clay, which is different from the rest of the stations that were sand-silt sediments, as the silt–clay sediments accumulated organic compounds; in addition, the smallest size of the grains in the sediments can accumulate greater amounts of PCBs. In addition, the values of PCBs in clay sediments have increased more than those in sandy sediments (Al-Zabad, 2021). A study by Barakat *et al.* (2013) indicated that sediments that are close to cities often have high concentrations of PCBs according to the local use of these pollutants.

The results showed that the increase in the concentrations of PCBs in the sediments of Qal'at Saleh and Al-Uzair stations in the summer may be due to the main roads adjacent to the Tigris River, where they are affected by waste from means of transportation and activated fishing boats that increase water pollution and then settle in sediments. Uzair station is directly affected by sewage and waste dumped from homes located near this station.

Temperature may have an impact on the high concentrations of PCBs in the summer; when the temperature rises, the processes of decomposition and chemical decomposition of organic compounds in the environment, including PCBs, occur. When the temperature rises, the reproduction of aquatic plants, especially reed plants, increases, and it has been found that reed plants can absorb and accumulate PCBs from water and sediments, which agrees with the study of Al-Zabad (2021). When these aquatic plants die, they are deposited in sediments and contribute to the high concentrations of PCBs in sediments.

This finding agrees with that of Karawi and Sabra (2012) in the Latakia River in Syria, who determined high PCB concentrations in the summer season.

The concentrations of PCBs decreased in the winter and autumn seasons at the study stations, which may be due to rainfall, which leads to diluted water causing an increase in water flow and thus contributes to reducing the concentrations of PCBs in sediments, or by transferring sediments loaded with PCBs away from the more concentrated areas and depositing them in other areas, which may lead to a decrease in PCBs concentrations in the previous areas. Sediments are affected by water currents that lead to the mixing of sediments with the water column due to the circular movement of water from the top to the bottom and then the top so that the sediment is washed away with pollutants towards the water column.

## Conclusion

This study provided data on the polychlorinated biphenyl (PCB) compound concentrations in the surface sediments at southern part of the Tigris River. The concentrations of these compounds in sediments recorded highest level in upper station as compared to the down stations, this may be due to human activities, household waste and neighboring agricultural lands that use fertilizers and pesticides as sources of PCBs compounds indicated that the sediments acted as a sink and source for this compound. Also, it was found that there are

temporal and local changes in the concentrations of PCBs in the sediments.

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**مركبات ثنائي الفينيل متعدد الكلور (PCB) في رسوبيات الجزء الجنوبي من نهر دجلة - العراق**

*الحسنين مصطفى الحساني *مكيه مهلهل خلف الحجاج ** حامد طالب السعد
* قسم البيئة ، كلية العلوم ، جامعة البصرة ، العراق
** قسم الكيمياء البحرية ، كلية علوم البحار ، جامعة البصرة ، العراق.

**المستخلص**

مركبات ثنائي الفينيل متعدد الكلور (PCB) ثابتة وسامة وتتراكم بيولوجيا وتتوزع على نطاق واسع في البيئة بسبب ثباتيها العالية وميلها إلى التراكم في أجسام الكائنات الحية مما يسبب آثارا صحية خطيرة على الكائنات الحية . تم جمع عينات الرسوبيات من الجزء الجنوبي من نهر دجلة للفترة الممتدة من خريف 2022 إلى صيف 2023 للكشف عن تواجد مركبات ثنائي الفينيل متعدد الكلور وتحديد تراكيزها. تم تحديد اثني عشر مركبا من مركبات ثنائي الفينيل متعدد الكلور في رسوبيات نهر دجلة ، وهي( PCB18 ,PCB52, PCB44, PCB31, PCB28 ,PCB153, PCB149, PCB141, PCB138, PCB101, ،PCB194, PCB189) , ظهر مركب ثنائي الفينيل متعدد الكلور شبيه بالديوكسين هو (PCB189). تراوحت تركيز مركبات ثنائي الفينيل متعدد الكلورالكلية في عينات الرسوبيات من (11.00 نانوغرام / غرام من الوزن الجاف) اثناء فصل الخريف إلى (38.26 نانوغرام / غرام من الوزن الجاف) اثناء فصل الصيف، وسجلت هذه المركبات أعلى مستوى في المحطات العليا مقارنة بالمحطات السفلية من النهر ، وقد يرجع ذلك إلى الأنشطة البشرية والنفايات المنزلية والأراضي الزراعية المجاورة التي تستخدم الأسمدة والمبيدات كمصادر لمركبات ثنائي الفينيل متعدد الكلور.

الكلمات المفتاحية: ثنائي الفينيل متعدد الكلور ، PCB ، نهر دجلة ، الرسوبيات ، التلوث