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An Overview on Organic Pollutant Levels in Surface Waters of Dimal Area, Central Albania

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ABSTRACT: Monitoring the presence of persistent organic pollutants in surface waters is essential for assessing environmental contamination and potential ecological risks. In this study, water samples collected from three streams and drainage canals in the Dimal area (Drenovicë, Shajnov and Sjepur), which discharge into the Osum River, were analyzed for selected groups of organic contaminants. The objective of the study was to evaluate the occurrence of organochlorine pesticides (OCPs), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) in these surface waters and to assess potential anthropogenic sources. The analysis was performed using gas chromatography equipped with flame ionization and electron capture detectors (GC/FID/ECD). Among the investigated organochlorine pesticides, only a limited number of compounds were detected, including heptachlor epoxide, endrin, endosulfan I + II, and endosulfan sulfate, with concentrations ranging from 0.5 to 5.2 ppb. Several PCB congeners were also identified, namely PCB 28, PCB 52, PCB 138 and PCB 153, with concentrations between 1 and 3.6 ppb. In addition, selected polycyclic aromatic hydrocarbons (PAHs), including fluoranthene, anthracene, benzo[a]anthracene, benzo[a]pyrene and benzo[g,h,i]perylene, were detected at concentrations ranging from 0.2 to 1.1 ppm. The occurrence of these persistent organic pollutants suggests the influence of historical pesticide use, agricultural activities and possible urban or industrial inputs in the studied area. Although only a limited number of compounds were detected, their presence highlights the persistence and environmental stability of these contaminants in aquatic systems. The findings emphasize the importance of continuous monitoring of organic pollutants in surface waters that ultimately flow into the Osum River in order to better understand contamination pathways and support environmental protection measures.

KEYWRDS: Dimal area, Osumi river, Water analyze, OCP, PCB, PAH, GC/FID/ECD

INTRODUCTION

Surface water pollution by persistent organic pollutants represents one of the most important environmental problems on a global scale. Compounds such as organochlorine pesticides, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) are characterized by high chemical stability, low biodegradability and the ability to bioaccumulate in living organisms and food chains (Jones & de Voogt, 1999; Schwarzenbach, Gschwend, & Imboden, 2016). Due to these characteristics, these substances can persist in the environment for long periods of time and pose a potential risk to aquatic ecosystems and human health.

Organochlorine pesticides have been widely used in agriculture over the past decades for pest control and increased agricultural production. However, many of these compounds have been banned or restricted in many countries due to their toxicity and persistence in the environment (Carson, 1962; Ritter, Solomon, Forget, Stemeroff, & O'Leary, 1995). Although their use has been significantly reduced, residues of organochlorine pesticides continue to be found in soil, sediments, and surface waters as a result of historical use and environmental transport.

Polychlorinated biphenyls (PCBs) represent another important group of persistent organic pollutants. These compounds are widely used in the electrical and electronic industries as dielectric and lubricating fluids in transformers and capacitors, due to their thermal and chemical stability (Breivik, Sweetman, Pacyna, & Jones, 2002). However, due to their persistence and toxicity, PCBs have been identified as hazardous pollutants and are included in the list of persistent organic pollutants regulated by the Stockholm Convention on Persistent Organic Pollutants.

Polycyclic aromatic hydrocarbons (PAHs) are another group of organic pollutants frequently found in the aquatic environment. These compounds are mainly formed during the incomplete combustion processes of organic materials, such as fossil fuels, wood and urban waste (Mastral & Callén, 2000). PAHs can enter surface waters through urban runoff, atmospheric deposition and industrial emissions, contributing to the pollution of aquatic ecosystems.

In Albania, rivers and surface water systems are exposed to various anthropogenic pressures, including agricultural activities, urban development and road transport. The Dimal area is characterized by significant agricultural activity and the presence of settlements that can contribute to the transport of pollutants to local water networks. The streams and drainage channels of this area represent important transport routes for pollutants that can end up in the Osum River, one of the main rivers of the country.

For this reason, monitoring of organic pollutants in these water systems is important to assess the level of pollution and to identify potential sources of contamination. This study aims to determine the presence of organochlorine pesticides, PCBs and PAHs in water samples taken from several streams and drainage channels in the Dimal area that flow into the Osum River, using gas chromatography with FID and ECD

detectors (GC/FID/ECD). The results of this study may contribute to a better understanding of the distribution of persistent organic pollutants in surface waters and serve as a basis for further environmental monitoring.

MATERIALS AND METHODS

Water sampling from Dimal area

Water samples from several streams and drainage channels from the Dimal area were taken at different stations in February 2026. Water samples were taken as follows: for Drenovicë water 3 stations were taken; for Sqepur water 3 stations were taken and for Shajnova water 4 stations were taken. All these waters flow into the Osumi River 1 liter of water was taken at each station according to ISO 5667-14:2016. The sampling map in the Dimal area is given below:

Figure 1. Map of water sampling stations from the Dimal area

Analyze of chlorinated pollutants in water samples

Liquid-liquid extraction was used for the isolation of organochlorine pollutants (pesticides, their residues and PCBs) from water samples. One liter of water and 2 x 40 ml of n-Hexane as extraction solvent were added to a separatory funnel. After extraction, the organic phase was treated with 5 g of anhydrous Na2SO4 to remove water. Florisil open columns were used for the purification of water samples. 20 ml of n-Hexane/Dichloromethane (4/1) was used to elute the columns. After concentration to 1 ml of n-Hexane, the samples were injected into GC/ECD (Lekkas *et al*, 2004; Vryzas *et al*, 2009; Kostantinon *et al*, 2006; Nuro *et al*, 2014; Borshi *et al*, 2016; Murtaj *et al*, 2014). Organochlorine pesticides and PCBs were analyzed simultaneously using Rtx-5 capillary column (30m x 0.25mm x 0.25µm) in a Varian 450 GC gas chromatograph equipped with PTV injector and ECD detector. Helium was used as the carrier gas (1 ml/min) and nitrogen as make-up gas (24 ml/min). Manual injection was done in splitless mode at 300°C. The detected pesticides were: DDT (p,p-DDE, p,p-DDD, p,p-DDT), HCHs (a-, b-, γ- and d-isomers), Heptachlor (Heptachlor and Heptachlorepoxide); Chlordanet (alpha and gamma isomers); Aldrins (Aldrin, Dieldrin, Endrin and their derivatives) and Endosulfans (Endosulfan alfa, Endosulfan beta and Endosulfan sulfate). PCB analysis was based on the determination of seven markers (PCB IUPAC No. 28, 52, 101, 118, 138, 153 and 180). Quantification of pesticides and PCB was based on the external standard method (Nuro *et al*, 2014; Borshi *et al*, 2016; Murtaj *et al*, 2014)

GC/FID determination of PAH in water samples

Two-step liquid-liquid extraction (LLE) was used for the extraction of PAHs from water samples. One liter of water was treated in a separatory funnel first with 40 ml Dichloromethane (first LLE step) and then with 40 ml n-Hexane (second LLE step). After extraction, the organic phase was dried with 5 g of anhydrous Na2SO4 to remove water. Extracts were concentrated in 1 ml n-Hexane using Kuderna-Danish and then injected into GC/FID for qualitative and quantitative analysis of PAH (Stogiannidis and Laane, 2015; Akkanen *et al*, 2005, Nuro *et al*, 2018; Borshi *et al*, 2018). Gas chromatographic analyzes of PAH in water samples were performed with a Varian 450 GC apparatus equipped with a flame ionization detector and a PTV injector. Capillary column VF-1 ms (30m x 0.33mm x 0.25µm) was used for the separation of 13 PAH according to EPA Method 525. Helium was used as carrier gas at 1ml/min. The FID temperature was held at 280°C. Nitrogen was used as carrier gas (24 ml/min). Hydrogen and air were the flame detector gases at 30 ml/min and 300 ml/min, respectively. The EPA 525 standard mixture was used for qualitative and quantitative PAH analysis. Acenaphthylene, Fluorene, Phenanthrene, Anthracene, Pyrene, Benzo [a] anthracene, Chrysene, Perylene, Fluoranthene, Benzo [b] fluoranthene, Indeo [1,2,3-cd] pyrene, Dibenzo [a, b] anthracene and Benzo [g, h, i] perylene were determined in water and sediment samples. PAH quantification is based on the external standard method (Nuro *et al*, 2018; Borshi *et al*, 2018).

RESULTS AND DISCUSSIONS

In this study were evaluated levels of some priority substances (organochlorine pesticides, PCBs and PAHs) in water samples (effluents of Osumi River) of Dimal area which is located in the central Adriatic Sea. Water samples were taken in February 2025, at different stations of surface waters of this area. Organochlorine pesticides, their degradation products and PCB markers were analyzed using the GC/ECD technique while PAH were analyzed by using GC/FID technique. OCP, PCB and PAH compounds are classified as priority substances due to their persistence and toxicity. Monitoring of them in water is important not only for the environment, but also for organisms (including human health).

Organochlorine pesticides

The analysis of organochlorine pesticides (OCPs) in surface waters from the Dimal area revealed a widespread presence of persistent organic pollutants, with total concentrations ranging from 0.558 to 5.211 ppb across sampling stations. The highest contamination was recorded at station WSQ3, indicating a potential local hotspot influenced by agricultural runoff and drainage channels. Among the detected compounds, endosulfan isomers (Endosulfan I, II and sulfate) and heptachlor epoxide were dominant, reflecting both historical use and environmental persistence. The presence of degradation products such as heptachlor epoxide and endosulfan sulfate suggests that these pollutants are not only residues of recent applications but also originate from long-term accumulation in soils and sediments. Similar profiles have been reported in agricultural regions across the Balkans, where organochlorine pesticides persist despite regulatory bans (Ćurčić et al., 2012).

A preliminary ecological risk assessment was performed using hazard quotient (HQ) values, calculated as the ratio between measured concentrations and guideline values (0.1 ppb for individual pesticides, EU standards). Several compounds, including Endosulfan I (HQ > 20), Endrin (HQ > 8) and Heptachlor epoxide (HQ > 9), significantly exceeded acceptable thresholds, indicating a high ecological risk for aquatic organisms. Even when considering total pesticide

concentrations, multiple stations surpassed safe environmental limits, confirming the potential for chronic toxicity effects. These findings are consistent with studies conducted in Albanian river systems, where elevated pesticide levels have been associated with agricultural practices and insufficient wastewater management.

Compared to other regions, the detected concentrations in the Dimal area are higher than those typically reported in Western Europe (<0.05 ppb), but comparable to values observed in developing agricultural zones in Southeastern Europe (0.5–3 ppb) (Loos et al., 2010). The relatively elevated levels, particularly in Sqepur, indicate ongoing diffuse pollution sources and highlight the vulnerability of surface waters receiving untreated agricultural runoff. The absence of DDT and its metabolites suggests that legacy contamination from this compound has diminished, while the persistence of other OCPs reflects their longer environmental half-lives.

Overall, the results demonstrate that organochlorine pesticides remain a significant environmental concern in the studied area, with clear evidence of both historical contamination and ongoing inputs. Continuous monitoring and the implementation of sustainable agricultural practices are therefore essential to reduce the environmental impact and protect aquatic ecosystems.

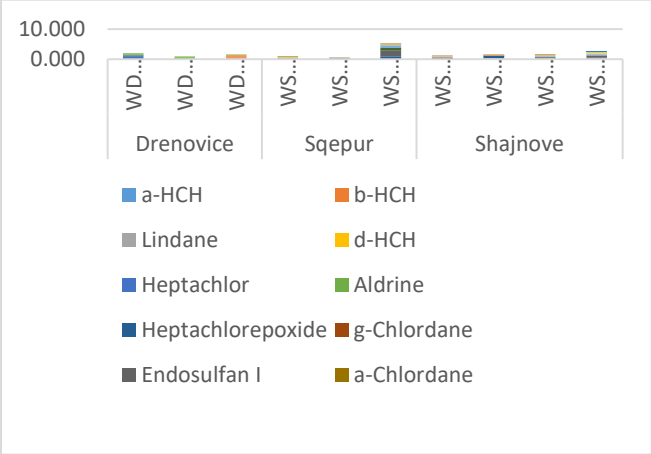

Figure 2. Total of pesticides in water samples of Dimal area

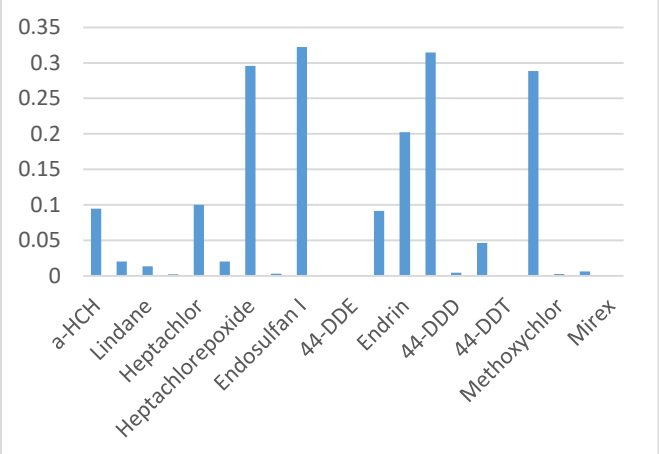

Figure 3. Profile of pesticides in water samples of Dimal area

Polychlorinated biphenyls

The analysis of polychlorinated biphenyls (PCBs) in surface waters from the Dimal area revealed their widespread presence, with total concentrations ranging from 1.083 to 3.473 ppb. The highest concentration was observed at station WSH1 (3.473 ppb), indicating a potential contamination hotspot, likely influenced by urban discharges and historical industrial inputs. Among the analyzed congeners, PCB 28 and PCB 52 were the dominant compounds, with average concentrations of 1.294 ppb and 0.601 ppb, respectively. These lower chlorinated congeners are generally more mobile and soluble in water, suggesting relatively recent inputs or remobilization from contaminated sediments.

Higher chlorinated congeners such as PCB 138, PCB 153 and PCB 180 were either absent or detected at very low levels, indicating limited accumulation of heavier PCBs in the aqueous phase. This distribution pattern is consistent with environmental behavior reported in river systems, where lighter PCBs dominate the dissolved fraction, while heavier congeners tend to bind to sediments (Zhang et al., 2015).

A preliminary ecological risk assessment was conducted using the hazard quotient (HQ), considering a guideline value of 0.01 ppb for individual PCBs (EU Environmental Quality Standards). The calculated HQ values for PCB 28 and PCB 52 exceeded 100 in several sampling points, indicating a very high ecological risk**.** Even total PCB concentrations in all stations significantly exceeded recommended limits, suggesting potential chronic toxicity for aquatic organisms. These findings are consistent with studies conducted in Albanian and Balkan rivers, where PCB contamination remains a concern due to legacy pollution and improper waste management (Cullaj et al., 2005; Ćurčić et al., 2012).

Spatially, the highest PCB levels were observed in Shajnove and Sqepur stations, indicating the influence of anthropogenic activities such as urban runoff, agricultural drainage and possible illegal waste disposal. In contrast, Drenovice showed slightly lower but still significant concentrations, suggesting diffuse pollution sources.

Compared to other regions, PCB concentrations in the Dimal area are significantly higher than those typically reported in Western Europe, where levels are usually below 0.01–0.05 ppb (Loos et al., 2010). However, they are comparable to concentrations reported in polluted river systems in Eastern and Southeastern Europe, where legacy contamination persists.

Overall, the results indicate that PCBs remain an important environmental concern in the studied area. Their persistence, toxicity and bioaccumulative nature highlight the need for continuous monitoring and remediation strategies to reduce their impact on aquatic ecosystems.

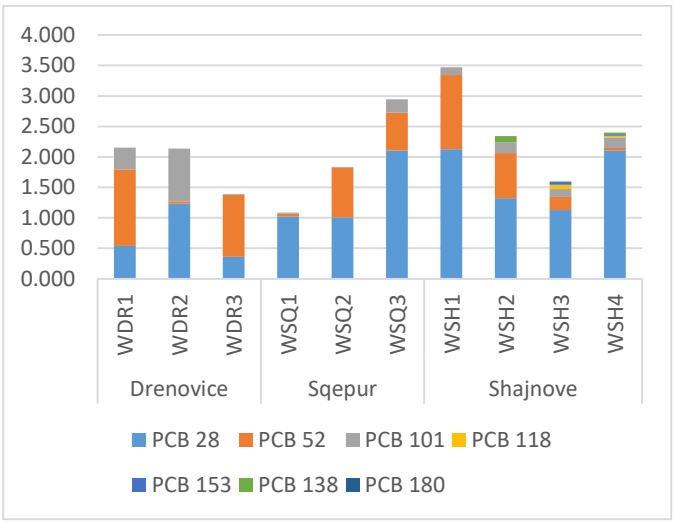

Figure 4. Total of PCB in water samples of Dimal area

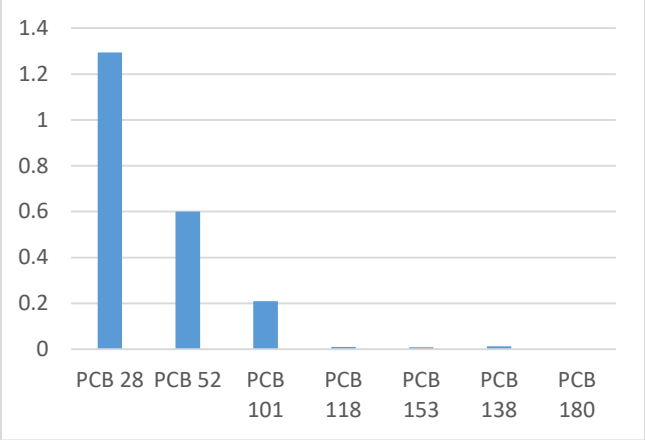

Figure 5. Profile of PCB in water samples of Dimal area

Polycyclic aromatic hydrocarbons

The analysis of polycyclic aromatic hydrocarbons (PAHs) in surface water samples from the Dimal area revealed a heterogeneous distribution, with total concentrations ranging from 0.141 to 1.234 ppb. The highest concentration was recorded at station WSQ3 (1.234 ppb), suggesting a localized pollution source, likely associated with anthropogenic activities such as fuel combustion, agricultural burning and urban runoff. Among the detected compounds, Benzo[a]anthracene (mean: 0.100 ppb), Pyrene (0.083 ppb) and Acenaphthylene (0.059 ppb) were the dominant PAHs, indicating mixed pyrogenic and petrogenic origins.

Lower molecular weight PAHs such as fluorene and acenaphthylene were more frequently detected across sampling stations, reflecting their higher solubility and mobility in aquatic environments. In contrast, high molecular weight PAHs (e.g., Benzo[k]fluoranthene and Dibenzo[a,h]anthracene) were absent or below detection limits, suggesting limited persistence in the dissolved phase and a tendency to associate with sediments. This pattern is consistent with previous studies on PAH behavior in river systems (Yunker et al., 2002).

A preliminary ecological risk assessment was conducted using hazard quotient (HQ) values based on European environmental quality standards (EQS). For several individual PAHs, particularly Benzo[a]anthracene and Pyrene, HQ values exceeded 1 in multiple sampling sites, indicating moderate to high ecological risk**.** The cumulative PAH concentrations at WSQ3 and WSQ2 also suggest potential chronic exposure risks for aquatic organisms.

Spatial distribution analysis indicates that Sqepur and Shajnove stations exhibit higher PAH contamination compared to Drenovice, likely due to increased human activity, including traffic emissions, domestic heating and agricultural practices. The presence of compounds such as Indeno[1,2,3-cd]pyrene and Benzo[b]fluoranthene further supports a combustion-related origin of contamination.

When compared to other regions, PAH concentrations in the Dimal area are higher than those typically reported in unpolluted European rivers (<0.1 ppb), but are comparable to moderately polluted rivers in the Balkans and Eastern Europe (Maliszewska-Kordybach, 1996; Stogiannidis & Laane, 2015). Studies in Albanian river systems have also reported similar contamination patterns, mainly linked to diffuse anthropogenic sources (Cullaj et al., 2005).

Overall, the results indicate that PAHs represent a significant environmental concern in the study area. Their distribution reflects ongoing anthropogenic pressure, and their potential toxicity underscores the need for continuous monitoring and implementation of pollution control measures.

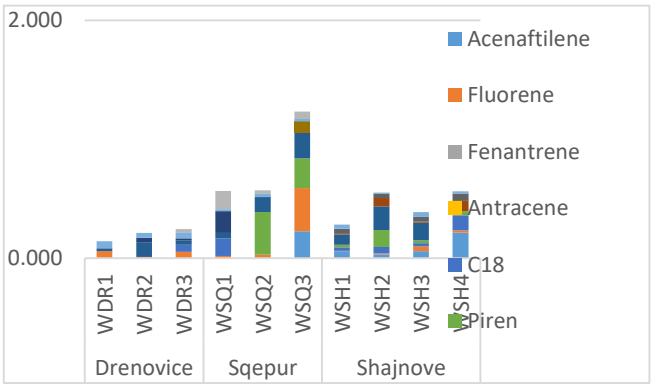

Figure 6. Total of PAH in water samples of Dimal area

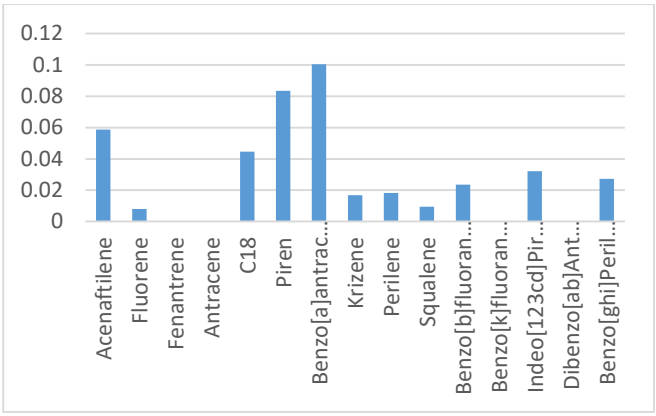

Figure 7. Profile of PAH in water samples of Dimal area

CONCLUSIONS

The present study provides a comprehensive assessment of organic pollutant contamination in surface waters of the Dimal area, focusing on polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and pesticides. The results clearly demonstrate that all three groups of contaminants are present in measurable concentrations, reflecting the significant influence of anthropogenic activities on water quality in the region.

PCBs were found to be the most critical group of pollutants, with total concentrations reaching up to 3.473 ppb. The dominance of lower chlorinated congeners (PCB 28 and PCB 52) suggests relatively recent inputs and highlights the role of ongoing diffuse pollution sources. The calculated hazard quotient (HQ) values indicate a very high ecological risk, particularly in stations such as Shajnove and Sqepur, where contamination levels were highest. These findings confirm that legacy pollutants such as PCBs remain a persistent environmental issue in the study area.

PAHs were also widely detected, with total concentrations up to 1.234 ppb. Their distribution pattern suggests mixed pyrogenic and petrogenic origins, associated with combustion processes, traffic emissions and agricultural activities. Although PAH concentrations were generally lower than PCBs, the ecological risk assessment indicates moderate to high risk in several sampling locations, particularly where higher molecular weight compounds were present.

Pesticide residues further contribute to the overall pollution profile, reflecting intensive agricultural practices in the area. The combined presence of these contaminants indicates cumulative environmental pressure and potential synergistic effects on aquatic ecosystems, which may not be fully captured by individual compound assessments.

Spatial analysis revealed that stations located in Sqepur and Shajnove consistently exhibited higher contamination levels compared to Drenovice, emphasizing the impact of human activities such as urban discharge, agricultural runoff and improper waste management. These patterns are consistent with findings reported in other river systems in Albania and the Balkan region, where diffuse and legacy pollution sources continue to affect water quality.

Compared to European environmental quality standards, the detected concentrations of PCBs and, in some cases, PAHs exceed recommended limits, indicating that the studied waters may pose risks to aquatic organisms and potentially to human health through bioaccumulation and trophic transfer.

In conclusion, this study highlights the urgent need for continuous environmental monitoring, stricter regulatory enforcement and the implementation of effective pollution mitigation strategies in the Dimal area. Future research should focus on sediment analysis, seasonal variation and advanced risk assessment approaches to better understand the long-term impact of these contaminants. Additionally, integrated management strategies are essential to reduce pollutant inputs and protect the ecological integrity of the Osum River system.

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