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Analysis of Organochlorine Pesticides using Gas Chromatography and Mass Spectrophotometer show an elevated pollution rate in Albanian soils

Tafa, Armela and Kertusha, Iva
College of Engineering and Technology, The American University of the Middle East, Kuwait.

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Corresponding Author:
armelatafa@yahoo.com

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ABSTRACT

Organochlorine pesticides (OCPs), also known as DDTs and Chlorinated Cyclodienes, are extensively used in agricultural settings for pest, weed, and ant control, leading to widespread concerns about water, air, and soil pollution. This study focuses on evaluating the concentrations of DDTs and Chlorinated Cyclodienes in nine soil samples collected from agricultural farms in Durres city, Albania. The soil samples were extracted using a Soxhlet apparatus, followed by column chromatography purification, and quantified using Gas Chromatography-Mass Spectrophotometry (GC-MS). The results revealed significant contamination of the soil samples with organochlorine pesticides, underscoring the environmental risks and potential threats to human health. It is important to note that this study solely pertains to Durres city and its agricultural lands, and the findings should not be generalized to all soils in Albania. The identification of pesticide pollution in these specific soil samples highlights the urgent need for mitigation strategies and reduced pesticide usage in the area. This pioneering research provides crucial insights into the levels of DDTs and Chlorinated Cyclodienes in agricultural farms within Durres city, fostering a foundation for sustainable farming practices and environmental preservation.

Introduction

Pesticides are chemical substances used in agriculture to protect crops from various pests, such as fungi, bacteria, mites, aphids, fruit worms, beetles, leafhoppers, moth larvae, and whiteflies. (Nicolopoulou-Stamati et al., 2016) Pesticides are divided into five main categories, named as: Fungicides, Insecticides, Bactericides, Rodenticides, and Herbicides. The objective of this study is to assess the concentration of Organochlorine pesticides (OCPs) and two of their subclasses, dichlorophenylethane, and chlorinated cyclodienes. The analyzed compounds include DDTs, aldrin, dieldrin, endrin, chlordane, endosulfan, and heptachlor. DDTs were first synthesized in the late 1870s and were used as a malaria vector control during World War II. (Nicolopoulou-Stamati et al., 2016). They have a significant impact on flora and fauna and can easily accumulate in marine sediment, soil, and fatty tissues (Mirmigkou et al., 2015). The United States of America banned the use of DDTs for any purpose in the 1970s due to their harmful effects on the environment and human health. (Mirmigkou et al., 2015). Chlorinated cyclodienes, on the other hand, are applied as insecticides in agricultural farms to control pests such as flies, mites, and ants. They have low volatility, chemical stability, and a slow rate of degradation, and can bioaccumulate in marine sediment and soil (Qu et al., 2017). Some of the chlorinated cyclodienes are used as insecticides to control pests and protect crops. Aldrin is one such chemical, used to control termites, corn, and rice pests, as well as to protect crops and wood from termites. However, due to its high persistence in the environment, it has been banned in many countries (Anonymous n.d.). Another insecticide, Dieldrin, has been used to control pests in corn, cotton, and citrus crops, but it was banned by the US Environmental Agency in 1987 due to its toxicity and persistence in the environment (Honeycutt et al., 2014). Endrin is also used as an insecticide for crop protection and can be removed from the environment mainly through rainout and dry deposition (Blaylock et al., 2005). Chlordane trans and Chlordane cis are two types of insecticides used to control pests in agricultural areas. They are very persistent in the environment, and their use has been banned in the US, EU, and many other countries worldwide since 1998 (Koshlukova et al., 2014). Endosulfan sulfate is another insecticide used to control various insects such as whiteflies, ants, and cabbage worms in crops like coffee, tea, and cotton. This chemical exists in alpha and beta isomers, which can be metabolized into Endosulfan sulfate and Endosulfan diol (Berntssen et al., 2017). Finally, Heptachlor Epoxide Trans is another pesticide used to control pests in agricultural crops. In 1988 due to its toxicity and persistence in the environment, its use was banned as well. (Blaylock et al., 2005).

The Stockholm Convention is a significant international agreement aimed at safeguarding human health and the environment by reducing or prohibiting the production of Persistent Organic Pollutants (POPs). This legally binding instrument was signed by 152 participating states in May 2004, with the purpose of banning the production of harmful chemicals like Aldrin, Dieldrin, Chlordane, DDTs, Endrin, Heptachlor, and Mirex. (Filder et al., 2008) The Convention allows the production of DDT and its metabolites for medicinal purposes, particularly for controlling disease vectors. However, stringent safety measures must be followed during the production process. (United Nations., n.d.).

Pesticides ''Hot Spot'': Porto Romano Enterprise - Pesticides 'Hot Spot': The Porto Romano Enterprise is located 7km from Durres city and is known as a pesticides 'hot spot' in Albania (Tafa et al., 2021). This area is highly contaminated due to the presence of former Chemical Enterprise that was active during the communist era in Albania, producing pesticides for agricultural purposes or leather treatment. After communism, the production of pesticides stopped, and the enterprise remained closed with tons of waste, causing the area to become one of the most dangerous in terms of soil, water, and air pollution (Borshi et al., 2016). The outcome of this study is of an elevated interest for the inhabitants of Durres city and governmental institutions due to the presence of this former chemical enterprise. Nevertheless, this study would provide with further recommendations on pesticides safe handling and how to reduce their effects in the environment and human health.

1.3 Impact of pesticides in Human Health and Environment: According to (Kaur et al., 2019), the global annual usage of pesticides is estimated at 5.2 billion pounds. In 2018, Albania recorded a usage of 442 thousand kilograms of pesticides, which represents a 30% increase from 1991 to 2018 (FAOSTAT., n.d.). In the USA, approximately 545 million kilograms of pesticides are used annually, with 20% for insecticides, 68% for herbicides, and 12% for fungicides for pest control. Aerial application accounts for 50% of pesticide usage, with only a small fraction (0.003%) of the applied pesticides reaching their intended targets, while the rest contaminates soil, water, and air (Pimentel et al., 2012). Soil pollution caused by pesticides is a significant concern. When absorbed by soil particles, pesticides can contaminate organic matter, affecting pH, salinity, alkalinity, and reducing soil fertility (Arora et al., 2016). The indiscriminate use of pesticides can also destroy soil microorganisms, such as microbes and earthworms, and damage flora and fauna, ultimately threatening different processes driven by soil microorganisms and affecting soil fertility (Aktar et al., 2009). Pesticides can bioaccumulate in plant tissues and food chains due to their lipophilicity, with OCPs being a significant culprit (Yohannes et al., 2014). The impact of pesticides on the environment ranges from minor pollution to ecosystem loss of species diversity (Yadav et al., 2017). Human exposure to pesticides can cause acute and chronic toxicity, with symptoms ranging from vomiting, nausea, fatigue, flu-like symptoms, and convulsions for acute toxicity to cancer, kidney failure, infertility, liver diseases, and neurological problems for chronic toxicity (Awasthi et al., 2019; Damalas et al., 2016). The focus of this study is to determine the concentrations and levels of DDTs and chlorinated cyclodienes in agricultural lands in Durres city and to evaluate the degree of soil pollution caused by pesticides. Through a comprehensive analysis of soil samples, we aim to not only assess the current contamination levels but also understand the potential ecological and health implications associated with pesticide pollution in Durres city's agricultural lands. The study also aims to provide recommendations for reducing pesticide usage in the studied areas. By offering practical recommendations for reducing pesticide usage, our study seeks to promote a holistic approach to farming that balances productivity and environmental stewardship, ensuring the long-term health and viability of the agricultural ecosystem in Durres city. The findings of this study will contribute to the existing body of knowledge on pesticide pollution in agricultural environments, providing valuable data for future research and facilitating evidence-based decision-making in pesticide management and agricultural sustainability.

Methodology

Study Area and Sampling

Durres, renowned for having the highest number of certified organic farms in Albania according to the Institute of Organic Agriculture (IOA), served as the ideal location for collecting soil samples in this study. A total of nine stations, corresponding to nine agricultural farms within Durres city, were selected for sampling purposes. The samples were carefully collected from a depth of 7 ± 2 cm beneath the ground surface, utilizing a spatula to ensure accuracy. To ensure the purity of the samples, any traces of manure and leaves were meticulously removed before placing them in glass containers. The sampling process took place in September 2019, immediately after the farmers had harvested their agricultural products in August, and approximately two weeks after the first rainfall occurrence. These specific collection procedures were implemented to capture the most representative and up-to-date data on the soil composition and pesticide levels in the Durres agricultural region.

Reagents and Materials:

Target pesticides, Aldrin, Dieldrin, Endrin, Chlordane trans, Chlordane cis, Endosulfan sulphate, α-Endosulfan, β-Endosulfan, Heptachlor Epoxide trans, Heptachlor Epoxide cis and DDTs (2.4-DDT, 4,4'-DDT, 2.4-DDD, 4.4-DDD, 2,4'-DDE, 4.4'-DDE)), where purchased at a local store in Tirana, Albania. They are used as comparison means for their quantification in the GC-MS. Hexane reagent grade (puriss <99%, analytical grade) was purchased by Sigma Aldrich.

Experimental Procedure

The soil samples underwent a meticulous preparation process to ensure accurate analysis. To achieve this, the samples were combined with anhydrous sodium sulphate (Na2SO4) at a ratio of 1:3. Extraction was carried out using a state-of-the-art Soxhlet apparatus, employing hexane as the solvent of choice. Precisely 10 grams of soil were carefully transferred onto the thimble filter and subjected to a 24-hour extraction process. To eliminate any dissolved sulphur impurities, the extract underwent a thorough treatment with activated copper.

Next, sample purification was conducted utilizing a pre-packed column chromatography with silica gel. The extract was expertly eluted with an additional 50 mL of hexane, with a controlled flow rate of 1.5 ml per minute. In the final step, the sample was preconcentrated to a volume of 1ml using a highly efficient rotatory evaporator. This concentrated sample was then skill fully injected into the Gas Chromatography-Mass Spectrophotometer (GC-MS) for further analysis This meticulous process of sample preparation ensures the removal of unwanted impurities and enhances the accuracy and reliability of the subsequent GC-MS analysis.

Experimental setup and Chromatography

Pesticides were quantified using a gas chromatograph (GC, Gas Chromatograph 7890A) coupled to a mass spectrometer (MS, Quadrupole Mass Spectrometer, 5979C, inert with XL EI/CI MSD with triple Axis Detector), both form Agilent Technologies. A 1 µL volume was injected by a GC PAL autosampler (CTC, Switzerland) into a spilt/splitless injector equipped with a splitless liner (5 mm inner diameter x 105 mm length, Thermo Fisher Scientific, Germany) at a temperature of 250 °C. The injector was operated in splitless mode, with a purge flow to split vent at 16mL/min. Separation of analytes was accomplished at a constant helium flow rate of 1.4 mL min^{-1} (corresponding to 34.5 cm s^{-1} linear flow velocity) and a pressure that corresponds 1.0241 bar. Pesticides were separated using and RTX-5 column (30m x 0.25 mm x 0.25 µm) with fused silica. The initial oven temperature was 60°C and maintained constant for two minutes. Then it was increased with 7°C/min till 220°C and was maintained constant for 3 minutes. Then the temperature was increased with 5°C /min till 270°C and maintained constant for one minute followed by an increase of 10°C until it reached 300°C and here maintained constant for 10 minutes. Initial injector temperature was 280°C. The calibration of the apparatus itself was done using standard solutions from the Environmental Protection Agency, EPA 8081 standard solution, with the calibration levels 0.05 μgL^{-1}, 0.1 μgL^{-1}, and 0.25 μgL^{-1}. These standard solutions served a quality control measure of the instrument performance (Tafa et al., 2020).

Quality Assurance and Control.

At each designated station, meticulous efforts were made to collect soil samples in a highly rigorous manner. The collection procedure involved obtaining triplicate samples, with the added precaution of duplicating two of these samples for the purpose of conducting control experiments. These control samples served as a vital reference point for comparison and validation.Measurements performed by the Gas Chromatography-Mass Spectrophotometer (GC-MS) were executed in triplicate, ensuring reliable and consistent data acquisition. To establish a baseline measurement, hexane of analytical grade was utilized as a blank sample. It is noteworthy that no traces of pollution were detected in the blank sample, indicating the absence of any interfering contaminants. The control experiments were conducted with utmost care, and their results exhibited no significant deviations when compared to the other soil samples. This outcome underscores the reliability and consistency of the overall experimental procedure. To establish the calibration curves, a comprehensive set of measurements was conducted in triplicate, allowing for robust statistical analysis. The correlation factor, denoted by R2, was determined to have an average value of 0.9976, indicative of a high degree of correlation and precision. Furthermore, the analytical sensitivity of our targeted analytes was assessed, revealing a lowest limit of quantification of 0.01 µg/Kg. This value serves as a crucial threshold, defining the minimum concentration at which our analytes of interest can be reliably and accurately detected and quantified.

Results and discussions

Statistical Methods.

To investigate potential variations in pesticide residue concentrations across different sites and geographical distances, a robust statistical analysis method known as one-way analysis of variance (ANOVA) was employed. This analysis aimed to ascertain whether there exist statistically significant differences in the measured concentrations. The statistical significance test was conducted with a high level of confidence, employing a 95% confidence level ($p<0.05$). This stringent threshold ensures that any observed differences between the concentrations of pesticide residues are not due to random chance, but rather reflect genuine disparities among the sampled sites and geographical distances. By employing ANOVA and adhering to a rigorous confidence level, we are able to draw meaningful conclusions about the statistical significance of the observed variations in pesticide residue concentrations. This analysis provides valuable insights into the potential spatial heterogeneity of pesticide pollution, contributing to a comprehensive understanding of the environmental impacts and distribution patterns of these harmful substances.

Results Representation of the DDTs

This section focuses on the presence of DDTs and chlorinated cyclodienes in soil samples. Figure 5 shows that DDTs are present in all soil samples, except for 2.4' – DDT which was not detected in station 3. The highest concentration of DDTs was detected in sample 9, with a mean concentration of 1.73 ± 0.58 µg/Kg. 4.4’ – DDTs were detected in all soil samples, with the highest concentration found in Station 3 (C = 8.85 µg/Kg) and the lowest in station 1 (C = 0.57 µg / Kg). The total sites, SD± SEM is registered to be 3.31 ± 1.10 µg/Kg. Both 2.4' – DDD and 4.4' – DDD were found in all soil samples, with the highest concentration of 2.4' – DDD detected in station 9 (C = 9.87 µg/Kg) and the lowest in station 4 (C= 0.3 µg/ Kg), with a mean concentration of 3.03 ± 1.01 µg/Kg. For 4.4' – DDD, the highest concentration was detected in station 6 (C = 6.68 µg / Kg) and the lowest in station 1 (C = 0.33 µg / Kg). The total sites, SD ± SEM was registered to be 2.10±0.70 µg/Kg. Finally, 2.4' – DDE was detected in all soil samples, with the highest concentration detected in station 8 (C = 10.83 µg / Kg) and the lowest in station 4 (C = 0.13 µg/ Kg). The total sites, SD ± SEM was registered to be 4.08 ± 1.36 µg/ Kg.

All stations show the presence of 4.4'-DDE, with the highest concentration detected in station 6 (C = 10.42 µg/Kg) and the lowest in station 4 (C = 0.1 µg/Kg). The highest concentration of DDTs is observed in station 6, with an SD ± SEM of 3.17 ± 1.06 µg/Kg, while the lowest concentration is found in station 4. The concentrations of DDTs do not show significant differences among the stations, as indicated by a $p > 0.05$ from the one-way ANOVA method. The stations can be ranked in decreasing order of concentration as follows: Station 6 > Station 9 > Station 8 > Station 2 > Station 3 > Station 1 > Station 5 > Station 7 > Station 4.

Comparison between DDTs concentrations detected and Standard Values

We compared the concentrations of DDTs in soil samples with Maximum Residue Limits (MRL) concentration of DDT, which is 0.015 mg/kg according to the guidelines published by Alberta Environmental Institution Agency in 2010 (Alberta Environmental Institution Agency, 2010). After converting it into the unit used in this article, which is µg/Kg, the MRL value equals 15 µg/Kg. Figure 2 graphically represents all the detected concentrations of DDTs in all stations, along with the minimum and maximum values, and the blue line at 15, which represents the MRL level. Our analysis indicates that the detected concentrations of DDTs in our soil samples are lower than the MRL values. By comparing the MRL values with the maximum concentrations in all soil samples, we conclude that the DDT concentrations are lower than the MRL values (Alberta Environmental Institution Agency., 2010).

Results Representation of the Chlorinated Cyclodienes.

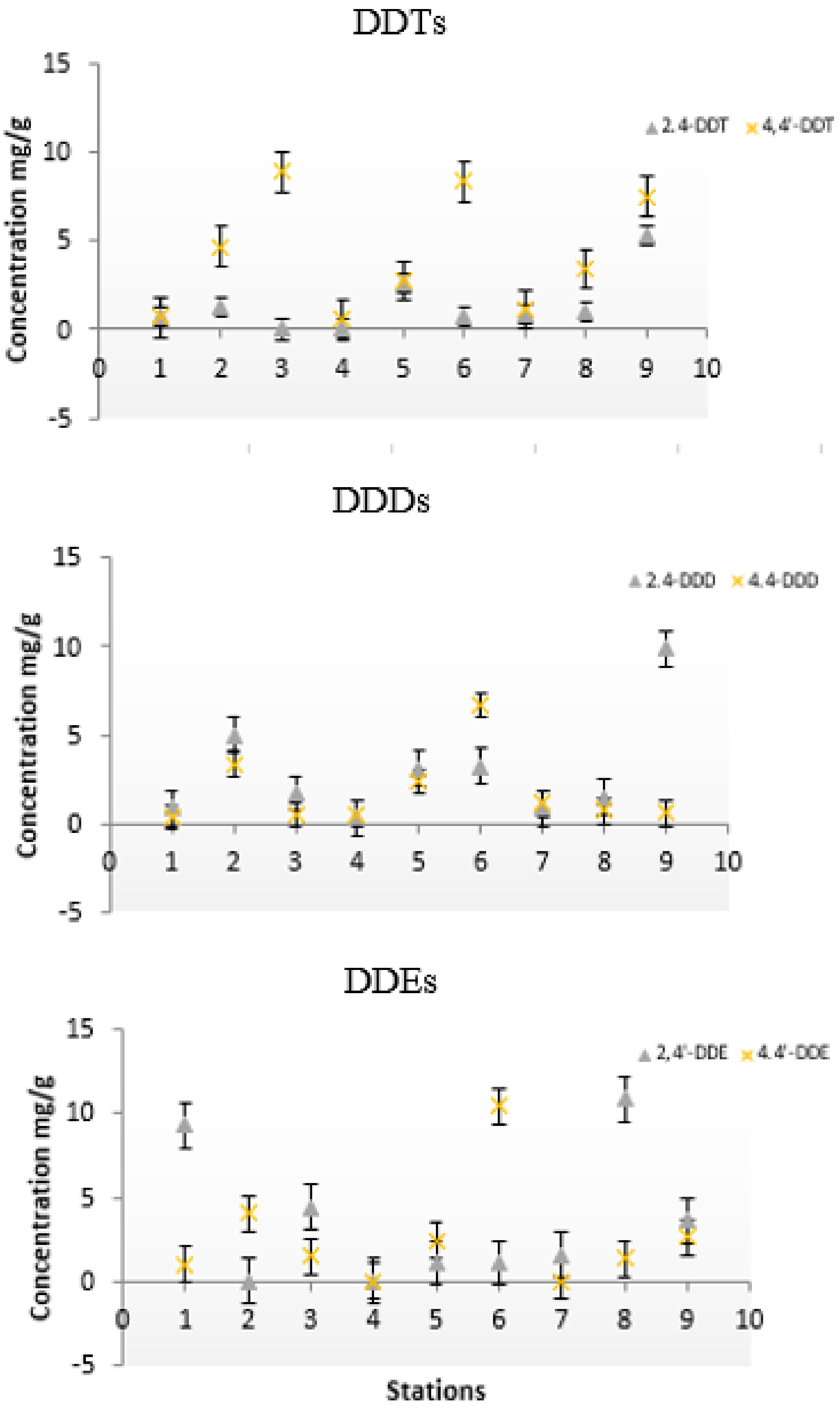

Figure 1. DDTs levels in soil samples

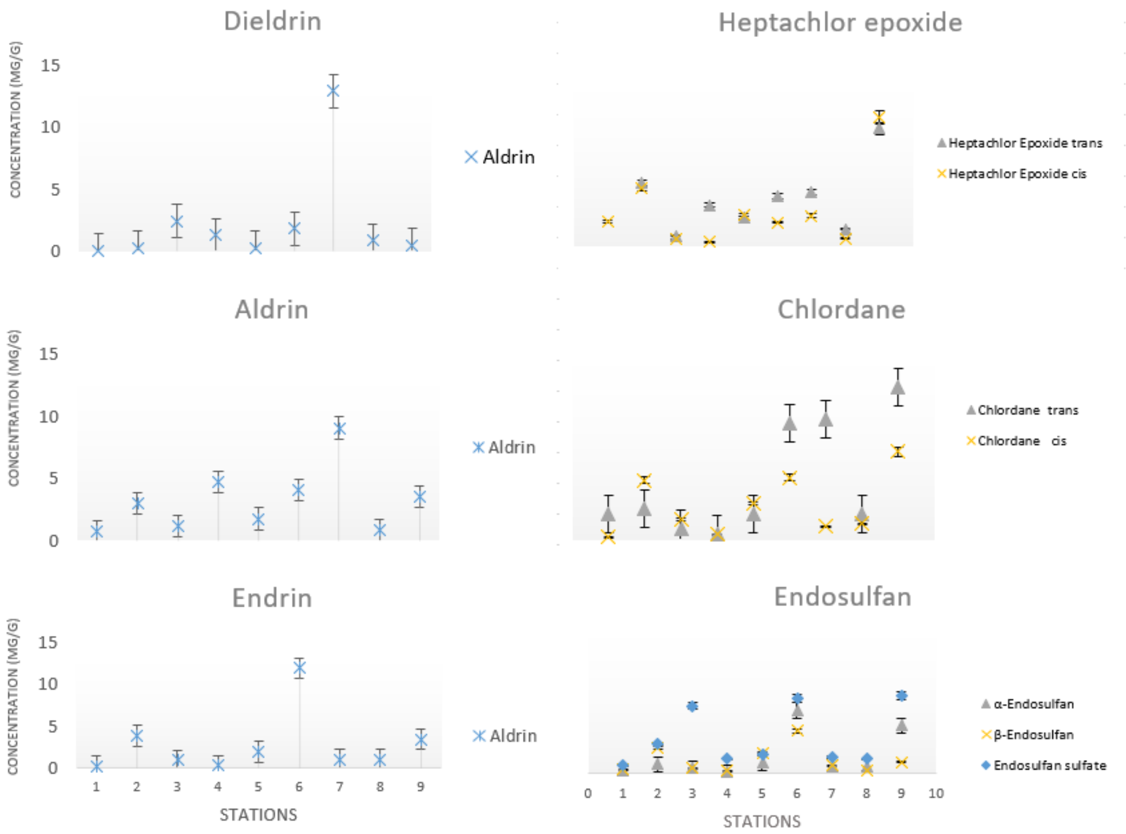

Figure 2 Chlorinated cyclodienes levels in in soil samples

The levels of chlorinated cyclodienes in soil samples are shown in Figure 2. Aldrin was detected in all soil samples, with the highest concentration observed at station 7 (C = 9.03 µg/Kg) and the lowest at station 1 (C = 0.75 µg/Kg). The SD ± SEM for all sites was 2.62 ± 0.87 µg/Kg. Dieldrin had the highest concentration at station 6 (C = 12.88 µg/Kg) and the lowest at station 4 (C = 0.26 µg/Kg), with an SD ± SEM for all sites of 4.16 ± 1.39 µg/Kg. Endrin had the highest concentration at station 6 (C = 11.91 µg/Kg) and the lowest at station 1 (C = 0.19 µg/Kg), with an SD ± SEM for all sites of 3.70 ± 1.23 µg/Kg. Chlordane trans had the highest concentration at station 9 (C = 10.94 µg/Kg) and the lowest at station 4 (C = 0.38 µg/Kg), with an SD ± SEM for all sites of 4.02 ± 1.34 µg/Kg. Chlordane cis had the highest concentration at station 9 (C = 6.34 µg/Kg) and the lowest at station 1 (C = 0.24 µg/Kg), with an SD ± SEM for all sites of 2.14 ± 0.71 µg/Kg. Endosulfan sulfate was detected in all soil samples, with the highest concentration at station 9 (C = 7.19 µg/Kg) and the lowest at station 1 (C = 0.74 µg/Kg), and an SD ± SEM for all sites of 2.65 ± 0.88 µg/Kg. α-Endosulfan had the lowest concentration at station 4 (C = 0.17 µg/Kg) and the highest at station 6 (C = 5.82 µg/Kg), with an SD ± SEM for all sites of 2.04 ± 0.68 µg/Kg. β-Endosulfan had the highest concentration at station 6 (C = 3.96 µg/Kg) and the lowest at station 4 (C = 0.25 µg/Kg), with an SD ± SEM for all sites of 1.25 ± 0.42 µg/Kg. Heptachlor epoxide trans and cis concentrations were also determined. The highest concentration of heptachlor epoxide trans was detected at station 1 (C = 23.12 µg/Kg) and the lowest at station 3 (C = 0.88 µg/Kg), with an SD ± SEM for all sites of 6.89 ± 2.30 µg/Kg. Heptachlor epoxide cis had the highest concentration at station 9 (C = 10.43 µg/Kg) and the lowest at station 4 (C = 0.38 µg/Kg), with an SD ± SEM for all sites of 3.13 ± 1.04 µg/Kg.

Station 6 recorded the highest concentration of Chlorinated Cyclodienes while Station 4 had the lowest concentration. The stations are ranked in decreasing order as follows: Station 9 > Station 6 > Station 1 > Station 2 > Station 7 > Station 5 > Station 3 > Station 4 > Station 8. Based on the one-way ANOVA analysis, we can conclude that there were no significant differences in the pesticide concentrations across the different stations since the p-value was greater than 0.05.

3.5 Comparison between Chlorinated cyclodienes concentrations detected and Standard Values

In the 2017 report titled "EQS limit and guidelines values for contaminated sites" by the European Union and Regulator central Baltic, permissible values for chlorinated cyclodienes were established. This comprehensive report provides a range of permissible values for various pesticides.

Specifically, for Aldrin, Dieldrin, and Endrin, the Maximum Residue Limit (MRL) is registered at 0.005 mg/kg. The concentrations reported in our study surpass the cumulative MRL for these substances. In the case of Heptachlor Epoxide Cis and Trans compounds, the MRL is reported to be 0.6 µg/Kg. By comparing the total sum of Heptachlor Epoxide detected in our study, it becomes evident that these concentrations exceed the MRL.

Regarding Chlordane Trans and cis, Endosulfan sulfate, α-Endosulfan, and β-Endosulfan, the MRL is registered at 0.004 mg/kg, which corresponds to 4 µg/Kg. Comparing the detected values with those indicated in the European Union directive, we can conclude that the concentrations in our soil samples are significantly lower. It is important to note that the European Union directive does not provide specific data for Chlordane. The MRL for Chlordane is outlined in the "Environmental management soil quality standards regulations" issued in 2007 by the state of Tanzania, a signatory of the Stockholm Convention. In this regulation, the upper limit for Chlordane concentration is set at 0.6 mg/Kg. The concentrations detected in our soil samples surpass the values determined in this study (Tanzania., 2007). These comparisons with established regulatory standards and international guidelines highlight the elevated levels of pesticide residues found in our soil samples. Such findings emphasize the importance of further monitoring and implementing effective measures to mitigate the adverse environmental impacts associated with pesticide pollution.

Comparison with other studies

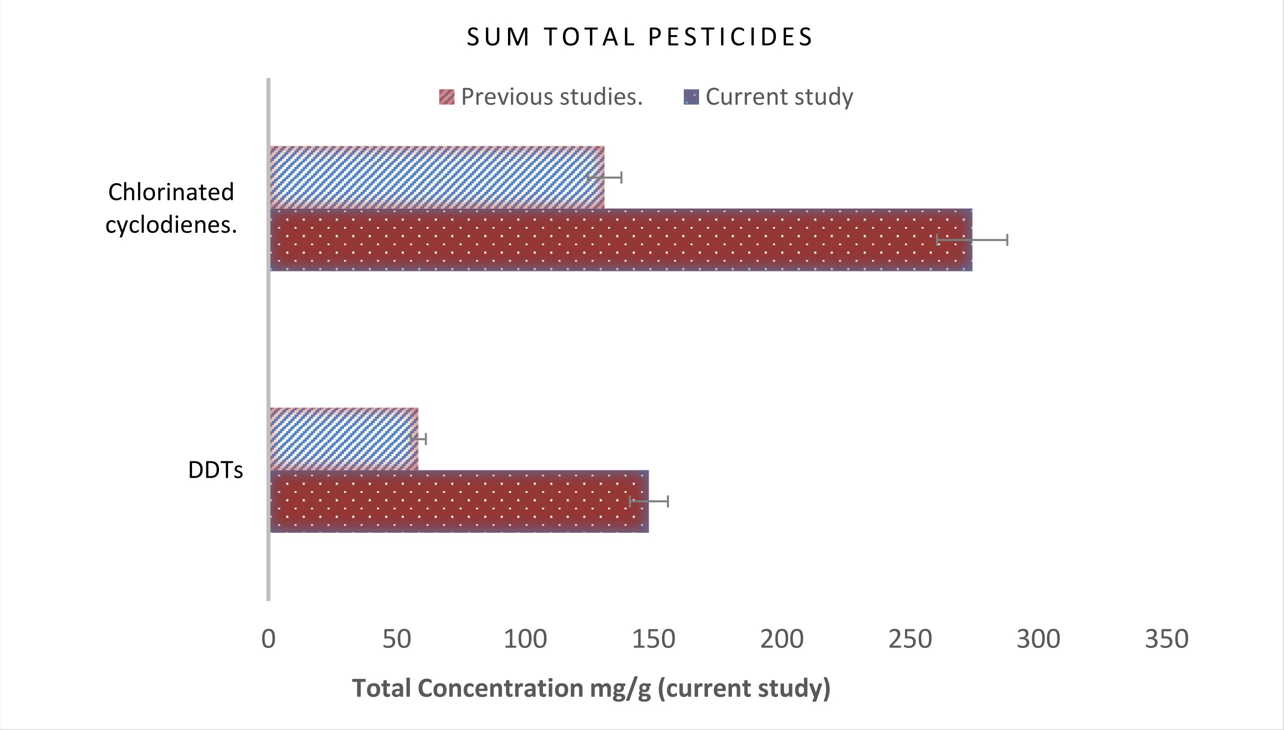

Figure 3 Comparison with other studies

Figure 3 provides a comprehensive comparison between the total pesticide concentrations observed in our soil samples and the findings from previous studies conducted in various regions of Albania. Specifically, we conducted a comparative analysis between Durres city and Lac city (Murtaj et al., 2019) regarding chlorinated cyclodienes, as well as between Durres city and Tirana for DDTs (Mukaj et al., 2016). Upon examining the results depicted in Figure 3, it becomes evident that the concentrations of chlorinated cyclodienes in Durres city surpass those found in Lac city. Additionally, the total concentration of DDTs in Durres city is higher when compared to Tirana. This disparity can be attributed to the continuous agricultural practices taking place in Durres city, which sets it apart from Tirana and Lac city. Consequently, we draw the conclusion that Durres city exhibits a higher degree of soil pollution in comparison to the other two regions. The findings highlight the significant impact of ongoing agricultural activities in Durres city, underscoring the need for effective strategies to mitigate pesticide pollution and safeguard the environmental well-being of the region.

Conclusions and Outlook.

This study offers valuable insights into the extent of soil contamination caused by DDTs and Chlorinated Cyclodienes residues in Albania. Through rigorous analysis, it was revealed that a significant number of pesticides were present in the soil samples, with Heptachlor epoxide Trans being the most commonly detected among the chlorinated Cyclodienes. These findings emphasize the widespread presence of these hazardous substances in the agricultural lands of Albania. The high levels of pesticide contamination observed in Albania can primarily be attributed to the absence of stringent regulations governing the pesticides market. This regulatory gap creates an environment where banned substances can easily be acquired through illicit channels, such as the black market. Consequently, the uncontrolled availability of these pesticides exacerbates the risk of soil pollution and its associated consequences. When comparing the concentrations of chlorinated Cyclodienes detected in this study to the maximum residue limits (MRL) established by various states, it was found that the levels were slightly higher. This indicates that the soil in Durres city is exposed to elevated concentrations of these pollutants, posing potential risks to the environment and human health. On the other hand, the levels of DDTs detected in the soil samples were comparatively lower than the established MRL values, suggesting a relatively lower risk associated with DDT contamination. Importantly, the pesticide levels observed in this study surpassed those found in previous soil studies conducted in other cities across Albania. This disparity can be attributed to two key factors. Firstly, the significant agricultural activity in Durres city, characterized by intensive pesticide usage, contributes to higher pesticide residues in the soil. Secondly, the proximity of the Pesticides enterprise, located in close proximity to the study area, may introduce additional contaminants, further exacerbating soil pollution. These elaborations provide a more comprehensive understanding of the study's findings, shedding light on the extent of soil contamination and the factors contributing to the observed pesticide levels in Durres city. In light of these significant findings, we put forth the following recommendations to effectively address the risks associated with pesticide contamination in Durres city: a) Regular monitoring of pesticides in the study area: Establishing a systematic monitoring program is crucial to minimize the potential for environmental pollution and mitigate associated health hazards. Conducting regular assessments of soil quality and monitoring pesticide residue levels will play a vital role in preserving a healthy and sustainable agricultural ecosystem. b) Conduct future studies on pesticide contamination in agricultural products: It is imperative to conduct comprehensive investigations to evaluate the extent of pesticide residues in crops cultivated on the farms in Durres city. This comprehensive data will provide essential insights into the safety and quality of agricultural produce consumed by the local population. Utilizing this information, informed decisions can be made regarding food safety regulations and the implementation of appropriate mitigation measures. c) Prioritize health monitoring of farmers and residents: The well-being of farmers and residents in the study areas should be given utmost importance. Regular health assessments, including blood tests to detect the presence of pesticides, are necessary to identify and address any potential health risks resulting from prolonged exposure. Early detection of health issues and appropriate medical interventions are vital in minimizing adverse health effects. By embracing these recommended measures, a deeper understanding of the impact of pesticides and pollution in Durres city can be attained. This pioneering study serves as a crucial foundation for assessing agricultural lands in Durres city and is expected to pave the way for future investigations in various agricultural regions across Albania.

Conflict of interest

The authors declare no conflict of interest.

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