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A presumptive and interactive map of PFAS contamination in Greece: a tool for the identification of possible exposure sources

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Abstract Per- and polyfluoroalkyl substances (PFAS) are emerging global contaminants that can have adverse environmental and human health effects. In recent years regulatory authorities have focused on setting stricter environmental limits and implementing precautionary principles. The extent and severity of PFAS contamination in Greece are still little known, despite the widespread occurrence of facilities that release the compounds. An assessment of potential sources of PFAS emission and population exposure in Greece was undertaken and the findings were used to create a presumptive and interactive map using QGIS software. Private and public industrial and governmental facilities including mining and landfill sites, wastewater treatment facilities, military bases, and airports, both on the mainland and on islands, were included. Contamination levels from existing studies in Greece were also mapped. The potential for population exposure was estimated based on the proximity of residence. This useful tool allows stakeholders and communities to rapidly and methodologically recognize possible sources, potential exposure, and public health risk, and can be expanded to incorporate future research.

Keywords: per- and polyfluoroalkyl substances (PFAS)-presumptive map-interactive map-potential sources-contamination levels

1. Introduction

Environmental contamination with per- and polyfluoroalkyl substances (PFAS) has become an important issue in recent years since PFAS can have negative ecological and human health impacts (CDC 2022). Specific forms of PFAS have been associated not only with malfunction of the thyroid and liver but also with multiple kinds of cancer, such as breast and prostate cancer. Additionally, serum PFOA levels have been associated with elevated triglyceride levels (ATSDR 2021). The extent of PFAS contamination has triggered a response in both the global scientific community and regulatory authorities (ECHA 2023, EPA 2023). For example, a proposal prepared by authorities in Denmark, Germany, the Netherlands, Norway, and Sweden (ECHA, 2023), aimed at the restriction of around 10 000 PFAS, was submitted to European Chemicals Agency in 2013.

Little is known in Greece regarding the occurrence of PFAS contamination despite numerous types of facilities that can potentially release the compounds such as landfill sites and wastewater treatment facilities. While some of these sources have previously been identified (Le Monde 2023), others, such as gold and copper mining sites and industrial facilities of plastic products, have not been acknowledged.

The current study aims to create an interactive map of the potential sources of PFAS in Greece through the combination of existing publications in the field and the identification of additional potential and known sites.

2. Methods

An assessment of potential sources of PFAS release and population exposure in Greece was undertaken and the findings were used to create a presumptive and interactive map using QGIS software. The main categories of potential sources included were gold and copper mining sites, landfills, wastewater treatment facilities, military bases, airports, oil industries, and industrial facilities of plastic production, both on the mainland and on islands. Locations of PFAS concentrations identified from previous studies reported in the literature were also mapped.

3. Results and Discussion

Categories of potential PFAS sources are shown in Figure 1.

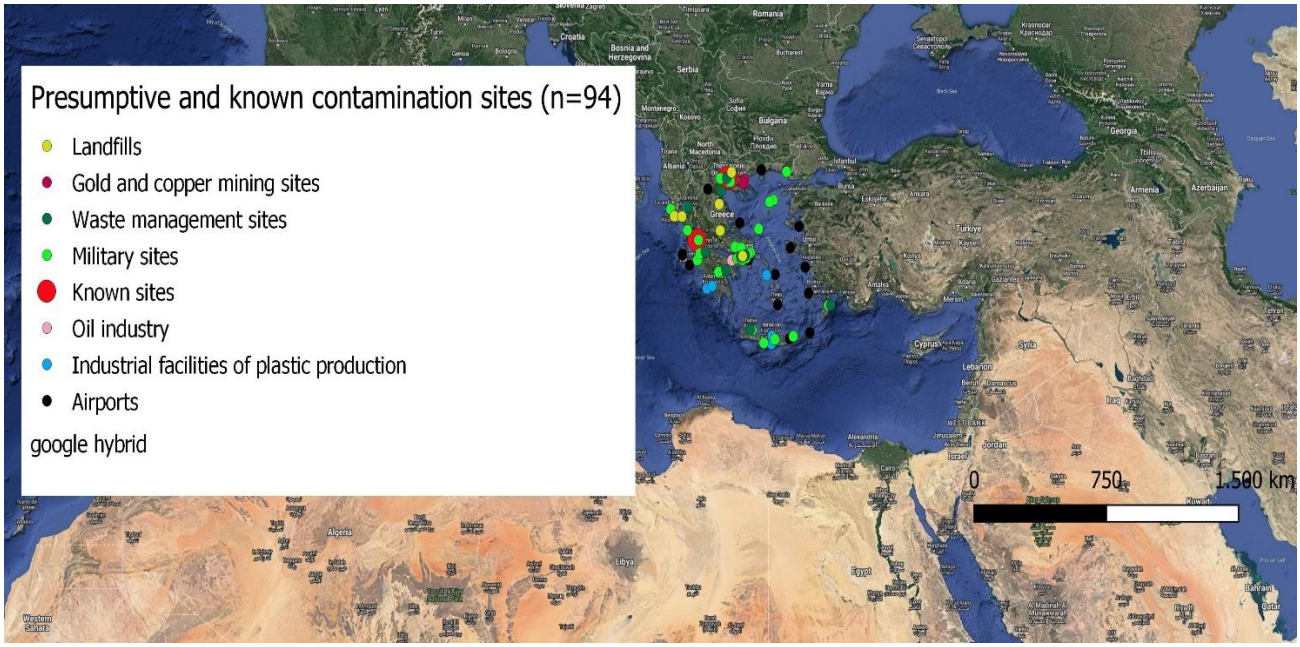

Figure 1. A presumptive and interactive map of PFAS contamination sites in Greece

Gold and copper mining sites, industries of plastic production as potential sources of PFAS in Greece, and sources of PFAS identified in existing studies were mapped for the first time. In total, 24 airports, 2 gold, and copper mining sites, 13 industrial facilities of plastic production, 6 landfill sites, 31 military sites, 3 oil industry facilities, and 12 waste management sites were identified and mapped. Known sources of PFAS in Greece (Besis et al 2019, Anagnostopoulou et al 2022), also mapped, included the wastewater treatment plant of the city of Agrinio, where the concentration of total PFAS was 0.3 ng L^{-1}. In office spaces, coffee shops, restaurants, and public libraries PFAS were also detected. Concentrations, detected in central air conditioning systems, ranged from 0.08 to 650 ng L^{-1}, exceeding the screening level for the combined concentration of PFOA and PFOS in air of 0.07 ng L^{-1} (EGLE, 2019). Based on the proximity of contaminated sources to residential and occupational spaces, there may be potential for population exposure, either through contaminated food and water or inhalation in cases where the contaminants may become airborne.

Presumed contamination sites, including airplane, railway, or car crash sites with fluorinated aqueous film-forming foam use, and firefighting training sites for which information was not publicly available, were not included.

4. Conclusion

This model provides researchers and stakeholders with a useful tool for implementation in an emerging public health-related issue. It can be useful for monitoring and remediation of PFAS-contaminated sites and can provide a rigorous reference and mapping of all main categories of PFAS sources in Greece. Further investigation could include the evaluation of additional categories of potential sources of PFAS contamination such as pharmaceutical industrial facilities and laboratory equipment discharge sites. As contaminated sites continue to be identified, spatial distribution relative to sources could also be mapped.

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