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Lindane Residues in the Water of the Iliki Lake, Greece

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The Iliki lake is located in the Central Greece, near Thebes (Figure 1). The surface of the lake is 22 km^2. Iliki partially supplies Athens with pottable water. During the last years, following a continuous drought, the level of the lake has dramatically fallen. Kopais is an intensively cultivated agricultural area, approximately 25000 Ha, next to the Iliki lake. Cotton, corn, potatoes, carrots, spinach, cabbage, cauliflower and other vegetables are cultivated in the fields of Kopais. Voiotikos Kifisos is a river that runs across the Kopais plain, where pesticides are extensively used, and through a channel discharges into the Iliki lake.

Lindane is the common name for gamma-hexachlorocyclohexane, an insecticide used for the protection of wheat, cotton, corn and beet cultivations against insects. Lindane's approved use in Greece is restricted to seed treatment and soil application 8-months before sowing of potato and 12-months before sowing of carrot cultivations. This restriction in use however has no practical effect since information exists that farmers make improper use of lindane. Lindane is degraded slowly in the environment. Its field half- life is usually well above 100 days (Wauchope et al 1992) depending on many factors e.g. the specific site, the type of the soil and the climate. Lindane migrates slowly in soil, however it has been found in ground, natural and drinking water at very low concentrations (U.S. E.P.A. 1988). In two previous studies (Miliadis 1993, 1994), water samples taken from 13 lakes and 8 rivers throughout Greece were analyzed for pesticide residues and no residues were detected, except for lindane in the Iliki lake. Lindane has also been detected in the water of the Strimon river, in N. Greece (Kilikidis et al. 1992). The aim of this investigation was therefore to determine the levels of lindane or other pesticide residues in the water of the Iliki lake and record its seasonal fluctuations.

MATERIALS AND METHODS

Water samples were taken from Mouriki, a water reservoir next to the Iliki lake, from which the water of Iliki is pumped to the water treatment plants near Athens. Sampling was usually performed on a monthly basis over a period of 2 years, from October 1991 to July 1993. Samples were collected from the surface water, in 2.5-L glass bottles and transferred to the laboratory for analysis, that was normally conducted within 24 hr of collection.

Water samples were extracted with CH_2Cl_2 and cleaned through a celite-activated

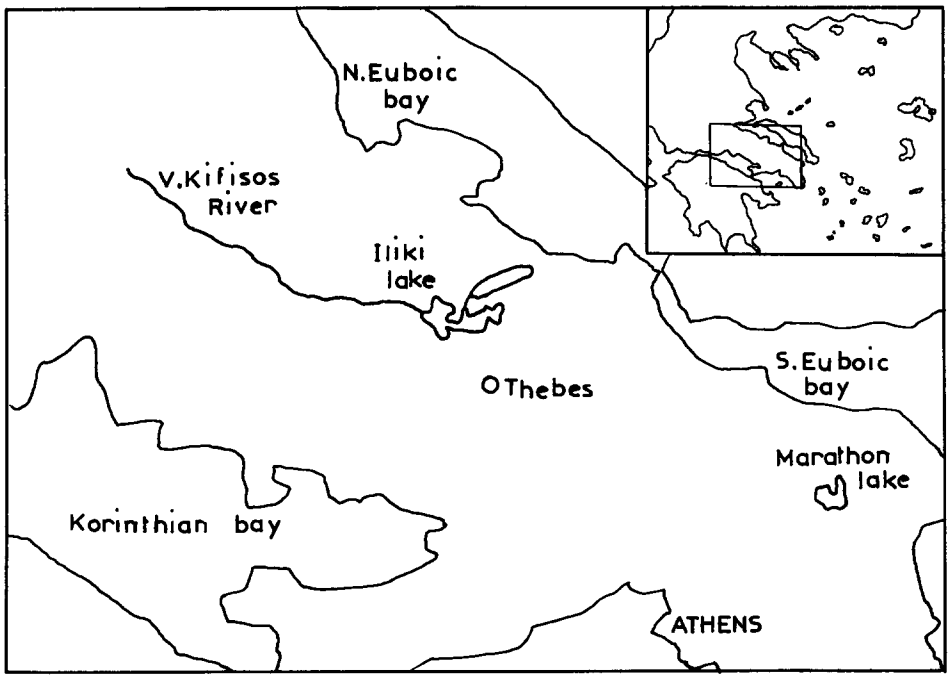

Figure 1. Map of the study area.

charcoal column according to a method previously described (Miliadis 1993). The method is a multiresidue procedure suitable for the determination of approximately 150 pesticides, including lindane.

The extracts were analyzed with a Varian 3700 gas chromatograph equipped with a Ni-63 electron capture detector (ECD) and a nitrogen-phosphorus detector (NPD). 1-μL of the sample extract was injected for analysis in both ECD and NPD. Lindane was detected by the ECD with a glass column containing 1:1 mixture of 10% OV-101 and 15% OV-210 on Chromosorb WHP (80-100 mesh). Quantification of lindane was achieved by measuring the peak height, by the use of a computer integrator. All determinations were conducted in duplicate and the mean values were calculated. Positive identification of lindane in the water samples was performed by additional 1-μL injections on a glass column containing 10% OV-101 connected to the ECD, or a 30 m x 0.25 mm i.d. DB-5 fused-silica capillary column connected to the ECD.

A method blank was analyzed with each sample, since small interfering peaks appeared in the blanks occasionally. The recovery of lindane from fortified water was 84-91% (fortification range: 10-200 ng/L), with a relative standard deviation less than 9%. The detection limit of lindane was 2 ng/L.

RESULTS AND DISCUSSION

Residues of lindane were found in all the samples taken, but no other pesticide residues were detected. Quantification of lindane in samples was made by

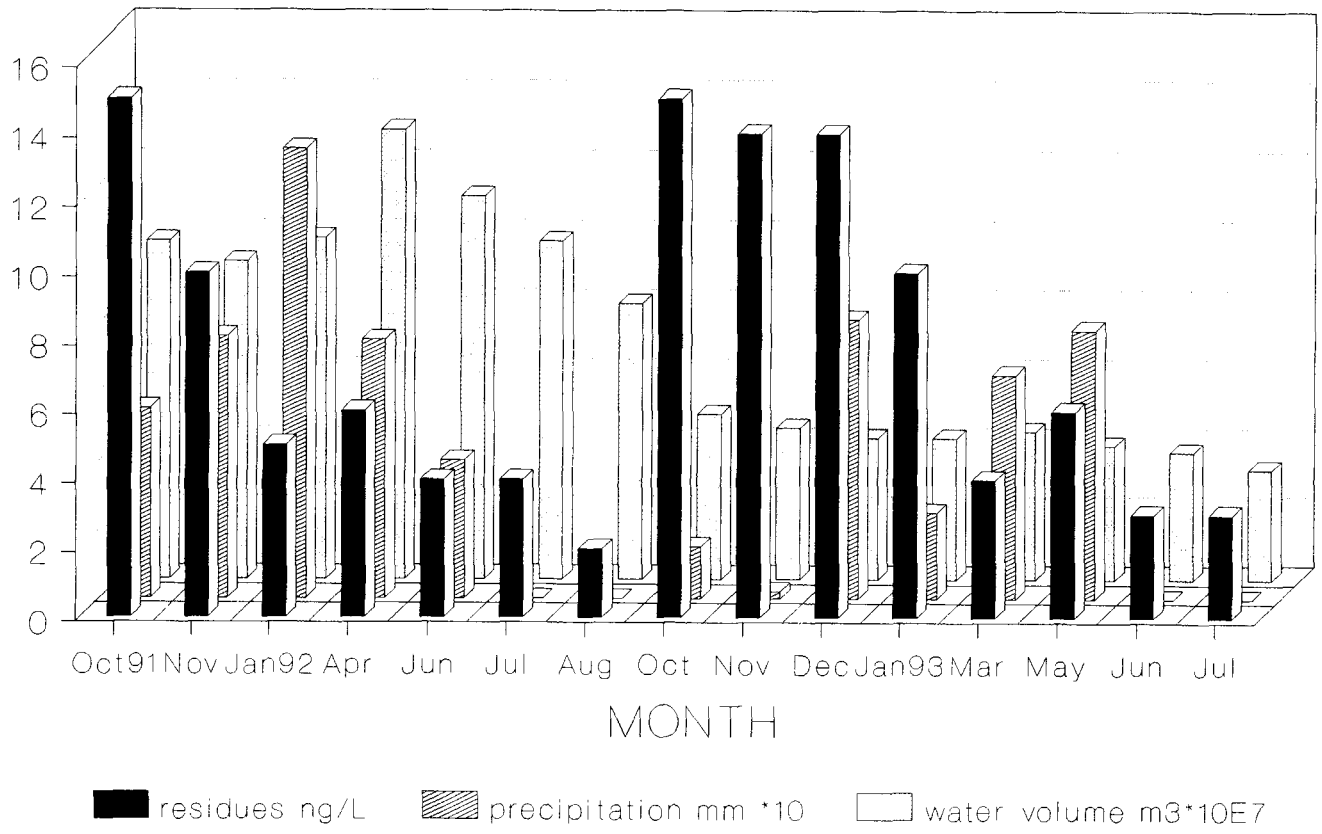

Figure 2: Lindane residues in the water of the Iliki lake

comparing the detector response for the sample to that measured for the calibration standard, within the linear range. The response of the electron capture detector for lindane was linear in the range 0.001-0.02 ng, with correlation coefficient r= 0.994.

The fluctuations of lindane residues (ng/L) detected in the water of the Iliki lake, related to the precipitation (mm x 10) and the water volume of the lake ($m^3 \times 10^7$) are shown in figure 2. As it is seen from this figure, maxima are observed in lindane residues (approx. 15 ng/L) in October 1991 and October 1992. This observation indicates the agricultural origin of the lake's pollution, since lindane is known to be used widely, although improperly, in the Kopais plain during the sowing of potato and carrot cultivations, which occurs every year in late July. This improper use has been reported to result in detecting lindane residues in these agricultural products of the Kopais plain (Aplada-Sarlis et al. 1994). Taking into account the fact that August and September are mostly dry months, lindane is shown to migrate into the lake's water during October. Thereafter, as shown in figure 2, lindane residues decrease gradually untill the summer of the next year, when minima in residues are observed (approx. 3 ng/L). However, as shown from the same figure, this decrease in residues was slower in the winter months of 1992-93 related to 1991-92. This is possibly attributed to the environmental factors that influence the pesticide concentration in water, as the very low precipitation during 1992-93, which resulted in a dramatic drop of the water volume of the lake and therefore in increased concentration of the residues.

The results of this study show that lindane residues in the water of the Iliki lake, although present, remain well below the EEC maximum acceptable concentration of 100 ng/L (E.C. Council Directive 1980). Moreover, Iliki supplies Athens with potable water mainly during the summer months, when the minima in lindane concentrations are observed. However, relying on our results, we suggested to the Water Company the removal of the cultivated fields, that today lie adjacent to the lake, to a distance of at least 1500 m from the shores of the lake.

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