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Investigation of selected metals in soil samples exposed to agricultural and automobile activities in Macedonia, Greece using inductively coupled plasma-optical emission spectrometry

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ABSTRACT

This study presents the results of selected metals in soils samples determined by inductively coupled plasma-optical emission spectrometry from five sampling sites in the rural area of the town of Damiano, in Macedonia, Greece, and four sampling sites along the 60 mile distance from Damiano to the airport of the city of Thessaloniki in Macedonia, Greece. It also compares the impact of automobile traffic to the impact of agricultural activities, and investigates how the use of pesticides and fertilizers could impact the concentrations of particular metals in soils found in agricultural areas. Animal manure was found to contain high amounts of Zn and Cu which could have impacted these concentrations at site G6, which is believed to have been the site of Alexander the Great's stables. The Cu and Zn dry mass concentrations at site G6 were 62 and 103 mg/kg (ppm) respectively, which were relatively higher than in other agricultural areas.

1. Introduction

Damiano in Macedonia, Greece is surrounded by a very unique environment, exceptional for every kind of agricultural activities. Dividing up the human activities, the impact of transportation and industries are insignificant around this area, which makes the environment very clean. Increased metal concentrations in the aforementioned area exclusively derive from the human activities that are related to the agricultural sector, which includes the use of fertilizers, pesticides, and insecticides. This study does not only focus on examining metal concentrations on rural areas, but also investigates samples alongside the 60 mile distance to Thessaloniki in Macedonia, Greece, where industrial and transportation activities are present. Samples G6 through G9 may appear similarities with our previous Lake Charles, Louisiana, USA, study due to their very similar environments. Although previous studies have been conducted by our laboratory studying sediment concentrations, no samples have been examined from agricultural soils or any samples from Greece [1–5, 6, 7].

Many past and present inorganic pesticides include metals such as As, Cu, and Pb. Prior to 1950 As pesticides were frequently used [8]. The use of pesticides can cause an increase in these metals as they do not degrade readily and persist for many years in the soils. They may be leached out of the soils by water, wind, and erosion. As and Pb are toxic to many organisms in small quantities, and Cu is toxic in large quantities. Food chain can undergo a bioaccumulation of heavy metal such as As and Pb, therefore it is important to determine the concentrations of these metals in environments [8].

The presence of As, Cd, Pb, and Fe in certain past and presently used inorganic fertilizers has been established. The maximum concentrations of Pb, Cd, and As in phosphate fertilizers used in the United States were determined to be 1700 ppm, 200 ppm, and 60 ppm, respectively [9]. Fe is also used in agricultural fertilizers. This shows that introducing fertilizers to soils could cause an increase in soil concentrations of the previously mentioned elements.

The aim of this study is to determine the concentration of selected metals in soils from agricultural areas and areas with high amounts of automobile traffic in Macedonia, Greece. These areas were compared to the pristine Lake Charles, Louisiana, USA, sediments in an attempt

Table 1
Sampling sites.

Site	Latitude	Longitude	Description
G–1	40°49′46.4″N	22°28′38.5″E	Agricultural area (Cotton field)
G–2	40°49′51.0″N	22°28′37.6″E	Agricultural area (Peach orchard)
G–3	40°49′50.1″N	22°28′55.0″E	Agricultural area (Peach orchard)
G–4	40°49′44.7″N	22°28′47.7″E	Agricultural area (Peach orchard)
G–5	40°49′47.0″N	22°26′54.0″E	Residential garden
G–6	40°43′21.3″N	22°41′42.3″E	Alexander the Great's horse stables
G–7	40°36′57.1″N	22°59′05.3″E	Forestry area near a high traffic highway
G–8	40°34′13.8″N	22°59′19.2″E	Agricultural area (Vineyard)
G–9	40°31′34.1″N	22°58′47.6″E	Airport area

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Table 2
Sampling sites.

Site	Latitude	Longitude	Description
Sed.2	30°06′37.69″N	93°10′55.82″W	23 m south of East Lincoln Road Bridge (low traffic)
Sed.3	30°06′41.20″N	93°10′51.07″W	120 m north of East Lincoln Road Bridge in a cultivated field

to determine whether the human activities from the Greek soils caused an accumulation of metals in the soils. Then the samples adjacent to automobile traffic were compared to the agricultural samples to see if there were any noticeable differences in the concentrations of the selected metals between the sites.

2. Materials and methods

2.1. Sample collection and preparation

Soil samples were collected from the sites listed in Table 1. These samples were obtained from rural and urban areas in Macedonia, Greece. To get the desired samples, a section in a PVC pipe fit to form a scoop was used. Once those soils were in the scoop, they were placed in a zip lock bag for storage and to be later observed in the lab. For each

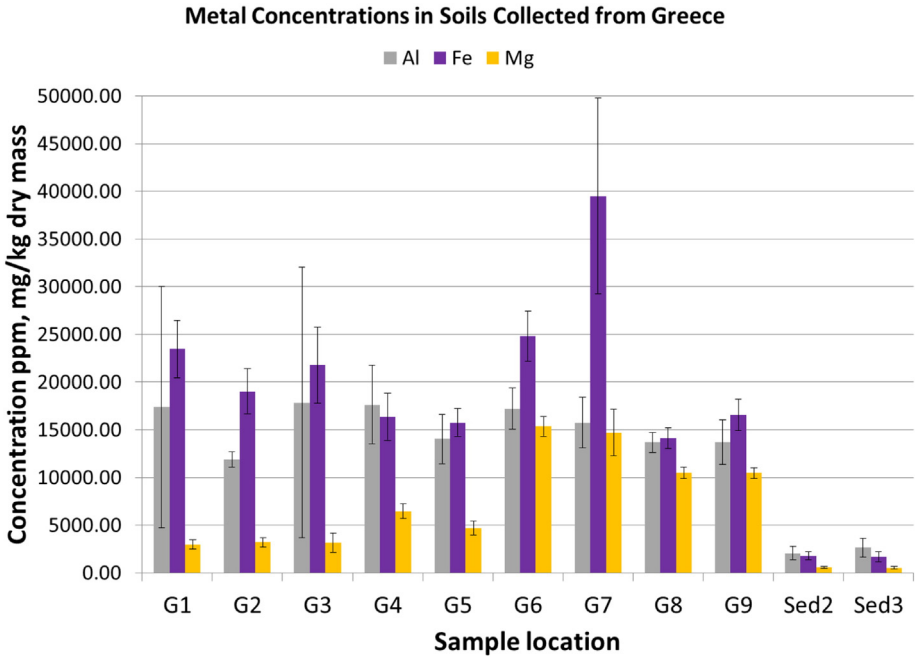

Fig. 1. Concentrations of Al, Fe, and Mg in soils collected from Greece in mg/kg (ppm).

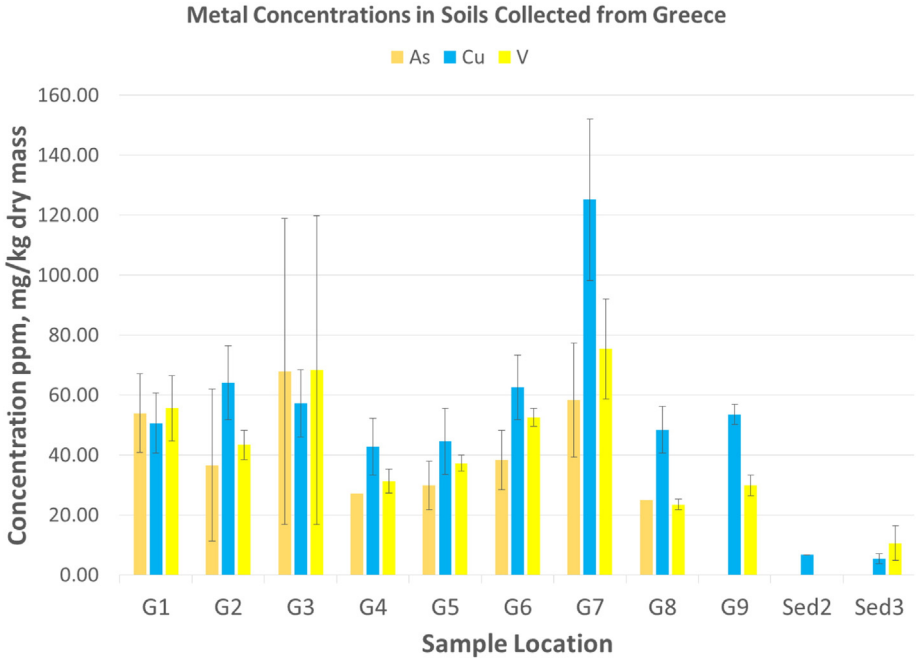

Fig. 2. Concentrations of As, Cu, and V in soils collected from Greece in mg/kg (ppm).