

*Chemical Ecology*

## Research of Long-Term Pollution by Petroleum Products with GC/MS

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**ABSTRACT.** Use of territories of the former military airfields for the civil purposes is a priority task. Monitoring of the polluted territories is necessary for providing opportunities of their further civilian use. Recommendations for rehabilitation will be developed on the basis of the monitoring results. GC/MS researches of the territories polluted by petroleum products at several airfields in East and West Georgia (Kopitnari and Vaziani) were conducted. Soil samples were taken at a depth of 15-215 cm. It was established that in places of long-term pollution, partial degradation of initial petroleum products by biological agents of soil takes place. A part of petroleum products is transformed into more hazardous residues in the contaminated areas even after a long period. Therefore, preliminary monitoring and elimination of residual pollution prior to transferring those territories for civilian applications are necessary. © 2015 Bull. Georg. Natl. Acad. Sci.

*Key words:* long-term pollution, oil products, military airfields, GC/MS.

### Introduction

Prior to civilian use of the former military airfields it is necessary to undertake ecological monitoring, remediation and rehabilitation of revealed contaminated areas and buildings and to study the possibilities of their further rational application. Ideally, the military bases should be involved in community activities. In this respect there is considerable international experience [1]. It is desirable that the appropri-

ate regulations of legal issues to be carried out considering local conditions and opportunities.

The territory of Georgia includes former military bases and military conflict zones (Fig.1). Along the Turkish border and Black Sea coast many military bases were located. Those sites are found to be heavily contaminated with obsolete and dangerous residues (e.g. rocket fuel components). The main attention is given to rehabilitation of the territories



Fig. 1. Former military airfields and conflict zones.

polluted by petroleum products. Our group works on neutralization of some components of liquid rocket fuel (Melange and Samin).

GC/MS as well as microbiological investigations of polluted areas of the former military bases are necessary for handling the less contaminated territories. Therefore, monitoring was conducted on the less contaminated territories of the former military bases and recommendations for remediation works were elaborated [2].

## Experimental

At first, the polluted territories of Kopitnari airfield in Western Georgia were investigated with the use of GC/MS and microbiological (for biological degradation assessment) methods. Earlier, in 2003, German experts conducted visual survey of the former Shirazi military airfield and made recommendations. According to that information, the most polluted areas in the presumably contaminated territories at Kopitnari Airfield are the lubricant warehouse, special warehouse for explosive materials and aircraft stations.

At Vaziani airfield the most contaminated spots with oil products are lubricant warehouses and aircraft refueling stations located on both sides of the runway. At each airfield 100-150 samples were taken.

Kopitnari airfield was built and put into operation in 1958-1960. For many years the civil and military airfields worked side by side sharing one runway, though they had different service infrastructures. The samples were taken along the perimeter

and within it by means of “cross shape” rule at the former Kopitnari military airfield. The samples were taken near the oil-products container (under the ground in the territory). The samples were taken from a depth of 15 cm. In some cases the samples were taken from different depths - 100 cm, 150 cm and 215 cm. The process of sampling and transportation is shown in Figs. 2-4. Those samples were preliminarily dried and treated with solvent; the extracts were studied by means of GC/MS (Fig. 5). The spectrum of each sample cover 10-12 pages containing information about 50-60 compounds. In some cases together with those samples the water samples were also taken.

It should be noted that GC/MS analysis [GC/MS (HP 6890/5973-USA)] was carried out according to the ISO and DIN standards (soil characteristics on PDH content, DIN-ISO 9377-2; PDH identification ISO-16703:2008; water characteristics PDH identification ISO-9377-2). Purification of solvents, acetone, heptane, hexane and toluene according to the standards, accurate protection of methodology, extraction and device calibration were performed successfully. Obtained results are reliable. Microbiological researches for assessment of the local degrading bacteria action on the contaminated territories are carried out as well.

## Results and Discussion

GC/MS analysis of samples taken from Kopitnari airfield shows that most of the territory is contaminated significantly exceeding the contamination standards accepted in Georgia (1000 mg/1 kg per soil). In some cases contamination is 100 times more than the norm. According to the rough estimation 15% of the territory is not polluted, 70 % is moderately contaminated, and 15% is badly contaminated. Part of the territory (40%) of aircraft stations is not contaminated, but 60% is moderately polluted. Strongly contaminated territory of lubricant warehouse coincided with the location of the overground iron containers, where the oil-products were placed. Most of the territory with its infrastructure is moderately contaminated, but pollution of the soil over the under-



Figs. 2, 3, 4. Taking and transportation of field samples.

ground containers is below the norm.

On the Vaziani airfield the contamination level several times exceeds the permissible norms. On this territory contamination is deeper compared to Kopitnari. Soil in Vasiani is granular and oil products residues can reach 2 m into depth or deeper. It is important to note that distribution of pollution in depth is not uniform. In other words, maximum pollution in one point is at various depths. There is no regularity in the spread of pollution. Probably, the degree of contamination differs according to the soil type and contamination duration. The soil is quite soft in Vasiani and the residues easily deposited in fatty clay layer. In case of Vaziani airfield, currently the territory of lubricant warehouses and aircraft refuelling stations are more polluted. Maximum spots of contamination are observed on the surface or at the depth of 100-150 cm.

## Conclusions

Some of the former military bases located on the territory of Georgia were abandoned and some were handed over to municipalities such as the airfield in the village of Meria. Their inspection was not carried out for more than 30 years. By means of GC/MS method quite enough material is collected and studied for recovery of the polluted environment.

The use of GC/MS method confirmed that in long term contaminated places the unit weight of the initial oil products degraded by soil biological agents increases. It was found that in polluted areas a part of petroleum products transform into more hazardous residues even after a long period. GC/MS researches about structure of residual oil product materials were conducted at contaminated territories of the former Kopitnari military airfield. According to the averaged data of various polluted sites the con-



Fig. 5. GC/MS Analysis.

tent of paraffin ( $C_8$ - $C_{12}$ ) was 1.5-6%; the content of aromatic hydrocarbons was as follows: monocyclic 0.2-1.2%; bicyclic 0.4-9.3%; tricyclic (anthracene, phenanthrene, cyclopentaphenanthrene, benzofluorene) 0.8-11.8%; tetracyclic (pyrenes, chrysenes, triphenylenes) 1.8-11.3%; pentacyclic (benzpyrene, benzacephenanthrylene) 0-15.7%; hexacyclic (dibenzopyrenes, indenopyrenes) 0-3.6%; aromatic ketones 0-9.3%; aromatic chlorine derivatives 0-9.2%; aromatic esters 29.4-78.2%. High molecular phenols, complicated amines, aza- and sulfur compounds are also presented in small quantities. It

should be noted, that the content of carcinogenic compounds in some cases is maximum and achieves 42.4%. Rapid reduction of paraffin is probably caused by the degrading local microorganisms, though certain quantity of condensed aromatic compounds and aromatic esters was noted as a result of long-term influence of environmental factors. Study with GC/MS shows that majority of territories are badly contaminated considerably exceeding the standards of contamination accepted for Vaziani airfield. Partially, phytoremediation processes caused by local plants decrease pollution [3-8].

Some experts consider that the transfer of the former military bases for the civil purposes is safe because under the influence of environment the soil surface is purified in 5 years, and there will be no problem of their further use. Our monitoring data on polluted territories of the former Kopitnari military airfield shows that dangerous residues of oil product transformation are collected in the depth of soil. In our opinion, implementation of preliminary monitoring on polluted sites is necessary in each case and after receiving the ecologically friendly results these territories can be used for civil purposes.

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ყოფილი სამხედრო აეროდრომების ტერიტორიების გამოყენება სამოქალაქო მიზნებისათვის პრიორიტეტულია. აუცილებელია ამ დაბინძურებული ტერიტორიების მონიტორინგი შემდგომი სამოქალაქო გამოყენების შესაძლებლობების შესაქმნელად. მონიტორინგის შედეგების საფუძველზე შემუშავდა რეაბილიტაციის რეკომენდაციები. ჩატარებულია აღმ. და დას. საქართველოში განლაგებული რამდენიმე აეროდრომის (კობიტნარი, ვაზიანი) ნავთობპროდუქტებით დაბინძურებული ადგილების კვლევა GC/MS გამოყენებით. ნიადაგის ნიმუშები აღებულია 15-215 სმ სიღრმეზე. დადგენილია, რომ გრძელვადიანი დაბინძურების ადგილებში ხდება საწყისი ნავთობპროდუქტების ნაწილობრივი დეგრადაცია ნიადაგის ბიოლოგიური აგენტებით. თუმცა, ხანგრძლივი პერიოდის გასვლის შემდეგაც დაბინძურებულ ტერიტორიაზე დადგენილია ნავთობპროდუქტების ნაწილის ტრანსფორმაცია უფრო საზიფათო ნარჩენებად, რის გამოც აუცილებელია სამოქალაქო გამოყენებამდე აღნიშნული ტერიტორიების წინასწარი მონიტორინგი და ნარჩენი დაბინძურების აღმოფხვრა.

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