

Using Secondary Metabolites in the Monitoring of the Condition of Tree Stands Under Industrial Pollution

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Abstract.—The aim of this paper is to determine the optimal physiological indicator in diagnosing the condition of tree stands under the stress of industrial pollution. Based on experimental results of the fumigation on pine seedlings with sulphur dioxide, acid rain treatment, and the effect of heavy metals on the seedlings, it is reasonable to use the secondary substances or the so-called stress metabolites for this purpose. The greatest changes under the stress of industrial pollution are in the content of essential oils in pine needles. The contents of essential oils were examined and compared in regions with different levels of industrial pollution. The results of this study permit us to conclude that the alpha-pinene content in pine needles is the optimal indicator for the early diagnosis of the condition of woody plants under the stress of industrial pollution.

Examining the physiological-biochemical makeup of the organs and tissues of forest plants is one way to diagnose early the damaging effects of industrial pollution.

This paper presents the results of experiments on the fumigation of pine seedlings with sulphur dioxide, artificial acid rain treatment, and the effect of heavy metals on the seedlings. It has been shown that pine responds to pollutants by changing the composition and content of secondary substances (essential oils, phenols, growth substances) - the so-called stress metabolites. It seems reasonable to use the changes in the content of essential oils as an indicator in the early diagnosis of the condition of woody plants (Fuksman *et al.* 1996, 1997a, 1997b).

Essential oils were compared in the needles taken from middle-aged pine stands growing in areas with various degrees of pollution. The examination was conducted in background monitoring stands ("Kivach" reserve, 60 km from Petrozavodsk), in local monitoring stands insignificantly polluted with sulphur dioxide (the impact zone of the Kostomuksha ore-dressing mill in the territory of Karelia and Finland), and in stands chronically heavily polluted with sulphur dioxide and heavy metals (the vicinity of the "Severonickel" industrial combine near Monchegorsk).

The most expressed response of pine to the action of pollutants is the changes in the composition of essential oils with a considerable increase in the relative share of the most volatile components, especially alpha-pinene (Fuksman 1998).

This fact was most vividly demonstrated in the study of pine stands near Monchegorsk. Chromatograms of essential oils in pine needles from the most heavily polluted sample areas contained primarily one peak, corresponding to alpha-pinene.

Essential oils are thus an optimal indicator in diagnosing the condition of the stands under the stress of industrial pollution. Their identification by gas-liquid chromatography is easy enough, does not require much time, and is characterized by high reproducibility. These are the criteria for choosing an indicator to diagnose the condition of a tree stand (Yarmishko 1997).

It is suggested that the results obtained in this study be used in developing a scale for evaluating of the condition of pines by alpha-pinene content in the needles. A portable chromatograph and the direct plant material chromatography technique without preliminary separation of essential oils (Stepanov and Dubovenko 1970) allow the tree stand condition to be evaluated on site.

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