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THE USE OF BARK OF SCOTS PINE IN ENVIRONMENTAL IMPACT ASSESSMENT OF CEMENT AND LIME DUST

WYKORZYSTANIE KORY SOSNY ZWYCZAJNEJ DO OCENY ODDZIAŁYWANIA NA ŚRODOWISKO PYŁÓW CEMENTOWO-WAPIENNICZYCH

Abstract: The study analysed bark of Scots Pine exposed to alkaline pollution from the cement factory Chelm. The range of impact of cement-lime dust on environment was determined based on water extracts of bark. Relationships between $\text{pH}_{\text{H}_2\text{O}}$ of bark and the distance from the dust emitter were studied using analysis of regression and linear correlation. These results were referred to the results from a forest control plot free of alkaline pollution. Precipitation of cement-lime dust decreased with the distance from the source of pollution, which was confirmed by the values of $\text{pH}_{\text{H}_2\text{O}}$ of pine bark. The greatest impact on environment of dusts from the cement factory Chelm was recorded at NE, ES and SW directions, where pH of the bark was < 6.0 at 3 km or even 5 km from the emitter. Multiple correlation coefficient between the distance from the emitter and the dust precipitation was from -0.66 to -0.98% .

Keywords: pine bark, cement-lime dust, bioindicators

Introduction

A cement factory emits gases and dusts to environment. Cement dusts that get to soil in excess enrich their genetic levels in calcium carbonate, which causes many consequences in phytocenoses [1]. Oligotrophic communities of pine forests are especially sensitive to even small changes. The range of the effect of alkaline deposition depends on *e.g.* the source and type of emission, distance from emitters, land relief, frequency and direction of winds [2]. Assessment of deterioration in the quality of forest environment caused by cement industry includes determination of the range of dust deposition and its amount that exceed the norm, and identification of qualitative and quantitative changes in the studied ecosystem. Bark is a good indicator of air pollution with cement-lime dust, as shown by papers of Sporek [2] and confirmed by other authors [3, 4]. But in the literature of the topic pine bark is mentioned mainly as a bioindicator of air pollution with compounds that cause acidification, mainly of sulphur and nitrogen, and of heavy metals [5-9]. The study was aimed to determine the range of impact on environment of the cement factory Chelm using pine bark as a bioindicator.

Material and methods

Bark of the Scots Pine (*Pinus sylvestris* L.) collected within 12 km from emitters of the cement factory Chelm was analysed. Fifty five sites were selected along eight directions of the wind rose, with the cement factory accepted as the middle in calculations. Bark was collected using draw-knife at the height of 1.50 m, according to the method of Sporek [2].

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Samples were collected at each site from five trees using the envelope method. The distance from the central tree was 10 m. In total, 275 samples were collected from standing trees. Additionally, a 0.25 ha plot exposed to strong effect of the cement work was delimited, where samples of bark were collected from 83 trees.

Bark was dried in room temperature, washed with deionised water and dried in a drier at 65°C for 24 hours. Dried plant material was ground in a mortar and milled into a powder in a percussion grinder. From each sample 4 g of the bark powder was taken, weighted with 0.001 g accuracy, placed in a beaker and filled up with 40 cm³ of distilled water. After 48 hours the content of each beaker was mixed and its pH_{H₂O} was measured up to two digital places. The electrode was calibrated using two buffer solutions of pH 4 and 7.

The relationships between pH_{H₂O} of bark and the distance from the source of dust emission were studied using analysis of regression and linear correlation. These results were referred to the results from the forest control plot free of alkaline pollution. The control plot was an experimental area in Niemodlin forests where monitoring of pollution to forest ecosystem has been conducted since 1996. Fifty five-years-old pine stands at this plot, which grows on podzols, is of good condition and correct height, without clear anthropogenic effects. Samples of bark for comparative studies were collected from 50 standing trees.

Results and discussion

Bark of the Scots Pine collected at the control plot had natural pH_{H₂O} in the range 3.2-3.97 and low coefficient of variation $v = 6.07\%$. The increment of this trait was 0.77 of the pH unit. The mean of these measurements was 3.60 pH_{H₂O}, and the mode was 3.63 (Table 1). These values are typical of pine bark from areas free of industrial imissions [2, 5, 10].

Table 1
Variation in reaction (pH_{H₂O}) of bark of the Scots Pine at the control plot (Bory Niemodlinskie) and at the plot polluted with alkaline dusts (near cement factory Chelm)

Parameter	Plots	
	control	polluted
pH _{H₂O} range	3.2-3.97	7.12-7.76
\bar{x}_{pH}	3.63	7.38
SD	0.22	0.18
Median	3.63	7.36
Mode	3.64	7.24
CV%	6.07	2.47
n	50	83

The pine stand at the plot exposed to strong anthropogenic pressure was in bad health condition. Despite similar age as at the control plot, pines at the study plot had weaker growth and considerable defoliation of canopies. The reaction of pine bark in 83 samples from a uniform plot is shown at Figure 1. Both the control and the polluted plots had common features such as low coefficient of variation and small standard deviation of the bark reaction. But the plots differed in reaction by 4 pH unit. At the polluted plot pH was in the range 7.12.-7.76, the mean pH was 7.38, and the coefficient of variation was 2.47%

(Table 1). The distribution of pH values of bark was right-skewed and showed that measurements were above 7.36 (median) for 50% of the samples. Other authors [2, 3] obtained similar distributions of bark pH.

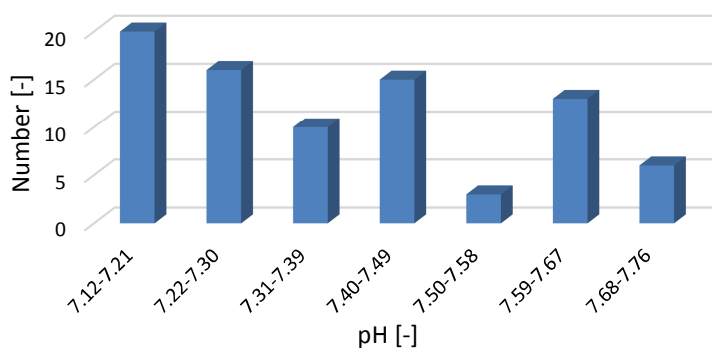


Fig. 1. Distribution of the reaction of bark of Scots Pine at the plot exposed to strong anthropogenic pressure from the cement factory Chelm

Comparison of the control plot free of alkaline pollution with the plot polluted with alkaline dusts (Table 1, Fig. 1) confirmed that the reaction of pine bark is with no doubt a bioindicator of air pollution with alkaline dusts. Thus it can be used to draw isolines of the range of impact of the cement factory on environment.

Based on that, sites for collecting samples of bark were chosen within 12 km from emitters of the cement factory Chelm. Precipitation of cement-lime dust decreased with the distance from the source of pollution. The distances of impact of alkaline dusts from the cement factory Chelm were determined based on the criterion of the reaction of bark by Sporek [2]. According to this author [2] pH of bark within the range 4.1-4.9 should be considered as vestigial. Swiercz [3] determined a similar range and distinguished ecotone zone where $\text{pH}_{\text{H}_2\text{O}}$ of bark is in the range 4.0-4.9. Alkalinisation of forest habitats occurs when pH of bark is ≤ 5.0 . Values ≥ 4.0 pH are accepted as a lack of alkaline pollution.

Table 2
Distances at which dust precipitated determined according to changes in the reaction of pine bark

Directions	Areas	The range of effect of alkaline dusts [m]			Multiple correlation coefficient r	Coefficient of determination r^2
		trace	clear	prominent		
		$\text{pH}_{\text{H}_2\text{O}}$				
		5.0	5.5	< 6.0		
NE	I	7400	5000	2700	-0.66	0.43
EN	II	5800	4300	2700	-0.83	0.68
ES	III	7400	6000	4400	-0.90	0.81
SE	IV	5300	4300	3300	-0.96	0.91
SW	V	8100	6200	4600	-0.66	0.43
WS	VI	4300	3100	1900	-0.83	0.68
WN	VII	4400	3500	2500	-0.90	0.81
NW	VIII	4100	3500	2900	-0.96	0.91

Analysis of the collected material showed a correlation between the distance from the emitter and the precipitation of dust determined from bark reaction. The multiple correlation coefficient was from -0.66 to -0.98% (Table 2). The coefficient of determination showed that participation of dusts from the cement factory Chelm in the qualitative changes was 43 to 91%, according to this indicator (Table 2).

Meteorological data (from the Institute of Meteorology and Water Management) shows that in the vicinity of Chelm winds that blow from west to east, (W-E), from northwest (NW) to southwest (SW) and from southwest (SW) to northeast (NE) are the most frequent. Thus the wind rose has an irregular half-oval shape. The largest distance of the impact of dust from the cement factory Chelm on environment was recorded at NE, ES and SW directions. The departure of distribution of dust pollution from the wind rose was caused by location of other sources of unorganised emission in the area, e.g. heaps, mines, access roads to mines, and by a lack of trees that would isolate these emitters from the surroundings. Analysis of regression and correlation showed that compact forest areas reduce movements of dusts from ca 12 km to ca 1 km.

Conclusions

1. Isolines of the zones of eutrophic effect in forest habitats can be drawn based on changes of bark reaction, which may be applied in determination of damage caused by deposited cement dust and in assessment of the quality of forest habitat.
2. Forest areas reduce movements of dusts from ca 12 km to ca 1 km. The negative impact of the cement factory on the vicinity can be reduced and even eliminated by appropriately located tree belts.

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Abstrakt: Analizie poddano korę sosny zwyczajnej znajdującej się pod presją zanieczyszczeń alkalicznych cementowni Chełm. Na podstawie wodnych wyciągów z kory określono zasięg oddziaływania pyłów cementowo-wapienniczych na środowisko. Zależności pomiędzy $\text{pH}_{\text{H}_2\text{O}}$ kory a odległością od źródła emisji pyłów badano metodą analizy regresji i korelacji liniowej. Wyniki badań odnoszono do wyników uzyskanych na leśnej powierzchni kontrolnej - wolnej od zanieczyszczeń alkalicznych. W miarę oddalania od źródła zanieczyszczeń opad pyłów cementowo-wapienniczych obniża się, co jest zrozumiałe, i znajduje potwierdzenie w zmiennych wartościach $\text{pH}_{\text{H}_2\text{O}}$ kory sosny. Najsilniej odnotowano presję w kierunku NE, ES i SW, gdzie w odległości 5 km od emitora pH kory było wyższe od 6,0. Współczynnik korelacji wielorakiej pomiędzy odległością od emitora a opadem pyłu wynosił od $-0,66$ do $-0,98\%$.

Słowa kluczowe: kora sosny, pył cementowo-wapienniczy, bioindykator