

DYNAMICS OF CHANGES IN SELECTED SOIL TRAITS IN THE PROFILES OF ARABLE SOILS ANTHROPOGENICALLY ALKALISED WITHIN THE KIELECKO-ŁAGOWSKI VALE (POLAND)

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Introduction: Well-developed cement and lime industry causes far-reaching transformations of soil cover [1, 2]. Pollutants are emitted in the form of dusts and gases, which in turn causes their release to all components of the environment, including soils [3, 4]. The chemical composition of cement and lime dust is relatively constant and depends on the composition of raw materials used in technological processes. The emitted dust contains mainly CaO (<43%) and is characterised by high pH_{KCl} values (<12.5) in terms of alkaline pH, which, due to many years of emission, significantly affects the properties of soil [5]. In the Świętokrzyskie Province, the cement and lime industry is characterised by dynamic development, and its level of technological achievement, production volume and raw material extraction scale is among the leading ones in Europe. Long-term alkaline pressure on the soils located in the area of 500 km² nearby Dyckerhoff Polska Sp. z o.o. Nowiny Cement Plant, “Trzuskawica” S.A. Cement Roadstone Holding, “Jaźwica” Mineral Resource Mine, “Lafarge” Dolomite Mine in Radkowiec, Lafarge Cement Plant in Małogoszcz, Lhoist S.A. Lime Production Plant in Bukowa has been lasting and thoroughly influencing basic physicochemical properties of the soils, especially the podsolcic ones formed on sands, since the 1960s. Significant amounts of calcium ions getting into the soil cause the effect of “over-fertilization”- alkalization which can chemically degrade soils [6]. Although soil alkalization is relatively rare in Poland, it is this process which has been responsible for the largest transformation of soils in the Świętokrzyskie Province in recent years.

The aim of the study was to reveal changes of particular physicochemical properties of the arable soils located in the monitored areas of the Kielecko-Łagowski Vale between 1978 and 2019 as a zone of long-term and declining alkaline emission.

Study Area: In June 2019, five soil profiles were collected in order to identify the types of soils and their physicochemical properties (the same areas were taken into account in 1978 and then in 2005). The profiles were located at a distance from 400 m to 3 km away from Dyckerhoff Polska Sp. z o.o. Nowiny Cement Plant (Figure 1), in the area of excessive cement and lime dust emission into soils.

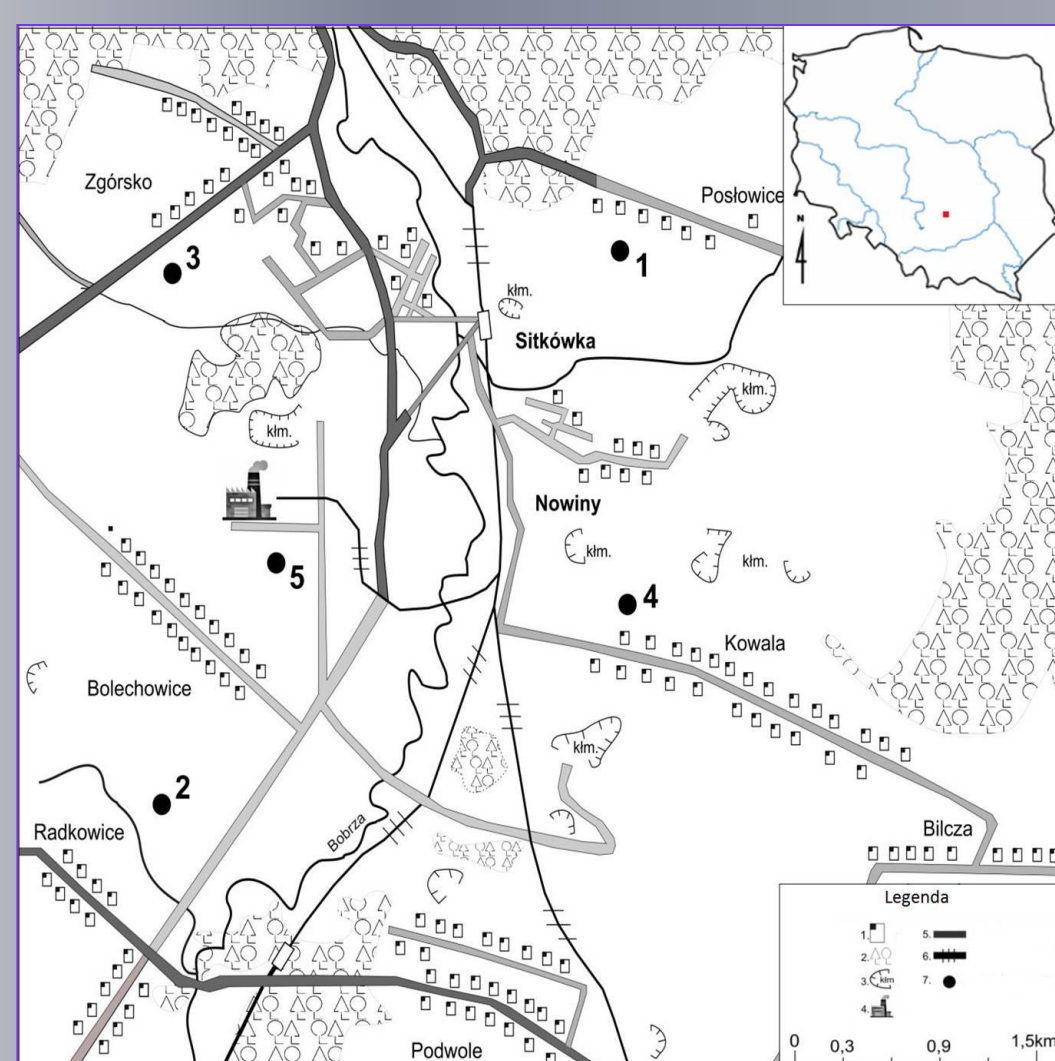


Figure 1. Location of soil pits depending on the distance from the dust emitter (Nowiny Cement Plant Sp. z o.o.). Key: (1) buildings; (2) forests; (3) quarries; (4) cement plants; (5) roads; (6) railways; (7) soil pits.

Data Collection and Analysis: During field works, the thickness of individual sub-horizons, grain size composition, colour based on the Standard Soil Colour Charts according to Munsell, and the type of soil humus were determined. Each soil sample taken from selected genetic horizons and sub-horizons was examined:

- a grain-size composition of earthy parts by sieve analysis and Casagrande's areometric method modified by Prószyński,
- soil reaction by potentiometric titration (pH H₂O, pH_{KCl}),
- organic carbon (C_{org}) by Tiurin and Alten's methods modified for horizons of humus,
- nitrogen in general (N_{org}) by modified Kjeldahl's method in Kjeltex Auto Analyzer,
- hydrolytic acidity H_h by Kappen's method in 0.5 M Ca(CH₃COO)₂ solution,
- sum of exchangeable basic cations (S) by Kappen's method in 0.5M NH₄Cl solution at pH 8.2,
- acidity H_w and exchangeable aluminium Al³⁺ by Sokołow's method,
- content of ingestible ingredients P₂O₅, K₂O, Mg by Enger-Rhiem's method PN-R-04023 (P₂O₅), PN-R04022 (K₂O), PN-R-04024 (Mg).

Dust fall of particle matter was studied by using trapping measure (Bergerhoff type). Glass funnels (input diameter: 7 cm, outlet diameter: 2 cm) connected to the bottles and exposed at 5 research positions were used in February, May, August, and November (Figure 2).

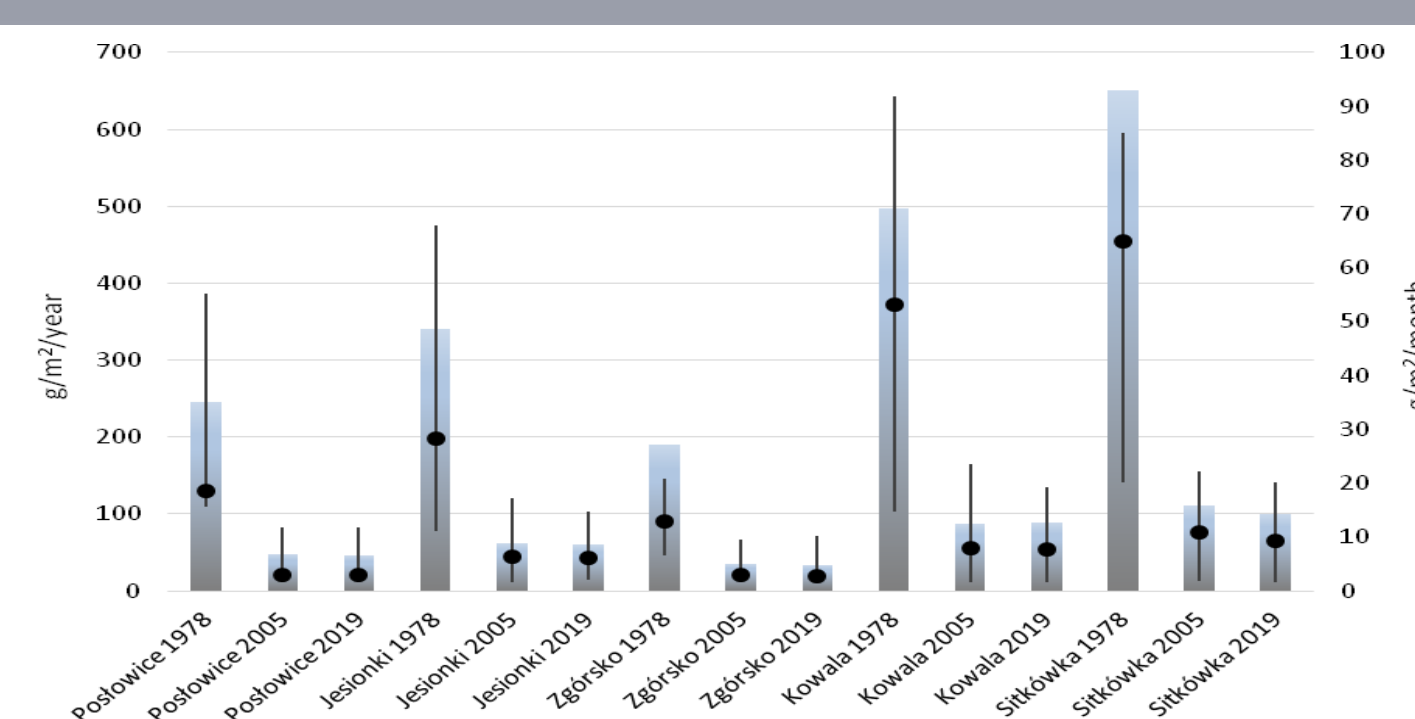


Figure 2. Dynamics of annual and monthly dust fall per g/m2 in soil profiles at selected research positions in (1) Połowie, (2) Jesionki, (3) Zgórsko, (4) Kowala, (5) Sitkówka.

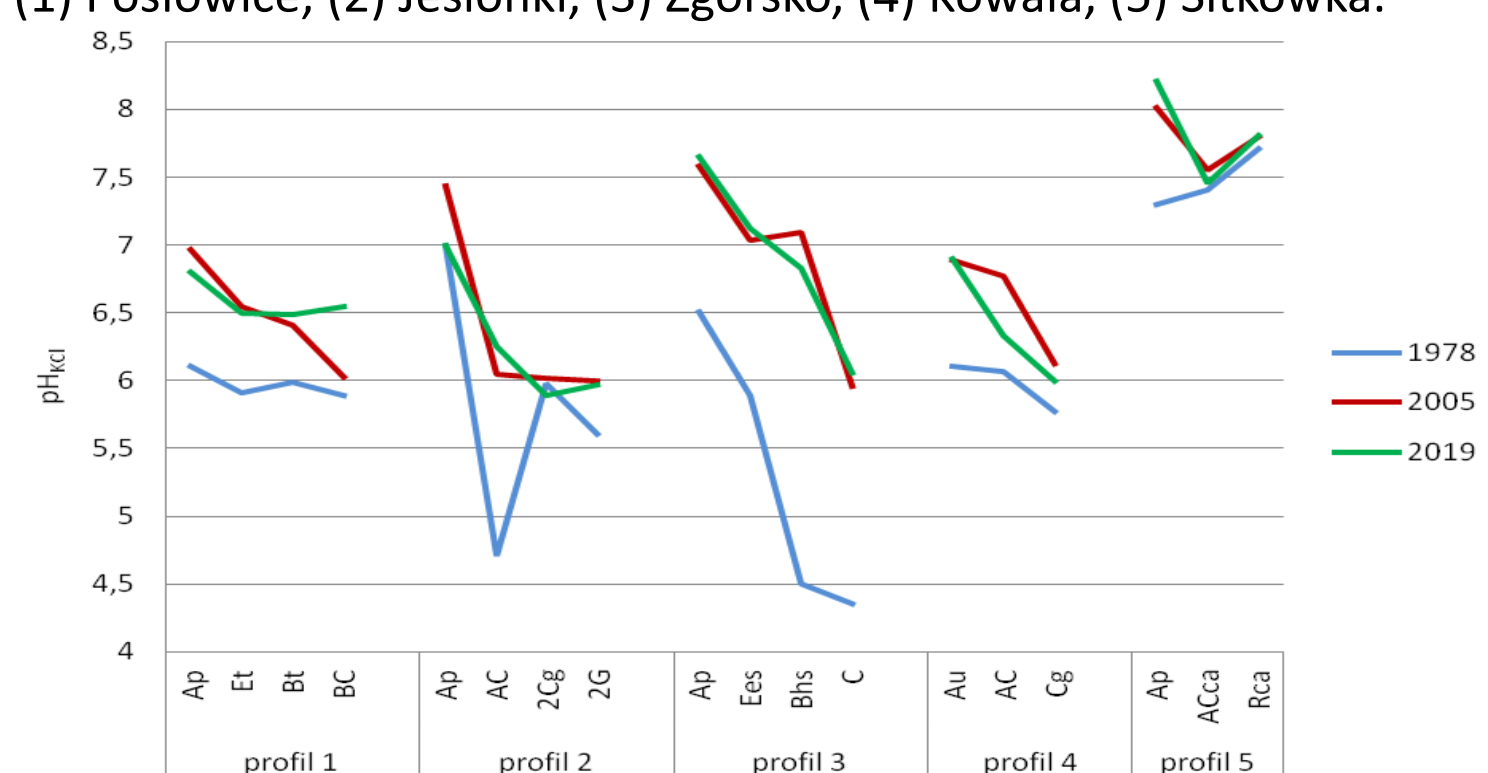


Figure 3. Dynamics of pH_{KCl} value ranges in individual horizons of the analysed soils between 1978 and 2019.

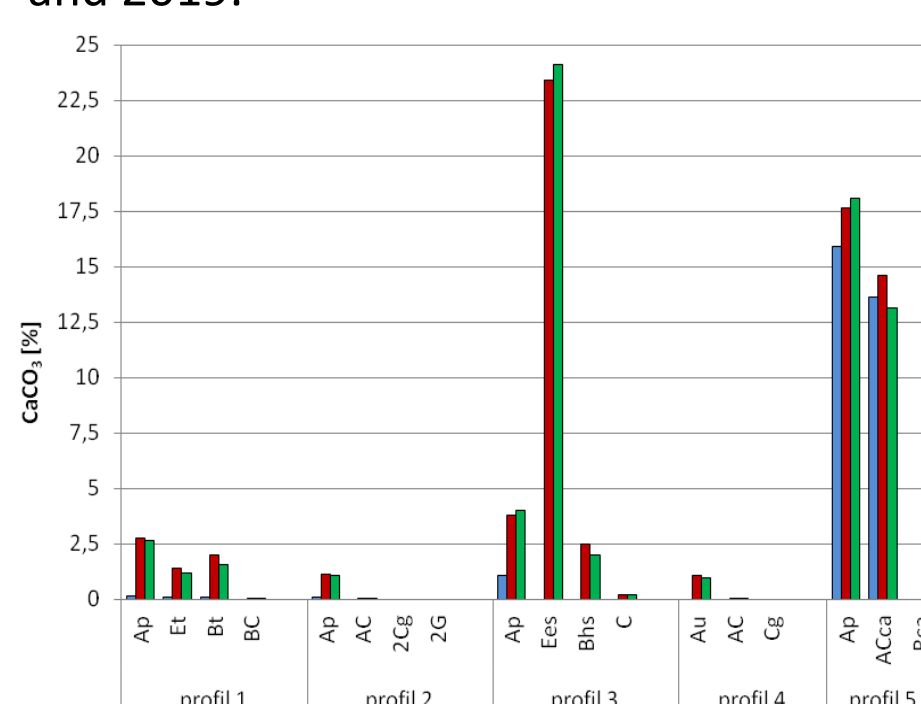


Figure 4. Dynamics of CaCO₃ [%] content in individual horizons of the analysed soils between 1978 and 2019.

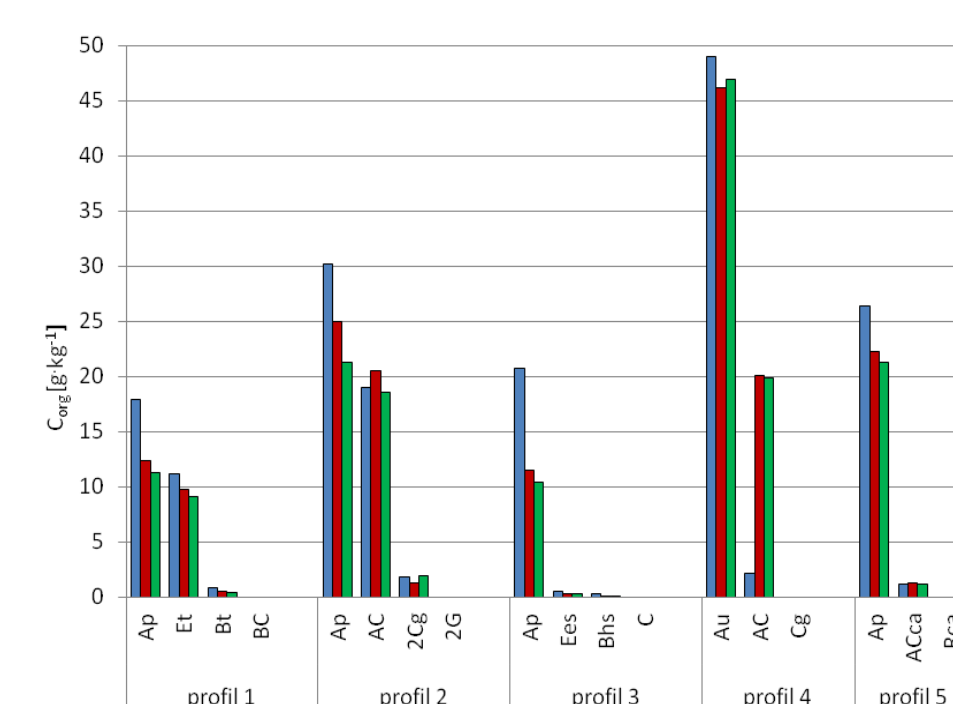


Figure 5. Dynamics of C_{org} [g kg⁻¹] content in individual horizons of the analysed soils between 1978 and 2019.

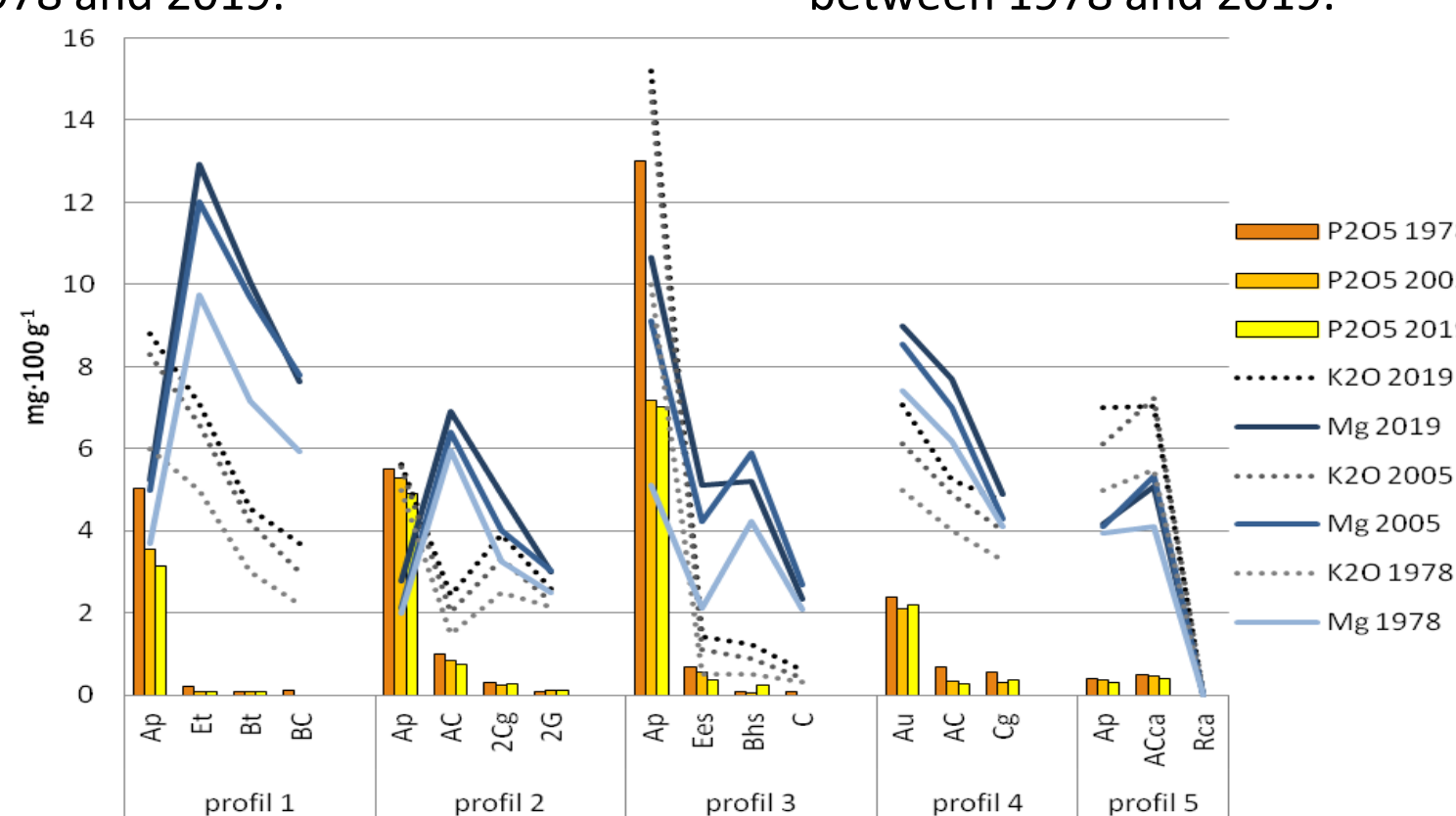


Figure 6. Changes in the content of digestible components (P₂O₅, K₂O, Mg [mg 100g⁻¹]) in various horizons of the analysed soils in 1978-2019.

Conclusions: Over 50 years since launching, Dyckerhoff Polska Sp. z o.o. Nowiny Cement Plant and other cement and lime plants have caused great modifications in soil cover functioning in this area. In spite of dust emission and immission decreasing, the effects of cement plant operations are still visible, especially in the podzolic soils with low buffer capacities. Regeneration of soils and the return to the original properties are hampered by the noticeable drop of alkaline dusts of >33.0 g / m²/year and other anthropogenic factors (dense network of roads, fertilisation). Constant immission of cement and lime dust has had a significant influence on the chemical quality and basic properties of the soils since 1966. It was found that the long-term effect of alkaline immission results in:

- higher pH of soil, and the highest values pH_{KCl} in humus horizons,
- increased CaCO₃ content in organic and organic-mineral horizons,
- decreased C_{org} content, especially in humus horizons,
- raised level of saturation of sorption complex with alkaline cations, despite reducing dust immission to the soils.

In recent years, the dynamics of observed changes has been getting smaller, and that is proved the research results.

1. Świercz, A. Wpływ pyłów cementowych na właściwości gleb bielicoziemnych. *Roczniki Gleboznawcze* 2003, 54, 3, 61-72.

2. Sowunmi, K.; Shoga, S.; M, A.O.; A, O.F.; Sowunmi, L. The Physiological and Microbiological Characteristics of Cement Dust Polluted Soil Around Lafarge Cement Industry, *Research Square* 2020.

3. Amani, J.; Kishore, Babu, G.; Lakshminipathi, R.; Ramachandra, Rao, G.; Chandrasekhar, K. Effect of Cement Dust Deposition on Soil Microbial Properties, *International Journal of Current Microbiology and Applied Sciences* 2018.

4. Bilen, S.; Bilen, M.; Turan, V. Relationships between Cement Dust Emissions and Soil Properties, *Polish Journal of Environmental Studies* 2019, 28, 5, 3089–3098.

5. Świercz, A. Analiza procesów glebowych i przekształceń roślinnych w zakwaszanych siedliskach leśnych regionu świętokrzyskiego. *Komitet „Człowiek i Środowisko” przy Prezydium PAN, Zeszyty Naukowe* 2005, 39, 1-21.

6. Ivanov, Y. V.; Kartashov, A. V.; Ivanova, A. I.; Ivanov, V. P.; Marchenko, S. I.; Nartov, D. I.; Kuznetsov, V. V. Long-term impact of cement plant emissions on the elemental composition of both soils and pine stands and on the formation of Scots pine seeds. *Environmental Pollution* 2018.