



An effect of excessive phosphorus application on some properties of soil colloids corresponding with acceleration of their mobility in soil

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This study was intended to provide a better understanding of the influence of high amounts of phosphorus on the properties of soil colloidal particles. Although phosphorus problems in the environment have been the point of interest in plenty of scientific research considering its diverse aspects, there are still pending issues that await further investigation. Hazardous environmental effects caused by the presence of excess phosphorus in soil are related to the risk of enhancing the leaching process of soil particles with phosphorus sorbed on their surfaces. This, in turn, accelerates the eutrophication process in aquatic ecosystems and contributes to soil degradation. The increased mobility of soil colloids in the presence of high amount of phosphorus is reported to be connected with higher dispersion and stability of soil particles. This phenomenon raises the question whether we are dealing with an effect of phosphorus sorption under conditions of its high concentrations. Therefore the object of the investigation was to examine the influence of an excessive amount of phosphorus on the specific surface area (SSA), particle size distribution (PSD), mineralogical composition, electrokinetic potential and stability against aggregation of the clay particle fraction of soil.

The research was carried out on two sorts of soil samples: (i) P-saturated soil (samples A–D); (ii) a reference soil (E). The soil samples A–D were taken from the Experimental Area of the Agricultural University of Wrocław (located in Pawłowice), where a three-year field experiment with phosphorus fertilisation was carried out. The av-

erage soil samples were taken from arable horizon of all plots fertilised with 0 and 180 kg P₂O₅ ha⁻¹ after the first and the last year of fertilisation. Additionally, the fifth soil sample (E) (with no agricultural history) was included into the experiment as the reference one due to its low content of soil phosphorus. The clay-sized fractions (<2μm) (A_k–E_k) were separated from all soil samples and used in a dry form to examine chemical and physical-chemical properties. Initially the SSA was determined with the BET-N₂ gas adsorption method. The oxalate-extractable aluminum (Al_{ox}), iron (Fe_{ox}) and phosphorus (P_{ox}) were assessed by extraction with acid (pH 3) ammonium oxalate solution (Schwertmann, 1964) and measured by ICP (Novozamsky *et al.*, 1986). The degree of P soil saturation was characterised by the saturation index *Z* (Beek, 1978; van der Zee & van Riemsdijk, 1988; van der Zee *et al.*, 1988): $Z = [P_{ox}] / 0.5([Al_{ox}] + [Fe_{ox}])$. The content of soluble phosphorus (P_{CaCl2}) was determined by extraction in 0,01M CaCl₂ (Houba & Novozamsky, 1998; Houba & Temminghoff, 1999). The P sorption experiment was conducted at two stages of reaction: after 1 day and 7 days of equilibration, respectively. The different doses of phosphorus were applied in the form of KH₂PO₄ solution with 0,01 M CaCl₂ solution as a background electrolyte. After the P sorption experiment, the P_{CaCl2} concentration in solution, PSD by light scattering method with the Mastersizer 2000 (Malvern), electrokinetic potential with Zetasizer 2000 apparatus and mineralogical composition by X-ray diffractometry were analysed. The behaviour of the clay fraction in samples A–D was observed in different time intervals by the PSD measurements and microscopic observations. The adsorption experiments and some chemical characteristics, besides clay-sized fraction (index *k*), were conducted also for the total soil samples (index *t*).

The SSA of the clay fractions (A–D) generally increased after P fertilisation. Their behaviour was more stable in samples after the third year of fertilisation (C, D): smaller aggregates were formed and the amount of particles with the smallest sizes was higher. The degree of P saturation showed that samples A–D were already oversaturated with P at the beginning of further P-adsorption experiment. The slopes of P adsorption isotherms (after 1-day equilibration) for saturated (A_t–D_t) and unsaturated (E_t) soil confirmed earlier results, although sorption of further P doses by clay fractions was continually observed in all samples. The reference soil (E) and the P-saturated (A) were capable of sorbing similar amounts of P by total soil samples (14 mmol kg⁻¹ (A_t), 15 mmol kg⁻¹ (E_t)), as well as by clay fraction (23 mmol kg⁻¹ (A_k), 25 mmol kg⁻¹ (E_k)) after the 7-day equilibrated adsorption. Equilibrium adsorption was still not achieved in both short-time and long-time adsorption reactions. More negative values of zeta potential were observed for clay particles with higher amounts of sorbed phosphorus. The potential was more negative for P-saturated clay samples in comparison to the reference one (E_k). Although the short-time adsorption did not affect significantly the zeta potential value, the longer time of sorption resulted in more neg-

ative values of zeta potential in all measured cases. Also the increase of the dispersion was noticed in the clay-sized fraction as an influence of the increasing amounts of the sorbed P. This was indicated by the results of both the PSD measurements showing the higher amount of smaller particles, and X-ray diffraction analyses pointing some transformations in mineralogical composition towards the increased amounts of the fine-crystalline minerals (e.g. smectite, chlorite and mixed-layer: illite-smectite, illite-chlorite, chlorite-smectite). The observed alterations in properties of clay fraction may enhance their potential stability and thereby – the mobility of soil colloids. Therefore leaching may be simultaneously accelerated as an effect of the excessive phosphorus accumulation on the surfaces of clay particles. A follow-up research effort is to work out the background of the impact of the P on the surface properties and degree of dispersion of soil colloids.

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