GEOMATICS AND ENVIRONMENTAL ENGINEERING • Volume 2 • Number 3 • 2008

Teresa Eckes*, Tadeusz Gołda*

Total Nitrogen Content as the Abundance Indicator for Autogenous Soils Discussion Article

1. Introduction

Soil quality classification carried on according to the principles contained in the Commentary to the chart of soil classes takes into account humus level thickness as one of the primary valuation elements (besides grain composition, water conditions, field position), which decide about classifying a soil in proper Polish valuation class [4]. However, the results of completed studies indicate that in some soil types, humus level thickness has been subject to deepening as a result of using larger and larger farm machines, allowing to plough deeper than its original thickness. Mechanical deepening of humus level applies first of all to brown soils and podzolic soils of lower, primary valuation classes [2]. Therefore, a question occurs whether humus level thickness may be acknowledged as an objective quality criterion, and whether mechanical deepening of this layer has direct effect on the improvement of productivity, and thus on soil quality valuation class increase? We should emphasize that organic matter content in humus level should be also an important criterion when assessing potential soils productivity. This parameter decides about many additional characteristics and is used when assessing the development of reclaimed formations, or for determining the degree of natural soils deterioration [8]. The terms: "organic matter", "vegetable earth" or "humus", contained in these classifications are generally understood, however they are not always interpreted correctly and in the same way, and various analytical methods are employed to assess them [1]. Certainly, the most precise in this regard is the analysis of humus compounds content based on the sum of determined fulvic acids, humic acids and humins. However, these analyses are labour- and time-

* Faculty of Mining Surveying and Environmental Engineering, AGH University of Science and Technology, Krakow

-consuming, and their use in mass-scale research is unlikely. Determination of organic matter content from sample mass decrement after annealing at the temperature of 550°C does not allow to separate humus compounds from e.g. fresh, non-decomposed vegetable matter, and furthermore the result of this analysis may be affected by compounds undergoing decomposition at this temperature.

Current trend in soil-science studies involves striving to develop rules allowing to classify the examined layer, level or type of soil on the grounds of analytical results or unequivocally determined characteristics. Good examples are: international diagnostic soil levels, separated on the grounds of clear-cut criteria (organic carbon content, phosphorus soluble in 1% citric acid, degree of sorptive complex saturation with basic cations), or existing and unequivocal classifications, as e.g. soil colour in humid or dry state, according to the Munsell's scale [7].

Distinguishing of certain units (type, subtype) in Polish soil classification is mostly based on descriptive criteria, whereas valuation classes are attributed according to specified item in the Commentary to the chart of soil classes. This is an expert classification, difficult to verify, because most of properties being taken under consideration do not have numerical values. In order to increase valuation reliability, it is required to perform certain analyses and, on their grounds, to specify numerical intervals, attributing an examined characteristic to a specific item. This task is difficult to carry out in soil-science studies performed over larger areas due to a large extent of field works and costs of laboratory determinations. Some compromise should involve striving to select at least some properties, which are essential for certain classification or valuation. These properties (characteristics) should be precisely defined, and their determination process should proceed according to widely accepted and standardised methodologies ensuring sufficient accuracy. Organic carbon content or total nitrogen content are certainly the indicators, which describe well the amount of organic matter.

The paper presents the analysis and proposed usage of total nitrogen content as the indicator allowing to determine abundance classes in autogenous soils. Soil samples for nitrogen content tests were taken from few areas.

2. The Object of the Research

Field tests of soils were performed in three areas selected according to the necessity to take into consideration diversity of soils. The researchers were taking into account the character of the ground, and soil type and class. The tests were carried out for soil classes II–VI, specified in the soil classification map as brown or podzolic soils (AB, A, B), consisting of sands, clays or loess.

The first area of tests, in vicinity of Kwaczała village (Małopolskie Voivodship, administrative district of Chrzanów), is located within the reach of southernmost part of the Wyżyna Krakowska upland. Soil pits were made on slopes gently inclined (1°–6°) towards east, south-east, north-east, or distinctly flattened plateaus and valley bottoms. In this region, sands and sands on clay are predominant in the subsoil, and loess occurs sporadically (loess-like formations).

The second area, south of Suchorzów village, at western slope of external dumping ground operated by "Machów" Sulphur Mine, is located on the right bank terraces of the Vistula River, within the Kotlina Sandomierska valley. The open pits were made on flat area. The subsoil consists of shallow sands on clays.

The third area of tests is situated within the Wyżyna Miechowska upland, which constitutes the highest elevated part of the Niecka Niedziańska basin. Soil pits were made within a vast ground elevation with minor fall, not exceeding 1°, towards east, and on a slope inclined 2°–6° towards south-east. The subsoil consists of loess.

66 soil pits were made in the examined areas. In these pits, samples were taken from six layers: 0–25 cm, 25–50 cm, 50–75 cm, 75–100 cm, 100–125 cm, 125–150 cm – in total 396 samples.

The analysis of total nitrogen content in soil samples (all layers) was performed according to the Kjeldahl method, using the set from Buechi [6]. Due to scarce amount of nitrogen in deeper layers, only the results obtained for layers taken at the depth not exceeding 100 cm were chosen for further considerations.

3. Methodological Guidelines

As it has been mentioned before, the basic problem is the selection of valuation elements, and the way of presenting them. In order to determine organic matter abundance, we may assume either total nitrogen content or organic carbon content, without any considerable reservations. These two indicators are favoured by prolonged and common use of both Kiejdahl method (currently to a large extent automated), and the C determination method according to Tiurin. Moreover, both determinations may be more and more often performed using the CN- or CNS-type autoanalysers. However, we cannot present the result of this examination as practised so far, that is only for the humus layer in percent. Determination of actual abundance requires combining test results for volumetric density and an element content with thickness of examined layer and area unit.

Therefore, we suggest that abundance indicators be specified as the amount of accumulated compound or element per area unit, e.g. Mg/ha or G/m^2, in a soil layer of certain thickness.

Sample taking depth is a disputable issue, because in autogenous soils both determined elements occur in sub-humus levels as well, however their amount considerably drops with increasing depth. Tests performed in 66 open pits indicate that the 0–50 cm layer contains 75–85% of N_{tot} content, compared to its total amount in the profile, which is well documented by charts compiled according to soil quality valuation classes shown in figures 1 (on the interleaf), 2 and 3.

Already from the depth of 25 cm, the N_{tot} content in most of the examined soils drops to the level of 0.02–0.08%, and in deeper layers of 50–75 cm and 75–100 cm it does not exceed 0.01–0.02%. The content lower than 0.02% N_{tot} is considered characteristic for soil-less formations [5].

Taking into account the above-listed results, we may introduce the following rules for field sample taking:

- mineral-humus level thickness is higher or equal 50 cm:
  - furrow sample taking from the 0–25 cm layer;
  - furrow sample taking from the 25–50 cm layer;
- mineral-humus level thickness ranges from 25 to 50 cm:
  - furrow sample taking from the whole humus level;
  - furrow sample taking from the remaining part of humus level, including sub-humus level down to the depth of 50 cm;
- mineral-humus level thickness lower than 25 cm:
  - furrow sample taking from the whole humus level;
  - sample taking from the sub-humus level down to the depth of 50 cm.

Additionally, it is necessary to take samples in intact condition from each examined layer in order to determine volumetric density.

Among autogenous soils there are also soils with humus level thickness exceeding 50 cm (degraded or deluvial black-earths), however carbon or nitrogen content in these soils is certainly so high that abundance calculated for the proposed depth will be high enough to rank these soils in highest abundance classes.

4. Research Results

Depending on their attribution to a specific valuation class illustrated on the soil quality classification map, the tested soils were ranked in three groups:

group I soils included in classes II and III,
group II soils included in class IV,
group III soils included in classes V and VI.

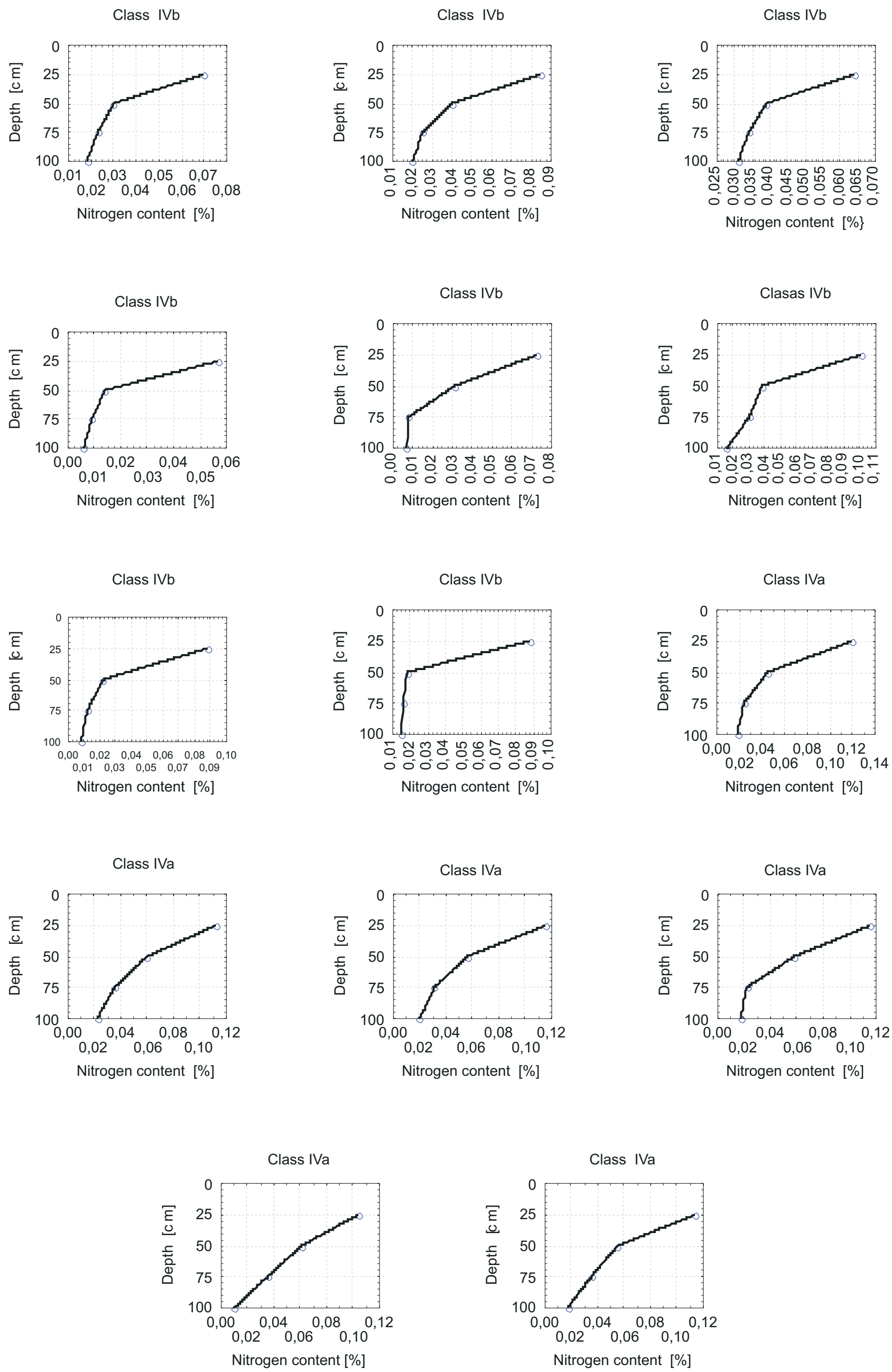

Fig. 2. Nitrogen content in class IVa and IVb soils

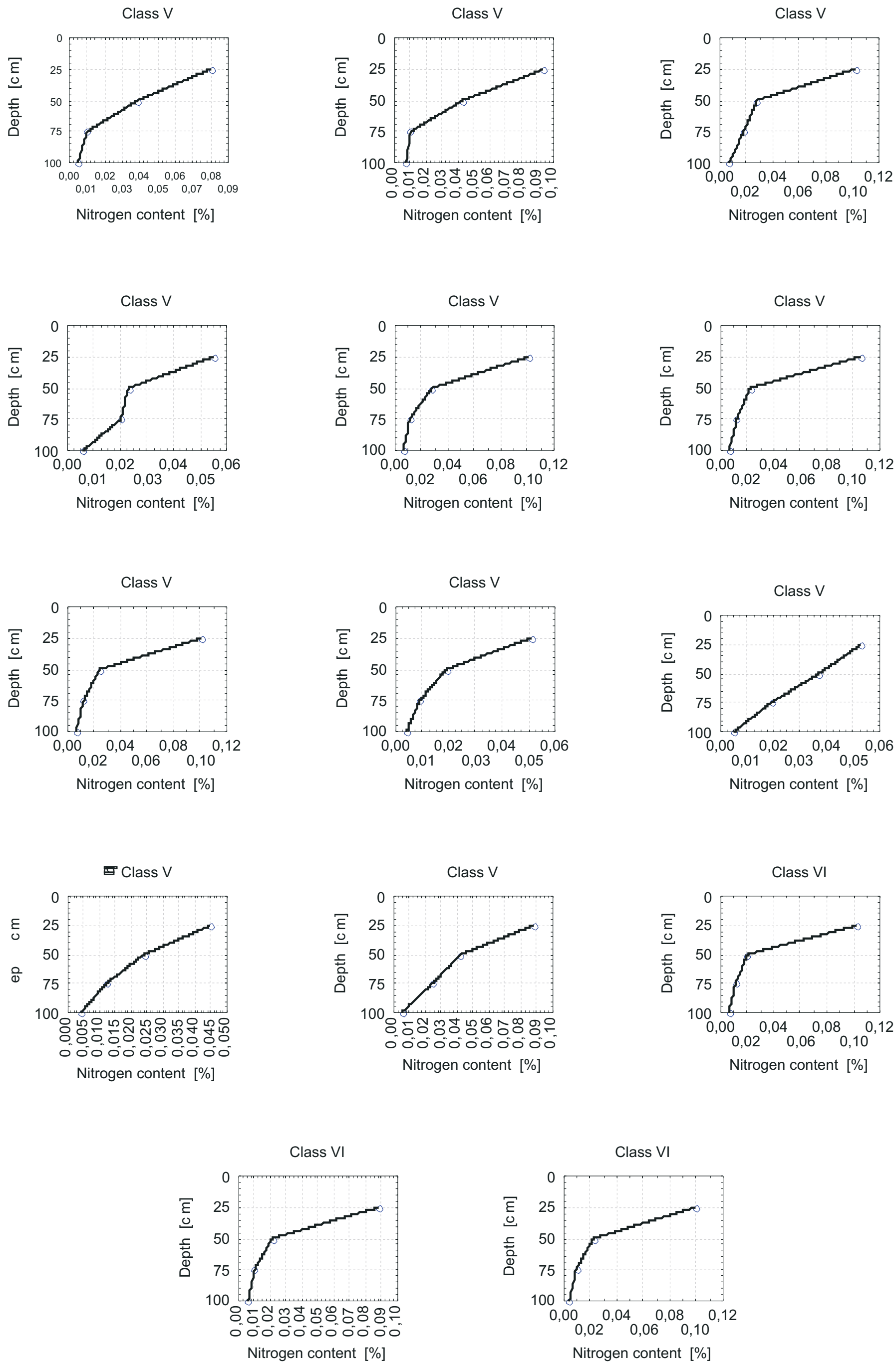

Fig. 3. Nitrogen content in class V and VI soils

The results of total nitrogen content tests down to the depth of 100 cm are shown in form of scatter diagrams, using the Statistica package (Figs 4–6). Due to this application requirements, content values specified in figures for the depth of 25 cm concern content in a furrow sample taken from the 0–25 cm layer, for the depth of 50 cm – for the 25–50 cm layer, etc. Percent nitrogen content values in the tested soils are illustrated in table 1.

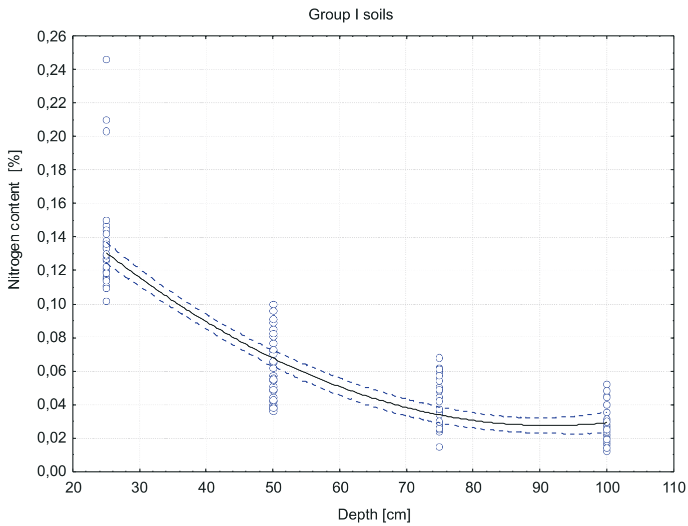

Fig. 4. Nitrogen content. Scatter diagram for group I soils

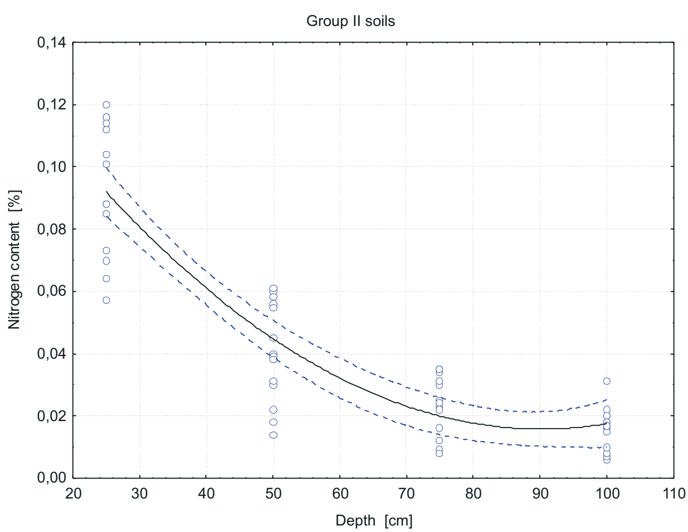

Fig. 5. Nitrogen content. Scatter diagram for group II soils

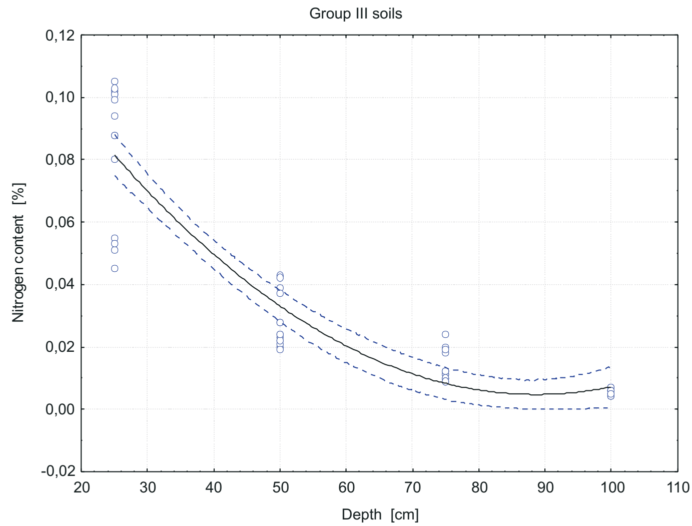

Fig. 6. Nitrogen content. Scatter diagram for group III soils

Table 1. Nitrogen content in the examined soils

Group of soils	Layer thickness [cm]	Nitrogen content [%]	
		Numerical intervals	Average
I	0–25	0,240–0,108	0,125
	25–50	0,118–0,030	0,070
	50–75	0, 070–0,020	0,040
	75–100	0,060–0,019	0,035
II	0–25	0,121–0,058	0,091
	25–50	0,062–0,017	0,043
	50–75	0,036–0,009	0,020
	75–100	0,030–0,002	0,019
III	0–25	0,108–0,042	0,080
	25–50	0,044–0,019	0,032
	50–75	0,020–0,010	0,012
	75–100	0,009–0,006	0,008

After having taken into account volumetric density for individual layers, nitrogen content per 1 ha in a 1m-thick layer, computed on the grounds of mean values was: in soil group I – 10.3 Mg, in group II – 7.1 Mg, in group III – 5.3 Mg. Whereas, for the 0–50 cm layer this content was as follows: group I – 7.7 Mg, group II – 5.4 Mg, group III – 4.5 Mg.

5. Interpretation of Results

The analysis of test results indicates distinct diversification of total nitrogen content, depending on soil quality valuation class, and keeping to the following rule: the higher class the larger abundance per 1 ha. We should remind here that the valuation class provided in cartographic documentations was taking into account not only humus level thickness, but also other properties of examined soil, first of all including soil profile grain composition. In the applicable classification, soil with lower humus level thickness but more favourable grain-size distribution reaches the same quality valuation position as soil with higher humus level thickness, but characterised by less advantageous mechanical composition, which may explain nitrogen content fluctuations in the 0–25 cm and 25–50 cm layers. Therefore, the examined profiles were put together in groups combining good, average and poor quality soils, and not strictly according to valuation classes attributed to them. Moreover, soil contour drawn on the soil quality classification map is a certain approximation obtained on the grounds of examination in primary, auxiliary and range open pits.

In spite of these factors, obtained results provide good documentation for the expected and known relation between soil quality valuation classes and organic matter content represented by total nitrogen content. The obtained results document accumulation of total nitrogen in subsurface layers (0–50 cm), in which there are from 75 to 85% of nitrogen contained in the whole profile. In the 50–75 cm layer, average nitrogen content is still 0.04% only in good soils (classes II and III), whereas nitrogen content at this depth in lower quality soils does not exceed 0.02%, which is deemed the limit value for soil-less formations.

6. Total Nitrogen as Abundance Indicator for Autogenous Soils

Total nitrogen content, computed according to the proposed methodology, may be used to develop an objectivized classification of Polish soils, based on verifiable analytical results. The obtained numerical value will be one of the elements taken into account while developing the algorithm of productivity represented by a “new” soil quality valuation class. This algorithm must also take into account grain composition, e.g. according to the proposal contained in the paper by Gruszczyński, Trafas [3], as well as other soil properties, including water capacity or complex saturation with basic cations. Development of a new classification will facilitate preparation of numerical soil maps and make it possible to add them to geodesic land information system (GIS).

Completed research and analyses allow to formulate the principles for preliminary abundance classification for autogenous soils as regards total nitrogen abundance. They are shown in table 2.

Table 2. Proposal to determine abundance classes for total nitrogen in autogenous soils

Abundance class	Total nitrogen content in the 0-50 cm layer [Mg]
Very high	> 8
High	6–8
Medium	4–6
Low	3–4
Very low	1–3
Soil-less objects	<1

The proposed classification constitutes first approximation for solving the problem of soil abundance valuation, and it must be made more specific. Thus, it will be necessary to continue this type of research both for nitrogen, and for other elements. Here, it is particularly important to develop the database containing output data.

7. Conclusions

Completed research allows to formulate the following conclusions:

1) total nitrogen content in close relation with density and thickness may be used as a numerical abundance indicator for autogenous soils;
2) according to the proposed methodology, the abundance of soils should be determined down to the depth of 50 cm;
3) calculated nitrogen content allows to classify soil in one of abundance classes presented in this paper;
4) continuation of the research, taking into account also soil size analysis, will possibly allow to verify the methodology and make the proposed abundance classes more specific.

References

[1] Bednarek R., Dziadowiec H., Pokojska U., Prusinkiewicz Z.: *Badania ekologiczno-gleboznawcze*. Wydawnictwo Naukowe PWN, Warszawa 2004.

[2] Eckes T., Gołda T.: *Podstawowe różnice pomiędzy treścią istniejących dokumentacji glebowych a stanem faktycznym*. Geomatics and Environmental Engineering (AGH quarterly), vol. 6, no. 2, 2007.

[3] Gruszczyński S., Trafas M.: *Klasyfikacja obiektów bezglebowych dla celów rekultywacji*. Inżynieria Środowiska (AGH quarterly), t. 6, z. 2, 2001.

[4] *Komentarz do tabeli klas gruntów w zakresie bonitacji gleb gruntów ornych terenów równinnych, wyżynnych i nizinnych wraz z regionalnymi instrukcjami dotyczącymi bonitacji gleb ornych terenów górzystych i komentarzami dotyczącymi bonitacji gleb użytków zielonych i gleb pod lasami dla użytku klasyfikatorów gleb i pracowników kartografii gleb*. IUNG, Ministerstwo Rolnictwa 1963.

[5] Ostrowska A., Gawliński S., Szczubiałka Z.: *Metody analizy i oceny właściwości gleb i roślin.* Katalog. Instytut Ochrony Środowiska, Warszawa 1991.

[6] PN-ISO 11261: *Jakość gleby. Oznaczanie azotu ogólnego. Zmodyfikowana metoda Kjeldahla*.

[7] Poziomy diagnostyczne gleb mineralnych. [on-line:] http://www.biol.uni.wroc.pl/instbot/stankiew/diag.htm

[8] Siuta J.: *Gleba. Diagnozowanie stanu i zagrożenia.* Instytut Ochrony Środowiska. Warszawa 1995.

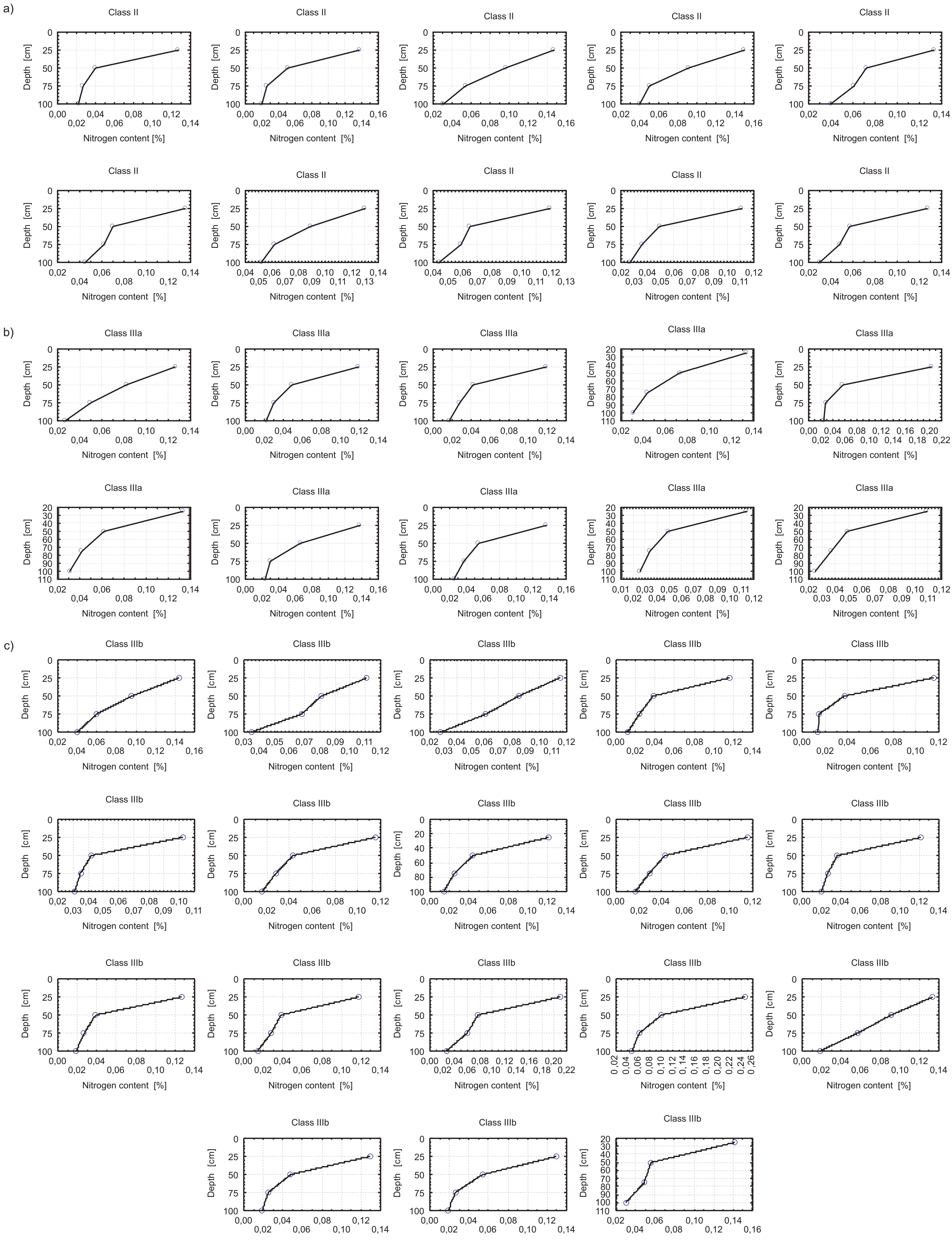

Fig. 1. Nitrogen content in class II (a), IIIa (b) and IIIb (c) soils