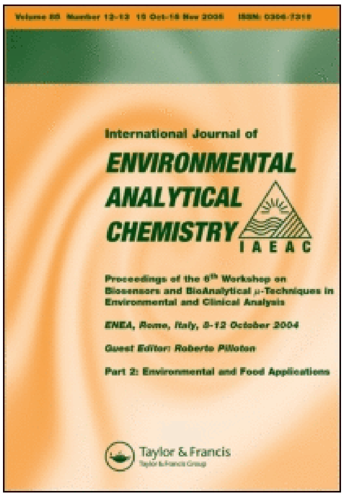

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Heavy Metal Contents in the Soils of Switzerland

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HEAVY METAL CONTENTS IN THE SOILS OF SWITZERLAND

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With the present investigation, which included in the first place the intensively used regions of Switzerland, it was tried to give a general view of the soil contents of lead, cadmium, copper, nickel and zinc. Using the extraction method with 2 M HNO_3, described in the "Ordinance Relating to Pollutants in Soil" (VSBo), approximated and not real total contents were determined. It was found that the values mostly lie below the guide levels in the VSBo. The influence of different site factors (geology, land utilization, aerosol emissions from industry, incineration plants and traffic) on the heavy metal contents in soil are discussed. Proceeding from the contents in the subsoil, indications about natural basic contents are made.

KEY WORDS: Heavy metals, ordinance relating to pollutants in soil, national fund programme "soil", national soil monitoring network (NABO), total contents, site factors.

INTRODUCTION

Within the programme of the National Fund (NFP 22 "Soil") it was decided to realize a project which should bring more clarity about the heavy metal contents in the soils of Switzerland[1]. Starting with 41 sites of the national soil monitoring network (NABO) 194 more sites altogether were fixed. The investigation which included in the first place the intensively used regions of Switzerland (mainly the "Mittelland") should give a general view of the soil contents of lead, cadmium, copper, nickel and zinc.

The contents of these elements were determined in 2 M HNO_3 extract according to the instruction of the Swiss Ordinance Relating to Pollutants in Soil[2]. The obtained values do not correspond to the real total contents. However, the authors are of the opinion that the pollution situations can be sufficiently described with this method.

The HNO_3-values do not say anything about the mobility or bioavailability. Many studies have shown that such parameters can better be assessed by a neutral salt extraction of the soils[3,4,5]. That is why guide levels are fixed in the mentioned ordinance also for $NaNO_3$-soluble concentrations of the elements lead, cadmium, copper, nickel and zinc.

The expected results with regard to approximated total contents are the following:

—Indications about frequently occurring levels of heavy metals in soils of intensively used regions in Switzerland as a function of different site factors.

—Gain of a greater security about the correctness of the guide levels in the VSBo.

—Indications about heavy metal pollution and the methods for its determination under different site conditions.

—Results about the order of magnitude of the natural basic metal contents in the investigated topsoils according to the heavy metal analysis in a great number of subsoils.

—Attempt to find regional differences due to pedogenous contents.

MATERIAL AND METHODS

The topsoils were sampled with 16 stickings over a square of 10 × 10 m. The sampling depth amounted to 20 cm. On unploughed sites like natural meadows and forests an additional layer of 0–5 cm was sampled.

The subsoil is defined as soil lying below 20 cm. At the beginning of the project subsoil samples were taken from a fixed layer of 60–80 cm what had the disadvantage that different layers or horizons became occasionally mixed during the sampling procedure. Therefore, in the second part the sampling depth was determined by a profile boring from which the lowest layer possible belonging to the same material as the topsoil could be recognized.

In the choice of sites different factors (geology, land utilization, aerosol emissions from industry, incineration plants and traffic) which could influence the heavy metal content in soils were considered. Figure 1 shows the NABO sites where further NFP sites have been fixed.

The dried (40°C in an oven with circulating air) and sieved (<2 mm) soil samples were used for the determination of an approximated total content (2 M HNO_3, 2 hours in a boiling water bath) and soluble content (0.1 M $NaNO_3$, shaking 2 hours at room temperature). These extraction procedures correspond to the official method of Switzerland described in the VSBo[2].

The soil contents are differentiated in the following way:

—The natural and pedogenous contents, respectively, are those heavy metal contents which originate from natural sources under the influence of soil forming processes.

—Accumulation contents are mainly related to anthropogenic sources.

—As the average value of different data the median is used which is much less influenced by extreme values than the average.

—With the frequently occurring levels a range is described in which 80% of the data around the median are situated.

RESULTS

For the elements lead, cadmium, copper and zinc Figures 2–5 show the typical distribution pattern with higher metal contents in the topsoils than in the subsoils.

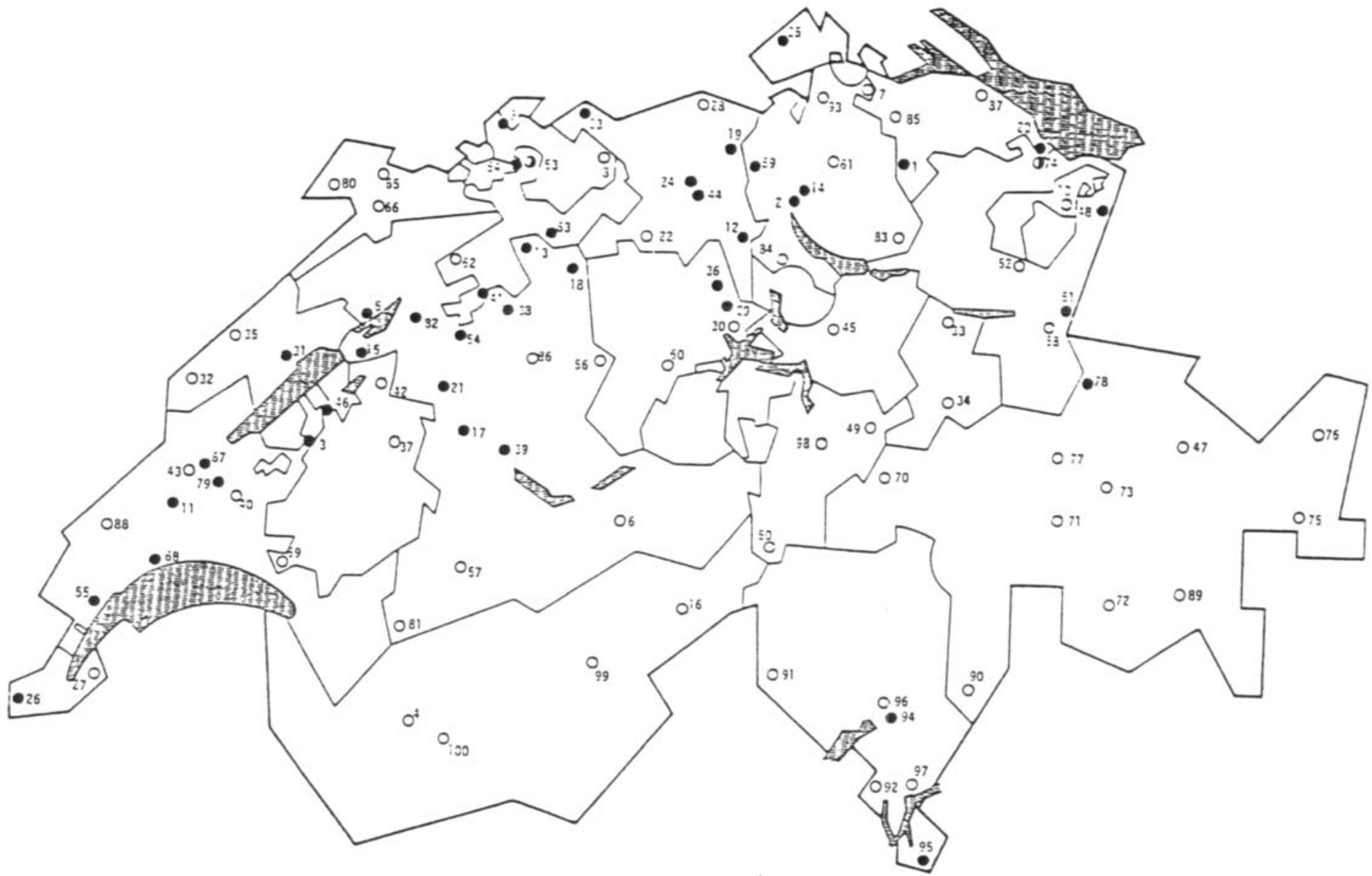

Figure 1 NABO sites with further NFP sites (filled circles).

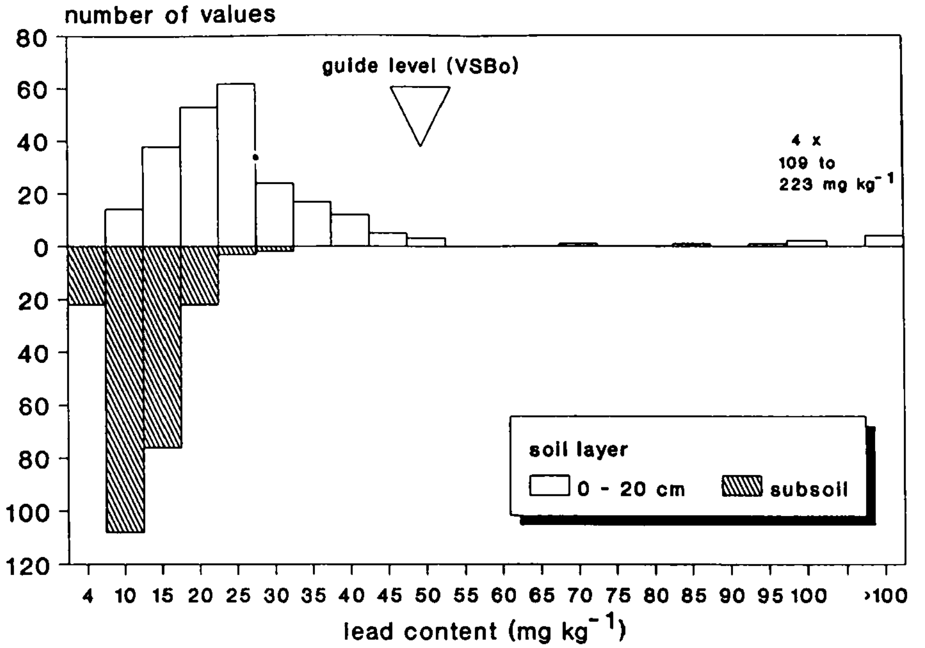

Figure 2 Lead contents (2 M HNO_3) of all sites in top- and subsoils.

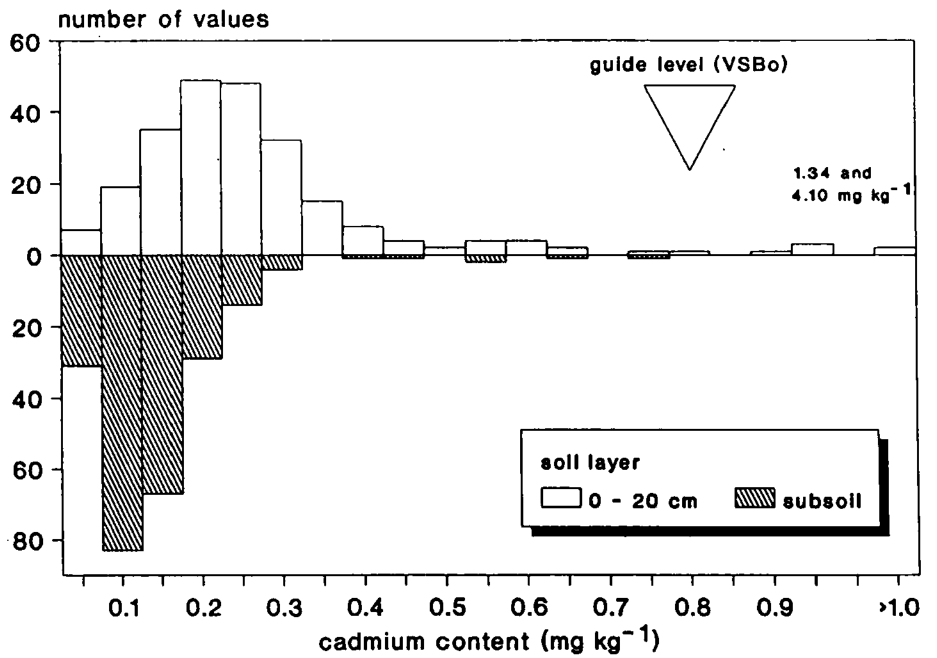

Figure 3 Cadmium contents (2 M HNO_3) of all sites in top- and subsoils.

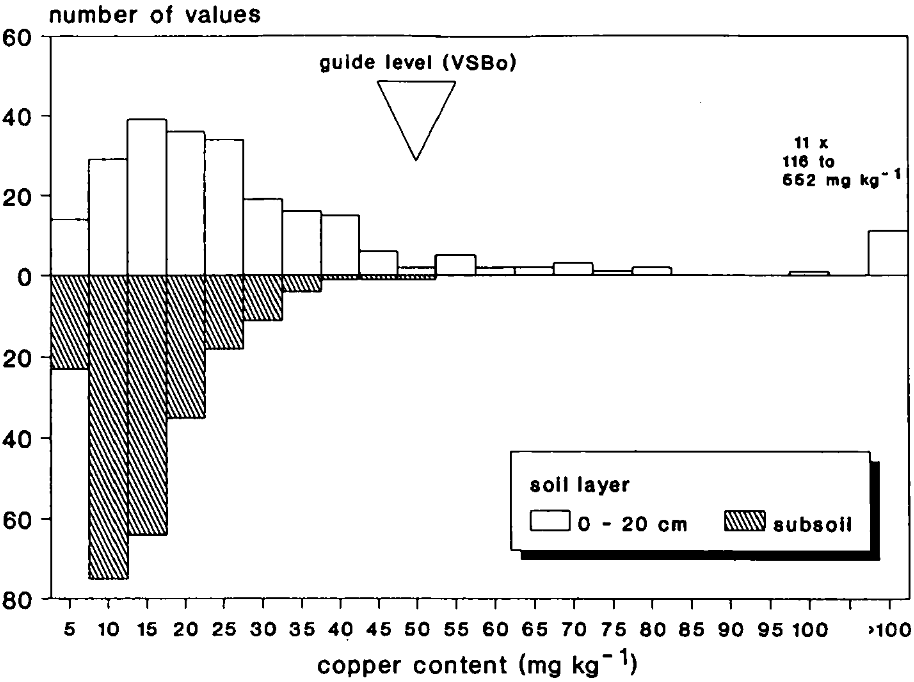

Figure 4 Copper contents (2 M HNO_3) of all sites in top- and subsoils.

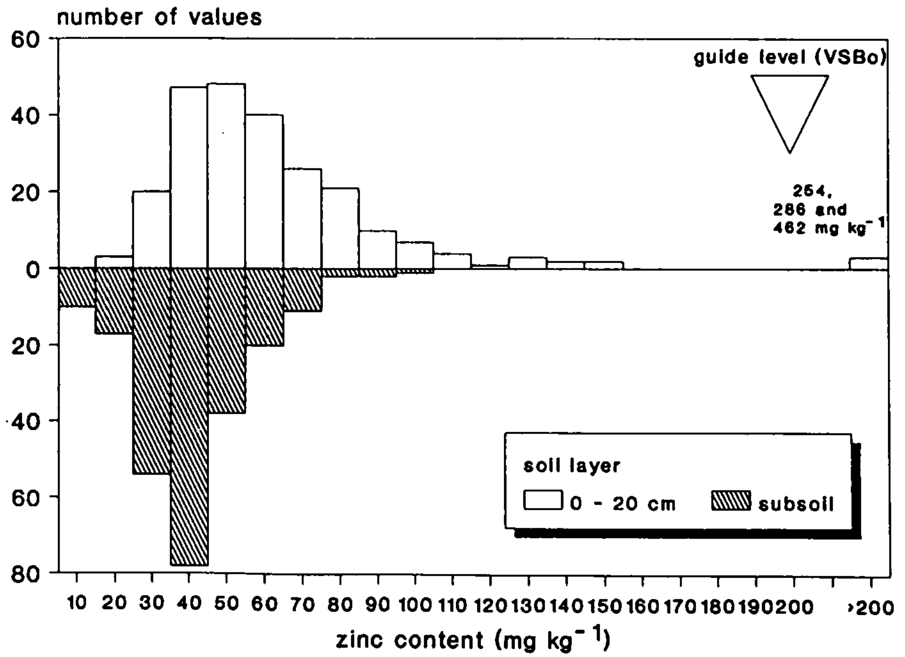

Figure 5 Zinc contents (2 M HNO_3) of all sites in top- and subsoils.

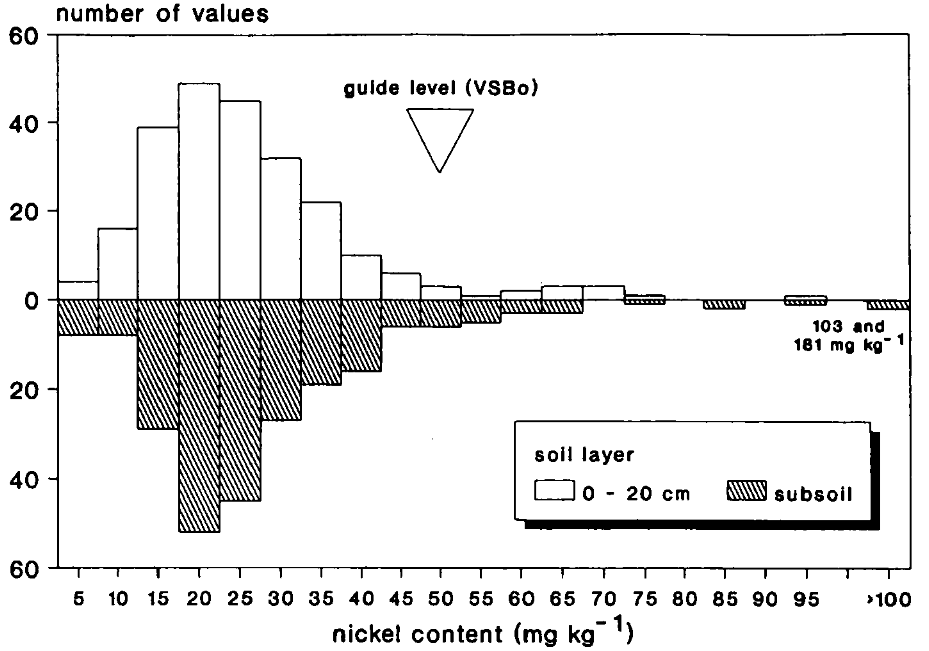

Figure 6 Nickel contents (2 M HNO_3) of all sites in top- and subsoils.

Such a distribution is usually explained by anthropogenic influences which lead to an accumulation in the topsoils. However, attention must be paid to differences in bulk density between topsoil and subsoil. Contrary to that is the distribution for nickel with equal or even higher contents in the subsoils (Figure 6) what may be an indication for pedogenous migration of nickel.

The most important figures of the total contents (median, frequently occurring level) of top- and subsoils are presented in Table 1. The frequently occurring levels of the subsoils are thought to correspond more or less to the natural basic metal contents.

Table 1 Most important figures of the total contents (2 M HNO_3) of lead, cadmium, copper, nickel and zinc in the soils of Switzerland

Element	*Topsoil (mg kg^{-1})*		*Subsoil (mg kg^{-1})*	
	Median	*Frequently occurring level*	*Median*	*Frequently occurring level*
lead (50)	23.8	13.5–40.5	12.1	7.8–18.2
cadmium (0.8)	0.23	0.11–0.45	0.12	0.07–0.23
copper (50)	23.3	9.0–61.0	13.8	7.8–27.0
nickel (50)	23.5	12.5–39.0	24.8	14.5–50.0
zinc (200)	56.1	33.0–94.0	39.9	23.5–60.0

Figures in parentheses: guide levels according to the VSBo in mg kg^{-1}.

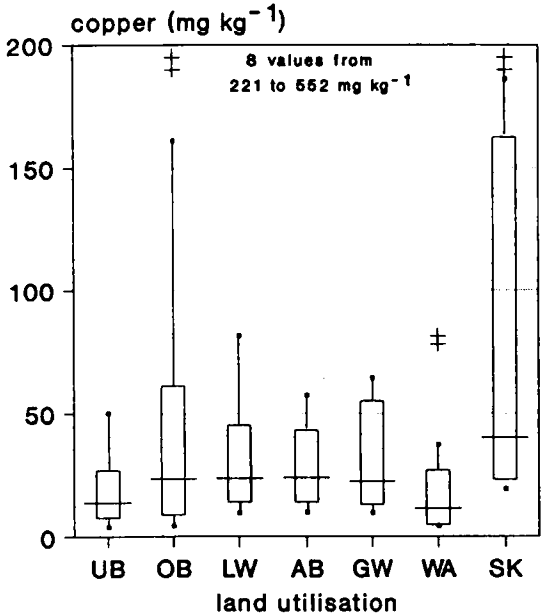

Figure 7 Copper contents (2 M HNO_3) as a function of land utilization. UB: subsoil; OB: topsoil; LW: agriculture; AB: arable land; GW: grassland; WA: forest; SK: fruit- and wine-growing, horticulture.

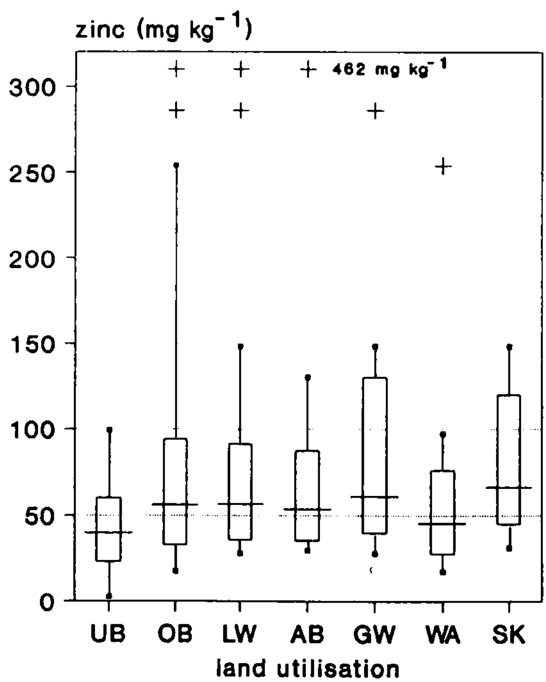

Figure 8 Zinc contents (2 M HNO_3) as a function of land utilization. UB: subsoil; OB: topsoil; LW: agriculture; AB: arable land; GW: grassland; WA: forest; SK: fruit- and wine-growing, horticulture.

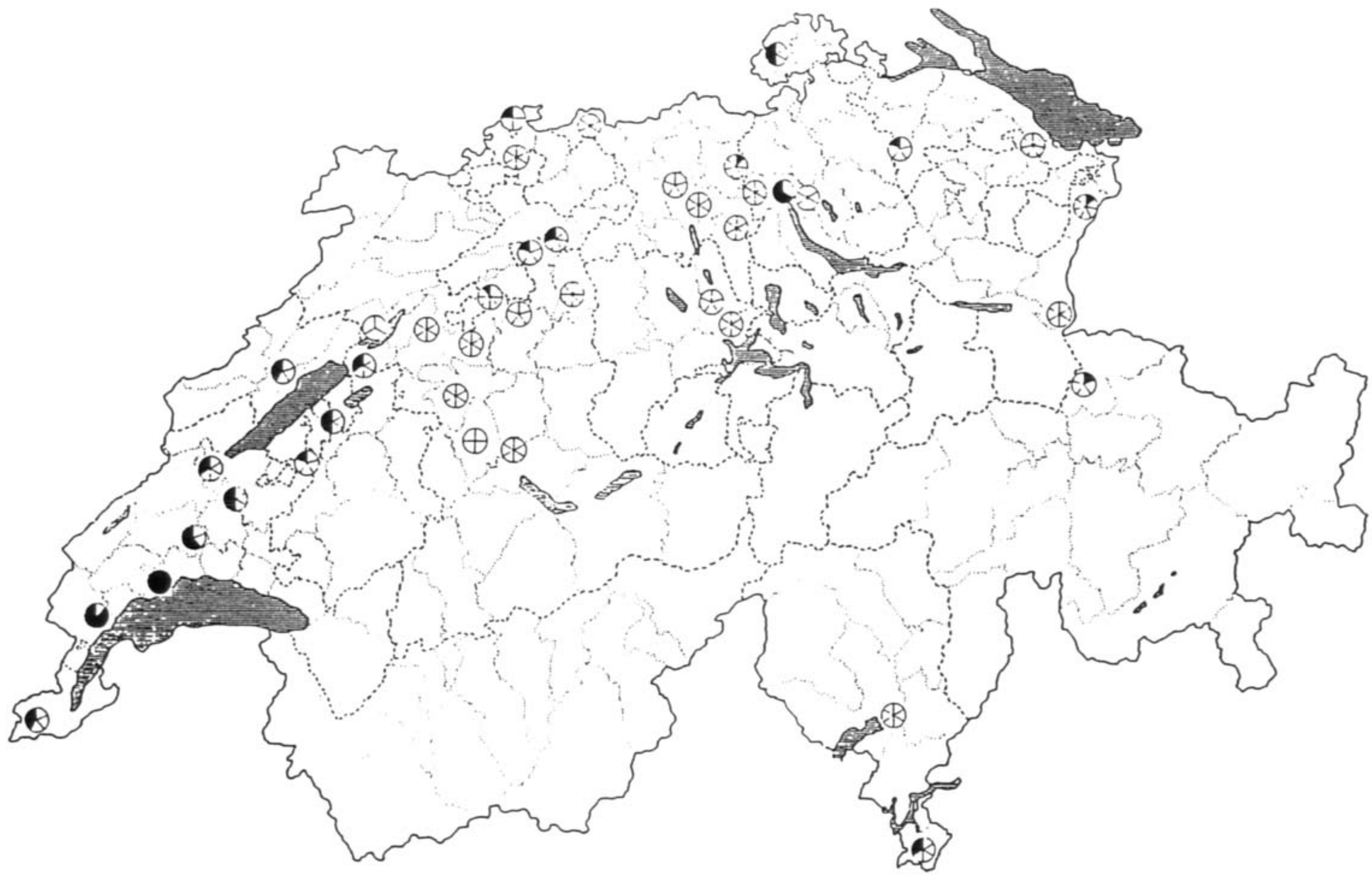

Figure 9 Soil contents (2 M HNO_3) of nickel: the black portion in the circles is an expression of the number of sites with contents >40 mg kg^{-1} in a group of subsoils.

The influence of land utilization can be seen from Figures 7–8. In case of copper the median is lowest in forest soils and highest in soils where copper has been used (e.g. viniculture). A similar but less pronounced picture is valid for zinc. In case of lead no influence of land use is visible.

Including all five investigated heavy metals the influence of the different site factors can be summarized as follows:

—Aerosol emissions from traffic, industry and incineration plants are mostly responsible for increased lead contents in topsoils.

—Some emission sources are locally important for raised cadmium and zinc contents in topsoils. In agriculture, inputs by fertilizers (cadmium), pig slurry (zinc) and plant treatment products (zinc) have to be considered.

—Copper is mainly brought in soils by agricultural practice (pesticides, pig slurry).

—No influence of emission sources and land utilization can be established for nickel. As increased subsoil contents are found in the catchment area of the glacier of the Rhône in the western part of Switzerland (Figure 9) the hypothesis is laid down that these contents are due to geological origin.

CONCLUSIONS

From the present study the conclusion may be drawn that the great majority of agricultural and forest soils show heavy metal contents which lie below the guide levels of the VSBo. Exceeded guide values can either be explained by land utilization (e.g. viniculture) or by distinct immission situations.

Further results about polluted areas are expected for a medium and long term from cantonal measuring campaigns. The NABO will bring information about background pollution of heavy metals.

A certain regional distribution of the natural basic metal content could be identified for nickel. The representation of potentially polluted areas needs the knowledge about the sources and fluxes of heavy metals.

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