Journal für Kulturpflanzen, 62 (2). S. 42–50, 2010, ISSN 0027-7479 Verlag Eugen Ulmer KG, Stuttgart

Frank Riepert[1], Anna Steindl[1], Rudolf Eibach[2], Michael Maixner[3], Christoph Reichmuth[1], Jörn Strassemeyer[4], Thomas Strumpf[1]

Monitoring of total contents of copper in organically and conventionally managed soils. Part 1: Study plan and preliminary sampling of copper and other anthropogenic induced heavy metal contents in vineyard soils

Erhebung von Kupfergesamtgehalten in ökologisch und konventionell bewirtschafteten Böden. Teil 1: Erhebungsplan und Vorbeprobung von Kupfer und anderen anthropogen eingetragenen Schwermetallen in Weinbergsböden

Abstract

The project aims to develop a survey designed for the representative assessment of copper contents in vineyard soils. The method development for the sampling of adequate monitoring areas is based on a preliminary survey of load distribution as well as on exposure assessment on selected areas of some typical vinery sites in Rheinland-Pfalz, differently managed and with different use history. Additionally to the sampling of selected areas, which reflects the spectrum of the load situation in viticulture, chemical quantitative analysis of soil samples collected from areas of known mode of cultivation and history followed by biological standard tests will be conducted. Obtained findings will serve for further method development, for preselection of adequate monitoring areas and for first indications of hazard potential. The project is a prerequisite for the performance of the long-term study "Development of current data of effects of copper contents in organic soils in viticulture, pomiculture and hopculture on soil life in terms of the strategy paper concerning further copper application in agriculture, especially in organic farming."

Key words: Copper, control of fungi, Peronospora, Plasmopora, vineyard soils, load situation in viticulture, risk potential, exposure assessment, preselection of adequate monitoring areas, regulation

Zusammenfassung

In Vorbereitung einer Feldstudie zur Erfassung der Kupfergehalte von Böden und zu den Auswirkungen auf Regenwürmer wird eine differenzierte Übersicht über die Höhe der Kupfergesamtgehalte anhand von Felderhebungen in der Dauerkultur Wein erarbeitet.

Die Methodenentwicklung zur Auswahl geeigneter Erhebungsflächen erfolgt unter Berücksichtigung einer repräsentativen Erfassung der Belastungsverteilung und der Expositionsabschätzung an ausgewählten Standorten unterschiedlich langer Nutzung und unterschiedli-

Institute
Julius Kühn-Institut – Federal Research Centre for Cultivated Plants, Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Berlin-Dahlem[1]
Julius Kühn-Institut – Federal Research Centre for Cultivated Plants, Institute for Grapevine Breeding, Geilweilerhof Siebeldingen[2]
Julius Kühn-Institut – Federal Research Centre for Cultivated Plants, Institute for Plant Protection in Fruit Crops and Viticulture, Bernkastel-Kues[3]
Julius Kühn-Institut – Federal Research Centre for Cultivated Plants, Institute for Strategies and Technology Assessment in Plant Protection, Kleinmachnow[4]

Correspondence
Dr. Thomas Strumpf, Julius Kühn-Institut – Federal Research Centre for Cultivated Plants, Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Königin-Luise-Str. 19, 14195 Berlin-Dahlem, Germany,
E-Mail: thomas.strumpf@jki.bund.de

Accepted
January 2010

cher Belastungshöhe in Rheinland-Pfalz. In Verbindung mit der Beprobung von ausgewählten Flächen, die das Spektrum der Belastungssituationen in der Kultur Wein abbilden, werden im Anschluss an die chemische Gehaltsbestimmung von Bodenproben aus Standorten bekannter Bewirtschaftungsweise und Historie biologische Standardtests durchgeführt.

Gewonnene Erkenntnisse dienen der Methodenweiterentwicklung, sollen erste Hinweise auf Gefährdungspotentiale geben und fließen in die Vorauswahl geeigneter Erhebungsflächen ein. Das Vorhaben ist Voraussetzung für die Durchführung einer Langzeiterhebung zur „Erarbeitung aktueller Daten zu den Auswirkungen der Kupfergehalte in Böden im ökologischen Wein-, Obst- und Hopfenbau auf das Bodenleben im Sinne des „Strategiepapiers zum Einsatz von Kupfer als Pflanzenschutzmittel in der Landwirtschaft unter besonderer Berücksichtigung des Ökologischen Landbaus".

Stichwörter: Kupfer, Bekämpfung von Pilzkrankheiten, Rebenperonospora, Plasmopara, Weinbergsböden, Belastungsverteilung, Risikopotential, Risikoabschätzung, Vorauswahl geeigneter Erhebungsflächen, Rechtssetzungen

1 Background, aim and scope

Since 150 years, copper-containing plant protection products are applied in Germany for controlling downy mildew (*Peronospora* spp.) on vine and hop as well as potato blight (*Phytophtora infestans*). Thus, copper products are among the oldest plant protection products.

From literature it is known that total copper contents in vineyard soils under long-time cultivation account for 46 to 2,880 mg Cu/kg soil (DM) (Moselle, Saar – 213 sampling sites) (median: 475 mg Cu/kg) and in hop-field soils under long-time cultivation 21 to 449 mg Cu/kg soil (DM) (Hallertau, Tettnang, Spalt und Hersbruck – 55 sampling sites) (KLOSKOWSKI, 1998). A current investigation of orchard soils in Southern Tyrol revealed total copper contents from 21 to 1,390 mg Cu/kg (median: 65 mg Cu/kg) (STIMPFL et al., 2006).

Despite high total copper contents in these soils, detectable bioavailable copper proportions from soil extracts are very low.

A literature survey (STRUMPF et al., 2009) showed that

a) the availability of data concerning total copper contents in specialized crops decrease depending on the dimensions of the cultivated area in the following order: vine > apple > hop,
b) at an average, vineyards with long-term copper applications (Moselle, Bordeaux, Champagne, Beaujolais, Rias Baixas) hold higher total soil contents than cultivated areas, newly developed for viticulture within the last decades (Australia, New Zealand),
c) long-term copper applications lead to detectable soil accumulations in all specialized crops (apple, vine, and hop),
d) Cu-contents in harvested products are fairly low even on highly contaminated sites. Risks for consumers can be excluded regarding intake and distribution pattern of copper in woody plants (fruit trees, vine). None of the examined tests showed evidence for copper loads in harvested products that could lead to usage limitations.

As copper cannot be metabolized in the soil, agricultural soils serve as a sink or source of Cu. Fixation and mobilization processes may decide whether the amount of the soil contaminant is causing toxicity to soil dwelling biota. Therefore, the determination of total copper contents can only serve as a first step and must be followed by reliable experimental data on bioavailability as a sound basis for risk assessment. As a considerable number of factors may be identified to impair soil biota on sites under agricultural use, careful validation of risk assessment, based on copper residues in soils is an essential requirement. Comprehensive literature about effects on soil organisms resulting from copper-containing plant protection products and other copper-containing sources in agriculture exists. On the basis of these investigations, it is known that long-term copper applications can have negative effects on many species living in the soil. Due to diverse sensibility of the particular species against copper a shift in species as well as a declining biodiversity may be the result on contaminated sites. An exact threshold is not yet determined.

Regulatory authorities are in conflict concerning risk-benefit analysis with regard to the renewal of marketing authorisation of copper-containing plant protection products, especially in organically cultivated crops where, despite big efforts, no effective surrogates are available to get part of a disease management system.

As long as alternatives for disease control are lacking, loss of copper-containing products could cause severe negative economic impact towards organic farming. According to regulatory authorities involved in environmental risk assessment, data records concerning the accumulation of copper in agricultural soils as a result of copper fungicide usage are considered to be insufficient.

In so far, a definitive risk assessment addressing both, the agriculturally used area in Germany and the magnitude of copper causing unacceptable adverse effects to soil biota appears impossible.

To establish limit values of critical loads of copper in soil, sampling should include all features or processes that may affect the expression of any toxic effect. As outlined by HEIJERICK et al. (2006), processes are related to the natural spatial variability (geochemistry), the amount released, the spatial and temporal distributions of these releases, and the large number of transportation, complexation, and dissolution processes. The analysis of exposure data in relation with site specific pedological and cultivation based factors intends to identify sites being representative and therefore worthwhile to be monitored for earthworm abundance and species variety representing sensitive and relevant indicator species.

Expert discussions about aim, scale, and sampling design of a field survey of copper contents in organic farming and, if appropriate, followed by earthworm monitoring on a number of selected sites resulted in a restriction of the envisaged sampling project on viticulture, mainly due to the experimental scale and costs.

For reasons of achieving a high degree of acceptability it was decided to harmonize the framework of the monitoring concept between national authorities involved in environmental risk assessment along with the pesticide approval. A steering group therefore comprises the Umweltbundesamt and the Bundesamt für Verbraucherschutz und Lebensmittelsicherheit.

2 Methods

2.1 Selection of sampling locations and description of field sites

In March 2009, samples were taken at several vineyard locations in south-western Germany (Fig. 1, 2). The ECOVIN Bundesverband Ökologischer Weinbau was involved to look for wine-growers prepared to participate in the survey. The selection was carried out in collaboration with the particular wine-growers according to requirements of a sampling design defined previously.

Exclusively sites comprising cultivated vineyards, formerly cultivated vineyards (positive control, preferentially more than 10 years) and reference areas (negative control e.g. meadow, garden, forest etc.) were chosen for sampling in order to determine natural geochemical loads of copper in spatial neighbourhoods. The selected sampling sites belong to the wine growing regions Rheinhessen (around Nierstein), Pfalz (around Mittelhaardt/German Wine Route and Southern Wine Route) and River Moselle (area Bernkastel).

Templates were prepared to record data of site description and identification, cultivation features and use patterns of disease control measurements. On site, wine-growers were interviewed about history, mode of cultivation, and copper inputs due to plant protection products and fertilization. In return, the farmer received

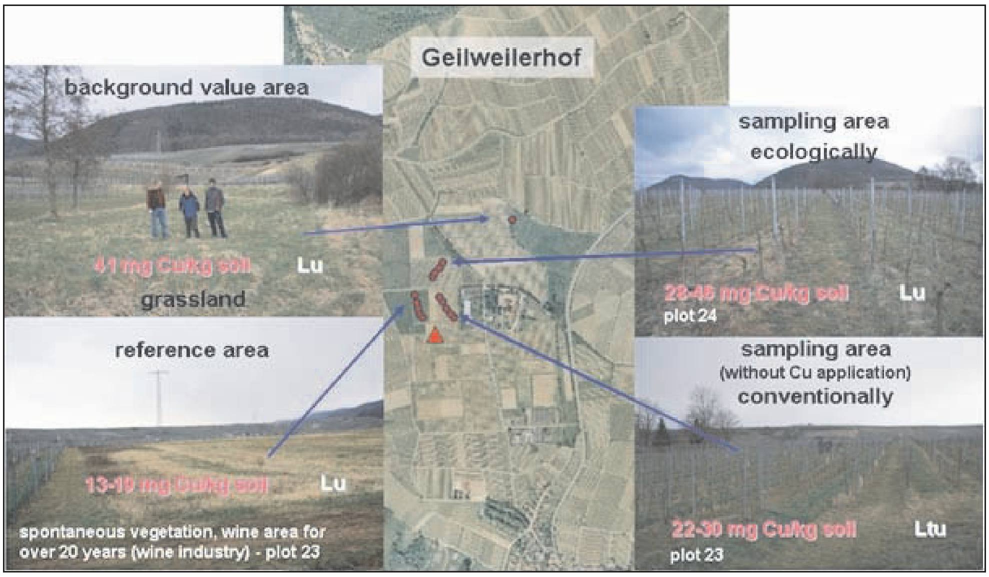

Fig. 1. Pfalz – Area Southern Wine Route. (PF_05). Representative evaluation of load distribution and the amount of total copper contents on the basis of field evaluations.

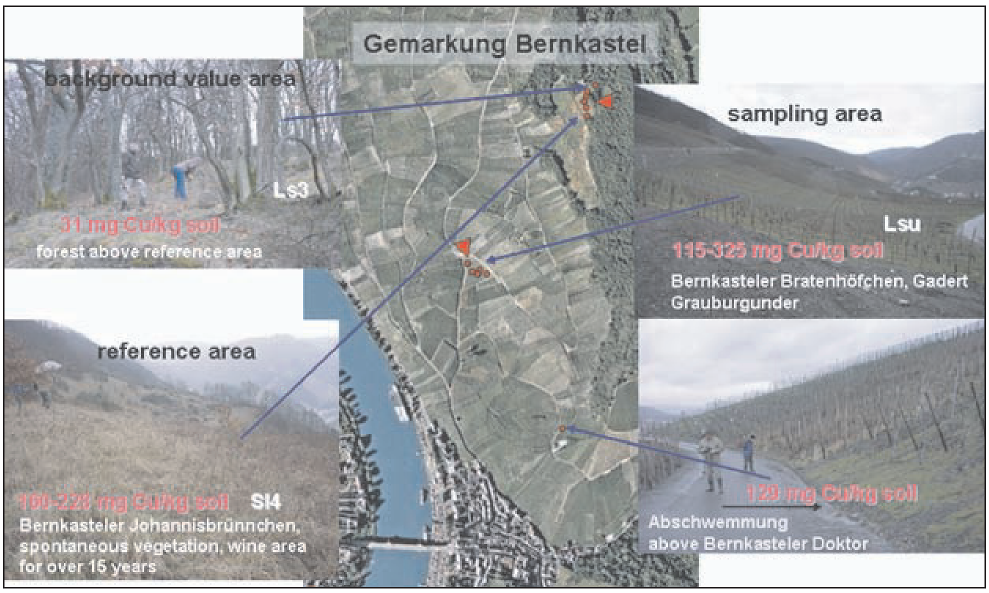

Fig. 2. Moselle – Area Bernkastel (Mo_02). Representative evaluation of load distribution and the amount of total copper contents on the basis of field evaluations.

sampling sites	Code	Soil type	Cu - total contents *[mg Cu/kg soil]*	Humus %	Area
Nierstein	RH_08	Ul2	42 - 143	8.3	cultivated vineyards (examination area)
		Ul3	77 - 112	9.1	former vineyards (reference area)
		Lu	124	9.5	background value area
Mittelhaardt/ German Wine Route	PF_02	Ltu	63 - 105	8.4	cultivated vineyards (examination area)
		Lt3	50 - 88	7.7	former vineyards (reference area)
		Ltu	42	8.1	background value area
Southern Wine Route	PF_04	Lsu	22 - 29	2.8	cultivated vineyards (examination area)
		Lsu	32 - 48	2.7	cultivated vineyards (examination area)
		Ul3	101	8.9	former vineyards (reference area)
		Lu	23	3.7	background value area
	PF_05	Ltu	22 - 30	3.1	cultivated vineyards (examination area)
		Lu	28 - 46	4.3	cultivated vineyards (examination area)
		Lu	13 - 19	2.2	former vineyards (reference area)
		Lu	41	4.7	background value area
Bernkastel	MO_01	Sl4	96 - 395	5.1	cultivated vineyards (examination area)
		Uls	20 - 56	2.9	former vineyards (reference area)
		Lu	14	3.4	background value area
	MO_02	Lsu	115 - 325	3.5	cultivated vineyards (examination area)
		Sl4	160 - 228	5.4	former vineyards (reference area)
		Ls3	31	9.8	background value area
	MO_03	Lu4	34 - 43	3.9	cultivated vineyards (examination area)
		Lu	168 - 304	5.7	cultivated vineyards (examination area)
		Ls3	248 - 360	6.5	former vineyards (reference area)
		Lu	22 - 24	4.5	background value area
	MO_04	Ls4	113 - 372	4.4	cultivated vineyards (examination area)
		Ls4	144 - 274	4.8	former vineyards (reference area)
		Lu	24	9.8	background value area
	MO_05	Ls3	31 - 77	2.8	cultivated vineyards (examination area)
		Ls3	35 - 37 (94)	2.9	cultivated vineyards (examination area)
		Lsu	16	3.6	background value area

Fig. 1a. Soil texture, total copper contents and humus on cultivated vineyards, former vineyards and background value area around Nierstein, (RH), Mittelhaardt/German Wine Route, Southern Wine Route (both PF) and Bernkastel (MO)

	As	Cr	Cu	Pb	V	Zn
As		0.4	0.7	0.5	0.0	0.4
Cr	0.4		0.5	0.2	0.7	0.3
Cu	0.7	0.5		0.2	0.3	0.2
Pb	0.5	0.2	0.2		0.0	0.5
V	0.0	0.7	0.3	0.0		0.1
Zn	0.4	0.3	0.2	0.5	0.1	

area Bernkastel (Mo_01-Mo_02; n = 66)

	As	Cr	Cu	Pb	V	Zn
As		0.3	0.0	0.4	0.4	0.4
Cr	0.3		-0.1	0.2	0.7	0.3
Cu	0.0	-0.1		-0.6	-0.3	-0.1
Pb	0.4	0.2	-0.6		0.5	0.7
V	0.4	0.7	-0.3	0.5		0.5
Zn	0.4	0.3	-0.1	0.7	0.5	

areas Nierstein, Mittelhaardt/German Wine Route, Southern Wine Route (PF_02, PF_04, PF_05, RH_08; n = 52)

Fig. 2a. Correlation coefficients between heavy metals relevant for soil biota in sampled vineyards

information on the intentions of the project. The exchange of information generally revealed the lack of analytical data on total copper contents in soils of cultivated sites or sites taken out of cultivation respectively used differently e.g. as private gardens.

Later on the sites provided by the growers were inspected and identified by taking pictures. In addition to the description of the sampling location a precise geographic determination of each sampling spot was achieved by using GPS.

2.2 Sampling methods

In vineyards under cultivation sampling was conducted typically along the vine-rows anticipating a worst case situation due to usual fungicide applications in these spots. At locations without vine cultivation samples were taken at regular spacing along a diagonal line or at random e.g. in neighbouring forest or other natural areas. At adjacent sites – where drainage was observed – soil was additionally collected from sediment spots found at the bottom line of the hills assuming potential "hot spots".

Sampling was carried out according to DIN, 1996, DIN, 1996a. Five spots per sampling site were diagonally measured, only considering soil horizons from 0 – 20 cm (horizon for later earthworm monitoring). Every spot was recorded by GPS.

2.3 Soil processing and analyses

Soil samples were air-dried and sieved (2 mm). The total heavy metal contents of 118 soil samples were determined after aqua regia (VDLUFA, 1991; UBA Texte, 1995) and pressure dissolution (LOFTFIELDS, UBA Texte

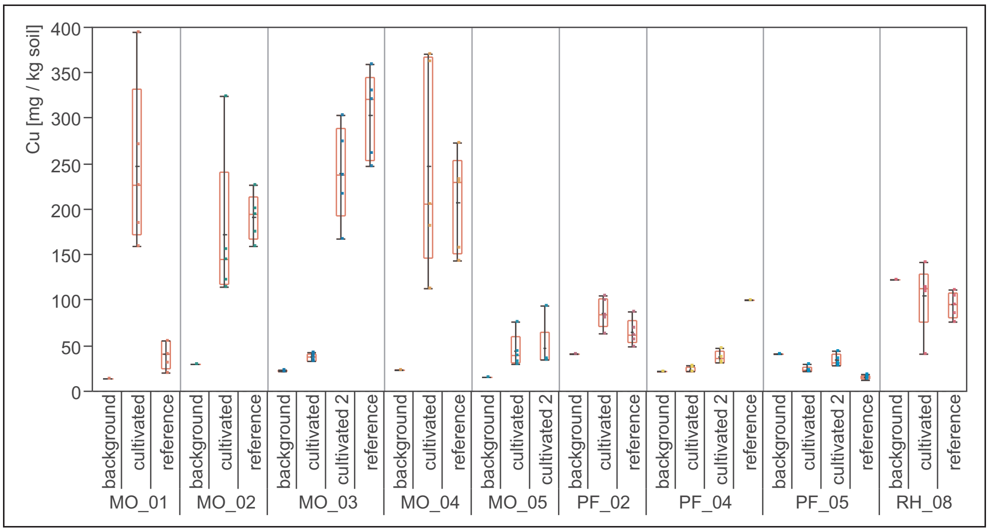

Fig. 3. Variabilty plots of total copper contents on cultivated vineyards, former vineyards and background values.

(1995a) by ICP-OES (**I**nductively **C**oupled **P**lasma **O**ptical **E**mission **S**pectrometry) with an IRIS Intrepid® (UBA Texte, 1995). Analogical, total contents of As, Pb, Cr, V, and Zn were measured. Contents of carbon (DIN, 1996b) and nitrogen (DIN, 1998) were determined with CNS-Elementaranalysator Vario EL. Pedological base parameters (soil particle size (DIN, 1997), pH (VDLUFA, 1991a), C_{org}, C/N) were collected for characterisation. The determination of the different soil types was performed according to DIN 4220 (DIN, 2008) in the triangular diagram.

3 Results

Increased copper contents in soils of diverse vineyards result naturally from soil forming rocks (e.g. Devon Slate) as well as from anthropogenic input as:

- Copper containing plant protection products applied for controlling Downy mildew (*Plasmopara viticola*), Grape anthracnose (*Elsinoe ampelina*) and “Roter Brenner” (*Pseudopezicula tracheiphila*) in vine,
- compost, containing pomace from copper treated grapes and
- municipal waste, mainly applied on steep slopes as soil amendment and/or for erosion protection.

These inputs resulted in considerable increase of total copper contents within the last century. In the past, copper-containing plant protection products with application rates of about 20-40 kg Cu/ha made up the lion’s share within the anthropogenic inputs.

The variability of total copper contents between and within the sampled sites is high (Fig. 3, Fig. 1a). **This result may be similar in other vineyards.** Some sites (e. g. PF_04, PF_05, Mo_03) show normal copper contents on cultivated vineyards. However, big differences in total copper contents were detected in cultivated vineyards, despite of low distances between the sites (e. g. Mo_02, Mo_03).

On cultivated vineyards and reference areas with higher total copper contents, inhomogeneous load distribution has always been identified.

All of the 9 sampled wine growing areas differ in history, copper load, mode of cultivation, geographical position (climate) and soil texture.

The load capacity of data from total copper contents, determined via ICP was confirmed after method comparison of dissolution processes for soil samples notably aqua regia (VDLUFA, 1991; UBA Texte, 1995) and pressure dissolution (UBA Texte, 1995a).

Both dissolution processes serve for the comparison of soil contents. Correlation of the two procedures is very high (r = 0.98) (Fig. 4). Reason for this could be that geogenic copper is bound to organic substance and only to a little extent to clay and silt components of the soil.

In other cases, the portions of the extracted contents of ecotoxicological elements can vary between 50 and 100% depending on the element and the mineral stock of the soil, as certain silicates and oxides cannot be diluted. Thus, a conversion to other elements is not possible.

Mobilization- and distribution of heavy metals is only possible via soil-plant pathway and via soil-water pathway, however in relatively small amounts.

Total soil contents resulting from anthropogenic activities provide a clear indication of the management history of particular vineyards. Among copper, some of the sampled areas showed higher concentrations of heavy metals as As, Cr, Pb, Zn, and V (Fig. 5).

Pb, As, and Cr were introduced by the application of lead-arsenate-insecticides and wood preservatives in vineyards.

From the 1890 s until the 1960 s, lead-arsenate [$PbHAsO_4$, $Pb_5OH(AsO_4)_3$] was a common plant protection product in agriculture worldwide. It was particularly applied for controlling the Colorado potato beetle, the codling moth and the larvae of the first generation of the vine moth.

Since 1905, first experiments with arsenic products were conducted in pomiculture and viticulture in Germany. The first list of plant protection products (1920) of the Biologische Reichsanstalt also included arsenic. In order to admit lead-arsenate in viticulture, several testing studies were commissioned in 1926 by the Reichsausschuss of Wine Research. There, high lead residues were noticed

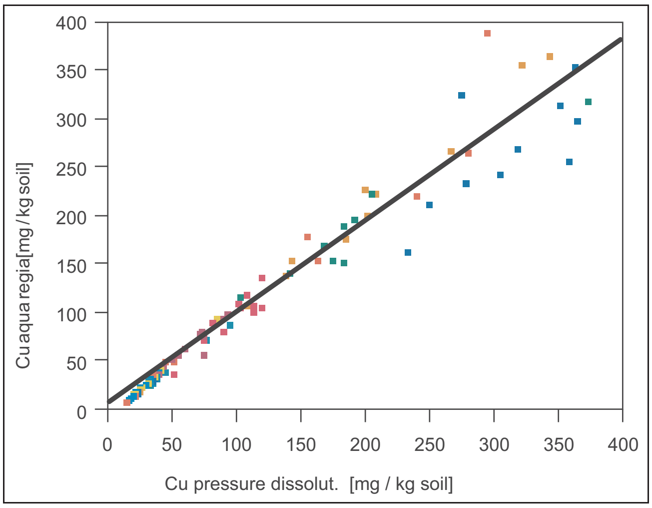

Fig. 4. Total copper contents in 113 soil samples after aqua regia and pressure dissolution. Correlation between the two dilution processes $r^2 = 0.95$ (linear regression: $y = 7.799 + 0.949x$).

(wine 0.5 – 9 mg Pb/l, pomace 8 – 14 mg Pb/kg, wine leaves 207 mg Pb/kg). In November 1927, the subcommittee for pest control in German viticulture argued for an application restriction of lead-arsenate instead of an admission.

In spring 1928, the Reich Ministry for food and agriculture prohibited the application and formulation of lead-containing compounds (ANONYMUS, 1928) in viticulture (PAUL, 1981).

Vine cultivation on poles was the most common form of cultivation in the 50 s and 60 s of the 20th century, and is still frequently applied in growing areas as Moselle, Ahr, and Mittelrhein.

A problem according to recent findings is that poles are impregnated with chromium, copper and arsenate to prevent wood-destructing fungi and insects (ISLAM et al., 2003; VOGELER et al., 2005; ROBINSON et al., 2006), as far as research results from New Zealand, Australia, Chile, South Africa and California can be transferred to Germany.

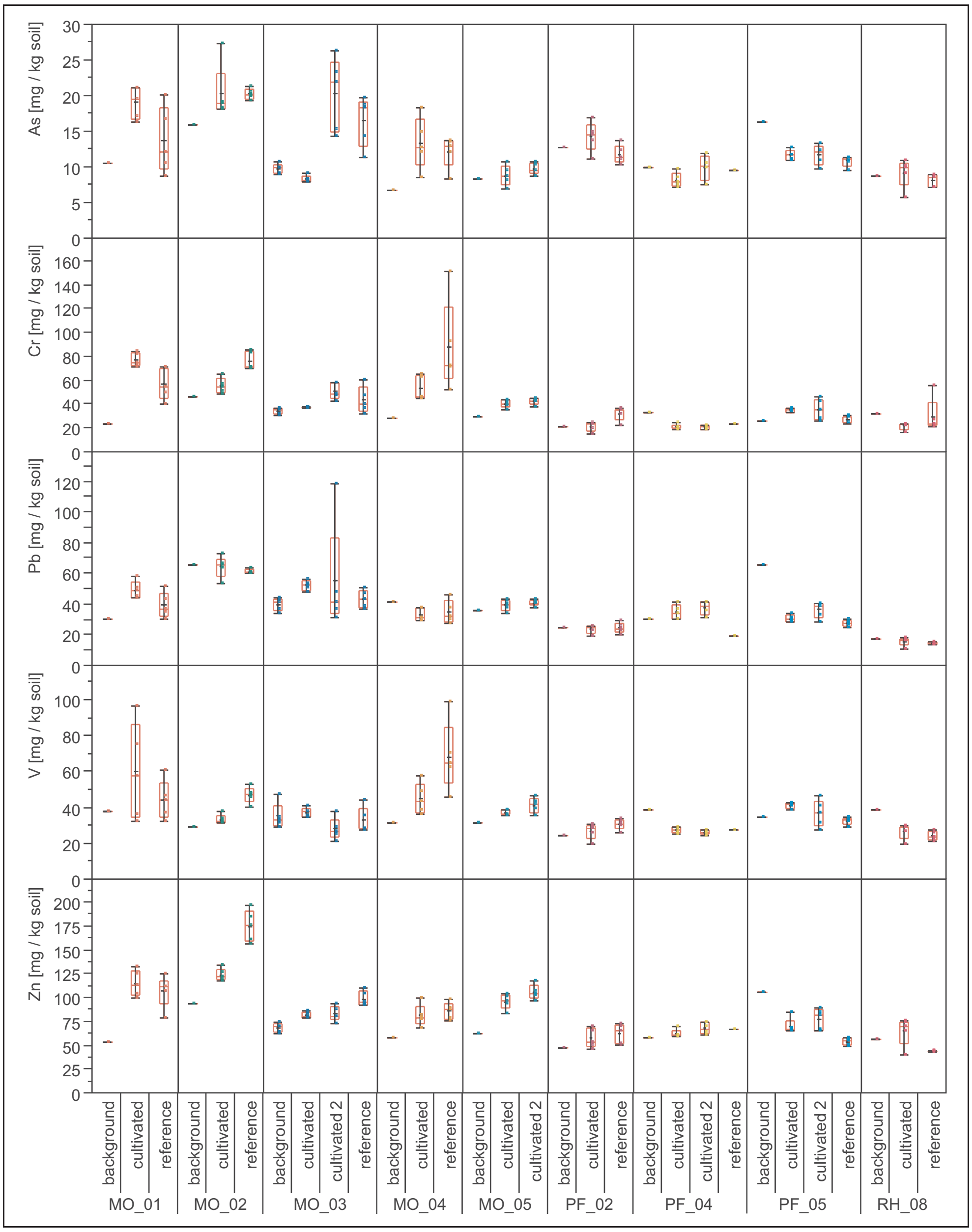

Fig. 5. Variabilty plots of total arsenic, chromium, lead, vanadium and zinc contents on cultivated vineyards, former vineyards and background values.

Heavy metals, particularly mobile arsenic from preservers were not only found in the soil around the poles but also in the groundwater in deeper layers. Responsible for the shifting of contaminants is among diffusion the downhill interflow in the soil cover.

Today, metal poles are mainly used in espaliers. The poles are zinc coated or possess a zinc-aluminium alloy for the protection against corrosion. The vines in espaliers are predominantly new varieties, among others created for mechanical harvesting. The contamination of the vine by zinc dissolved from metal poles depends on the zinc alloy as well as on the predominant type of soil. Investigations showed that contents of zinc are very high (2500 – 3000 mg zinc/kg) especially in the soil next to poles, which negatively affects plant growth (LVWO Weinsberg, 2009).

Vanadium as accompanying element of ferrous metal represents an indicator for the application of metal poles in viticulture. Vanadium compounds possess diverse biological significances. One characteristical feature of vanadium is that it occurs anionic as vanadate as well as cationic as VO_2^+, VO^{2+} or V^{3+}. Vanadate resembles phosphates and accordingly acts similar. As vanadate has a stronger bonding to adequate enzymes than phosphate, it is able to block and control enzymes of phosphorylation. Example for this is the Na+/K+-ATPase, which controls transportation of Natrium and Kalium in cells. A blocking can be rapidly reversed by Desferoxamine B, forming a stable complex with vanadate (REHDER, 1991).

Vanadium plays a role for photosynthesis in plants. It is able to catalyze the reaction for the formation of D-Aminolevulinic acid in the absence of an enzyme. This reaction is an important pre-stage for the formation of chlorophyll (REHDER, 1991). Lysimeter trials showed chlorosis and growth depressions in agricultural and horticultural cultures [celery (*Apium graveolens* L.), pipe tobacco (*Nicotiana tabacum* L.), sugar beet (*Beta vulgaris* var. *altissima* L.), tomato (*Solanum lycopersicum* L.), sunflower (*Helianthus annuus* L.) and cabbage (*Brassica oleracea* L.)] with total soil contents of vanadium > 50 mg/kg soil (STRUMPF and PESTEMER, 2003).

The sampled areas showed big differences in history, mode of cultivation, plant protection, geographical situation, spatial distribution and soil parameters. The calculated correlation (Fig. 2a) between contents of single total heavy metals in the sampled vineyard soils only provides an indication of former mode of cultivation.

Soil samples from steep slopes in the central Moselle region possessed As and Cr contents exceeding background contents of neighbouring areas. This indicates former applications of poles impregnated with copper-chrome-arsenate (Fig. 5 – Mo_1, Mo_2, Mo_4). As today, alloyed metal poles are used in viticulture, total soil contents of zinc are significantly higher (Fig. 5 – Mo_01 - Mo-05).

Applications of lead-arsenate did not occur around Bernkastel in the past (Pb-contents on vineyards ~ Pb-contents on background area), however, sporadically as on the sampled area Mo_3 (Pb-contents on vineyards > Pb-contents on background area).

In contrast, total arsenic, chromium, lead, vanadium and zinc contents on cultivated vineyards, former vineyards and background value area do not significantly differ.

4 Discussion

Two of the selected sampling areas that are cultivated according to the rules of organic farming will be exemplarily presented:

In 1926 the breeding of new vine cultivars containing high resistance against pests, stress factors caused by weather as well as high wine quality was started on "Geilweilerhof" (PF_05). With the help of resistance breed-

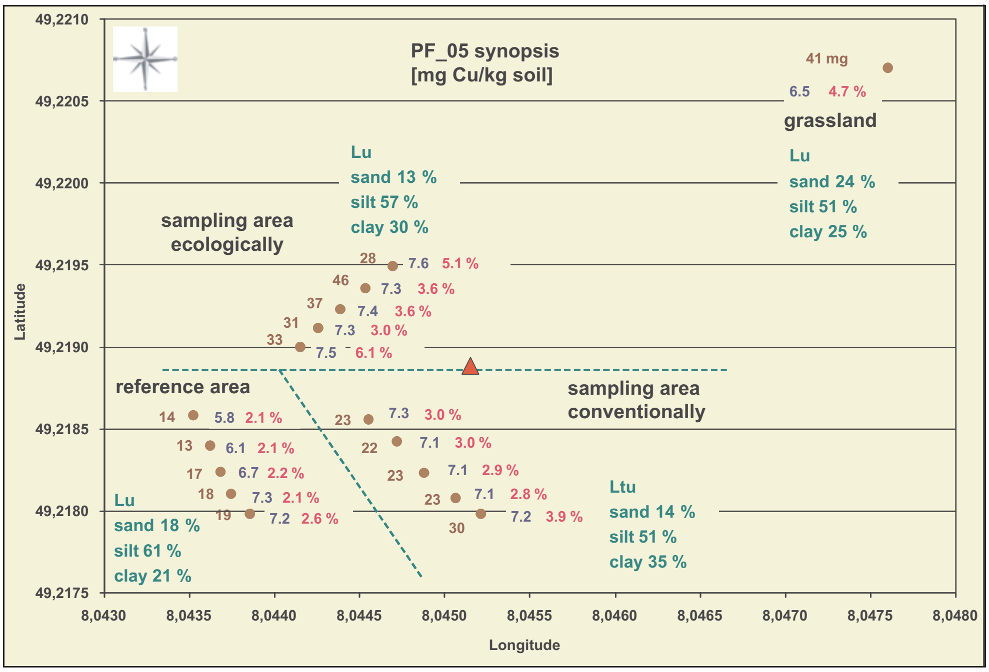

Fig. 6. Ecologically and conventionally managed sampling areas, former vineyards and background value area for evaluating copper loads on site PF_05. Distribution of total copper content, pH, humus and soil particle size.

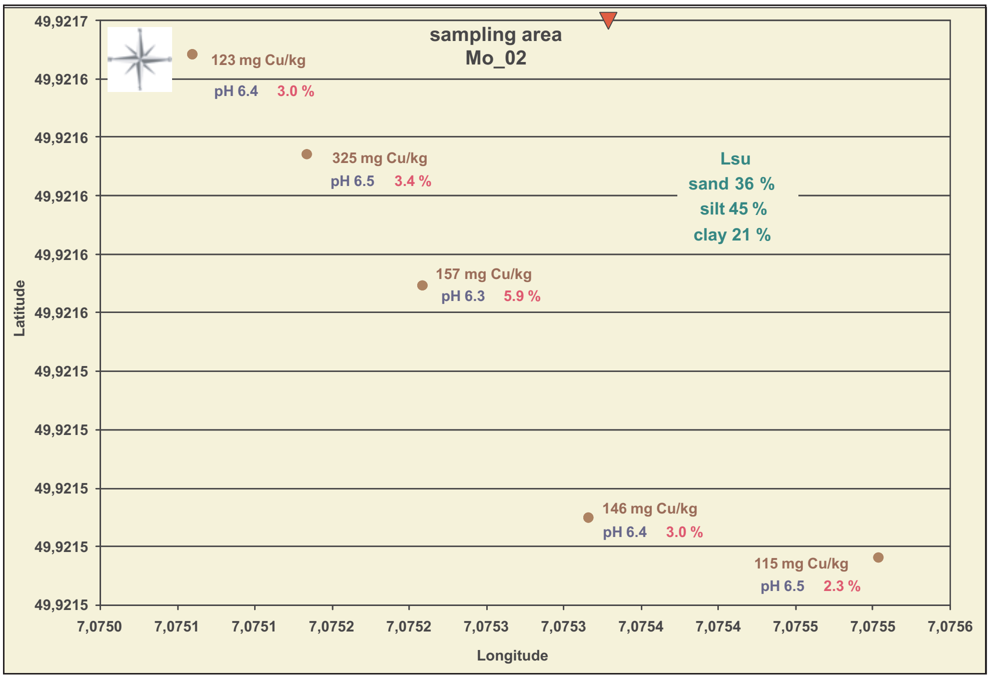

Fig. 7. Organically managed sampling area for evaluating copper loads on site Mo_02. Distribution of total copper content, pH, humus and soil particle size.

ing, plant protection (in ecological viticulture especially for controlling pathogens with copper compounds) can be reduced or even left out to some extend. This may be one reason why the selected sampling areas, conventionally or ecologically cultivated, did not indicate peak loads of copper despite of 80 years of cultivation (Fig. 6).

No increase of total copper contents could be detected on the sampled area (Fig. 6). Since decades, this sampling area was planted with different vine varieties. The selected positive reference area is situated directly next to the first sampling area, and was cultivated for a very long time. Now it lies fallow since more than 20 years. The area is overgrown with herbaceous plants. The second sampling area is ecological cultivated since 6 years and is currently planted with the vine cultivars Regent, Kalandro, Weißburgunder, Spätburgunder.

The nearby negative control area (meadow) had never been treated with copper compounds. The calculated Cu-background value of ~ 40 mg Cu/kg soil is higher than the total copper contents in the sampling and reference area of "Geilweilerhof".

Samples taken from vineyards in the Moselle Region around Bernkastel (Fig. 2 – Mo_02) that is characterized by steep slopes resulted in total load peaks of > 300 mg Cu/kg soil (Fig. 7) for a location that is managed according to organic farming („Bernkasteler Bratenhöfchen – Gadert"). The testing area has been cultivated with Grauburgunder since 1997 and is in use for a very long time.

The positive reference area (Fig. 8) was not cultivated since more than 15 years. In the meantime, a heather biotope evolved spontaneously on the slate gravel. The negative reference area, situated directly above the fallow, was never treated with copper in the past and resulted in a background value of ~ 30 mg Cu/kg soil.

As copper primarily bounds to soil organic matter with elevated total copper contents mainly occurring in the topsoil, emergence of „hot spots" evolved by avulsion after "run-off" events were expected. Thus, soil from avulsion above the well-known site „Bernkasteler Doktor" was additionally sampled (Fig. 2). The analysed total soil content of ~ 130 mg Cu/kg soil was in the range of the testing and reference area of the vineyards around Bernkastel.

5 Conclusions

1. Results show that a selection of vineyards from different wine growing areas with different load situations and mode of cultivation and the selected methodology are promising approaches for the project "Preparation of a field study for the investigation of copper contents in organic soils and effects on earthworms".
2. The comprehension of conventionally cultivated vineyards into the representative acquisition of load distribution is reasonable and will be incorporated into sampling.
3. At least 5 sites with different copper contents, and neighbouring adequate positive and negative reference sites should be selected for a monitoring program covering preferably all German wine growing areas. The history of the site, the mode of cultivation, copper entries via plant protection products and fertilization, different geographical positions of the vineyards (climate), and differences in soil texture have to be considered.
4. Parameters for adequate areas for maintenance monitoring according to the directive of the commission 2009/37/EG of April 23rd 2009 concerning the modi-

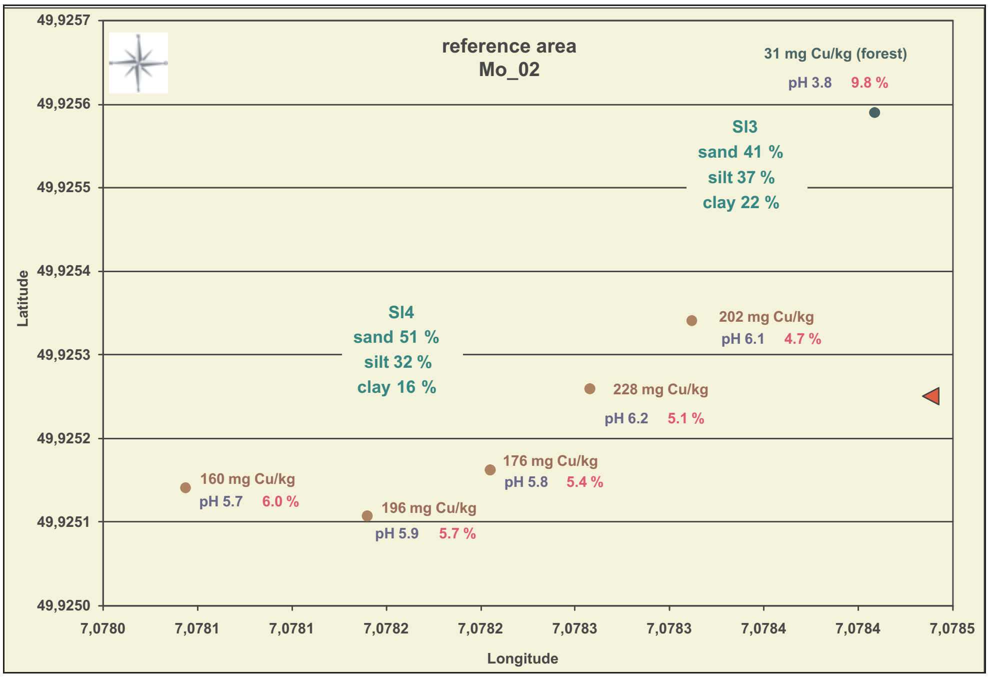

Fig. 8. Former vineyard and background value area (forest) for evaluating copper loads on site Mo_2. Distribution of total copper content, pH, humus and soil particle size.

fication of the directive 91/414/EWG of the European Commission for the purpose of the acceptance of the agents Chlormequat, copper, Propaquizafop, Quizalofop-P, Teflubenzuron and Zeta-Cypermethrin cannot be given yet by the Julius Kühn-Institut (JKI).

5. Responsibilities for representative evaluation of load distribution and total copper contents on the basis of field evaluations in specialized crops as hop and apple will be agreed within the partners in October 2009.

References

ANONYMUS, 1928: Verordnung zur Ausführung der Verordnung über die Schädlingsbekämpfung mit hochgiftigen Stoffen. 29. März 1928, Reichsgesetzblatt Teil I Nr. 16 vom 5. April 1928.

BELOTTI, E., 1998: Assessment of a soil quality criterion of a field survey. Applied Soil Ecology **10**, 51-63.

DIN, 1996: E DIN ISO 10381 – 1: Bodenbeschaffenheit – Probenahme: Anleitung zur Aufstellung von Probenahmeprogrammen.

DIN, 1996a: E DIN ISO 10381 – 4: Bodenbeschaffenheit – Probenahme: Anleitung für das Vorgehen bei der Untersuchung von natürlichen, naturnahen und Kulturstandorten.

DIN, 1996b: DIN ISO 10694: Katalytische Rohrverbrennung unter Sauerstoffzufuhr bei hohen Temperaturen.

DIN, 1997: DIN 19683 – 2: Bodenuntersuchungsverfahren im Landwirtschaftlichen Wasserbau – Physikalische Laboruntersuchungen, Bestimmung der Korngrößenzusammensetzung nach Vorbehandlung mit Natriumpyrophosphat.

DIN, 1998: DIN ISO 13878: Katalytische Rohrverbrennung unter Sauerstoffzufuhr bei hohen Temperaturen.

DIN, 2008: DIN 4220: Bodenkundliche Standortbeurteilung – Kennzeichnung, Klassifizierung und Ableitung von Bodenkennwerten (normative und nominale Skalierungen).

HEIJERICK, D.G., P.A. VAN SPRANG, A.D. VAN HYFTE, 2006: Ambient Copper Concentrations in Agricultural and Natural European Soils: An Overview. Environmental Toxicology and Chemistry **25** (3), 858-864.

ISLAM, A., A.J.M.S. KARIM, H.M. KHALED, B.K. MITRA, M.A.M. MIAH, 2003: Arsenic sorption characteristics of four agricultural soils of Bangladesh. Asian Journal of Plant Sciences 2, 1149-1152.

KLOSKOWSKI, R., 1998: Verbleib von Kupfer in Boden und Wasser nach Anwendung von kupferhaltigen Pflanzenschutzmitteln. Berichte aus der BBA (Darmstadt), 34-36.

KÜHLE, J.C., 1986: Modelluntersuchungen zur strukturellen und ökotoxikologischen Belastung von Regenwürmern in Weinbergen Mitteleuropas (Oligochaeta: Lumbricidae). Inaugural Dissertation, Rheinische Friedrich-Wilhelms Universität, Bonn.

LOFTFIELDS X., 1986: Bedienungsanleitung Aufschlussautoklaven für die Mineralstoffanalytik – Loftfields Analytische Lösungen. Neu Eichberg.

LVWO Weinsberg, 2009: „Zinkeintrag durch Stahlpfähle" http://www.landwirtschaft-mlr.baden-wuerttemberg.de /servlet/PB/menu/1040038_l1/index.html. Accessed 7. August 2009.

PAUL, C., 1981: Arsen zur Schädlingsbekämpfung im Weinbau. Schriften zur Weingeschichte, Wiesbaden, ISSN 0302 0967, 58,1904-1942.

REHDER, D., 1991: Bioanorganische Chemie des Vanadiums. Angew. Chem. **103**, 152–172.

ROBINSON, B.H., M.M. GREVEN, S.R. GREEN, S. SIVAKUMARAN, P. DAVIDSON, B.E. CLOTHIER, 2006: Leaching of copper, chromium and arsenic from treated timber vineyard posts in Marlborough, New Zealand, Science of the Total Environment **364**, 113-123.

STIMPFL, E., M. AICHNER, A. CASSAR, C. THALER, O. ANDREAUS, A. MATTEAZZI, 2006: Zustandserhebung der Südtiroler Böden im Obstbau, Laimburg Journal Vol. **3** (1), 74-134.

STRUMPF, T., W. PESTEMER, 2003: Total and Plant Available Contents of Nutrient and Noxious Elements in Urban Soils and their Transfer Rates to Plants. Poster. „Second International Symposium on Plant Health in Urban Horticulture", 27. – 29. August 2003, Berlin.

STRUMPF, T., U. STENDEL, C. VETTER, 2009: Gesamtgehalte von Kupfer in Böden des Kernobstanbaus, Weinbergen und Hopfenanlagen (Total Copper Contents in Apple Orchard Soils, Vineyard Soils and Hop-field Soils). Journal für Kulturpflanzen **61** (4), 117–125.

VOGELER, I., S.R. GREEN, M.M. GREVEN, B.H. ROBINSON, C.W. VAN DEN DIJSSEL, B.E. CLOTHIER, 2005: Environmental risk assessment of CCA leaching from treated vineyard posts. HortResearch Client Report No. 17659, pp. 44.

UBA TEXTE, 1995: Methodenhandbuch Bodenschutz Teil 1, 10/95, Teil 22: Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlammuntersuchung (DIN 38 406); ISSN 0722-186X, 86.

UBA TEXTE, 1995a: Methodenhandbuch Bodenschutz Teil 1, 10/95, Druckaufschluss mit HF/HCLO4/HNO3; ISSN 0722-186X, 49.

VDLUFA, 1991: (Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten) Methodenbuch, Band I. Die Untersuchung von Böden, A 2.4.3.1. Darmstadt, VDLUFA-Verlag.

VDLUFA, 1991a: (Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten) Methodenbuch, Band I. Die Untersuchung von Böden, A 5.1.1. Darmstadt, VDLUFA-Verlag.