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Comparison of different types of peat corers in volumetric sampling

Erityyppisten turvekairojen vertailu tilavuustarkkojen näytteiden otossa

Aki Pitkänen, Jukka Turunen & Heikki Simola

Aki Pitkänen, Heikki Simola, Deparment of Biology, University of Eastern Finland, P.O.Box 111, FI-80101 Joensuu, Finland, email: aki.pitkanen@uef.fi
Jukka Turunen, Geological Survey of Finland, Neulaniementie 5, FI-70210 Kuopio, Finland

As part of an investigation of the long-term effects of ditch-draining on peat deposits, we cored peat samples altogether from 51 peatland sites that had been earlier inventoried by volumetric coring by the Geological Survey of Finland (GTK) during the 1980s. In most cases, it proved possible to match the old and new profiles cored of the same site, especially concerning their lower parts, in which typically no big changes seem to have taken place. However, comparison of the results revealed a recurring, albeit not systematic bias: the dry bulk density values of the GTK data tended to be somewhat smaller than our corresponding results. In cases where peat compression can be ruled out, a plausible explanation is that the piston corer did not function properly. This paper describes a test series in which we compared the GTK piston corer, a 1-m box corer and a Russian peat corer in quantitative sampling of peat strata. The piston corer proved to have a slight tendency to underperform, particularly with peats rich in sedge, cottongrass or wood remains. Implications of the variable sampler performance on quantitative peat inventories are discussed.

Key words: corer performance, peat coring, peat samplers, volumetric sampling

Introduction

The Geological Survey of Finland has investigated approximately 1.8 million ha of the 9.4 million ha area covered by peat in Finland. The goals of the peat inventory include the mapping of potential peatland sites suitable for peat excavation but also to estimate the resources and values of the conservation and various environmental aspects (Virtanen 2008). While peat deposits constitute by far the largest store of terrestrial organic carbon (C) in Finland (about 6 000 million tonnes, or 6 Pg C; Turunen 2008), their C balance emerges an issue of particular significance in regard of climate change (Limpens et al. 2008, Ojanen et al. 2010).

As part of an investigation of the long-term effects of ditch-draining on peat deposits, we visited 51 peatland sites in 2009 inventoried by volumetric coring by the GTK during the 1980s. Our attempt was to obtain comparable quantitative data of exactly the same coring sites, which we were able to locate with GPS, using the initially precise positioning data of the GTK surveys. Overall, the re-visitation approach proved useful (unpubl. data), but comparison of the results showed that the dry bulk density (BD) values of the GTK data tended to be somewhat smaller than our corresponding results. Earlier, Tolonen & Ijäs (1982) have compared the Russian peat corer and the piston corer of GTK at six sites. They found that in some cases, depending on peat properties, the piston type corer may underestimate the peat mass. Nevertheless, they found both types equally accurate as sampling devices because the differences between devices were not conspicuously high. In our data, the differences between samplers were obvious even in sites in which the peat thickness has remained the same as in the GTK survey, so peat compaction due to subsidence appears an unlikely cause (cf. Schothorst 1977).

The aims of the present paper are: 1) to present results of our comparisons of the performance of three commonly used quantitative peat corer models, and 2) to discuss the implications of our findings in the wider context of peat inventory studies.

Material and methods

Peat samplers

The piston corer described by Korpijaakko (1981) was designed in the GTK specifically to obtain quantitative volumetric peat samples for the nationwide peat inventory survey. The core tube is made of steel, and is divided into three parts, which have screw threads at their joining ends and are screwed together with brass collars. The lowermost tube part has a sharpened cutting edge; the middle part is exactly 20 cm long, and will hold the volumetric sample; the top part is provided with a cap on which the sinking rod is fastened and which has a hole to let through the piston rod. Inside the tube there is a cone-tipped piston that is placed at the lower end of the tube when the device is hammered down to the starting level, and then held in position when the coring tube is hammered further down, to take in the sample. When lifting the corer, the piston is held in the top position at the upper end of the tube. Sampling with this device is rather slow, while just a single 20-cm long sample is retrieved at a time. Furthermore, the device is not suited for sampling the easily compressed uppermost peat layer; therefore in the GTK surveys the top 0–20 or 0–30 cm was not sampled quantitatively.

The box-corer used in the present study is a modification of a design introduced first by Jeglum et al. (1992). It is a metal box, (cross section 10 × 10 cm), with three sides made of steel plate and one side open with guiding slits at the margins for the closing blade. The box is pushed down with the fourth side open. When the final depth is reached, the closing blade with its sharp and pliable steel tip is pushed into place. To avoid compression of the possible loose top surface layers, a starting cut for the closing blade with the box's dimensions can be made with a sharp long-bladed knife down to 20–30 cm depth. At the lower end of the box, the guiding slits curve across the box, leading the blade to cut loose the core and to close the box properly for retrieving. After the corer is lifted up, the blade is removed, and the volumetric samples can be directly cut from the open box-corer.

The so called Russian peat corer was actually reconstructed in Scotland (Jowsey 1966) on the basis of sketchy illustrations of a peat sampling device used in the Soviet Union (Belokopytov & Beresnevich, 1955, according to Jowsey 1966). The sampling chamber consists of a steel half-cylinder with one sharpened edge, on which a flat steel blade is attached so that it turns around the central axis of the cylinder. The narrower side of the blade fits precisely to turn inside the half-cylinder, while the broader side acts as an anchor to keep the blade in position during sampling. The lower tip of the coring head is shaped as a half-cone, and at its upper end there is a fixture for the sinking rod. When sinking, the half-cylinder is positioned at the rear of the flat blade, and at the sampling depth it is turned 180° by the rod to cut and secure the sample against the blade face.

In our survey we have used a model with a sample chamber 50 cm long and with inner diameter of 50 mm. Even though the sample size with this corer is considerably smaller than with the two other models dealt with, it proved to be quite reliable for the quantitative sampling, providing good reproducibility as judged by the pairwise sample series obtained at each site. Prerequisites for good performance are of course that the corer is in perfect condition, with the cutting edge of the chamber sharpened, and that the sampling and sample treatment are conducted with great conscientiousness. As compared with the above mentioned piston corer, a definite advantage of the Russian-type corer (as well as the box corer) is that upon recovery, after opening of the chamber, the sample is fully exposed for inspection, so a defective sample can be immediately discarded and a better one cored for replacement.

Peat sampling

Box and Russian corer sampling in 2009

In June 2009 we cored altogether 51 volumetric peat profiles at former GTK survey sites, by using the box corer for the uppermost strata (maximally 0–100 cm) and the Russian corer for the deeper layers. This data set represents five municipalities in different parts of middle Finland (south and middle boreal forest vegetation zones), between the latitudes 62° and 65° N.

The sampling sites had to fulfil the following criteria: volumetric peat sampling results obtained by GTK during the 1980s available; forestry drainage carried out before (or shortly after) the GTK survey; peat thickness about 2 m; initial peatland site type representative for the area; no evidence for other disturbance factors than the ditching.

At each site, we located the original GTK coring point with GPS. At several sites we were able to find old marking posts or other indications of the GTK coring. At each site we cored with the box and Russian corers two complete peat profiles. These were subsampled in the field into consecutive volumetric 10-cm slices, and analysed in the laboratory of the Ecological Research Institute of the University of Eastern Finland in Joensuu for fresh mass, dry mass and ignition residue.

Piston corer test sampling in 2010

We noted some irregularities between ours and the old GTK results that appeared not to reflect time-related changes, but rather some differences between performances of the different corer models. Therefore, we decided to test the old piston corer by taking with it replicate samples from some of our 2009 sites. We chose six representative sites in the Pieksämäki area (62°08’ – 62°24’ N, 26°40’ – 27°10’ E) for this test purpose, and cored them with the piston corer in June 2010. Leino & Silen (1988), Leino (1988) and Leino (1992) present the original GTK results of the test sites: Vipusuo, Kolmisopensuo, Kittisuo, Saunakankaansuo, Isosuo and Rajasuo. At each of these six sites we took a sample series from a depth of 20 cm down to the mineral bottom with the piston corer following the established practice by GTK, to compare with the results of our own sampling of the previous year and the results of GTK of the 1980s.

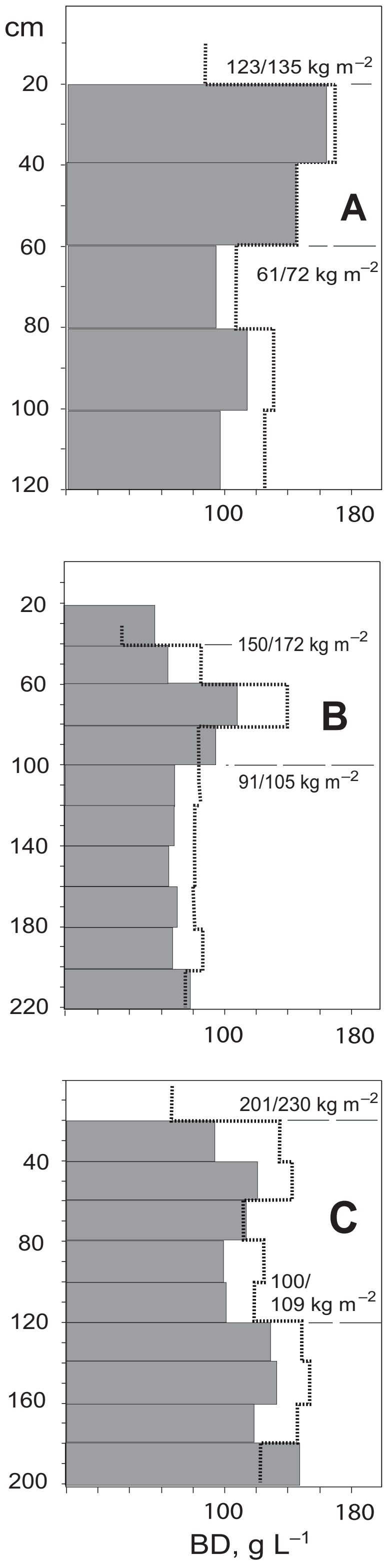
Calculations

Bulk density values (BD; g L^{-1}) for each of the 10-cm subsamples were obtained from the dry and ash weight results (in grams, proportional to sampler cross section x_i cm^2) by multiplication by the ratio 100:x_i; for the 20-cm piston corer samples an additional correction factor 0.5 was applied. The *cumulative masses* were obtained by summing up the (corer cross-section specific) subsample weights across the entire profile or specified depth intervals (the weighted quantities multiplied by factor 10,000:x_i to obtain values g m^{-2}).

Results

Comparison of the bulk density results

Three examples of the pairwise compared BD profiles up to 20 cm depth below the surface are shown in Fig 1. The old GTK and our profiles show rather similar overall features; it is worth mentioning that also the ash content profiles in each pair of the compared sample series are very closely similar except for the uppermost 20–30 cm sections. In the lower and middle parts of



each profile pair, the characteristic shifts of the BD values show rather similar patterns, which seems to indicate that no marked compaction in these sections has taken place during the time lapsed between GTK and our coring. However, in Rajasuo (Fig 1A) the peat surface has subsided by about 10 cm and in Isosuo (Fig 1B) by 30 cm, whereas in Saunakankaansuo (Fig 1C) our crude analysis, allowing only 10-cm resolution, does not reveal any subsidence.

In these example cases all the major changes possibly related to ditch drainage seem to be confined to the uppermost 20 or 30 cm section of the profiles as they stand at present. It is indeed conceivable that the possible compaction (subsidence) of the peat and other soil processes potentially altering the BD values (e.g. new biomass input by tree roots) mainly would occur in the uppermost peat section only, particularly, while in the Finnish conditions even drained peat deposits usually retain rather high water table

Fig. 1. Comparison of peat dry bulk density (BD) profiles taken from three sites in the Pieksämäki area in Finland; A: Rajasuo, B: Isosuo, C: Saunakankaansuo. Grey bars show the Geological Survey of Finland (GTK) results of early 1980s and the dotted line shows our 2009 results of the same sites. The uppermost 0–20 cm section of peat, which was not quantitatively sampled in the GTK survey, is excluded from this comparison. The vertical positions of the GTK and our profiles have been correlated so that their basal parts are at the same stratigraphical level; depth scales according to the GTK data. The figures marked on the horizontal lines at each profile are the organic matter (dry mass) pools of the GTK's and our cores, respectively, calculated upwards from the base of each profile to the designated level.

Kuva 1. Turpeen kuivatilavuuspainoa (BD)kuvaavien profiilien vertailu kolmelta tutkimuspisteeltä Pieksämäen alueelta; A: Rajasuo, B: Isosuo., C: Saunakankaansuo. Geologian tutkimuslaitoksen (GTK) 1980-luvun alkupuolella ottamien näytteiden tulokset esitetty harmaina pylväinä; tämän tutkimuksen tulokset vuodelta 2009 esitetty katkoviivoin. Ylin 0–20 cm kerros on jätetty vertailussa huomioonottamatta, koska tästä kerroksesta ei ole aiempia kvantitatiivisia näytteitä. Turveprofiilit on asetettu syvyyden suhteen siten, että sekä GTK:n että omien profiiliemme pohjat ovat samoilla stratigrafisilla tasoilla. Syvyysasteikot vastaavat GTK:n aineistoja. Kuviin on merkitty GTK:n ja tämän tutkimuksen profiilien kumulatiivisia kuiva-aineen kertymäarvoja laskettuna ylöspäin profiilien pohjasta vaakaviivoin osoitetuille stratigrafisille tasoille.

level throughout the summer. Unfortunately, the GTK survey data does not contain quantitative data of the top 20 cm of the profiles.

However, our profiles taken with the Russian and box type peat corers indicate higher BD values at almost all stratigraphic levels. Excluding compaction of peat, there is actually no relevant biological or geological process that would cause any measurable increase in BD values in deeper peat layers at drained sites. Thus, the apparent increase in the BD in the 2009 profiles compared with the old GTK results is best explained as an artefact, caused by somewhat systematically incomplete performance of the 1980s piston corer.

When looking at the paired BD profiles that seem almost unaltered in their vertical dimensions, it is strange to note the higher average BD levels and the consequent apparent increase in the cumulative mass inventories or storages of our cores when compared with the old GTK results (see Fig. 1). In Rajasuo (Fig 1a), the GTK survey obtained for the lowermost 60 cm about 10 kg m^{-2} less dry mass than what we found in our coring for the corresponding sequence. In Isosuo (Fig 1b), the difference is 14 kg m^{-2} for the basal 120 cm, and a further 8 kg m^{-2} for the 60 cm stratum above that, giving a total excess of 22 kg m^{-2} for our core. Also in Saunakankaansuo (Fig 1c), our BD values exceed those of GTK for most of the profile, resulting in a total difference of 29 kg m^{-2} in the cumulative dry mass. On average, the BD values of samples taken with the box corer and the Russian corer, compared to the ones taken with a piston corer from the same stratigraphic levels tended to be higher although the difference between the average BD's was not significant ($p = 0.52$). The mean BD of our samples taken in 2009 (box type and Russian corer) was 115 g L^{-1} (s.d. ±32), which is significantly higher than the mean BD (100 g L^{-1}, s.d. ±31) of the samples of GTK ($p = 0.03$). In contrast, the corresponding average of our piston samples taken in 2010 (111 g L^{-1}, s.d. ±32) did not significantly differ from the 2009 results.

Comparisons of the cumulative mass results

As a summary of the peat corer testing, the organic matter pools derived using the different peat corers are shown in Fig 2. In four out of the six sites, the 2010 piston corer values were smaller than those obtained by the box and Russian corers in 2009, thus indicating some tendency for a systematic or persistent underperformance bias. As there is no conceivable mechanism for overperformance for any of the corer models, we indeed conclude that underperformance of the piston corer is a plausible explanation. In three of the sites shown in Fig. 2, there was no change in peat thickness detectable by our 10-cm resolution, so the GTK results of the sites (Kolmisopensuo, Vipusuo, Saunakankaansuo) appear directly comparable with the 2009 and 2010 results. Comparing the 1980s results of GTK to the results of 2009 indicate deficient function of the piston corer. However, in two cases the piston corer samples taken in 2010 gave the same results as the box and Russian corers in 2009. The discrepancies between the data of GTK and of ours demonstrate an irregular tendency of the piston corer to underestimate the cumulative peat mass.

Discussion and conclusions

Results of the test series presented in this paper indicate that the piston-corer model tends to give slightly smaller BD values than the other two corer models. On some instances, the cumulative mass underestimation may result to a considerable error in total peat mass inventories derived from the volumetric results (cf. Fig 1). This type of error is not of great significance as regards single-site inventories, as typically it is a matter of a few percents of the total peat mass only. However, such a bias will constitute a serious factor of uncertainty for the nationwide assessment of peat resources and their carbon storage, and especially for their long-term changes (Turunen 2008).

When looking at our large coring material of 51 sites (unpubl. data), in which similar discrepancies were noted in several other sites too, we could not identify a single or systematic cause for the apparent coring error. It appears that the underestimated BD values most likely occur in poorly decomposed sedge peat or in strata with abundant *Eriophorum* remains or with coarse wood. It is conceivable that such fibrous and

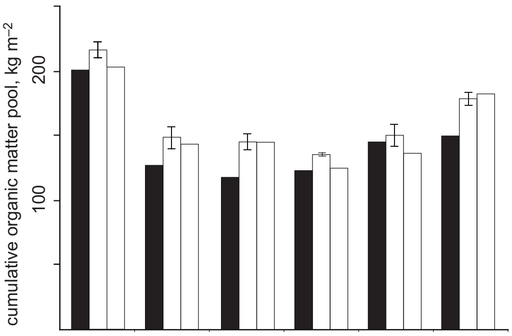


Fig. 2. Comparison of organic matter (dry mass) pools of six peatland sites in the Pieksämäki area, as obtained by the GTK piston corer in the 1980s (left column, black), in 2009 by box and Russian corers (middle column; average of two replicates; their range indicated with the whiskers), and in 2010 by the piston corer (right column). The uppermost 20 cm of peat is excluded from the cumulative sums. The coring sites from left to right are: Kolmisopensuo, Kittisuo, Vipusuo, Rajasuo, Isosuo, and Saunakankaansuo.

Kuva 2. Kuuden Pieksämäen alueen suotutkimuspisteen kumulatiivisten kuiva-ainekertymien vertailu (vasemmalta alkaen): Kolmisopensuo, Kittisuo, Vipusuo, Rajasuo, Isosuo, ja Saunakankaansuo. GTK:n mäntäkairalla 1980-luvulla ottamat profiilit esitetty mustina pylväinä. Keskimmäinen valkoinen pylväs kuvaa v. 2009 venäläisellä ja laatikkokairalla otettujen kahden profiilin keskiarvoa (vaihteluväli esitetty palkein). Oikeanpuolimmaisessa pylväässä esitetty v. 2010 mäntäkairatulokset.

poorly penetrated peat types would occasionally be pushed ahead of the cutting edge of the piston corer, and thus not get fully taken into the tube as a volumetric sample.

Although it seems that certain peat types may be more difficult to sample in terms of accurate quantity, it is not possible to determine any correction factor for the BD results obtained with the piston corer. The error seems not to occur regularly with fibrous and woody peat types. The main design problem of the piston type sampler is that it is not possible to control that the sample is truly volumetric. When opening the chamber, it is not easy to judge whether the sample obtained is deficient, especially when the fault is relatively small. The Russian peat corer and the box type sampler allow one to immediately assess the acceptability of the sample, and it is easy to repeat the sampling if any deficiency is observed.

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Tiivistelmä: Eri tyyppisten turvekairojen vertailu tilavuustarkkojen näytteiden otossa

Tässä tutkimuksessa selvitettiin kolmen turvekairan näytteenottotarkkuutta sekä arvioitiin sen vaikutusta seuranta-aineistojen luotettavuuteen. Tutkimuksessa verrattiin Geologian tutkimuskeskuksen (GTK) mäntäkairalla 1980-luvulla ottamia kvantitatiivisia turvenäytteitä vastaaviin uusiin laatikko- ja venäläisellä kairalla otettuihin näytteisiin. Aineisto kerättiin kairaamalla uudelleen tilavuustarkat turvenäytesarjat GTK:n 51 tutkimuspisteeltä, joilta oli olemassa vastaavat 1980-luvulla otetut näytteet. Useimmissa tapauksissa voitiin todeta vanhemmat ja uudemmat samoilta pisteiltä otetut turveprofiilit toisiaan vastaaviksi erityisesti alempien osien suhteen, joissa ei yleensä ollut havaittavissa mitään suuria muutoksia. Kuitenkin tulosten vertailu osoitti usein, joskaan ei systemaattisesti, että GTK:n kuivatilavuuspainot olivat jonkin verran tämän tutkimuksen tuloksia pienempiä. Niissä tapauksissa, joissa turpeen tiivistyminen voitiin sulkea pois, ainoaksi selitykseksi jäi se, ettei GTK:n käyttämä mäntäkaira ole toiminut kunnolla. Mäntäkairalla oli jonkin verran taipumusta ottaa vajaita näytteitä, erityisesti sellaisesta turpeesta, jossa on runsaasti sara-, tupasvilla- tai puujäänteitä. Tulosten merkitystä kvantitatiivisten turvetutkimusten suhteen tarkastellaan artikkelissa.

Avainsanat**:** turvekaira, turvetutkimus, volumetrinen näytteenotto

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