GCP/RAF/271/FIN-FM/13 (En) August 1994

FIELD MANUAL FOR THE SECOND YEAR OF LIMNOLOGICAL SAMPLING ON LAKE TANGANYIKA

by

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FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS

Bujumbura, August 1994

PREFACE

The Research for the Management of the Fisheries on Lake Tanganyika project (LTR) became fully operational in January 1992. It is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Finnish International Development Agency (FINNIDA).

LTR's objective is the determination of the biological basis for fish production on Lake Tanganyika, in order to permit the formulation of a coherent lake-wide fisheries management policy for the four riparian States (Burundi, Tanzania, Zaïre and Zambia)

Particular attention is given to the reinforcement of the skills and physical facilities of the fisheries research units in all four beneficiary countries as well as to the buildup of effective coordination mechanisms to ensure full collaboration between the Governments concerned.

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* a series of **technical documents (GCP/RAF/271/FIN-TD)** related to meetings, missions and research organized by the project; and

* a series of **manuals and field guides (GCP/RAF/271/FIN-FM)** related to training and field work activities conducted in the framework of the project.

For both series, reference is further made to the document number **(01)**, and the language in which the document is issued: English **(En)** and/or French **(Fr)**.

For bibliographic purposes this document should be cited as follows:

Plisnier, P.-D. Field manual for the second year
1994 of Limnological Sampling on Lake Tanganyika.
FAO/FINNIDA Research for the Management of the
Fisheries on Lake Tanganyika.
GCP/RAF/271/FIN-FM/13 (En): 47p.

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1. INTRODUCTION

In this field manual, the procedures and the experimental plan for the second year of limnological sampling of LTR are presented. The field work as well as the laboratory work is described here. The detailed procedures for analyses are extensively dealt with in the manuals provided with the water analyses kit and should be read carefully when performing analyses. Main analyses procedures are available in each station. References for the complete analyses manuals are given in the last part of this document.

2. DIFFERENCES WITH THE FIRST YEAR OF SAMPLING

The main differences with the first year of sampling is that the horizontal gradient (pelagic to coast) will be given more attention as well as for preliminary analyses on river and rain water. Also, complete analyses of 24 H cycles will be reduced to the parameters that have shown more variation during the first year or the parameters that are likely to be important in the understanding of the vertical migration of the zooplankton during a 24 H cycle.

Some new parameters to measure will be introduced in this manual (SRP, TDP, dissolved oxygen,...).

Also, different with last year is that the study of the carbon—energy cycle will start this year. Some practical aspects of this component will be introduced briefly here to integrate this work with the limnological samplings. Detailed instructions will be provided in a different document.

3. DEFINITION AND FIELD OF STUDY

A major goal of limnology is to understand the functional relationships and productivity of freshwater ecosystems resulting from multiple interactions between the abiotic (chemical and physical) parameters and the biotic environment. It is a very wide subject and covers many aspects of the study of the aquatic environment. It is necessary to define more precisely here which fields of limnology are studied in this component of the Lake Tanganyika Research (LTR) Project, particularly for the second year of sampling.

The following parameters are included in the study:

- Dissolved oxygen (DO)
- pH
- Conductivity (C)
— Total Phosphorus (TP)
— Total Dissolved Phosphorus (TDP)
— Soluble Reactive Phosphorus (SRP)
- Ammonia (NH_4-N)
- Nitrates ($N0_3^-$-N)
- Nitrites ($N0_2^-$-N)
- Turbidity

- Calcium (Ca^{++})
- Magnesium (Mg^{++})
- Alkalinity (HCO_3^-, CO_3^-,OH^-)
- Chloride (Cl^-)
- Sulphate ($S0_4^-$)
— Silicate ($Si0_2$)
- Chlorophyll *a* (Chl *a*)

For the carbon energy budget component, some extra parameters will have to be measured in addition to the ones cited above. These are:

- primary productivity (PP) with ^{14}C method
— respiration

The study of these last parameters will be extensively presented by Professor J. Sarvala in a separate document.

4. OBJECTIVES

The objectives of the limnological study is to assess, in a space and time sequence, the above listed parameters needed to understand better the chemical, physical and biological environment of Lake Tanganyika on a regional basis during at least 2 complete annual cycles. Because of their important role for the biological production of the lake, special emphasis will be given to the nutrients study (N, P).

The results obtained, linked with other results of the Project's components (hydrodynamics, zooplankton,...) should enable the Project to reach its general objective: to understand better the basis of the biological production of Lake Tanganyika and to provide the necessary guidelines for an appropriate fisheries management.

5. SAMPLING AND ANALYSES

Different types of sampling will be done: regular bi-weekly horizontal sampling H, monthly vertical sampling (V), intensive field sampling (24 H cycle, every 2 months) and seasonal sampling (4 times per year). The location, the timing of sampling and the parameters to measure in the field and in the lab and the practical way to proceed are explained below.

Before detailing each type of sampling, Table 1 presents a summary of the second's year program.

Table 1: Example of a monthly sampling (order depending on the 24H cycle).

Week	Limnology	Zooplankton	Carbon Energy (CE)
1	Horizontal H (from site A to coast)	Zooplankton site A at 9 H	Primary production + respiration (site A)
2	Vertical sampling V at 10 H	Zooplankton site A at 9 H	
3	Horizontal H (from site A to coast)	Zooplankton site A at 9 H	Primary production + respiration (site A)
4	rain analysis or river analysis or accuracy checks or intensive cycle	Zooplankton site A at 9 H and/or 24 H cycle	

5.1 Bi-Weekly horizontal sampling (type "H")

(tied with zooplankton and carbon-energy budget)

5.1.1 Time and location

The horizontal sampling will be performed every two weeks on Tuesday at 9.00 H a.m. (Burundi time). It will be performed at site A which was defined previously and already used during the first year of sampling. The horizontal transect will include 4 station. Site A will be the first station and because it is a part of the horizontal transect, we will call it "Hi". The three other station will be situated on a straight line from Hi to the shore. The second station, situated at 1000 in from the shore, is "H2". The third station, situated at 500 in from the shore, is "H3". The last station of the transect is the most coastal one. It is situated at 50 meters from the shore and is called "H4" (see Appendix 8).

5.1.2 Parameters to measure at H1 (site A)

The following parameters will be measured during the horizontal sampling

- on the lake: transparency of the water (SD) at the beginning and the end of the sampling, water temperature, dissolved oxygen, pH and conductivity.

- in the lab : TP, TDP, SRP, NH_4-N, $N0_2^-$, $N0_3^-$, Chl *a* and turbidity.

The sampling depths for those parameters are shown in form H (Appendix 2).

5.1.3 Parameters to measure at H2, H3 and H4 sites.

Concerning the horizontal transect at the other stations, the parameters to measure are the same as for H1. The only difference is that only surface and 10 in depth water will be sampled. Make sure that the water sampled is clean and free from interference with the boat operation (beware of hot water rejected to cool the engine, oil, fuel...).

5.1.4 How to proceed ?

A. Get the boat ready (start preparation at least the day before going on the lake in order to avoid any delay due to a poor preparation of the boat)

— prepare fuel reserve, oil;
- check if engine is in good condition;
— life jackets must not be forgotten and should be used especially
during bad weather conditions to avoid any accident;
— check the proper functioning of the tools such as the winch, etc...

B. Prepare field equipment: Get everything ready the day before going on the lake (checklist form in Appendix 1).

General equipment
1) GPS + recorded position of sampling site;
2) Sampling tube of 7.4 litres + messenger (you will need bigger quantities of water sampled than the previous A sampling);
3) Cable of appropriate length with adequate marks. Apart from the every 10 meters marks, you should add marks for 2
and 5 meters.

Equipment for zooplankton

4) Plankton net (see zooplankton manual);
5) Two buckets of 20 litres content;
6) Bottles (3) to keep the sample;
7) Formalin and syringe.

Equipment for carbon energy-budget - primary production
(see specific information in C/E manual)
8) Integrating radiation meter;
9) Acid washed glass liquid scintillation vials with

plastic screw cap, volume 20 ml;
10) Rack for vials mentioned here above;
11) Black plastic to cover the samples;
12) Disposable gloves;
13) Adjustable pipette 0-40 µl;
14) Radiocarbon stock solution;
15) Buoy;
16) String with glass vials attachments at appropriate depths;
17) Closed box for storing samples (no coolant).

Equipment for carbon energy–budget – respiration

18) Dividing tube;

19) Rack with 20 acid washed oxygen bottles.

IMPORTANT: the draining tube of the sampling bottle(s) should be elongated as it has to be placed in the bottom of the sampling bottles, especially the bottom of the oxygen bottles (respiration measurements)

Equipment for Horizontal limnological sampling H

20) recording form (FORM-H1) (latest version);
21) Secchi disk;
22) protractor (desk type);
23) plastic beaker of 500 ml;
24) pH meter (calibrated) and conductivity meter (calibrated);
25) T°+ 0_2 probe (calibrated) with cable and stirrer; (make sure to bring a spare battery);
26) Precision thermometer if probe is not available;
27) 13 (site H1) + 6 (sites H2, H3 and H4) = 19 clean plastic bottles of 2 litres and 26 (site H1) + 12 (sites H2, H3 and H4) = 38 bottles of 1 litre (cleaned with HCl diluted and rinsed carefully) + tag ("Hi/date/depth"). You will need for each depth where Chl *a* is measured, 3 litres of water (1 bottle of 2 litres and 1 bottle of 1 litre);
28) Boxes to keep the water for Chl *a* in the shade (not in the ice);
29) Cool boxes to keep the 13 + 6 = 19 bottles of 1 litre in the ice for other parameters as before;
30) One bottle with deionised water (to clean electrodes..).

C. Radio confirmation: It is very important that every station does the sampling at the same time (every two weeks on Tuesday at 9.00 H, Burundi time: start of the sampling at 0 m). If this is really not possible for your station, you should contact the other stations beforehand to fix together another date of that week for the H–sampling exercise.

D. Proceed to sampling site H1 **(=** A) using GPS. Meanwhile, you should warm up the oxymeter (20 minutes).

E. Be sure to reach the correct position within time (9.00 H a.m. Burundi time). Record the time, team sampling, weather conditions
on the lake etc... on Form-H1.

F. Measure Secchi disk transparency (average of three different observers) (this is the first measurement).

G. Start with zooplankton net hauling from 100 meters depth. Proceed as indicated in zooplankton field manual.

H. Sample water for Carbon-energy budget from the depths indicated in the instruction manual particular to that component. Prepare the radio—active samples to be incubated. You should be particularly careful when handling radioactive isotopes for obvious safety reasons. Follow exactly the instructions of the carbon—energy manual.

I. Start *in situ* incubation at 9.30 H.

J. Proceed with the field measurements at each depth while the incubation takes place (9.30 H to 11.30 H), following the order below.

K. Measure T° and 0_2 with the probe *in situ* (from 80 meters to the surface). Allow a few seconds during 0_2 measurement at each depth until the reading stabilises. Check carefully the shape of your temperature profile. Generally, apart from a possible surface cooling due to the effects of the wind and evaporation, the profile shows a decrease from the top water to the deeper waters. In case of particularities such as warm water below cold water (it is possible but very rare) it is important to repeat your measurements to confirm your temperature profile.

L. Start sampling at 0 meters. The top of the 2 litres tube should be just under the surface. Avoid any possible surface pollution from the boat's oils, cooling water, etc...

Pour 400 ml of water in a clean beaker. Then, measure the following parameters in this order

A. conductivity (position 2 on conductivity meter)
B. pH

The order of those two measurements should absolutely be this one as KCl is sent in the sample for the pH measurement and this of course influences the conductivity measurement (for depths of 90 and 100 meters, temperature and DO are also measured in the bottle at this step).

M. Respiration measurements must be carried out in the shade: pour water through a dividing tube into two acid washed oxygen bottles at the same time. The draining tube should be inserted in the bottom of the bottles. Pour the water gently in and let the bottle flow over at least 3 bottle volumes before replacing the caps and placing the bottles in a box. Avoid mixing: place pipe in bottom of bottle (the pipe needs to be extended). Check that the label on the bottle is correct. Keep the bottles in a

cooler box.

N. Repeat the sampling at each depth shown in form Hi and steps 12 and 13. Keep 3 litres of water (in the shade) for each depth where Chi a will be measured and 1 extra litre (in a cooler box with ice) for every depth for the other measurements.

When the lake is rough, it might be difficult to have a vertical hauling. In this case, either, use a bottle with some weight attached to it (when a good electrical winch is available) or measure the angle between the rope and the vertical line and, using Appendix 13, add appropriate length to reach the appropriate depth.

Example: you measure an angle of 240 between the vertical line **S** and your rope and you want to reach the depth of 100 meters. From
Appendix 13, you see that you need to let go 109,5 in of rope to reach that depth. A small protractor (desk type) is needed to measure the correct angle.

0. When the last depth is reached, record time on form-H1. The sampling should end before 11.30 H.

P. At 11.30 H, take the incubated samples out of the water and store them in the shade in a box with no coolant.

Q. Before leaving, record SD transparency for the second time on form—H1 as preliminary experiments have shown that this parameter
may change rapidly with the time of the day and the radiation probably (due to a possible light inhibition of phytoplankton). Then proceed toward station H2.

R. On your way back, you have to stop three times: the first time at site H2 (1000 m from coast), the second time at site H3 (500 meters from coast) and the third time at site H1 (50 meters from the coast). Each time, transparency will be measured with the Secchi disk as well as surface parameters (T°, DO, pH, C). A water sample of 4 litres must be taken from surface water and at the depth of 10 m for analyses in the lab (see form H—1).

S. Once you reach the lab, start the laboratory analyses (see Chapter 6) the same day for the following parameters:

Primary productivity
Filtering of the samples, unless whole water technique may be applied (following instructions of Carbon-energy component in another manual).

Respiration
DO - Modified Winkler method: For H1 at each 10 meters depth: addition of precipitation chemicals, dissolution and titration of one bottle of each pair.

Alkalinity: For H1 at specified depths.

For Chl *a*
Filtration of 3 litres from each sampled depth (or different quantity following instructions to be provided later). Keep filtered samples in fridge (4°C) for later extraction. The minimum number of depths for this analysis are 0 and 10 meters for each site and several depth for Hi site that will be detailed later (after initial trials).

TDP (total dissolved phosphorus): Use surface water samples only of four sites (Hi to H4). Use water that has been filtered over a 0.45 µm filter (after initial trials, this type of filter might also be used for Chl *a*, so the filtered water from Chi a test could be used for this test) and perform tot P (HACH method 10013, program n°535, results in P04---).

SRP (soluble reactive phosphorus): Use surface water of four sites (H1 to H4). Use also water that has been filtered through a 0.45 µm filter (same remark as above) and perform reactive phosphorus test (HACH method 10011, program n°535, results in P04---).

TP (total phosphorus): Use surface water samples of four sites (H1 to H4). Perform HACH method 10013 (program n°535, results in P04 ---) as during the first year of sampling on non filtered water.

The latter 3 parameters involve 12 measurements. With a good organisation, you can process at the same time, using the COD reactor, the 4 samples of TDP and the four samples of TP and then perform the reactive phosphorus test on those 8 samples + the 4 samples of SRP (12 analyses). Given the importance of phosphorus in our study, it is asked to take particular care for those analyses. Please, repeat any doubtful analysis.

After preservation of the water bottles at 4°C for one night, carry out the following measurements:

For horizontal sampling on surface water only:

- NH_4-N
- $N0_3$-N
- $N0_2$-N
- $Si0_2$

For H1 only at each depth and H2. H3. H4 at 0 and 10 m:

- Turbidity

For respiration study, 24 H after the addition of chemicals for precipitation in the first bottles: this concerns site H1 at each 10 meters depth after preservation of samples kept near original temperature, not at 4°C !, perform this analysis:

- DO with Modified Winkler method (for respiration study on remaining half pair of bottles).

5.2 Vertical sampling (type "V")

5.2.1 Time and location

The vertical sampling will be carried out once a month on a new site (called "V") that will allow sampling down to 140 meters in Burundi and Tanzania and 160 meters in Zambia. The starting time of sampling V will be 10 H (Burundi time): the reason is that on the way to this sampling, the weekly sampling at site A for zooplankton should be performed at 9 H. There will be no sampling for zooplankton at site V. The exact dates for this sampling V (preceded by zooplankton at site A) will be provided in a separate document (updated SSP sampling scheme).

The location of this sampling type "V" should be in the pelagic area (not less than 5 km from shore). The sampling plan is shown in form-V1 (see Appendix 3).

5.2.2 Parameters to measure

The parameters to measure are:

- on the lake:

  transparency (SD), water temperature, dissolved oxygen, conductivity and pH.

- in the laboratory:

  TP, TDP, SRP, NH_4-N, $N0_2$, $N0_3$, Chi a and turbidity.

There are 10 different sampling depths for each station. Mpulungu will sample deeper (160 meters) because of a deeper epilimnion in the south, while sampling at 70 meters should be done in Bujumbura and Kigoma because heterogeneity has been noticed several times around that depth for several parameters.

The sampling depth and the measurements are summarised in form V-1 (Appendix 3).

5.2.3 How to proceed ?

1. Get the boat ready (start preparation at least the day before going on the lake):

— prepare fuel reserve, oil, life jackets...
- insure that the winch is OK.

2. Prepare equipment:
(see also checklist in Appendix 1):

- GPS + recorded position of sampling site;
- the 7,4 litres tube for sampling (take a second tube of 7,4 litres as a reserve in case of a problem with the first one);
— a rope of 300 meters long (marks every 10 m). Even if the sampling does not go that deep, this length is advised in case of non vertical sampling when angle correction must be applied;
— the messenger;
— a protractor (to measure angle with vertical and correct length of rope);
— Secchi disk with rope (visible marks every 10 cm);
— plankton net (see zooplankton manual, vertical haul from 100 m)
- two buckets of 20 litres content;
- bottle to keep zooplankton sample;
- Formalin and syringe;
— 1 beaker of 500 ml (plastic);
- pH meter (calibrated) and conductivity meter (calibrated);
— oxygen and temperature probe + cable and stirrer;
— 10 acid washed plastic 2 litres bottles + 20 acid washed plastic bottles of 1 litre (cleaned with HCl 10 % or H_2S0_4 2%) with tag indicating “V/date/depth”. Prepare tags before sampling. Indication can be permanently written on the bottles also;

NB: For each depth there will be 3 bottles: (1) one bottle of 2 litres; (2) one bottle of 1 litre for Chl *a* (total = 3 litres to keep out of light with no coolant for filtration for Chl *a*); and (3) one bottle of 1 litre for the rest of the analysis to keep in cool box with coolant (total of water sampled per depth is 4 litres).

- 1 bottle with distilled water (to clean electrodes);
- cool box with ice to keep 10 sampling bottles of one litre each;

3. Radio confirmation: same remarks as before on the importance of a common date for sampling by all stations.

4. Proceed first to sampling site “A” with GPS to reach the place before 9 H and measure Secchi disk transparency.

5. Perform the lifting of the zooplankton net at 9 H at site A as usual. There is no other measurement or sampling after this at this site in order to reach site V as soon as possible.

6. Proceed to sampling site “V” with GPS to reach the place before 10 H. Before arriving at destination V, warm up the Oxymeter during 20 minutes.

7. Measure Secchi disk transparency.

8. Measure T° and 0_2 with probe: immerse the probe at defined depth (down to 80 meters). Start measuring from the surface. Allow enough time for 0_2 measurement until the reading stabilises. For measurement deeper than 80 meters, place the probe carefully in the bottle, without shaking it and measure T° and DO.

9. Start sampling from 0 in and then proceed to deeper samplings. Use 7,4 litres tube to sample.

10. Using the pipe, pour 4 litres of samples in 1 bottle of 2
litres and 2 bottles of 1 litre. Check tag V/date/hour/depth. The bottles for Chl *a* should be marked differently as those will be kept in the shade with no coolant. Keep the rest of 1 litre bottles (10) in cooler box. Take 0,4 litres in a beaker for conductivity and pH measurement.

11. Use the beaker containing 0,4 litres of water to measure,
in the following order (don’t inverse this sequence)

A. Conductivity (position 2 on conductivity meter)
B. pH

12. Repeat sampling steps 8 to 11 for each depth shown in form-

13. «NOTE: Author omitted Step #13»

14. When the last depth is reached, measure Secchi disk for the second time and record time on form—V1.

15. Proceed back to the station as soon as the experiment is finished.

16. Start to filtrate 3 litres of water (or other quantity to be confirmed later on) for analyses of Chl *a*.

17. Using 0.45 µm filters, filter about 50 ml for each depth in order to analyze TDP and SRP. If filtering for Chl *a* is done with this same filter, the filtered water can be used for TDP and SRP measurements.

18. Proceed with the analyses of TDP and SRP using <u>filtered</u> water and for TP using <u>non filtered</u> water.

19. The other analyses can be done the next day after preservation at 4°C in the fridge.

5.3 24 H cycle (sampling B)

5.3.1 Time and location

A 24 H cycle will be carried out every 6 or 8 weeks. The hours of sampling remain the same: 12 H, 18 H, 24 H and 06 H (Burundi time). The dates of the sampling are chosen to alternate full moon nights with new moon nights cycles. The scheduled dates of B sampling are provided in the updated SSP sampling scheme.

Site "B" is mainly sampled for the zooplankton component. There is no change in the field work but, for the laboratory work, only turbidity and Chi a will be analyzed for each session (form in Appendix 4).

5.3.2 Parameters to measure

The parameters to measure in the field are: transparency (SD), water temperature, dissolved oxygen, conductivity and pH.

In the laboratory, apart from the samples for sampling C (see below), only turbidity and Chl *a* will be analyzed.

The sampling will be done at every 20 meters down to 140 meters. After that, one sample should be taken at 200 meters and one at 300 meters (170 and 230 m will be added in the South for zooplankton).

Form–B1 should be used to record the sampling B results (see Appendix 4).

5.3.3 How to proceed ?

1. Get the boat ready (start preparation at least the day before going on the lake): prepare fuel reserve, oil, life jackets...; ensure that the winch is OK; be sure to have enough fuel for each trip to the lake. Check if lights on boat are working.

2. Prepare equipment: see check-list in Appendix 1.

We just mention here some specific material for 24 H cycle: clock, eventually camping material if a base must be installed on shore, flash light, food, drinks...

3. Radio confirmation: Get the confirmation of the B sampling by radio. If radio contact is not possible and conditions are OK for 24 H cycle, proceed for this sampling at the scheduled date. If you can't go on the lake for some major reason, proceed to site B the next possible day. It is very important that the B-

sampling is done as much as possible at the same time by all stations. Any change that can be foreseen should be communicated as soon as possible using the radio in order for all the station to shift to a new, identical date.

4. Proceed to sampling site “B” using the GPS.

5. Be sure to reach site B in time (12 H, 18 H, 24 H, 06 H).

6. Measure Secchi disk transparency during day time.

7. Measure T° and 0_2 with probe as you do for other samplings (H and V).

8. Start sampling from 0 m and then proceed to deeper samplings. Use 7,4 litres tube to sample.

9. Pour 4 litre from the tube into the sample bottles (3 litres for Chl *a* and 1 litre for turbidity or other analyses). Check tag B/date/hour/depth. Don’t keep the 3 litres for Chl *a* in box with coolant. Just keep it in the shade and in a box with no coolant. Take 0,4 litres in a beaker for conductivity and pH measurements.

10. Filter the rest of the tube in a 50 µm net . Proceed as indicated in the Zooplankton field manual. Especially if a good electrical winch is available, two bottles of 7,4 litres will be sampled at each depth down to 140 meters. The total volume water filtered will be 10,4 litres (14,8 litres less 4 litres for limnology sample bottle and 0,4 litre in beaker for analyze on the boat).

11. Use the beaker containing 0,4 litres of water (see point 9) to measure:

A. Conductivity (position 2 on conductivity meter
B. pH

12. Repeat sampling steps 8 to 11 for each depth.

13. When the last depth is reached, record the time on FORM-B1 form (see Appendix 4).

14. Proceed back to the shore base or to your station at the end of the experiment.

15. After the cycle, as soon as you are back, a “fresh” team can filtrate directly the water for the Chl *a*. Once it is filtered, the analyze can be performed either the same day (preferably) either the next day following the instructions for the conservation of the samples (see separate document). The turbidity can also be measured that day or the next day.

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5.5.3 How to proceed ?

1. Use one or more very clean bucket(s).
2. Just before collection, rinse it with distilled water then with the rain water itself.
3. Place it outside to be filled with rain water.
4. A soon as you have a good quantity (as much as the rain permits: 1 or 2 litres would be ideal), pour 0.3 1 in a beaker to measure (1) the conductivity (2) the pH, then discard this sample (contaminated with KCl used for measuring the pH).
5. Pour the rest of the rain water with a clean (!) funnel into a clean water sample bottle with appropriate tag.
6. If possible, measure T° of rain—water directly.
7. Process pH, TP, TDP, SRP and NH_4-N analyses the same day.
8. For the other parameters, if direct analysis is not possible, preserve it in the fridge for a night (4°C), then analyze the next day if possible (or the following days after appropriate conservation).
9. send a sample for external analysis of Na^+ and K^+ through Bujumbura headquarters (with tag showing the station name and “P/date”).

5.6 River water (R) sampling and analyses

5.6.1 Time and location

The river water samples (sampling R) have to be collected 3 times per year from each main river: Rusizi (in Burundi), Malagarazi (in Tanzania) and Lufubu (in Zambia). The sampling should be done during:

— a dry season (once during the period from July to early September).
— at the beginning of the rainy season, about one month after the first rain (once during the period October to November).
— at the end of the rainy season (once during the period March to early May).

The reason is that seasonal variation might be expected between those periods.

5.6.2 Parameters to measure

The parameters include all the ones that can be analyzed on river water and are found in form-P/R1. (Appendix 6). A minimum of three analyses will be done for each parameter.

5.6.3 How to proceed ?

1. Use the same equipment as for sampling V and C (Appendix 1). Don't forget the form-P/R1. Be sure that the boat used is appropriate for the depth of the river mouth. Eventually use a smaller boat such as an inflatable boat.

2. Proceed to the mouth of the river. Be sure to sample river water and not river water mixed with lake water. If it is difficult or dangerous (hippos...) to reach the river with a small boat then you can sample from a bridge passing over the river as close from the lake as possible if such a bridge can be found.

3. The depth of sampling is at the surface (avoid perturbation from floating algae, plants, branches, etc...). You need to collect a minimum of 9 litres of water (18 litres if Chl *a* is analyzed). A bigger quantity of water sampled gives you full opportunity for laboratory analyses without being short of sampled water. One or two clean 20 litres jerrycan could be collected also. (Chl *a* consumes 3 litres of water to be filtrated for each analysis !)

4. Apart from the measurements to be done in the field, process the water the same day for TP, TDP SRP, Chl *a* and NH_4–N analyses.

5. If direct .analyses of the other parameters are not possible, analyze the next day after appropriate conservation. Each parameter is measured 3 times (3 repetitions per parameter as indicated by "R" on the form). This is the reason why you need 9 or 18 litres of water. If variation is noticeable between those 3 analyses, then proceed with additional analyses if you have enough water.

6. Send a sample for external analyses for Na^+ and K^+ trough Bujumbura headquarters (with tag showing the station name and "R/date")

5.7 Satellite Limnology

The objective of satellite limnology is to collect at several position and during several moment of the day mainly information on parameters that could be related with primary production such as transparency (SD), turbidity and Chi a. The collected data will provide complementary information on the repartition in space of the parameters described above. This can provide ground truth data for satellite pictures.

Beside the correlation with satellite images, this aspect of the study provides information which is:

1) spread over during the day, allowing the study of a possible vertical migration of the algae tied with solar radiation;

2) spread in space (study of the heterogeneity in your area).

Because the hydrodynamic teams spend the longest time on the lake at regular intervals and at different locations, it seems to be the most appropriate team to ask to carry out this short, additional sampling (about 10 minutes per sampling maximum).

5.7.1 Time and location

During hydrodynamic experiment: 3 Secchi disk measurements have to be done and 1 surface water sample taken (4 litres) a three moments of the day (Burundi time):

- between 07 and 09 H;
- at 12.30 H;
- between 16.00 and 17 H.30.

The GPS position is recorded each time. Regular same positions would be better but it is not essential. The morning and evening hours are not precisely defined because this depends of too many local constraints in each station. Nevertheless, the sampling at 12H30 is the only time that is fixed for each station (Burundi time) to allow a comparison between stations at this hour generally each team is on the lake. If a different timing is required because of different satellite passages, it will be communicated to the team. In any case, with or without satellite, the data collected will be very interesting.

5.7.2 How to proceed ?

1. The hydrodynamic team takes on the boat:

- one Secchi disk;
- 3 bottles of 2 litres and 6 bottles of 1 litre;
- the form–S1 (see Appendix 7);

- one box to keep sampled water in the shade (no need for coolant)

If Chl *a* is not yet measured, 3 bottles of 1 litres are sufficient).

2. The boat goes toward the beginning of the hydro line that is studied for that day. The flow cylinders are released in the water, after which the following is done for satellite limnology.

3. Secchi disk depth is carefully recorded by three different persons. A sample of water is taken at the surface (1 litre for turbidity, 3 more litres if Chi a is studied). Avoid eventual pollution of surface water by the boat! The team records the results of SD on the form-S1, the time and the position are indicated. For recording coordinates: use degrees, minutes and hundreds of minutes as it is given by the GPS (so not seconds!).

4. The team then proceeds with the hydrodynamic work.

5. At 12H30 precisely and during the late afternoon, the same procedure (n°3) as in the morning is repeated.

6. Coming back to the lab, the samples are given to the limnology team for analyses of turbidity and Chi a.

6. ANALYSES IN THE LABORATORY

Information concerning the order to follow for the analyses of samplings of type H, V and C is provided below. Reference for detailed procedures of the HACH Manual are given here. It should be mentioned also that with an appropriate number of glassware and a good organisation, the same analyses for several samples can be performed simultaneously. After dissolution of chemicals, the timer can be run once and a proper shift between zero sampling measurements and sample measurements can be done in a sequence of analyses. A considerable amount of time can be gained that way with no loss of precision, providing that the minimum time for each reaction is respected.

6.1 Analyses for sampling of types H

After sampling on the lake and coming back to the laboratory, one team should start the analyses with the spectrophotometric methods in the order described below. The general principle is to write down the results in the way the spectrophotometer gives them, without transformation (except when you have been diluting and for titration methods (sampling C) where multiplication factors are sometimes used).

1. Primary productivity: only the filtration will be done in the lab (unless whole water technique is used, complete information will be sent later following preliminary experiments). The samples must then be sent to Bujumbura for scintillation detector measurements. Remember the safety precautions (read carefully the manual for carbon—energy budget).

2. Respiration (see the carbon—energy manual).

3. Chl *a* (see instructions in separate document).

4. The analyses of TP, TDP, SRP, Alkalinity and NH_4-N should also be carried out the same day (see below).

6.2 Analyses for sampling of types H and V

A. The same day of the H or V sampling, the following has to be done:

1. **TP** (Total Phosphorus): this analysis should be done directly on <u>non filtered</u> water. If direct analysis is not possible, you can store at < 40 °C up to 24 H after collection, <u>method</u> : n^0 10013 (with COD reactor) of HACH manual— program n° 535; results expressed in P04---.

2. **TDP** (Total Dissolved Phosphorus): the same analysis as above

(TP) but on filtered water (0.45 µm). method: no. 10013 (with COD reactor) of HACH manual -program no. 535 (results expressed in P04---).

3. **SRP** (Soluble Reactive Phosphorus): also to be analyzed using filtered water (0.45 µm)). Ideally, this analysis should be done directly. If this is not possible, at least filtering should be done the same day. The sample can be stored at < 4°C up to 24 H and longer with addition of mercuric acid solution (see Table 2a). Even if preserved, it is advised anyway to perform the analysis as soon as possible. NB: This is the same analysis as the P04--- analysis done before with the difference that it is done on filtered water. method: HACH n° 10011, program n° 535, results in P04---.

4. **Alkalinity** ($HC0_3$, CO_3^-, OH-) (sample volume 100 ml, fill completely the bottle, storage at **< 4°** C up to 24 H).

5. **NH_4-N** (analyze should be done directly, acidification allows storage at **< 4°** C up to 28 days, see Table 2). method : n°8038, page 319 of HACH manual.

B. The day following the sampling day, these analyses have to be performed:

6. **$N0_3^-$** (storage at < 4° C up to 24-48 H, acidification is needed for preservation up to 28 days, see Table 2)
method : n°8192 (page 291) of HACH manual.

7. **NO_2^-(**storage at < 4° C up to 24 H, addition of Mercuric Chloride solution is needed for storage up to 28 days, see Table 2) method : n° 8507 (page 309) of HACH manual.

8. Extraction and measurement of **Chl *a*** if not done during the first day.

9. Turbidity (storage is possible at < 4° C up to 48 H). Remember to have extreme care in handling the measuring cell. You can e.g. perform the turbidity measurements when you have to wait for reaction or digestion of previous analyses.

If you can't analyze the samples directly, more details on the preservation of samples are given in chapter 9. Nevertheless, it is necessary to analyze the mentioned parameters as soon as possible.

Very important: after performing analyses, before discarding the remaining sample water, it is essential that the responsible of limnology in your station checks the results to see if one or several measures that might show "abnormal" (at first sight) values should be repeated. Drawing a fast profile of the results will help you to find those "out of trend" measurements. Look also at absolute values of the whole profile to detect any bias. Write
results that you can't trust (for some reason) in italic when recording them and give eventual comments on the bottom of the form. In any case, it is good to be critical about your own work in order to find ways to improve the quality and the reliability

in order to find ways to improve the quality and the reliability of the results. So try to solve the problems as much as possible as soon as they arise.

6.3 Analyses for sampling of type C

The analyses of sampling C should be performed in the order described below. The sample for alkalinity can't be kept for more
than 24 H and should be analyzed first.

Alkalinity (HCO_3^-, CO_3^{--}, OH^-) (sample volume 100 ml, fill completely the bottle, storage at ≤ 4° C up to 24 H method: Titrimetric method, page 34, Digital Titrator Manual (try range 100 - 400 mg/l as $CaCO_3$).

Ca^{++} hardness (sample volume 100 ml, direct analyze or acidification and storage at ≤ 4° C up to 7 days, see Table 2). method: Titrimetric method, page 79, Digital Titrator Manual (try range 10 - 40 mg/l as $CaCO_3$).

Total Hardness (sample volume 100 ml, direct analyze or acidification and storage at ≤ 4° C up to 7 days, see Table 2). method : Measure of Total Hardness, titrimetric method, page 72, Digital Titrator Manual (try range 100-400 mg/l as $CaCO_3$). 504 (sample volume 25 ml, storage at ≤ 4° C up to 7 days) method : n° 8051 of HACH Manual

$Si0_2$ Low range (0 to 1,6 mg/l): generally this method will be used for pelagic water sampled between 0 and 100 meters (sample volume 50 ml, storage at < 4°C up to 7 days). method : n° 8186, page 479 of HACH Manual.

$Si0_2$ High range (0 to 100 mg/l). Generally this method will be used for very coastal water or water sampled below 100 meters (sample volume 25 ml, storage at ≤ 4° C up to 7 days). method : n° 8185, page 485 of HACH Manual.

Cl^- (sample volume 100 ml, storage up to 7 days) method: Titrimetric (silver nitrate) method, page 51, Digital Titrator Manual (try range 10-40 mg/l as C1)

Na^+ and K^+ : Keep at least 200 ml of water for each sampling depth in a polyethylene bottle. Add 0,1 ml of concentrated HCl per 100 ml of sample. Tag it properly (country, station, coordinates, date, hour and depth + instruction "for Na^+ and K^+ analyses"). Send it the same month to Bujumbura.

7. REMARKS CONCERNING THE APPARATUS

A few things have to be kept in mind concerning 6 kinds of methodology, each one tied with an apparatus. More details are found in the corresponding manuals and it is advised that at least a few persons go through these manuals in each station.

7.1 Spectrophotometer

Detailed information can be found in 2 manuals:

- HACH DR/2000 Spectrophotometer. Instrument manual.

- HACH DR/2000 Spectrophotometer Handbook - Procedure Manual

Particularly, note the following:

When you turn the wavelength control knob, it is important to remember to always approach the desired wavelength from higher wavelength to get a better accuracy and repeatability. When the display flashes, it means that the recommended wavelength was not set properly.

When a pre—measured reagent has been added to the sample, you should respect the time indicated in the procedures as these allows full development of the colour (due to the reaction between the reagent and the substance to measure).

Batt/l key can be used to check the condition of the battery (used with shift key).

It is of first necessity to keep the sampling cells very dry and clean as this affects the measurement in a very important way. Measurement of volumes should be done by using a calibrated pipette to insure accuracy. Considering that several parameters show very low concentrations, this will help you to keep bias and measurement errors at their lowest possible level.

7.2 Digital titrator

The use of the digital titrator and the analyses are described step by step in “HACH - Digital titrator - Model 16900-01 — Manual “.

It is advised to keep a specific delivery tube for each particular solution. Keep a tag about 1 cm from one end of the delivery tube and indicate to which product this delivery tube is corresponding.
Turn the knob of the digital titrator very slowly at the end as some reactions are slow and you might loose the precision by going too fast. With accuracy checks ampoules (known concentration), check carefully the change of colour of each test past this will help you to assess more precisely the change of colour to expect during future titrations.

7.3 pH-meter

The pH—meter should be calibrated every week and particularly before any important type of sampling.

For calibration, proceed as follows:

1. Open a pH 4.01 (red) HACH powder pillow. Dissolve in 50 ml of deionized water. Use the electrode to stir the solution and rinse the electrode afterwards.

2. Prepare another solution by opening a pH 7 (yellow) powder pillow and dissolve as above.

3. Press **I/O** button of pH-meter.

4. Press **pH**

5. Press **Auto/manual**

6. Place the electrode into the pH 4.01 HACH Powder Pillow Buffer and press the dispenser button until it clicks. Wait for 30 seconds. Press **Standard** and wait until the pH indicators stop flashing.

7. Rinse the electrode with deionized water and repeat step 6 with pH 7 solution.

8. Press **pH**. Rinse the electrode. The calibration is completed and your pH–meter now measures the correct pH.

To measure an unknown sample (routine measurement): Place the clean electrode into the sample. Press the dispenser button until it clicks. Read pH after the stability indicator stops flashing. In case of wide and aberrant variations of pH measured, a probable air bubble should be removed by shaking the probe as a thermometer and by pressing several times the dispenser. Sometimes, the primary knob must be turned (towards the left) to eject drops of KCl and air bubbles.

7.4 Conductivity meter

After switching the conductivity meter on, press CND and use range n° 2. Express the results in µS/cm. Rinse the probe thoroughly with demineralised water after each measurement. Calibration of the conductivity meter is needed every three months normally. The use of the standard 1.99 µS/cm and the CAL control screw are explained in the manual of the conductivity meter, pages 14 and 15.

7.5 Turbiditymeter

1. Warm up the turbiditymeter in 0-1000 NTU range for 30 minutes before performing analyses.

2. The sample cells should be very clean (no finger prints, scratches...) especially when measuring low turbidity as it is often the case for lake Tanganyika.

3. Rinse the cell with a small amount of sample water.

4. Fill approximately with 25 ml of test sample (between 24

and 26 ml).

5. Dry the exterior part of the cell with clean, lint free cloth of tissue. Especially the bottom of the cell should be clean and dry.

6. Try to always use the same cell in the same direction (small mark on the top to show facing side).

7. When the 0-1000 NTU or 0-100 NTU range is used, don't forget to place the cell riser.

8. Standardisation should be performed with secondary standard (GELEX) before each measurement in a given range. Primary standardisation should be done every 3 months with Formazin, following the instructions in the turbiditymeter manual, page 11 (paragraph 4.6.2).

9. Cover the sample with light shield.

10. Read the results (eyes above meter scale, the reflection of the needle shouldn't be seen).

11. In standby position, don't turn the instrument off but remove the cell and put on 0-1000 NTU range.

12. Turn off the turbiditymeter but only when all the measurements of the day have been done.

7.6 Oxymeter and temperature probe

1. Follow the instructions concerning the installation of the membrane. Be especially careful to remove all air bubbles (first use the little diaphragm with a blunt object, "pump" several times to get the bubbles out, then fill the probe with KCl and place the membrane by stretching it carefully over the probe). At the end, it should be clean, with no DO trapped and filled up with KCl.

2. The membrane should be replaced every 4–6 weeks or less if used often (always check the day before the experiment if there are no air bubbles trapped or if it is dry: if so, then proceed with replacement of the membrane and refilling with KCl solution.

Be sure to ask more solution in time to avoid any shortage in the supply of the KCl solution.

3. It is possible to connect the oxymeter to A/C current in the lab with the adapter provided but the measurements must be done in the field using energy from the alkaline batteries placed inside the oxymeter.

4. The probe should be left inside the plastic cap where a wet tissue should be placed: avoid that the probe gets dry.

5. The cable (80 meters long) should be marked at every 10

meters depth + at the depth of 2 and 5 meters; so, marks should be visible at 0, 2, 5, 10, 20, 30, 40, 50, 60, 70 and 80 meters.

6. Keep the oxymeter tied with the battery of the stirrer in the protective case + tighten the adhesive strip to avoid it to move inside. Try to keep the protective case flat when you carry it (avoid carrying it with the handle). Place a sticker on the top of the protective case to show which side should be kept up. Buy a plastic basket to keep the cable with stirrer + the protective case of the oxymeter. When not in use, the probe (very fragile) should be separated from the cable. The plastic protection should be screwed at the end of the probe and placed inside the plastic calibration "bottle" with a humid piece of cloth. It can be placed inside the protective case if there is no risk for it to be smashed by the weight of the oxymeter and battery unit..

Procedure of operation on the lake

Start some 20 minutes before reaching the sampling position:

7. Switch the instrument "on" in the °C position during 5 minutes. The probe is connected and placed in the calibration bottle with the humid piece of cloth. The stirrer is not connected. Wait for the temperature reading to stabilise.

8. Switch the instrument to mg/l position and wait during **15** minutes for the system to stabilise.

9. Calibrate the instrument (once per sampling day) using the procedure on page 10 of the manual "Calibration in air in mg/l, correcting for atmospheric pressure or altitude". Here is a summary:

(1) Read temperature using **°C** position;
(2) Use table A of oxymeter manual to find solubility of oxygen at 760 mm Hg for 0 salinity (value accurate enough in this case);
(3) Multiply this value by 0,91 to correct for the altitude;
(4) Turn to function **mg/l CAL**;
(5) Introduce the value found in step 3 using the display setting keypads;
(6) Turn to function **mg/l** and wait a few seconds: CAL will appear and the oxymeter will beep. When the reading is stable for 2–3 minutes, the oxymeter is ready for measurements.

10. To ensure that your instrument can measure 0 mg/l or very low concentrations with precision, you need to apply in the laboratory, every week, the procedure "offset the meter zero". This procedure is shown in pages 18-19 of the D.O. meter manual. For this, you need sodium sulphite (NA_2S0_3) and cobalt chloride ($CoCl_2$) in order to get a "zero oxygen environment".

In case these chemicals are not available, either discard results below 0.5 mg/l DO (the relative error is too high below

this value) or sample water very deep where you are 100 % sure that there is no DO. Introduce the probe very slowly into the sampling bottle and apply the procedure “offset the zero meter”.

11. The stirrer plugs can be plugged into the battery unit and the probe connected to the stirrer. To avoid torsion of the cable, the probe might need to be unplugged for a moment. In this case, you should wait a moment for the oxymeter to re–stabilise after the re–connection of the probe. There should be 1 mm between the end of the probe and the top of the stirrer. Use a piece of metal of that thickness (such as a spark plug gauge) to check this thickness. Then try the stirrer to ensure proper functioning (normal movement and no noisy shaking)

12. Start the temperature and DO measurement beginning at 0 meter down to 80 meters. The other way around is also acceptable because the boat is drifting and the water column is not disturbed. Always, allow some 20-30 seconds for stabilisation of the readings.

13. For sampling lower than 80 meters, use the sampling bottle. Open carefully the top lid of the bottle. Switch off the stirrer. Place the clean electrode (after cleaning with deionised water to avoid spoiling the water sampled) at some 50 cm depth inside the bottle. It is very important to do this very slowly to avoid shaking and oxygen input from the atmosphere. Then start the stirrer and measure first the concentration of dissolved oxygen and afterwards the T°. Here, T° and DO measurements are done in the inverted order to reduce the time between sampling and the DO measurement.

14. Don’t switch the oxymeter off between measurements as a period of 15 minutes of warm-up time would be needed every time you do so. Switch it off only when the last depth is reached (300 meters of sampling of type B or after extra sampling designed to find exact 0 mg/l DO depth in a 10 meters wide layer).

8. CLEANING THE MATERIAL AND THE LAB

The bottles and sample cells should be cleaned with H_2SO_4 (2%) %) or HCl (10%) as several forms of phosphorus will be analyzed
often. After cleaning the cells with acid, rinse them with tap water first then demineralized water. No detergent should be used as its phosphate content will contaminate the samples.

You will have a better chance of avoiding contamination, and get more accurate results, if the lab and the dishes (glasses bottles, titration apparatus and measuring devices) are kept as clean as possible. It might be a good idea to have every week for example a person responsible for keeping the material and the lab clean. The importance of this job shouldn’t be underestimated.

9. CONSERVATION OF THE SAMPLES

Several analyses should already be done during the sampling day itself. After the field work, a new team should be ready in the lab to start directly with the lab analyses.

For several analyses, it is nevertheless possible to keep the samples at ≤ 4° C in the dark for less than 24 H—48 H. Before analysing, you should let them warm up to room temperature.

The samples that can not be analyzed within the next 48 H should be carefully preserved following the instruction of Table 2.

TABLE 2 (a): Procedure and time of preservation when direct analysis is not possible. Necessary quantity of sample is also indicated; including sample for blanks (Sampling types V and/or H).

Type of analysis	ml	Procedure	Time
TP and **TDP**	25 25	Refrigerate at ≤ 4°C	24 H
SRP	50	**A.** Refrigerate the sample at ≤ 4°C	24 H
		A. For longer storage, add 4.0 ml of mercuric chloride solution to 1 litre of sample and mix. **B.** Refrigerate the sample at ≤ 4°C. **C.** Prevent mercuric interference by adding 0,1 g sodium chloride/ litre of solution.	>24 H
Nitrogen Ammonia **(NH_4N)**	50	**A.** If Cl_2 is present, add 0.1 N sodium thiosulphate (1 drop/0,3 mg/l Cl_2). **B.** Adjust sample pH to 2 or less with H_2SO_4 (ACS) (> 2 ml of H_2SO_4 /litre of sample) **C.** Refrigerate the sample **D.** Before testing, warm to room temperature **E.** Neutralise with 5.0 N NAOH solution **F.** Correct the test results for volume addition (*).	28 days

Nitrite (NO_2^--N)	50	**A.** Storage at ≤ 4° C	24 H
		A. Add 4 ml of Mercuric Chloride solution/ litre of sample and mix	28 days
		B. Refrigerate the sample	
		C. Before testing, warm to room temperature (*)	
N i t r a t e (NO_3^--N)	55	**A.** Storage at ≤ 4° C	24-48 H
		A. Adjust sample pH to 2 or less with 2 ml of H_2SO_4 *(ACS)* per litre of sample.	28 days
		B. Refrigerate the sample	
		C. Before testing, warm to room temperature	
		D. Neutralise with 5.0 N NAOH solution	
		E. Correct the test results for volume addition (*)	
Turbidity	40	**A.** Storage at 4° C	48 H
T O T A L quantity	295		

TABLE 2 (b): Procedures and time of preservation when direct analysis is not possible. Quantity of necessary sample is also indicated; including sample for blanks (Sampling of type C).

Type of analysis	ml	Procedure	Time
A l k a l i - nity	100	**A.** storage at ≤ 4° C	24 H
Ca^{++}	100	**A.** Add 1.5 ml Nitric Acid per litre sample	7 days
		B. Refrigerate the sample	
		C. Neutralise to pH 7 with NaOH before testing	

T o t a l Hardness	100	**A.** Adjust sample pH to 2 or less with concentrated nitric acid (HNO_3) or sulphuric acid (H_2SO_4). **B.** Refrigerate the sample at 4°C **C.** Neutralise to pH 7 with ammonium hydroxide (NH_4OH) before testing	7 days
$SO4^{-}$	25	**A.** storage at ≤ 4° C	7 days
SiO_2 (LR)	50	**A.** storage at ≤ 4° C	7 days
SiO_2 (HR)	100	**A.** storage at ≤ 4° C	7 days
Cl^{-}	100	**A.** no refrigeration necessary	7 days
Na^{+}	100	**A.** add 0,1 ml of concentrated HCl	6 months
K^{+}	100	**A.** add 0,1 ml of concentrated HCl	6 months
T O T A L QUANTITY	775		

(*) correction of test results for volume addition:

1. Determine the total volume of initial sample, acid added and base added.
2. Divide the total volume by the initial volume.
3. Multiply the test result by this factor.

10. MANAGEMENT OF THE STOCK OF CHEMICALS

Keeping track of the exact amount of chemicals in stock is a fastidious but important job to avoid any delays in the program due to the shortage of certain chemicals.

A spreadsheet called STOCK has been provided to each station to keep track of its respective stock of chemicals. This form is linked automatically with a spreadsheet called "REP-FRM" (replenishment form) listing the chemicals and the quantity that needs to be ordered. Here are the steps to follow:

a) First, complete the column "Stock list" of the form "STOCK"(in the lab). Be sure that you use the same units as the ones shown in the file FORM: If unit is "a box of 100 pills" and you have 164 pills, just write 1.64. For more convenience, you could also count only the boxes that are full and forget about counting the pills in the used (incomplete) ones. It will just add to your security of stock.

b.) Then, on the computer, you open the file "STOCK" (this is the same form listing the common chemicals used by LTR) and you just enter the data in the column "Stock list"

2. Open the file "REPL-FRM". As it is linked with the file STOCK, the information is already updated. Only the presentation is different from STOCK file; print this file REPL-FRM.

3. Send the print of the file "REPL-FRM" to LTR Bujumbura (keep a copy also) and one copy to the coordinator of limnology in Mpulungu.

For your information, in the hidden column of "Stock", there are estimations on the number of chemicals of each kind that is needed (function of quantity needed per test, of sampling for the old program up to August and sampling for the new program starting in August) When you enter the situation of your stock list of chemicals, a small test is performed: if the quantity of chemicals is less than half of the one needed for one year, then the message "to order" appears in the file REPL.FRM. If your quantity is equal or more than what is needed for 6 months, than the message "OK" appears. The minimal quantity to order is rounded to one, while all quantities are rounded to avoid fractionated quantities.

For your convenience, three different lists of chemicals are presented in Appendices 9, 10 and 11. Each of them is sorted according to different criteria.

11. LIMNOLOGICAL DATABASE

The forms used to record the results have been introduced in the first part of this manual and are found in Appendices 2 to 7.

It is extremely important to avoid input of data that you think are unreliable (because of possible problems during sampling or analysis...). This is why, before entering data in the computer, they should be checked by the person in charge of limnology in your station.

After each week of sampling and validation by the person responsible for limnology in the station, enter the data that have been validated in the appropriate files. If problems are suspected, it is better in such case to leave parts of the forms blank or to put data in italic, with some comments. If results have been performed more than once for the same depth, the responsible of limnology in your station should decide on what to do: either an average of all; or an average of the ones that have been performed the best, and discarding the ones resulting from doubtful analyses due to mistakes in the operation, for example, or uncertainty about the way it was carried out.

As soon as the original form on disk has been opened, use the command "SAVE AS..." to give it an appropriate name following this procedure:

1. Letter(s) code for the **type** of sampling:
There are 7 possibilities:

- **H** for horizontal (every two weeks)
- **V** for vertical (once per month)
- **B** for sampling type B (24 H cycle; every 6–8 weeks)
- **P** for precipitation (**=** rain water; 4 per year)
- **R** for river (3 per year)
- **C** for sampling of type C (seasonal sampling; 4 or 6 per year)
- **S** for satellite limnology (during hydrodynamic cruises)

2. The **date** of the sampling follows: format **YYMMDD** should be used as this allows an automatic classification by the computer

ex: 930803 = 1993 August 3

If it is a sampling B: use always the first day for a 24 H cycle.

3. The **Country code** follows

Burundi = A, Tanzania = B, Zambia = C, Zaire = D

There are no additional characters, not even for sampling B as all the results of sampling B will be inputted in the same file.

Example : B940803A is the data file for a sampling of type B started the 3 th. of August 1994 in Burundi.

Please, do not change the design of the form (by inserting or deleting columns and rows, as macros procedures wouldn't run properly in this case (the information that is written in a particular cell, example: F18, H3 etc..., should be the same type of information for each station !). This will help to avoid mixing up the data and to allow a fast processing.

At the end of each month, a disk containing copies of the forms for sampling of each type performed during that month should be sent to the coordinator for the limnology component in Mpulungu. Copies of the files on paper should also be sent with the disk (printout after input of data in computer). For security, you should keep a duplicate of each form on disk and on paper in your station.

It is advised that you print profiles of your measurement every month to have a better follow-up of the limnological condition of the lake near your station. A standard file for doing so will be sent to each station for homogeneity and it will be asked that you send it with your results.

12. ACCURACY TESTS

Accuracy tests have to be performed regularly in order to check the procedures followed, the material used as well as the chemicals. It is a very important aspect of the study because it allows us to get confidence in the methods that we use. It allows us to improve the techniques that we use.

Accuracy tests should be done in three cases:

1. On a regular basis, every 4 month.
2. After receiving new material or chemicals.
3. If there is a change of the whole team performing the analyses.

The form to record the results is copied in appendices 12/1 and 12/2. After filling the form in the computer, results should be carefully checked by the responsible of limnology to see if the number of the test are sufficient. Normally, 3 experiments per test are sufficient. If important variation is found between experiments, more experiments should be done. It is important to write into "remarks" in which way analyses are done eventually differ one from the other in order to give appropriate interpretation and find the best procedure. After inputting the results into the computer (file ACCUR2), give an appropriate name
(ex: AC94lOA is the accuracy test (AC) file of October 1994 for Bujumbura (A)). Make a print of it and send a copy (form and disk) to the coordinator of limnology in Mpulungu with your eventual comments.

The general principle of accuracy checks is to add known and increasing concentrations to a sample and to check if the results of the analyze correspond to the expected increases of

concentrations. Detailed explications are provided in the HACH Manual after the procedure for each analysis.

13. REFERENCES

HACH - Portable HACH One pH meter Model 438-00

HACH — Model 44600- Conductivity/TDS meter

HACH - DR/2000 Spectrophotometer. Instrument manual.
For use with software version 3.

HACH — DR/2000 Spectrophotometer Handbook - Procedure Manual

HACH — Digital titrator — Model 16900—01 — Manual

HACH — Instrument manual. Laboratory turbidimeter.
Model 2100A

APPENDIX 1 : FIELD EQUIPMENT CHECK LIST	Sampling types						
	H	V	B	C	R	P	S
	Horizontal	Vertical	24 H cycle	Seasonal	River	Rain (prec.)	Satellite L.
General equipment							
GPS + recorded position of sampling site	x	x	x	x	x		x
Sampling tube of 7.4 litres + messenger	x	x	x	x	x		x
Cable of appropriate length with adequate marks	x	x	x	x	x		x
Radiation meter	x	x	x		x		x
Equipment for zooplankton :							
Plankton net (see zooplankton manual)	x	*	x				
Two buckets of 20 litres content	x	*	x				
3 Bottles to keep sample	x	*	x				
Formalin and syringe	x	*	x				
Equipment for CE budget - primary production							
Acid washed glass liquid scintil.vials, plastic screw cap,20	x						
Rack for above vials	x						
Aluminium foils	x						
Black plastic to cover samples	x						
Disposable gloves	x						
Adjustable pipette 0-40 µl	x						
Radiocarbon stock solution	x						
Buoy	x						
String with glass vials attachment at appropriate depth	x						
Closed box for storing samples (no coolant)	x						
Equipment for CE - budget - respiration							
Dividing tube	x						
Rack with 20 acid washed oxygen bottles	x						
Equipment for limnological sampling							
Recording form	x	x	x	x	x	x	x
Secchi disk	x	x	x		x		x
protractor (desk type)	x	x	x	x	x		
1 plastic beaker of 500 ml	x	x	x		x	x	
pH meter (calibrated) and conductivity meter (calibrated)	x	x	x		x	x	
T°+ O2 probe (calibrated), cable, stirrer, spare battery	x	x	x		x		
Precision thermometer if probe is not available	x	x	x		x		
Clean plastic bottles of 2 litres	19	10	20	7	1	1	3
Clean plastic bottles of 1 litre	38	20	60	0	0	0	6
Boxes to keep samples for Chl a (no coolant)	x	x	x		x		x
Cool boxes with coolant	x	x	x	x	x	x	
One bottle with deionised water	x	x	x	x	x	x	x

* zooplankton material is needed on the way to V sampling when stopping at A site.

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY - sampling H (from site A to shore)

Station (full name) :		Latitude :	
Team sampling :		Longitude :	
Team analysing :		Hour start:	
Date (DDMMYY) :		Hour end:	
Lake condition :		Before sampled water discarded, results data checked by :	
Cloud cover :	*from 1 (= no clouds) to 5 (= covered)*	Before entering data in computer, data checked by :	
Radiation at start:	Radiation at end:		

Measure conductivity before pH !

SITE A (=H1) 9 H Burundi time	Depth (m)	Zoop.	B.D.			T° °C (probe)	D.O. mg/l (probe)	C. uS/cm	pH	Turb. NTU	T. P. mg/l (PO4---)	T.D.P mg/l (PO4---)	S.R.P mg/l (PO4---)	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	SIO2 mg/l	Chl a mg/m3	Pr. Prod. g C/m2-D	Respiration DO start mg/l	Respiration DO end mg/l	Alkalinity P. Alk mg/l	Alkalinity T. Alk. mg/l
				start	end																		
	0		1.																send				
	2		2.																send				
	5		3.																send				
	10		Av =																send				
	20																		send				
	30																		send				
	40																		send				
	50																		send				
	60																		send				
	70																		send				
	80																		send				
	90																		send				
	100																		send				

	Depth (m)	B.D. 1.	B.D. 2.	B.D. 3.	B.D. Av.	T° °C (probe)	D.O. mg/l (probe)	pH	C. uS/cm	Turb. NTU	T. P. mg/l (PO4---)	T.D.P mg/l (PO4---)	S.R.P mg/l (PO4---)	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	SIO2 mg/l	Chl a mg/m3
SITE H2	0																	
Time :	10																	
SITE H3	0																	
Time :	10																	
SITE H4	0																	
Time :	10																	

H 1 = site A, H2 = 1000 m from coast, H3 = 500 m from coast, H4 = 50 m from coast

NB 1 : TDP and SRP after filtration (0.45 µm) NB 2 : Alkalinity in CaCO3

Remarks:

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY - Monthly Vertical Sampling (V)

APPENDIX 3 : FORM-V1

Station (full name) :		Latitude :	
Team sampling :		Longitude :	
Team analysing :		Hour start :	
Date (DDMMYY) :		Hour end :	
Lake condition :		Before sampled water discarded, checked by :	
Cloud cover :	from 1 (= no clouds) to 5 (= covered)	Before entering data in computer, checked by :	
Radiation at start :	Radiation at end :		

Site V - Vertical sampling at 10 Hours - Burundi time

Depth (m)	Station		S.D. start	S.D. end	T° °C (probe)	D.O. mg/l (probe)	C. uS/cm	pH	Turb. NTU	TP mg/l PO4---	TDP mg/l PO4---	SRP mg/l PO4---	NH4-N mg/l	NO3-N mg/l	NO2-N mg/l	SIO2 mg/l	Chl a mg/m3		
0	each	1.																	
10	each	2.																	
20	each	3.																	
30		Av =																	
40	each																		
50																			
60	each																		
70	A and B																		
80	each																		
90																			
100	each																		
110																			
120	each																		
130																			
140	each																		
150																			
160	C																		

NB 1 : TDP and SRP after filtration (0.45 µm) - NB 2 : Conductivity to be measured before pH !

Remarks :

Station code : A = Buj.-Uvi , B = Kigoma, C = Mpulungu

LAKE TANGANYIKA RESEARCH PROJECT (Limnology form-B1)

24 H cycle (12-18-24-06 H - Burundi time)								
Station :					Latitude :			
Date (DDMMYY) :					Longitude :			
Team sampling :								
Team analysing :								
Time start								
Time end								
SD		1.	2.	3.	Av.			
	Start							
	End							
Lake condition :								
Cloud cover :			*1 (= no clouds) to 5 (= covered)*					
Radiation start:								
Radiation end:								
Moon clarity:			*1 (= full-bright) to 5 (no moon)*					

Depth	Station		T°	D.O.	C.	pH	Turb.	Chl a
(m)	Zoopl.	Hydr.	°C	mg/l	µS/cm		NTU	mg/m3
0	each	each						
10								
20	each	each						
30								
40	each	each						
50								
60	each	each						
70								
80	each	each						
90								
100	each	each						
110								
120	each	each						
130								
140	each	each						
170	MP	MP						
200	MP	each						
230	MP	MP						
300		each						

NB : Measure Conductivity before pH !
MP = for Mpulungu

Remarks :

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY - Seasonal Sampling C - (FORM-C1)

Station :			
Team sampling :		Latitude :	
Team analysing :		Longitude :	
Date (DDMMYY) :		Hour beginning :	
Lake condition :		Hour ending :	
Before discarding water, checked by :			
Before entering data on computer, checked by :			

Station C (=B) (at the beginning of 24 H cycle following schedule)									
Depth	Na +	K+	Tot Hardness	Ca++	P. Alkal.	Tot. Alkal.	Cl-	SO4--	SiO2
(m)	mg/1	mg/1	mg/1 as CaCO3	mg/1 as CaCO3	mg/1 as CaCO3	mg/1 as CaCO3	mg/1	mg/1	mg/1
0	send	send							
50	send	send							
100	send	send							
150	send	send							
200	send	send							
250	send	send							
300	send	send							
BOTTLE	country/C/date/H/depth + coordinates		C/date/H/depth						

NB 1: Results of Ca++, tot hardness, P. alk. and tot alk. should be expressed as CaCO3 (no transformation after the test)

NB 2 : For analysis of Na+ and K+: preserve sample following field manual instruction an send to Project HQ before the end of the month.

FORM-C1 30/7/94

Remarks :

LAKE TANGANYIKA RESEARCH PROJECT - LIMNOLOGY (Rain or River Analysis) - FORM P/R1

Station :			Latitude :
Origin of water :	(rain,river name...)		Longitude :
Date (DDMMYY) :			H. start :
Team sampling :			H. end :
Team analysing :			Depth (m) :

R.	S.D.	T°	D.O.	C.	pH	Turb.	TP	TDP	SRP	NH4-N	NO3-N	NO2-N	Chl a
	m	°C	mg/l	µS/cm		NTU	mg/l PO4---	mg/l PO4---	mg/l PO4---	mg/l	mg/l	mg/l	mg/m3
1													
2													
3													
4													
5													
6													

R.	Na +	K+	Tot Hard.	Ca++	Mg++	P.Alkal.	Tot.Alkal.	Cl-	SO4--	SiO2			
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l			
			(expressed as CaCO3)										
1	send	send											
2	send	send											
3	send	send											
4	send	send											
5	send	send											
6	send	send											

NB 1 : R = repetition. Generaly 3 repetitions will be sufficient unless important variations are noticed between measurements.

NB 2 : Mg ++ obtained by difference between Tot Hardness and Ca ++

Remarks :

SATELLITE LIMNOLOGY (FORM-S1)

to be done in PELAGIC area (> 2 km from shore)

Station name :	
Team:	
Responsible:	
Month (MMYY)	

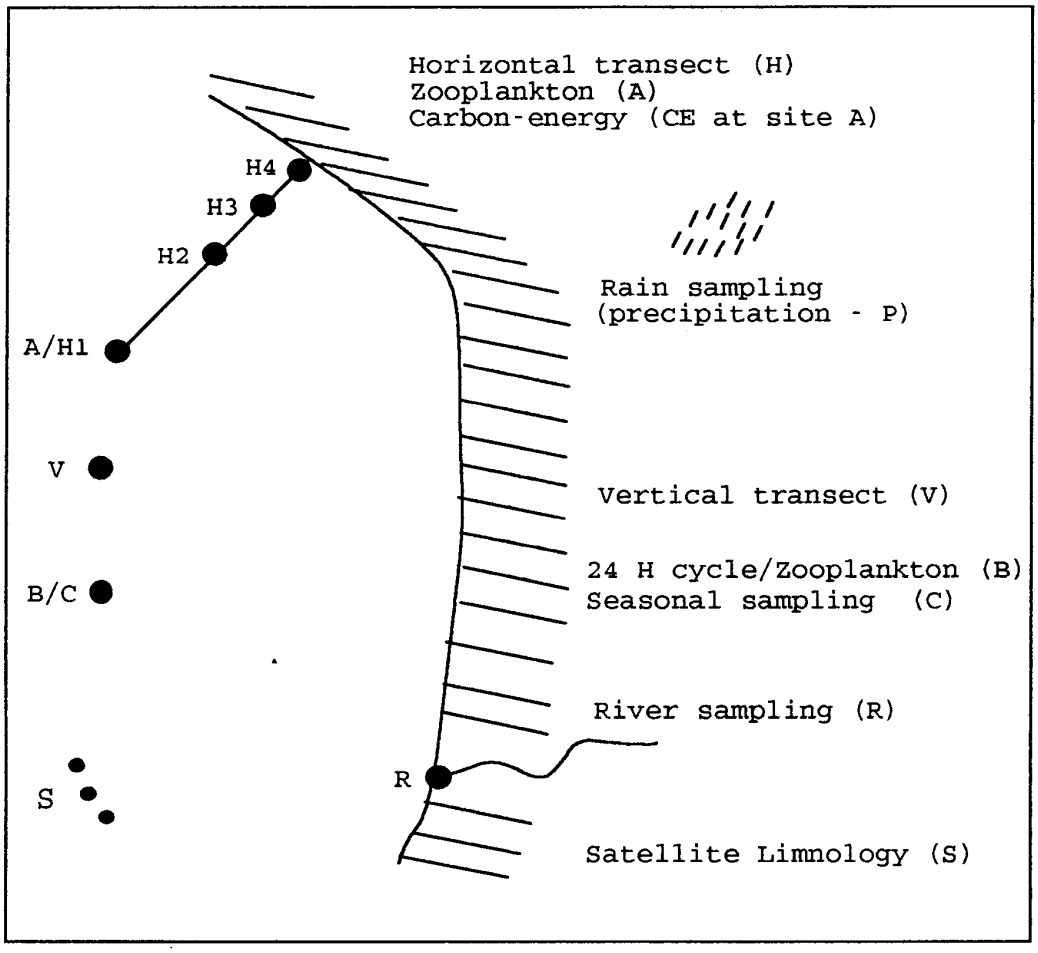
During hydrodynamic experiment: 3 Secchi disk are measured and 1 surface water sample taken (4 liters) beween 7 and 9 H (A), at 12.30 H (B) and between 16.00 and 17 H.30 (C) (Burundi time). Record each GPS position. Regular same positions would be better. 12 H 30 is the only time that is fixed for each station (Burundi time). Coordinates : use DD (degrees), MM.OO (minutes and hundreds of min. as given by the GPS)

DATE	Exp.	HOUR	LAT.	LONG	Line	Secchi disk (00,0m)				Turb 0 m	Chl a
		HH MM	DD MM,00	DD MM,00		SD 1	SD 2	SD 3	Average	NTU	(mg/m3)
	A				1						
	B				1						
	C				1						
	A				2						
	B				2						
	C				2						
	A				3						
	B				3						
	C				3						
	A				4						
	B				4						
	C				4						
	A				(5)						
	B				(5)						
	C				(5)						

In case that other measurements are done outside than during the hydrodynamic, please use the space below:

	A										
	B										
	C										
	A										
	B										
	C										
	A										
	B										
	C										
	A										
	B										
	C										
	A										
	B										
	C										

Appendix 8 : Schematic drawing of sampling design in one station.



Type	Experiment	Teams	Frequency
H	Horizontal transect	Limnology	2/month
A	Zooplankton lifnet	Zooplankton	4/month
CE	Primary prod. + respiration	Limno/ Finland	2/month
V	Vertical transect	Limnology	1/month
P	Precipitation (rain analysis)	Limnology	4/year
R	River water analysis	Limnology	3/year
B	24 h cycle - zooplankton	Zoopl/Limno	6/year
C	Seasonal sampling	Limnology	6/year
S	Satellite limnology	Hydro/Limno	4/month

Appendix 9 : Products list classified by methods.

Method	Products	ref	A/C an	STOCK List	Units STOCK
Alkalinity	Bromcresol green-methyl red powder pil	943-99	A		Box of 100 pills
Alkalinity	Phenophtalein powder pillow	942-99	A		Box of 100 pills
Alkalinity	Sulfuric acid titr. cartr. 0.16	14388-01	A		Titration cartridge
Alkalinity	Sulfuric acid titr. cartr. 1.6	14389-01	A		Titration cartridge
Ca++	Amonium hydroxide for Ca++ (10%)	14736-32	C		Standard solution bottle
Ca++	Calver 2 calcium indicator pillow	852	A		Box of 50 pills
Ca++	Nitric acid	2540-49	C		ml Nitric Acid
Ca++	Potassium hydroxide standard sol, 8.0	282-37	A		Standard solution bottle
Ca++	Titraver Solution EDTA	14364-01	A		Titration cartridge
Cl-	Chloride 2 indic powder pill.	1057-66	A		Box of 50 pills
Cl-	Silver nitrate 0.2256 N	14396-01	A		Titration cartridge
Cl-	Silver nitrate 1.128 N	14397-01	A		Titration cartridge
misc.	H2SO4 99-100%	4111023	A/C		ml H2SO4 99-100%
misc.	HCL concentrated 37 %	4140303	A/C		ml HCL 37 %
misc.	NaOH pastillen	4117373	A/C		mg pastillen NAOH
misc.	Paper tissue		A/C		boxes
NH3-N	Mineral Stabilizer	23766-26	A		Standard solution bottle
NH3-N	Nessler Reagent	21194-49	A		bottles (500 ml)
NH3-N	Polyvinil Alcohol dispersing agent	23765-26	A		Standard solution bottle
NH3-N	Sodium thiosulfate	323-32	C		Standard solution bottle
NO3 (LR)	bromine water	2211-20	C		Standard solution bottle
NO3 (LR)	Nitraver 6	14119-46	A		Box of 50 pills
NO3 (LR)	Phenol solution	2112-20	C		Standard solution bottle
NO3 (LR)+NH3	Sulf. acid sol. acs-500 ml for NO3+NH3	979-49	C		ml H2SO4
NO3 (LR)+NO2	Nitriver 3 (for NO3-N, NO2-N)	14065-66	A		Box of 50 pills
pH	Hach one reference electrolyte	21950-01	A		Titration cartridge
SRP (asc)	Phosver 3	2209-99	A		Box of 100 pills
SRP (molyb)	Molybdovanate reagent	20760-32	A		Standard solution bottle
SRP (molyb)	Sodium chloride ACS	182-01	C		bottle 454 g
SRP (molyb)+NO2	Mercuric chloride solution for PO4+NO2	14994-43	C		Standard solution bottle
SIO2 HR+LR	Citric acid powder pill for SIO2 HR+LR	14548-99	A		Box of 100 pills
SIO2 HR	Acid reagent powder pillow	1042-66	A		Box of 50 pills
SIO2 HR	Holmium trichloride powder pillow	23432-67	A		Box of 10 pills
SIO2 HR	Molybdate reagent powder pillow	1041-66	A		Box of 50 pills
SIO2 LR	Amino acid F reagent	22538-69	A		Box of 100 pills
SIO2 LR	Molybdate 3 reagent	1995-32	A		Standard solution bottle
SO4--	Sulfaver 4 reagent powder pill.	12065-66	A		Box of 50 pills
Tot P(COD)+PO4---	Phosver 3 for TOT P COD+ PO4---	2209-99	A		Box of 100 pills
Tot P + TDP	Potassium persulfate powder pillow	2451-66	A		Box of 50 pills
Tot P + TDP	Sodium hydroxyde sol 5 N for TOT P	2450-32	A		Standard solution bottle
Tot P + TDP	Sulfuric acid solution 5.25 N	2449-32	A		Standard solution bottle
Tot P + TDP (COD)	Potassium Persulfate	20847-69	A		Box of 100 pills
Tot P + TDP (COD)	Sodium Hydroxide 1 N	1045-53	A		Standard solution bottle
Tot P + TDP (COD)	Sulfuric Acid 1.00 N	1270-53	A		Standard solution bottle
Tot. Hardn	Amonium hydroxide for Tot. Hardn.	14736-37	C		Standard solution bottle
Tot. Hardn.	Buffer sol hardness 1	424-32	A		Standard solution bottle
Tot. Hardn.	EDTA 0,08	14364-01	A		Titration cartridge
Tot. Hardn.	EDTA 0,8 M	14399-01	A		Titration cartridge
Tot. Hardn.	Man-ver 2 hardness indic.	851	A		Box of 50 pills

A= analysis, C = conservation

Appendix 10 : Products list by reference number order.

ref	Method	Products	A/C an	STOCK List	Units STOCK
851	Tot. Hardn.	Man-ver 2 hardness indic.	A		Box of 50 pills
852	Ca++	Calver 2 calcium indicator pillow	A		Box of 50 pills
4111023	misc.	H2SO4 99-100%	A/C		ml H2SO4 99-100%
4117373	misc.	NaOH pastillen	A/C		mg pastillen NAOH
4140303	misc.	HCL concentrated 37 %	A/C		ml HCL 37 %
1041-66	SIO2 HR	Molybdate reagent powder pillow	A		Box of 50 pills
1042-66	SIO2 HR	Acid reagent powder pillow	A		Box of 50 pills
1045-53	Tot P.+TDP (COD)	Sodium Hydroxide 1 N	A		Standard solution bottle
1057-66	Cl-	Chloride 2 indic powder pill.	A		Box of 50 pills
12065-66	SO4--	Sulfaver 4 reagent powder pill.	A		Box of 50 pills
1270-53	Tot P + TDP (COD)	Sulfuric Acid 1.00 N	A		Standard solution bottle
14065-66	NO3 (LR)+NO2	Nitriver 3 (for NO3-N, NO2-N)	A		Box of 50 pills
14119-46	NO3 (LR)	Nitraver 6	A		Box of 50 pills
14364-01	Ca++	Titraver Solution EDTA	A		Titration cartridge
14364-01	Tot. Hardn.	EDTA 0,08	A		Titration cartridge
14388-01	Alkalinity	Sulfuric acid titr. cartr. 0.16	A		Titration cartridge
14389-01	Alkalinity	Sulfuric acid titr. cartr. 1.6	A		Titration cartridge
14396-01	Cl-	Silver nitrate 0.2256 N	A		Titration cartridge
14397-01	Cl-	Silver nitrate 1.128 N	A		Titration cartridge
14399-01	Tot. Hardn.	EDTA 0,8 M	A		Titration cartridge
14548-99	SIO2 HR+LR	Citric acid powder pill for SIO2 HR+L	A		Box of 100 pills
14736-32	Ca++	Amonium hydroxide for Ca++ (10%)	C		Standard solution bottle
14736-37	Tot. Hardn	Amonium hydroxide for Tot. Hardn.	C		Standard solution bottle
14994-43	SRP (molyb)+NO2	Mercuric chloride solution for PO4+NO	C		Standard solution bottle
182-01	SRP (molyb)	Sodium chloride ACS	C		bottle 454 g
1995-32	SIO2 LR	Molybdate 3 reagent	A		Standard solution bottle
20760-32	SRP (molyb)	Molybdovanate reagent	A		Standard solution bottle
20847-69	Tot P + TDP (COD)	Potassium Persulfate	A		Box of 100 pills
2112-20	NO3 (LR)	Phenol solution	C		Standard solution bottle
21194-49	NH3-N	Nessler Reagent	A		bottles (500 ml)
21950-01	pH	Hach one reference electrolyte	A		Titration cartridge
2209-99	SRP (asc)	Phosver 3	A		Box of 100 pills
2209-99	Tot P(COD)+TDP+SRP	Phosver 3 for TOT P COD+ PO4---	A		Box of 100 pills
2211-20	NO3 (LR)	bromine water	C		Standard solution bottle
22538-69	SIO2 LR	Amino acid F reagent	A		Box of 100 pills
23432-67	SIO2 HR	Holmium trichloride powder pillow	A		Box of 10 pills
23765-26	NH3-N	Polyvinil Alcohol dispersing agent	A		Standard solution bottle
23766-26	NH3-N	Mineral Stabilizer	A		Standard solution bottle
2449-32	Tot P + TDP	Sulfuric acid solution 5.25 N	A		Standard solution bottle
2450-32	Tot P + TDP	Sodium hydroxyde sol 5 N for TOT P	A		Standard solution bottle
2451-66	Tot P + TDP	Potassium persulfate powder pillow	A		Box of 50 pills
2540-49	Ca++	Nitric acid	C		ml Nitric Acid
282-37	Ca++	Potassium hydroxide standard sol, 8.0	A		Standard solution bottle
323-32	NH3-N	Sodium thiosulfate	C		Standard solution bottle
424-32	Tot. Hardn.	Buffer sol hardness 1	A		Standard solution bottle
942-99	Alkalinity	Phenophtalein powder pillow	A		Box of 100 pills
943-99	Alkalinity	Bromcresol green-methyl red powder pi	A		Box of 100 pills
979-49	NO3 (LR)+NH3	Sulf. acid sol. acs-500 ml for NO3+NH	C		ml H2SO4
	misc.	Paper tissue	A/C		boxes

A = analysis, C = conservation

Appendix 11: Products list by alphabetical order.

Products	Method	ref	A/C an	STOCK List	Units STOCK
Acid reagent powder pillow	SIO2 HR	1042-66	A		Box of 50 pills
Amino acid F reagent	SIO2 LR	22538-69	A		Box of 100 pills
Amonium hydroxide for Ca++ (10%)	Ca++	14736-32	C		Standard solution bottle
Amonium hydroxide for Tot. Hardn.	Tot. Hardn	14736-37	C		Standard solution bottle
Bromcresol green-methyl red powder pil	Alkalinity	943-99	A		Box of 100 pills
bromine water	NO3 (LR)	2211-20	C		Standard solution bottle
Buffer sol hardness 1	Tot. Hardn.	424-32	A		Standard solution bottle
Calver 2 calcium indicator pillow	Ca++	852	A		Box of 50 pills
Chloride 2 indic powder pill.	Cl-	1057-66	A		Box of 50 pills
Citric acid powder pill for SIO2 HR+LR	SIO2 HR+LR	14548-99	A		Box of 100 pills
EDTA 0,08	Tot. Hardn.	14364-01	A		Titration cartridge
EDTA 0,8 M	Tot. Hardn.	14399-01	A		Titration cartridge
H2SO4 99-100%	misc.	4111023	A/C		ml H2SO4 99-100%
Hach one reference electrolyte	pH	21950-01	A		Titration cartridge
HCL concentrated 37 %	misc.	4140303	A/C		ml HCL 37 %
Holmium trichloride powder pillow	SIO2 HR	23432-67	A		Box of 10 pills
Man-ver 2 hardness indic.	Tot. Hardn.	851	A		Box of 50 pills
Mercuric chloride solution for PO4+NO2	SRP (molyb)+NO2	14994-43	C		Standard solution bottle
Mineral Stabilizer	NH3-N	23766-26	A		Standard solution bottle
Molybdate 3 reagent	SIO2 LR	1995-32	A		Standard solution bottle
Molybdate reagent powder pillow	SIO2 HR	1041-66	A		Box of 50 pills
Molybdovanate reagent	SRP (molyb)	20760-32	A		Standard solution bottle
NaOH pastillen	misc.	4117373	A/C		mg pastillen NAOH
Nessler Reagent	NH3-N	21194-49	A		bottles (500 ml)
Nitraver 6	NO3 (LR)	14119-46	A		Box of 50 pills
Nitric acid	Ca++	2540-49	C		ml Nitric Acid
Nitriver 3 (for NO3-N, NO2-N)	NO3 (LR)+NO2	14065-66	A		Box of 50 pills
Paper tissue	misc.		A/C		boxes
Phenol solution	NO3 (LR)	2112-20	C		Standard solution bottle
Phenophtalein powder pillow	Alkalinity	942-99	A		Box of 100 pills
Phosver 3	SRP (asc)	2209-99	A		Box of 100 pills
Phosver 3 for TOT P COD+ PO4---	TP (COD) + TDP+SRP	2209-99	A		Box of 100 pills
Polyvinil Alcohol dispersing agent	NH3-N	23765-26	A		Standard solution bottle
Potassium hydroxide standard sol, 8.0	Ca++	282-37	A		Standard solution bottle
Potassium Persulfate	TP + TDP (COD)	20847-69	A		Box of 100 pills
Potassium persulfate powder pillow	Tot P.	2451-66	A		Box of 50 pills
Silver nitrate 0.2256 N	Cl-	14396-01	A		Titration cartridge
Silver nitrate 1.128 N	Cl-	14397-01	A		Titration cartridge
Sodium chloride ACS	SRP (molyb)	182-01	C		bottle 454 g
Sodium Hydroxide 1 N	TP + TDP. (COD)	1045-53	A		Standard solution bottle
Sodium hydroxyde sol 5 N for TOT P	TP + TDP.	2450-32	A		Standard solution bottle
Sodium thiosulfate	NH3-N	323-32	C		Standard solution bottle
Sulf. acid sol. acs-500 ml for NO3+NH3	NO3 (LR)+NH3	979-49	C		ml H2SO4
Sulfaver 4 reagent powder pill.	SO4--	12065-66	A		Box of 50 pills
Sulfuric Acid 1.00 N	TP + TDP. (COD)	1270-53	A		Standard solution bottle
Sulfuric acid solution 5.25 N	TP + TDP.	2449-32	A		Standard solution bottle
Sulfuric acid titr. cartr. 0.16	Alkalinity	14388-01	A		Titration cartridge
Sulfuric acid titr. cartr. 1.6	Alkalinity	14389-01	A		Titration cartridge
Titraver Solution EDTA	Ca++	14364-01	A		Titration cartridge

A= analysis, C = conservation

Station:		Lake Tanganyika Research Project							Water:		(L = lake, D = deionised)				
Month:		LIMNOLOGY: ACCURACY TESTS							Analyst :						
Year :									Results of accuracy checks corrected						
	METHOD	Add	Results of accuracy checks						(values of blanco (no addition) substracted)						
	UNITS	ml	exp 1	exp 2	exp 3	exp 4	exp 5	exp 6	exp 1	exp 2	exp 3	exp 4	exp 5	exp 6	Aver.
Tot P / TDP	10013	0.00													
	mg/l PO4---	0.10													
	COD	0.20													
	(new)	0.30													
	Remarks :														
PO4 --- / SRP	10011	0.00													
	mg/l	0.10													
	COD	0.20													
	(new)	0.30													
	Remarks :														
NH4+	8038	0.00													
	mg/l NH4-N	0.10													
		0.20													
		0.30													
	Remarks :														
NO3-	8192	0.00													
	mg/l NO3-N	0.10													
		0.20													
		0.30													
	Remarks :														
NO2-	8507														
	mg/l NO2-N	1													
	Sol = 1 mg/l	2													
		3													
	Remarks :														
Tot Hardness	Dig titr.	0.00													
	mg/l	1.00													
	as CaCO3	2.00													
	Manual	3.00													
	page 72	Remarks :													
	rge=100-400														

Station:		Lake Tanganyika Research Project							Water:		(L = lake, D = deionised)				
Month:		LIMNOLOGY: ACCURACY TESTS							Analyst :						
Year :									Results of accuracy checks corrected						
	METHOD	Add.	Results of accuracy checks						(values of blanco (no addition) substracted)						
	UNITS	ml	exp 1	exp 2	exp 3	exp 4	exp 5	exp 6	exp 1	exp 2	exp 3	exp 4	exp 5	exp 6	Aver.
Hardness Ca++	Dig titr.	0,00													
	mg/l	0,10													
	as CaCO3	0,20													
	Manual	0,30													
	page 79	Remarks :													
	range=10-40														
Alkalinity	Dig titr.	0,00													
	mg/l	0,10													
	as CaCO3	0,20													
	Manual	0,30													
	page 34	Remarks :													
	rge= 100-400														
Cl-	Dig titr.	0,00													
	mg/l	0,10													
	as CL-	0,20													
	Manual p. 51	0,30													
	(silv. nitrate)	Remarks :													
	range=10-40														
SO4- -	8051	0,00													
	mg/l	0,10													
		0,20													
		0,30													
	Remarks :														
SiO2	8186	0,00													
low range	mg/l	0,10													
		0,20													
		0,30													
	Remarks :														
SiO2	8185	0,00													
high range	mg/l	0,10													
		0,20													
		0,30													
	Remarks :														

Length of cable to take angular correction into account (in m)

Depth sampled	Angle with vertical																											
	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°
10	10,1	10,1	10,2	10,2	10,3	10,4	10,5	10,6	10,8	10,9	11,1	11,3	11,5	11,8	12,1	12,4	12,7	13,1	13,5	13,9	14,4	14,9	15,6	16,2	17,0	17,9	18,9	20,0
20	20,1	20,2	20,3	20,4	20,6	20,8	21,0	21,3	21,6	21,9	22,3	22,7	23,1	23,6	24,1	24,7	25,4	26,1	26,9	27,8	28,8	29,9	31,1	32,5	34,0	35,8	37,7	40,0
30	30,2	30,3	30,5	30,7	30,9	31,2	31,5	31,9	32,4	32,8	33,4	34,0	34,6	35,4	36,2	37,1	38,1	39,2	40,4	41,7	43,2	44,8	46,7	48,7	51,0	53,6	56,6	60,0
40	40,2	40,4	40,6	40,9	41,2	41,6	42,1	42,6	43,1	43,8	44,5	45,3	46,2	47,2	48,2	49,4	50,8	52,2	53,8	55,6	57,6	59,8	62,2	65,0	68,1	71,5	75,5	80,0
50	50,3	50,5	50,8	51,1	51,5	52,0	52,6	53,2	53,9	54,7	55,6	56,6	57,7	59,0	60,3	61,8	63,5	65,3	67,3	69,5	72,0	74,7	77,8	81,2	85,1	89,4	94,4	100,0
60	60,3	60,6	60,9	61,3	61,8	62,4	63,1	63,9	64,7	65,7	66,8	68,0	69,3	70,8	72,4	74,2	76,1	78,3	80,7	83,4	86,4	89,7	93,3	97,5	102,1	107,3	113,2	120,0
70	70,4	70,7	71,1	71,6	72,1	72,8	73,6	74,5	75,5	76,6	77,9	79,3	80,8	82,5	84,4	86,5	88,8	91,4	94,2	97,3	100,8	104,6	108,9	113,7	119,1	125,2	132,1	140,0
80	80,4	80,8	81,2	81,8	82,4	83,2	84,1	85,1	86,3	87,6	89,0	90,6	92,4	94,3	96,5	98,9	101,5	104,4	107,7	111,2	115,2	119,6	124,5	129,9	136,1	143,1	151,0	160,0
90	90,5	90,9	91,4	92,0	92,8	93,6	94,6	95,8	97,1	98,5	100,1	101,9	103,9	106,1	108,6	111,2	114,2	117,5	121,1	125,1	129,6	134,5	140,0	146,2	153,1	160,9	169,8	180,0
100	100,6	101,0	101,5	102,2	103,1	104,0	105,1	106,4	107,9	109,5	111,3	113,3	115,5	117,9	120,6	123,6	126,9	130,5	134,6	139,0	144,0	149,4	155,6	162,4	170,1	178,8	188,7	200,0
110	110,6	111,1	111,7	112,5	113,4	114,4	115,7	117,1	118,6	120,4	122,4	124,6	127,0	129,7	132,7	136,0	139,6	143,6	148,0	152,9	158,4	164,4	171,1	178,7	187,1	196,7	207,6	220,0
120	120,7	121,2	121,9	122,7	123,7	124,8	126,2	127,7	129,4	131,4	133,5	135,9	138,6	141,5	144,7	148,3	152,3	156,6	161,5	166,8	172,7	179,3	186,7	194,9	204,2	214,6	226,4	240,0
130	130,7	131,3	132,0	132,9	134,0	135,2	136,7	138,3	140,2	142,3	144,6	147,2	150,1	153,3	156,8	160,7	165,0	169,7	174,9	180,7	187,1	194,3	202,2	211,2	221,2	232,5	245,3	260,0
140	140,8	141,4	142,2	143,1	144,3	145,6	147,2	149,0	151,0	153,2	155,8	158,6	161,7	165,1	168,9	173,0	177,7	182,8	188,4	194,6	201,5	209,2	217,8	227,4	238,2	250,4	264,2	280,0
150	150,8	151,5	152,3	153,4	154,6	156,0	157,7	159,6	161,8	164,2	166,9	169,9	173,2	176,9	180,9	185,4	190,4	195,8	201,8	208,5	215,9	224,2	233,4	243,6	255,2	268,2	283,1	300,0
160	160,9	161,6	162,5	163,6	164,9	166,4	168,2	170,3	172,6	175,1	178,0	181,2	184,8	188,7	193,0	197,8	203,0	208,9	215,3	222,4	230,3	239,1	248,9	259,9	272,2	286,1	301,9	320,0
170	170,9	171,7	172,6	173,8	175,2	176,9	178,7	180,9	183,4	186,1	189,1	192,5	196,3	200,5	205,1	210,1	215,7	221,9	228,8	236,3	244,7	254,1	264,5	276,1	289,2	304,0	320,8	340,0
180	181,0	181,8	182,8	184,0	185,5	187,3	189,3	191,6	194,1	197,0	200,3	203,9	207,8	212,3	217,1	222,5	228,4	235,0	242,2	250,2	259,1	269,0	280,0	292,4	306,2	321,9	339,7	360,0
190	191,0	191,9	192,9	194,2	195,8	197,7	199,8	202,2	204,9	208,0	211,4	215,2	219,4	224,0	229,2	234,9	241,1	248,0	255,7	264,1	273,5	284,0	295,6	308,6	323,2	339,8	358,5	380,0
200	201,1	202,0	203,1	204,5	206,1	208,1	210,3	212,8	215,7	218,9	222,5	226,5	230,9	235,8	241,2	247,2	253,8	261,1	269,1	278,0	287,9	298,9	311,1	324,9	340,3	357,7	377,4	400,0
210	211,2	212,1	213,2	214,7	216,4	218,5	220,8	223,5	226,5	229,9	233,6	237,8	242,5	247,6	253,3	259,6	266,5	274,1	282,6	291,9	302,3	313,8	326,7	341,1	357,3	375,5	396,3	420,0
220	221,2	222,2	223,4	224,9	226,7	228,9	231,4	234,2	237,3	240,8	244,8	249,2	254,0	259,4	265,4	271,9	279,2	287,2	296,0	305,8	316,7	328,8	342,3	357,3	374,3	393,4	415,2	440,0
230	231,3	232,3	233,5	235,1	237,0	239,3	241,8	244,8	248,1	251,8	255,9	260,5	265,6	271,2	277,4	284,3	291,9	300,2	309,5	319,7	331,1	343,7	357,8	373,6	391,3	411,3	434,0	460,0
240	241,3	242,4	243,7	245,4	247,3	249,7	252,4	255,4	258,8	262,7	267,0	271,8	277,1	283,0	289,5	296,7	304,6	313,3	323,0	333,6	345,5	358,7	373,4	389,8	408,3	429,2	452,9	480,0
250	251,4	252,5	253,9	255,6	257,7	260,1	262,9	266,0	269,6	273,7	278,2	283,1	288,7	294,8	301,6	309,0	317,3	326,4	336,4	347,5	359,9	373,6	388,9	406,1	425,3	447,1	471,8	500,0
260	261,4	262,6	264,0	265,8	268,0	270,5	273,4	276,7	280,4	284,6	289,3	294,5	300,2	306,6	313,6	321,4	329,9	339,4	349,9	361,4	374,3	388,6	404,5	422,3	442,3	465,0	490,6	520,0
270	271,5	272,7	274,2	276,0	278,3	280,9	283,9	287,3	291,2	295,6	300,4	305,8	311,8	318,4	325,7	333,7	342,6	352,5	363,3	375,3	388,7	403,5	420,0	438,6	459,4	482,8	509,5	540,0
280	281,5	282,8	284,3	286,3	288,6	291,3	294,4	298,0	302,0	306,5	311,5	317,1	323,3	330,2	337,7	346,1	355,3	365,5	376,8	389,2	403,1	418,5	435,6	454,8	476,4	500,7	528,4	560,0
290	291,6	292,8	294,5	296,5	298,9	301,7	304,9	308,6	312,8	317,4	322,7	328,4	334,9	342,0	349,8	358,5	368,0	378,6	390,2	403,1	417,5	433,4	451,2	471,0	493,4	518,6	547,3	580,0
300	301,7	302,9	304,6	306,7	309,2	312,1	315,4	319,3	323,6	328,4	333,8	339,8	346,4	353,8	361,9	370,8	380,7	391,6	403,7	417,0	431,9	448,3	466,7	487,3	510,4	536,5	566,1	600,0

Appendix 13 : Length of cable (in m) to take angular correction into account to reach a particular depth of sampling (when vertical sampling is not possible).