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# Groundwater Sampling for Helium / Noble Gases

## using copper tubes

## General remarks

The art of sampling dissolved gases in groundwater, especially such a mobile gas as He, lies in resolving the following potential problems:

1. Avoid gas exchange with the atmosphere during sampling
   Solution: Use tight connections between well and sampler
2. Avoid air contamination by inclusion of air bubbles
   Solution: Flush sampler and tubing well, remove any remaining air bubbles
3. Avoid loss of dissolved gases by degassing (formation of a gas phase)
   Solution: Keep sampling system under sufficient pressure to suppress degassing
4. Avoid leakage of gas in or out of the sample during transport and storage
   Solution: Use absolutely gas tight containers (copper tubes).

## Well selection and preparation

Not all wells or pumps are suitable for noble gas sampling, because of the requirements of closure against air or other gas phases and of sufficient pressure to prevent degassing. Closed boreholes are highly desirable, open wells or springs are problematic, because they allow gas exchange. Ideal are artesian wells with sufficient pressure or wells pumped by a submersible pump. Sucking pumps should be avoided, they most likely induce degassing. Pressure tanks often contain a pressurized gas phase, which may exchange with the water and induce uncorrectable gas fractionations. If pressure or storage tanks are present, the water should be taken *before* it enters the tanks. Sampling after chemical treatment or filtering of the water should also be avoided if possible.

Before sampling, the well should be sufficiently flushed (pump out at least once the volume of the borehole). During flushing, temperature and electrical conductivity should be checked to see if the values stabilise. After flushing of the well, a tight connection to the copper tube has to be established (see below).

## Connection of sampler to well, pressure regulation

The sample containers consist of a copper tube which is mounted on an aluminum rack (see figure). On both ends, the tube is fixed by stainless steel clamps, which are used to create a gas-tight seal. Before connecting to the well, the copper tube should be centered in both directions, i.e., along the length of the aluminum frame and between the two screws of the stainless steel clamps. The ends of the tube should stick out of the frame on both sides by a few cm. These end-pieces are needed for the connections both in the field and in the lab. The copper tube has to be squeezed completely within the cutting edge of the clamps, therefore it needs to be centered in the clamps. The adjusted copper tube is fixed in its position by tightening the screws by hand.

The copper tube is connected to the pump, tap or other point of water withdrawal through flexible plastic tubing. Ideally, a tap near the well head is used. Often, several hoses need to be connected in order to reduce the diameter to the size of the copper tube. We usually deliver a piece of tubing that fits tightly on the copper tube. We recommend to use this piece as the last part in the connection. In order to withstand water pressure, we use inner braided PVC tubing, and in order to allow detection of bubbles, we prefer transparent tubing. All connections, also on the copper tube, should be secured with hose clamps.

The complete tubing has to be sufficiently flushed (about one minute) and checked for bubbles. Bubbles tend to stick at connections. They can be removed by squeezing and bending the hoses or knocking against the tubing. During the whole sampling procedure, it is recommended to hold the copper tube at a slight angle to the horizontal, such that air bubbles can rise along with the water flow and are flushed out of the system.

Sometimes, air is sucked in at connections of the tubing, particularly if the diameter of the tubing increases in flow direction. Try to avoid such configurations (always go from large to small diameter) and tighten all fittings to avoid leakage. Slight leakage out of the tubing may be tolerable.

If bubbles form due to degassing of the water, an increase of pressure can often help to suppress degassing. If the pressure can be regulated, keep it as high as the stability of the connections allows. The stability can be checked easily by putting a thumb on the outlet. The pressure should also be regulated such as to avoid any sound (rush) in the tap or connections, as it may indicate turbulence or degassing.Usually, the pressure is fine when the water jet after the copper tube reaches for several meters. If the pressure is low or if it is impossible to avoid bubbles, you may take the sample anyway but mark it accordingly.

## Closure of the samplers

Once the system is well rinsed, the sample is isolated by first closing the outlet clamp, and then the clamp on the inlet side. The clamps are closed by tightening two screws using a hexagonal wrench (usually delivered with the containers, please return with samples!). First tighten one screw until the two parts of the clamp touch on this side. Then close the other screw almost entirely, and return to the first screw to do the same. Finally tighten both screws as much as you can with the wrench, but without additional tools. The clamps are correctly closed if there is no space left between their two parts. *Check that no gap is visible between the clamps in the vicinity of the screws.* The copper tube is now shut absolutely gas tight.

If the connections break before the inlet side is closed, replace the bad sample tube with one of the spare cooper tubes that we usually deliver, and take a new sample.

## Sample identification and additional data

To identify the samples, you may put stickers or tape on the aluminum racks or write directly on them with a water-proof marker. Usually we will provide or even prepare some tape on the frames, on which the sample identification can be noted. Additional information should be written down in a field book.

For each sample, note at least the sample identification, location, well name, and date of sampling in your field book. To interpret noble gas data, we need some additional data, such as temperature and salinity (electrical conductivity) of the water, altitude of the well, altitude of the presumed recharge area, and if possible mean annual temperature in the recharge area. At least the water temperature and the approximate elevation at the sampling site should be known. We strongly recommend to measure temperature and electrical conductivity of the water during sampling for noble gases.

## Packing and transport

After sampling, the containers may be shaken to remove the water in the outer ends of the copper tubes. In the case of very saline water, the containers (especially the steel clamps) should be flushed with fresh water to prevent corrosion. The containers are best packed in our boxes, where wooden ledges are used to staple them in rows of 6 containers each. The ledges keep the containers at fixed distance and prevent them from moving.

If smaller numbers of samplers are shipped in improvised packaging (cardbord boxes or similar), care must be taken to avoid bending or even breaking of the outer end-pieces of the copper tubes. Try to protect the ends against impacts during transpor.

# The most important points step by step:

**Pump long enough to flush the borehole completely.**

**Find a suitable tap or other outlet of the well/pump for connection.**

**Avoid pressure tanks, sucking pumps, and any contact with air or gas phases.**

**Connect the copper tube by a tight combination of tubing.**

**Check if the connections withstand the pressure when the outlet is closed.**

**Flush the tubing, remove bubbles in the hoses, keep pressure high.**

**Check that the Cu-tube is approximately centered on the clamp.**

**Close clamp at the outlet completely (no gap), then at the inlet .**

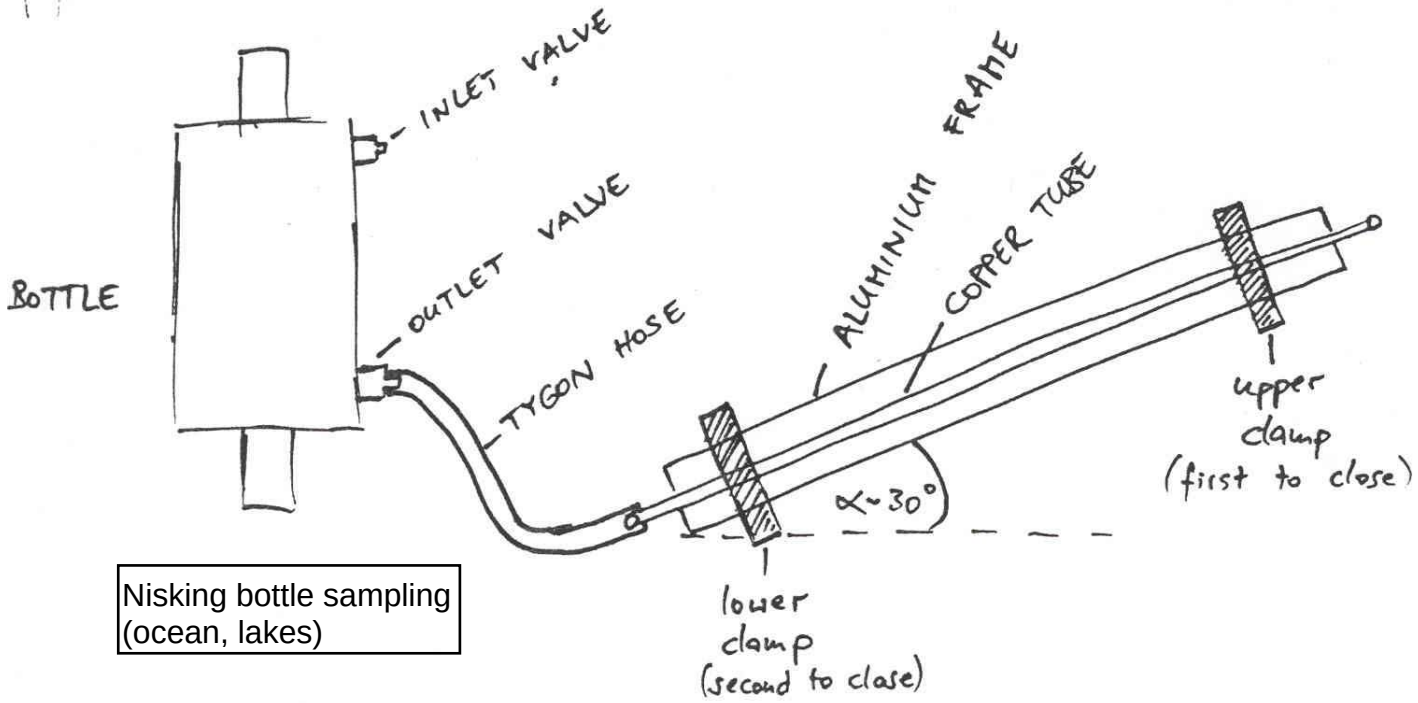
**Identify the samples (name, location, date).**

**If possible note temperature, conductivity and altitude of the well.**

**Protect the ends of the copper tube from bending and breaking.**

# ILLUSTRATION OF THE HELIUM SAMPLING PROCEDURE

A)




Nisking bottle sampling (ocean, lakes)

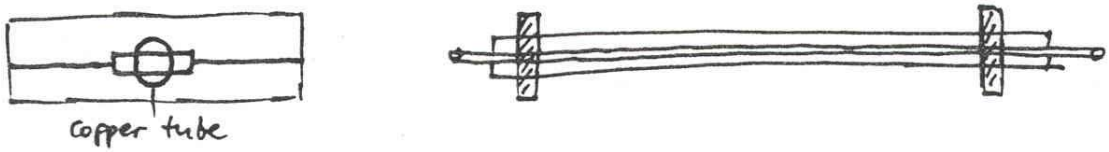
B)

CROSS-SECTION OF A CLOSED CLAMP

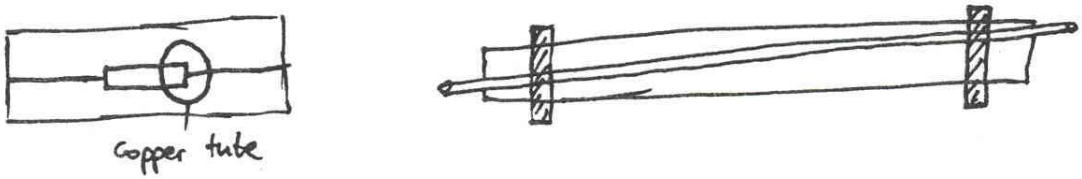
TOP-VIEW OF THE CONTAINER

Heidelberg type sampler

GOOD:



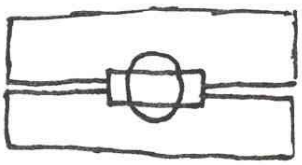

BAD:



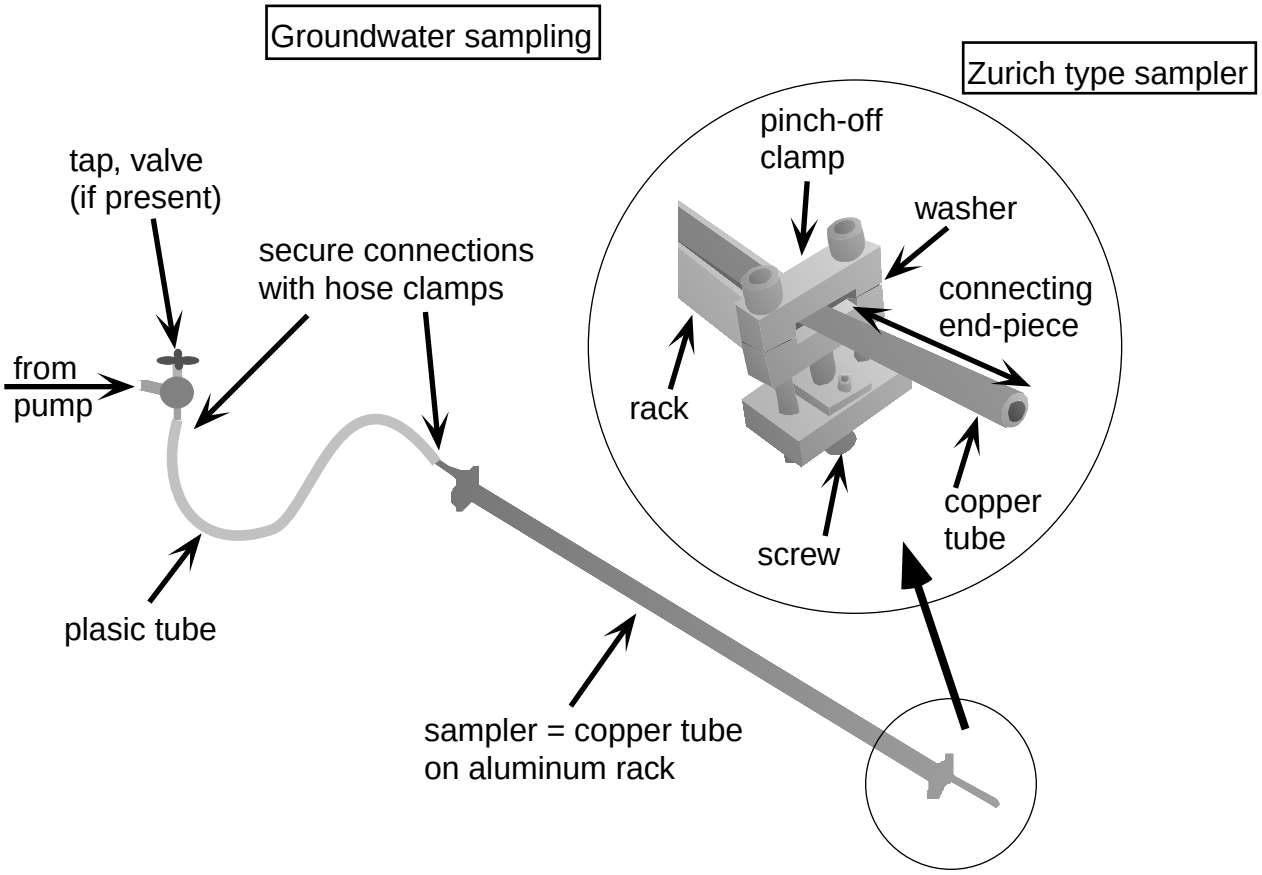

Please make sure that the copper tube is centered.

C) CROSS-SECTION OF A CLOSED CLAMP

BAD:



Please make sure that both parts of the clamp are close together (no visible gap)




Schematic drawing of the setup for noble gas sampling from groundwater wells.
One pinch-off clamp is shown enlarged in the insert.