Cost-effective eDNA filtering pump systems

Design considerations and examples

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Introduction

Filtering water samples to extract environmental DNA ('eDNA') by scientific institutes or NGO's is often done with either expensive commercial pump systems, or home-built creations that are not reliable.

This brief paper details some pointers for the semi-professional to be able to create a reliable pump system whilst maintaining cost-effectiveness.

Goal

The goal is to create a reliable and cost-effective vacuum pump system for the specific use of pulling sampled seawater through a micropore filter in order to extract eDNA material both when mains power is available and when it's not.

(Note that this document does not provide solutions for 'in situ' pumping)

Work method sequence of events

1. The Niskin bottle is attached to a line with a weight to seafloor. When the bottle has reached the desired depth, it is closed and recovered. Water sampling is now completed
2. The Niskin bottle is recovered and ca. 1.5 litre of water is filtered on board.
3. The filter with the DNA is preserved and is analysed in the lab. This method allows to detect which species are present at the location.

During step 2 in the sequence of events the pump system is used.

Filtration system components

A commonly used apparatus for filtering is the Rocker MF31 filtration unit, depicted in fig 1. The vacuum pump system is connected to the vacuum pump coupling and this pulls the water from the seawater container over the filter located in the filter holder. The wastewater container fills up with the filtered water and needs to be emptied regularly by means of the watewater spout.

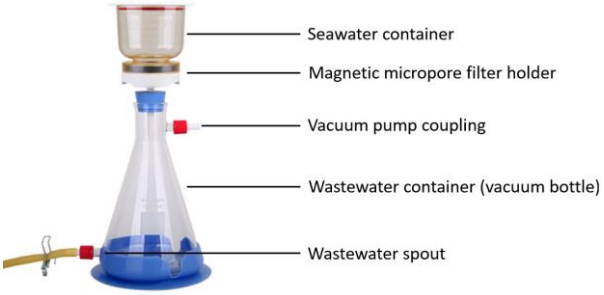


Figure 1: MF31 filtration apparatus with part description

Design considerations pump system

- The vacuum pump is connected to the vacuum pump coupling via a hose. In order to have a working pump system it needs the correct diameter inlet for the hose connected to the vacuum bottle and filter unit.
- Sometimes there is no mains electricity at sea, therefore the pump needs to be able to operate on battery power e.g. via a power bank (12-24V)
- Pumps have been damaged due to the unwanted suction of seawater into the inlet so a moisture sensor warning of water in the pump inlet is a wanted feature.
- Often samples are taken in triplicates at multiple locations resulting in lots of man-hours spent filtering. More powerful (and thus quicker) pumps can alleviate this issue.
- Parallel filtering (multiple filtering at once) can reduce filter times as well

Vacuum pumps

Three systems are built:

- One 220V pump for when mains power is available
- Two 12-24V (& 220V) portable pump systems when mains power is not available

Practical considerations

- By using off the shelf components such as watertight electrical junction boxes we can make a cost-effective system.
- The system is integrated into a hardcase with pluckable foam for safe transport.
- The portable systems are not equipped with the moisture sensor as this would make the electrical work a lot more difficult, making the systems larger and more complex. The goal for these portable systems is to have cheap, light weight, easy to make and use portable systems.
- As the 220V pump is more expensive it needs to be protected against failure better. For the 220V pump the moisture sensor is included before a liquid filter. This results in extra electrical components such as leds, sensor, voltage transformator and all necessary electrical wiring and watertight enclosure.

Costs

Hardware costs for the three systems combined are in the order of magnitude of 600-1000€ depending on pump specifications and requirements and access to required tools and small materials.

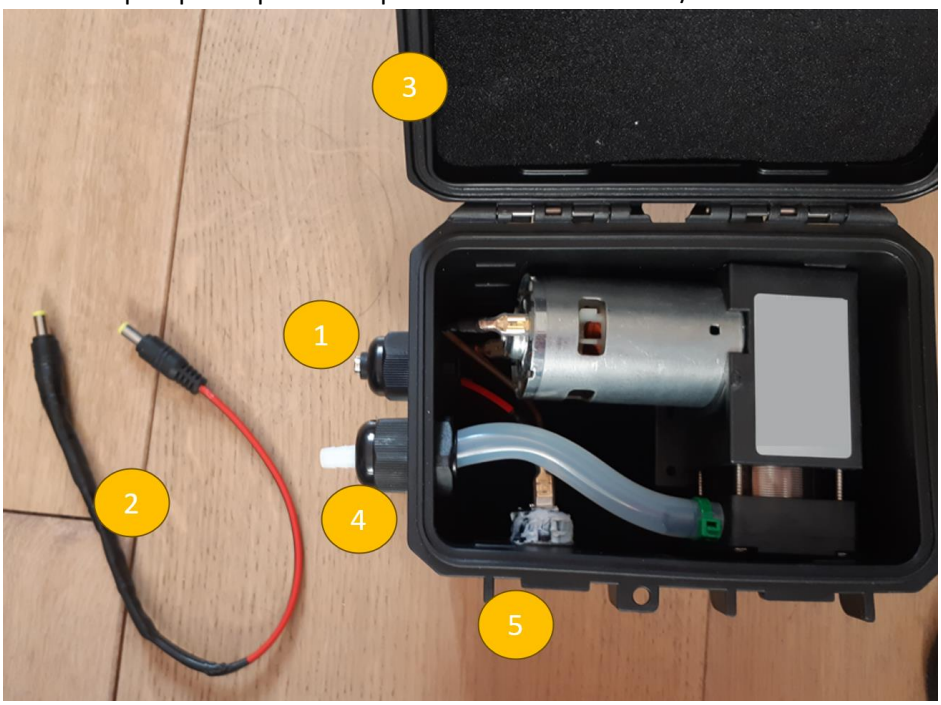
Portable pump system

Figure 2: Power consumption at 16V

The smaller pumps have a power consumption of ~30W at 16V.

Portable pump system instructions

The small pumps are put in a separate hardcase and a on/off button is connected for easy operation.



The steps for operation:

0) Check that the on/off switch is in the off position
1) Connect mains or power bank to the power inlet,
2) If necessary, use provided cable
3) Open the case slightly to prevent overheating
4) Attach filtration system suction hose to vacuum pump hose coupling
5) Press on button to start the pump

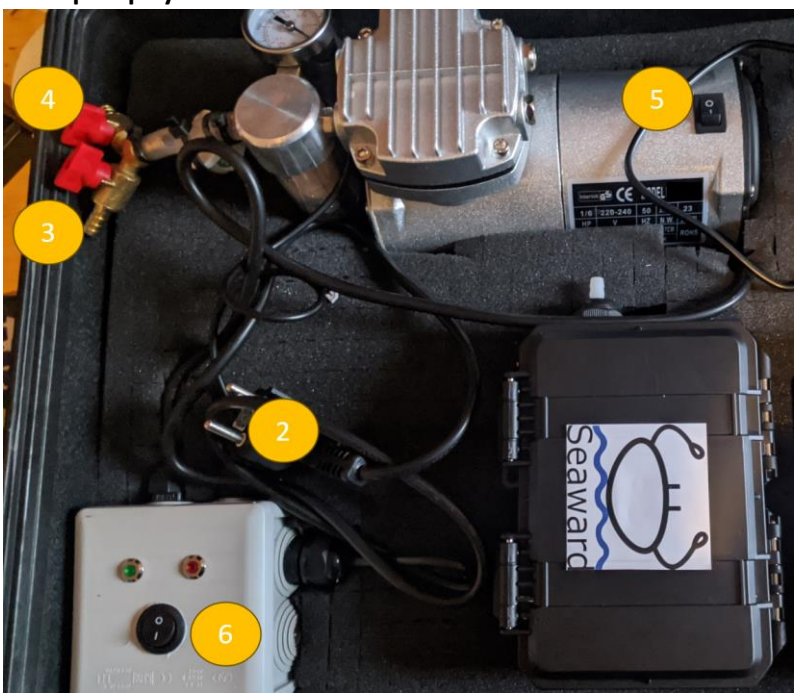
220V pump system

The 220V system consists of a ~70W vacuum pump able to sustain -0.06 MPa suction and a suction speed of 23 L/min

Figure 3: pump inlet closed gives approx. -0.06 MPa or -600mmHG

Figure 4: Power consumption 220V pump

220V pump system instructions



The steps for operation:

0) Check that both switches (one on junction box, one on the pump housing) are in the off position
1) Remove pump from the case to prevent overheating (Note: junction box can also be removed if situation warrants this) – not show in above figure
2) Connect power
3) Attach filtration system suction hose to vacuum pump hose coupling(s)
4) Make sure the ball valves are in the correct positions
5) Press on button on the pump to prime
6) Press on button on the junction box to start the pump; green light will be on

Red led: water detected between liquid filter and ball valve, stop pump immediately and check for water