A compact and low-cost do-it-yourself water level meter

Nils Michelsen

Institute of Applied Geosciences, Technische Universität Darmstadt, Darmstadt, Germany

Correspondence
Nils Michelsen, Institute of Applied Geosciences, Technische Universität Darmstadt, Schnittspahnstr. 9, 64287 Darmstadt, Germany.
Email: michelsen@geo.tu-darmstadt.de

Groundwater level measurements underpin most, if not all, hydrogeological studies. While the advent of automatic pressure transducers may give the impression that manual measurements have become less important, this is not the case. They provide much-needed reference data (Rau et al., 2019) and pressure transducers are not generally affordable for everyone. Hence, many measurements are still conducted manually. Most of them are carried out with electric water level tapes (also known as dip meters; Rau et al., 2019). The principle of these tapes is that an electrical circuit is completed at the probe tip upon water contact, triggering a visible and/or audible signal at the tape reel (at ground surface). Despite the simplicity of this concept, these devices often cost several hundred Euros and are not readily available in some parts of the world. A number of textbooks and blogs provide circuit diagrams and build guides (Brassington, 2007; McGill, 2016), but home-made constructions are somewhat hampered by the fact that measuring tapes with integrated wires are difficult to reproduce.

One way to circumvent this problem is to use a probe that is self-contained and can thus be fixed to an ordinary, generally affordable measuring tape. Examples are the classic plopper (e.g., Rau et al., 2019) or the ‘Pocket Dipper’ by Groundwater Relief (2020). When the latter is switched on, it emits a high-pitched sound that is dampened when it is immersed in water.

Here, I use a complementary design, in which water contact causes a light signal at the probe (inside the well) that is visible from the wellhead. This approach is far from new, but corresponds to the concept of a pioneer version of the electric water level meter (developed in the 1930s by the company Spohr, Frankfurt, Germany; Spohr, 2021). Yet, the use of this concept has been greatly facilitated by the emergence of cheap off-the-shelf ‘LED baits’ used for fishing (see Figure 1 and Video S1). These pocket-sized and water-proof devices often only cost a few Euros and start flashing upon water contact to attract fish. To create a water level meter, the device is simply attached to a measuring tape by means of a binder clip, with the electric contacts located at the zero mark. When necessary, it can be additionally secured (e.g., with Velcro, electrical tape, etc.). Often it is advisable to add a small weight to keep the measuring tape hanging straight (although this may necessitate regular checks of the tape for deformation). As shown in the video, the ‘construction’ and an initial test with a glass of water are a matter of seconds and require no tools.

The second part of the video shows a test in an observation well with a water level of 27.92 m below top of casing (diameter: 10 cm). When the sensor hits the water surface, the flashing LEDs are visible at the wellhead and by moving the tape up and down, the level can be determined with a precision resembling that of traditional electric tapes (approx. ±0.01 m). Tests conducted in wells with water levels of 29.65, 31.64, and 36.20 m below top of casing (diameter: 10 cm) suggest that the method is applicable up to about 30 m, but too challenging beyond that depth. Obviously, riser pipes or other objects obstructing the view will cause problems as well.

While deeper groundwater levels occur in nature, for instance in arid areas (Schulz et al., 2017), many parts of the world feature shallow groundwater in the mentioned depth range. First-order estimates of the global depth-to-water distribution (Fan et al., 2013) suggest that >60% of the Earth’s terrestrial surface shows groundwater at <20 m below ground, and about 80% shows groundwater at <40 m below ground.

Repurposing an off-the-shelf consumer product, designed for an entirely different purpose, has hence enabled an easy-to-build, widely applicable device at a fraction of the cost of the traditional tool. It may thus be seen as part of a larger movement of technology transfer from the consumer sector to science (Hut et al., 2010).

One may criticize the presented solution, because the button cell batteries are not exchangeable due to the epoxied interior. However, the indicated life-time, frequently stated as >100 h, suggests that the device is probably usable for numerous measurements (theoretically tens of thousands), which balances out this shortcoming to some extent. Another disadvantage is that it is less comfortable to operate...
than an electric tape, because one has to concentrate more to identify the point at which the probe hits water and the LEDs light up.

Despite these minor downsides, the presented compact water level meter may be a low-cost alternative to traditional electric tapes for researchers and practitioners on a tight budget. Moreover, its small size allows it to serve as a backup (e.g., stored in the backpack or glovebox). Finally, school or citizen science projects, currently often focusing on surface water (e.g., Etter et al., 2020; Lowry & Fienen, 2013), could benefit from this simple DIY tool. In such projects, it may be helpful to study groundwater and increase the participants' awareness of this hidden resource.

ACKNOWLEDGEMENTS
Richard van Deursen is gratefully acknowledged for his help with the video.

DATA AVAILABILITY STATEMENT
Not applicable.

ORCID
Nils Michelsen https://orcid.org/0000-0001-8538-0038

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SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Michelsen, N. (2021). A compact and low-cost do-it-yourself water level meter. *Hydrological Processes*, 35(5), e14205. https://doi.org/10.1002/hyp.14205