Chapter 16
Development of a Low-Cost Groundwater-Level Measuring Device

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1 Introduction

Water is an essential and vital component of our life support system. The groundwater resources are being utilized for drinking, irrigation, and industrial purposes. However, in recent years, due to the increase in population and other economic activities, serious concern has been expressed that groundwater resources have been overexploited, while their conservation has been slow and there is fear that groundwater may become inadequate to support future development activities. It is, therefore, pertinent to evolve strategies for sustainable water resource management. There is a growing concern about the deterioration of groundwater quality. The quality of groundwater has undergone a change to the extent that the use of such water could be hazardous.

Central Ground Water Board, under the Ministry of Water Resources, is the National Apex Agency for investigations, evaluation and management of groundwater resources has the mandate to develop and disseminate technologies, and to monitor and implement national policies for the Scientific and Sustainable development and management of India's Ground Water Resources, including their exploration, assessment, conservation, augmentation, protection from geogenic pollution and distribution, based on principles of economic and ecological efficiency and equity [1, 2].

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However, a few NGOs and other organizations are also involved in hydrogeological investigations of groundwater and monitoring of the behaviour of water table fluctuations and water quality. During the RuTAG regional workshop in Jaipur one such NGO, Ramkrishna Jaidayal Dalmia Seva Sansthan, Chirawa, Rajasthan, mentioned the problems with the water-level measuring device, which was developed by the NGO in an unprofessional way. The said device for water-level measurement does not accurately measure the depth of groundwater in an observation well. It also gets affected by the presence of moisture and cascading water in the well and eventually gives a false reading. The device often gets stuck in between the rivets joining the socket and the well casing leading to breakage and damage to the cable. The devices which are commercially available are expensive and have a high maintenance cost. Therefore, RuTAG IIT Delhi took the initiative to develop a robust and low-cost groundwater level measuring device which can be easily fabricated and repaired at the village level market.

2 Device Developed by NGO and Reported Problems

Ramkrishna Jaidayal Dalmia Seva Sansthan, a Chirawa-based NGO developed a device to collect data related to the status of the water table in and around Chirawa district in Rajasthan, India (Fig. 1). The device was made in an unprofessional way using a 12-in. long section of plastic tube having one inch inside diameter. Two copper electrodes having 3 mm diameter and 9 in. long are casted inside the plastic tube at equal distances apart using adhesive. The casted electrodes hang inside the tube from one end which is sealed using adhesive, and the other end of the pipe is left open for water to enter (Fig. 2). The electrodes are attached to the coaxial cable which is further connected to a circuit which drives beeper and is powered by a 9 V battery (Fig. 3). Coaxial cable is around 100 m long and is wound around a plastic reel. The said circuit is placed inside the reel as shown (Fig. 3). The working of the device is such that when the switch is put to the on position, the line is slowly released down the well casing. The line is lowered until the probe dips in the water. When two electrodes inside the tube encounter conductive fluid, the circuit is completed and buzzing starts. The operator grabs the measuring point, records the engraved unit at the measuring point and repeats the steps to determine a consistent measurement.

2.1 Problems Encountered with the Device Developed by NGO

The device developed by the NGO has problems associated with it. It was observed during the investigation that the device inaccurately measures the depth of groundwater in an observation well because of the various reasons such as extended length

Fig. 1 Device developed by NGO

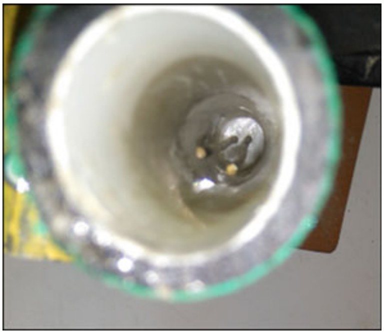

Fig. 2 Electrode hanging inside tube

Fig. 3 Circuit inside plastic reel

Fig. 4 Cord connected using M-seal

Fig. 5 Low-quality cord

and the absence of insulation or spacer between the two copper electrodes, leakage in adhesive, etc. (Fig. 2). The two electrodes which are cast using adhesive, and are unnecessarily longer in length, hang inside the tube with very less distance in between them eventually come in contact with each other whenever the tube is shaken or in the presence of some vibration. The cord connection with electrodes is insulated using adhesive and M-seal (Fig. 4). Most of the time it gets affected by the presence of the moisture and the cascading water in the well leading to a false reading. The shape of the tube is also a major contributor to breakage and damage to the probe. The device often gets stuck in between the rivets joining the socket and the well casing leading to breakage and damage. Low-quality cord often breaks in tension (Fig. 5). The structure is made using used cord reel which is fixed over a stand made of wood. The overall structure lacks robustness to hold cord reel effectively.

3 Proposed Design Modifications

Design modifications were conceived keeping in view the difficulties reported as well as the desirable characteristics in such gadgets. Since water-level detection sensors work on the basic principle of conduction through the water, it was decided that the design should be such that it can be fabricated and repaired at a village level and should be helpful in boosting livelihood. Moreover, it was decided that device usage methodology should be in compliance with IS: 15896:2011 and IS: 6935:1973 [3, 4]. Therefore, the following design modifications were envisioned:

- The probe should have a shape and size which can be easily lowered and taken out of the well under all circumstance.
- Weight of the probe shall be enough to keep the wire straight.
- The coaxial cord of the probe should be thin and have high tension load capacity.
- The cord shall not get stretched in length under its own weight and weight of probe.
- The cord shall be marked with graduation similar to those on an acceptable tape on the cord.
- The sensor should be robust and must not get affected by vibration and impact.
- Sensor should work in various water quality parameters possible.
- The probe should be designed such that it has the capacity to remain vertically stable while lowering the cable down the well.
- Probe weight should be optimum to keep it vertically stable while hanging.
- The beeping circuit should have indicators to reflect the working status of the circuit.
- A CAD model should be made prior to the fabrication of the device to analyse the workability of the design.

4 Device Developed by RuTAG IIT Delhi

The device developed by RuTAG IIT Delhi is low cost, robust and can be fabricated using machines and tools, which are easily accessible at a village or a town level. The circuit is kept simple and is designed on the principle of conduction through water. The CAD model was made to analyse the dimensions and workability before fabrication (Fig. 6). The design incorporates plumb bob for vertical stability and O-ring, cable gland to stop water penetration. The probe has electrodes fitted inside insulating material such as nylon to make is shock resistant (Fig. 7). The coaxial cable has a high tension capacity under loading. The details of the device fabricated are as follows:

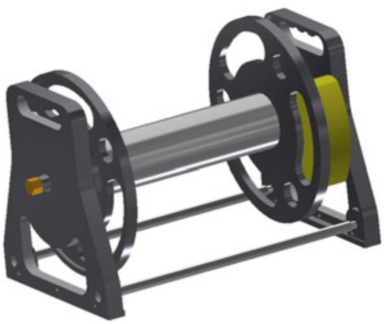

Fig. 6 CAD model of the proposed design

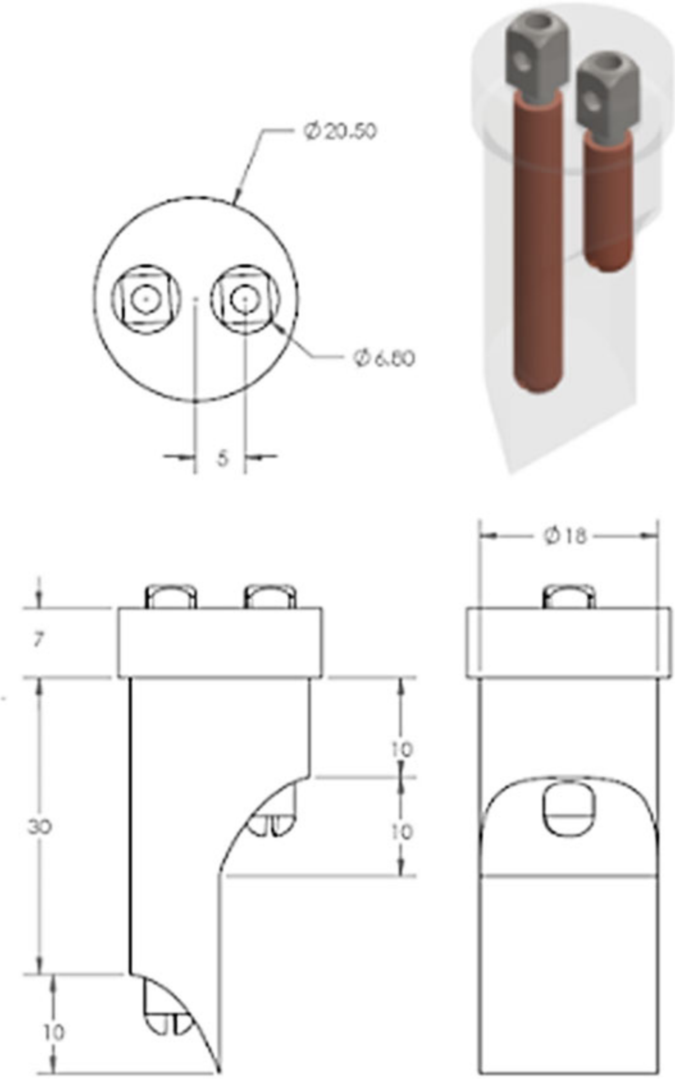

Fig. 7 Electrodes fitted inside nylon spacer

- The outer shell of the probe is made using rust-resistant stainless steel grade.
- The outer casing of the probe is an assemblage of four parts, i.e. plumb bob, perforated tubular body, high-pressure cord holding gland (Fig. 8) and sensor (Fig. 9).
- One end of the probe is fitted with a plumb bob for vertical stability and another end for holding coaxial cord through a leak-proof gland.
- The probe has improved operational stability using plumb bob as added mass.

Fig. 8 High-pressure gland

Fig. 9 Split view of the probe

- The perforated tube incorporates a sensor and also allows subsurface water or air to enter the cylinder.
- Novel sensor arrangement to eliminate false alarm due to shock and moisture (Fig. 10).
- When the sensor (copper electrodes) encounters conductive fluid, the circuit is completed and the audible beep starts buzzing at the surface and depth is measured from the marked cable.
- Better quality cord for high tension load capacity.
- Robust aluminium alloy based cast cable reel with better operational life (Fig. 11).
- Fabricated device (Fig. 11).

Fig. 10 Novel probe

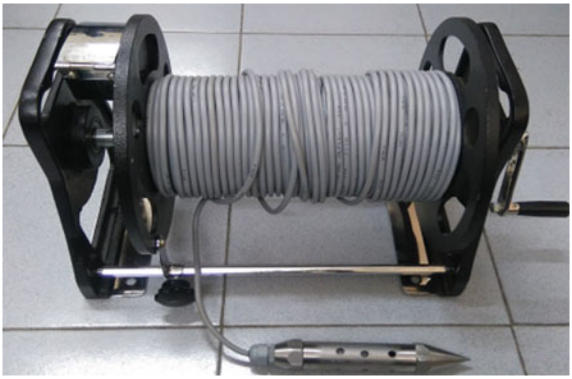

Fig. 11 Fabricated groundwater-level measuring device

5 Testing of the Fabricated Measuring Device in the Field

Testing of water-level metre was done in wells located in IIT Delhi (Fig. 12) and in Chirawa district in Rajasthan (Fig. 13). Reliability test of the device was done using two types of water first one is with Bisleri water and second with tap water in the lab at IIT Delhi. It was assumed that Bisleri has less total dissolved solids than tap water. Device worked fine in both the waters. Device will be tested with other waters in the coming future. Locally available devices in the market are lighter and made with cheap materials and are not robust in construction. RuTAG device is robust and made using superior materials. Approximate cost of the prototype is around ten thousand rupees and devices available in the market are higher than the prototype cost. If the device is commercially mass produced, the cost is expected to drastically reduce further. RuTAG device is almost in use with NGO from past two years and no complaint has been received so far. The device was tested in Chirawa and IIT Delhi. Working and methodology for testing the device were as per said Indian Standards

Fig. 12 Testing at IIT Delhi

which is as follows: when the switch was turned to the 'on' position and the cord was released slowly down the well casing. The cord was held firmly and allowed to fall free inside the casing. The line was lowered in the casing in such a way that operator could cautiously check the 'feel' of the cord and probe. As the probe goes deeper, the weight increased. The water-level metre is lowered until it indicates the probe is in water and to check if the probe becomes stuck or hung-up operator checks the 'feel' of the cord and probe about every 20 feet by gently bouncing the probe about two feet. When the sensor (copper electrodes) encounters conductive fluid, the circuit got completed, and the audible beep starts buzzing, and water-level metre indicates water. Operator grabs the measuring point which is an embossed unit length. Record the water-level measurement at the measuring point on the data sheet. Repeat the steps to determine a consistent measurement. Slowly rewind the line and probe onto the reel. Turn off the water-level metre, sanitize it and replace the well cap. Testing results at both place in IIT Delhi and Chirawa were satisfactory.

Fig. 13 Testing at Chirawa, Rajasthan

6 Conclusion

This paper gives a detailed description of all the phases of the device improvements on which the team majorly worked. The work included framing the problem, performing site visits, preliminary testing of the fabricated design and the improved prototype. The problems faced by the NGO in Chirawa have been addressed and the solution has been proposed. A modified device has been developed, tested in the village and is in use at the time of writing this paper. The device has resulted in substantial improvement in working and usage. The vendor for mass production and supply have been identified. The solution is appreciated by the users. Further effort is required for promoting its use in the village. It is hoped that the design improvements will help the grassroots agencies and villagers to have relatively reliable groundwater table data.

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