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## Development of an Automatic Tube well Discharge Measuring Instrument for Successful Aquifer Management

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### INTRODUCTION

- Groundwater supplies **over 60% of irrigation** and **90% of drinking water** in Pakistan
- Pakistan has **1.2 million tube wells**, most operating **without discharge monitoring**.
- Uncontrolled tube well extraction causes **aquifer depletion up to 1–1.5 meters per year Over-pumping**, **20–30% irrigation water loss**, and **declining water tables** in many regions.
- Current manual methods are inaccurate, labor-intensive, and non-scalable. A low-cost, automatic, and locally designed device is needed for real-time data collection and groundwater regulation.

**Figure 1: Conventional Methods of Discharge Measurements**

### AIM

- To develop and test an **automatic tube well discharge monitoring system** that provides **real-time data** for optimizing **groundwater extraction and recharge management** in Pakistan.

### METHOD

- Adopted the V-model approach, dividing the system into sensing, processing, and communication modules for independent testing and reliable integration.
- Utilized JSN-SR04T ultrasonic sensor (±3 mm accuracy) and ESP32 microcontroller for real-time monitoring.
- Integrated a solar-powered system using 18650 Li-ion battery and TP4056 controller for off-grid operation.
- Implemented FreeRTOS-based firmware for multitasking (sensor polling and data transmission).
- Designed a modified Manning's equation algorithm with temperature compensation for accurate discharge measurement.

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

- Performed laboratory tests (0.5–5 L/s) under ISO 3455 standards and field trials on 15 tube wells.
- Evaluated performance on accuracy (±5%), power autonomy, data reliability, and user satisfaction.

A

B

**Figure 2: Device and Observation using the Device**

### RESULTS & DISCUSSION

- Achieved ±3.8% average error ($R^2$ = 0.998) and up to ±1.8% accuracy in 1–5 L/s range.
- Tested on around 50 tube wells for 30 days, showing 96.3% accuracy and 92% LoRa data transmission success.
- Solar-powered system ran 10 days per charge; cost 70% lower than commercial units.
- Stable under pump shocks, sediment, and power issues; slight accuracy drop below 0.5 L/s or in turbid water.

**Table 1: Manual and Device Values Comparison with Errors**

| Manual Flow (L/s) | Measured IOT Flow (L/s) | Error (%) |
|---|---|---|
| 1.32 | 1.36 | -4.0 |
| 1.19 | 1.21 | -2 |
| 1.12 | 1.15 | -3 |
| 1.24 | 1.22 | 2 |
| 2.3 | 2.6 | -3 |

**Table 2: Sensor Calibrations**

| Sensor Type | Voltage Output (V) | Flow Rate (L/sec) | Calibration Error (±) |
|---|---|---|---|
| Ultrasonic | 1.2 | 3.5 | 0.1 L/sec |
| Hall Effect | 2.4 | 6.8 | 0.15 L/sec |

**Table 3: Troubleshooting Common Issues**

| Issue | Possible Cause | Solution |
|---|---|---|
| No data Transmission | Loose WiFi/LoRa Connection | Check Antenna and Reset module |
| Inconsistent Readings | Sensor Misalignment | Re-align and Recalibrate sensor |

### CONCLUSION

- Achieved **±1.8%** accuracy and **96.3%** consistency in real-time tube well discharge monitoring.
- Operated **10 days per charge with 30%** lower cost, ensuring sustainable groundwater management.

### REFERENCES

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