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## BORE-WELL RESCUE PRELIMINARY ANALYSIS USING A SENSOR FUSION SYSTEM IN COMPLIANCE WITH CHILD POSITION POSTURES

**Sriramireddy.K**

Research scholar, Department of Mechanical Engineering, VFSTR, Andhra Pradesh, INDIA

Email id: [Sriramireddy.kamireddy@gmail.com](mailto:Sriramireddy.kamireddy@gmail.com)

**D.Satyanarayana**

Professor, Department of Mechanical Engineering, VFSTR, Andhra Pradesh, INDIA

Email id: [dsatya2312@gmail.com](mailto:dsatya2312@gmail.com)

**T. Ch. Anil kumar**

Assistant Professor, Department of Mechanical Engineering, VFSTR, Andhra Pradesh, INDIA

Email id: [tcak\\_mech@vignan.ac.in](mailto:tcak_mech@vignan.ac.in)

### Abstract

The aim of this paper is to develop the procedure to perform simulations on rescuing children fell in bore-well using proposed robot design. In India, bore-wells serve as one of the primary means to satiate the water needs of the population. Despite its advantage, unmanaged or abandoned bore-wells have proved fatal for children who mistakenly fall into the same. Bore-well rescue mechanisms have been extensively researched by researchers and are tailor-made to suit specific incidents or specific types of bore-well traps. Rescuers require quick access to bore-well conditions to expedite the rescue operation. Till date, no research in the past had covered the importance of a nation-wide bore-well condition database which must contain bore-well conditions across different locations of the nation. In this regard, the authors propose a bore-well inspection and rescue framework with the primary emphasis laid upon the creation of a preliminary simulated bore-well analysis database. This paper also highlights the real-time performed case studies wherein bore-well condition data were collected from three select regions of Andhra Pradesh, India. The bore-well condition data includes air quality, humidity and temperature inside a bore-well against its depth and the data was collected in different durations of a day. Furthermore, the authors also warrant the need to analyze the position of the child trapped inside a bore-well wherein simulations of a bore-well environment with a trapped child were performed using ZEISS ZEN software. The findings of the study revealed that the condition of a trapped child becomes abnormal with increases in depth and charts are also prepared which display the severity and the need to save the trapped child. Using the collected data, rescuers can quickly select a suitable bore-well rescue mechanism.

**Keywords:** Bore-well Rescue Operations; Sensor Fusion Systems; Bore-well Inspection; Child Position Simulation

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About the authors : Sriramireddy.K

Corresponding author- \*Email: [Sriramireddy.kamireddy@gmail.com](mailto:Sriramireddy.kamireddy@gmail.com)

本文的目的是开发使用建议的机器人设计来执行模拟救援跌倒在井眼中的儿童的程序。在印度，钻孔是满足人民用水需求的主要手段之一。尽管有其优势，但事实证明，未经管理或废弃的钻孔对于错误地陷入其中的儿童来说是致命的。钻孔救援机制已被研究人员广泛研究，并为适应特定事件或特定类型的钻孔陷阱而量身定制。救援人员需要快速进入钻孔条件以加快救援行动。迄今为止，过去没有研究涵盖必须包含全国不同地点的钻孔条件的全国钻孔条件数据库的重要性。在这方面，作者提出了一个钻孔检查和救援框架，主要重点放在创建初步模拟钻孔分析数据库上。本文还重点介绍了实时进行的案例研究，其中从印度安得拉邦的三个选定地区收集了井眼条件数据。钻孔条件数据包括钻孔内的空气质量、湿度和温度与其深度的关系，并且这些数据是在一天的不同持续时间内收集的。此外，作者还保证需要分析被困在钻孔内的儿童的位置，其中使用蔡司 ZEN 软件对有被困儿童的钻孔环境进行了模拟。研究结果显示，被困儿童的状况随着深度的增加而变得异常，并且还准备了图表，显示了拯救被困儿童的严重程度和必要性。使用收集到的数据，救援人员可以快速选择合适的钻孔救援机制。

**关键词：**井眼救援行动；传感器融合系统；井眼检查；儿童姿势模拟

## 1.0 Introduction

India is one among the fastest growing nations in the world. Despite technological advancements, young labor population, and resourceful nature, India suffers from several challenges; one among the many challenges is water scarcity[1]. Water is an important resource to mankind. Whilst the Earth is made 71 percentage of water, access to potable water and water for other uses (Agriculture, Construction) with low levels of salinity is still limited in India. With growing population and urbanization, one way to satiate the water needs of the nation is to lay bore-wells, a relatively better idea when compared to digging wells[2].

According to India Water Portal [3], domestic purpose bore-wells must be drilled with a diameter between 4.5 and 6 inches whereas high yield bore-wells are drilled with a diameter

of 6 inches, especially for large buildings, apartments, and agricultural purposes. Despite regulatory measures by the Government of India on drilling and maintaining bore-wells, bore-wells have been a threat to the life of children who by chance fall into these pits. Since 2009, reports claim that more than 40 cases of children falling into bore-wells were recorded, wherein only 30 per cent of these cases were saved successfully; despite recovery measures, 70 per cent of the cases failed with the loss of innocent lives[4]. When a child gets trapped in a bore-well, not all rescue techniques are suitable. Firstly, local arrangements are made. Failure of local arrangements leads to the intervention of government officials, especially military personnel who digs a hole parallel to the bore-well. When the vertical distance of the trapped child is reached, a horizontal path is made to

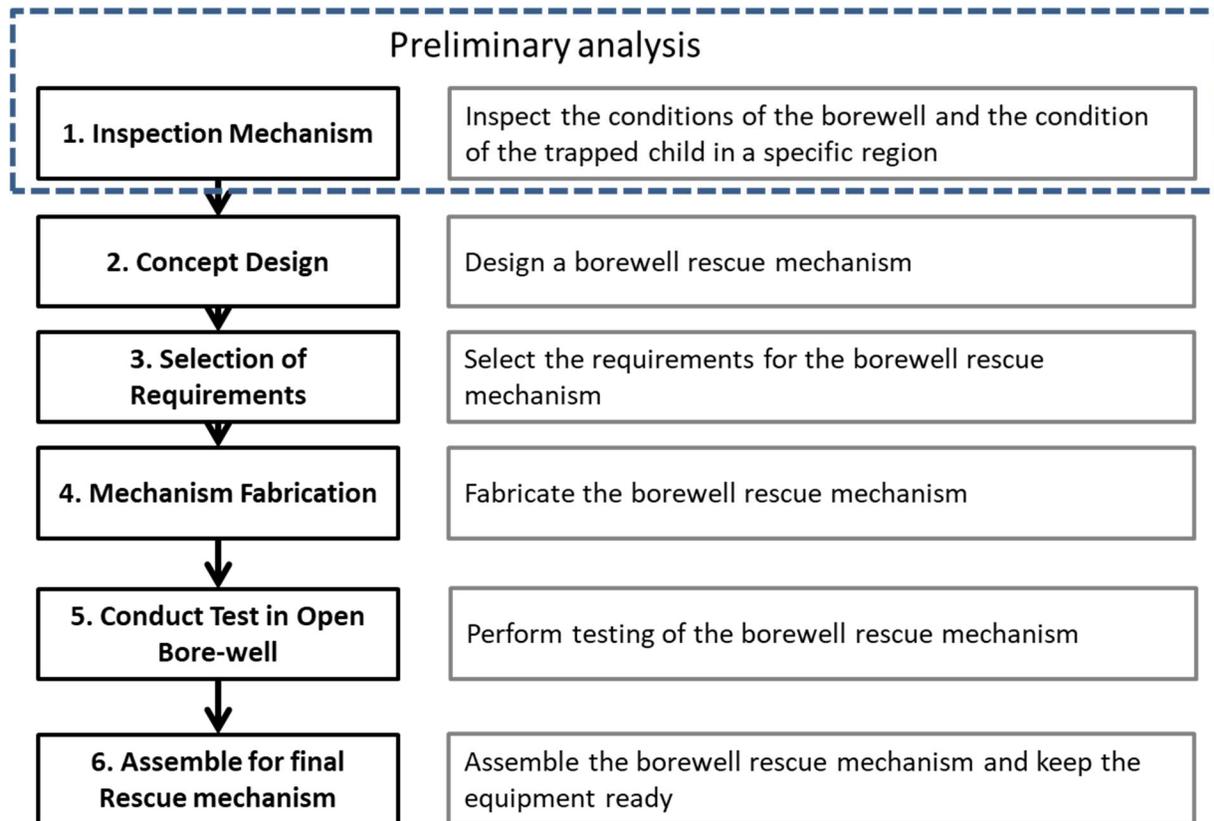
reach the child. Such a recovery mechanism requires a lot of resources and energy. In some situations, quick military responses might not be feasible[5].

To improve the chances of success in recovering children from bore-wells, researchers and academicians across the world contributed significantly towards the design and fabrication of rescue mechanisms. Bore well rescue robotic systems are proposed by researchers as viable bore-well rescue systems, owing to their robust nature. Several rescue forms were proposed, designed, and fabricated by researchers in the past, wherein the major requisite of these mechanisms is to ensure the survival of the child who fell into bore-wells.

Sujatha et al[6] proposed the design and implementation of child rescue robot which uses gear motors, camera with micro-controller, robotic arms, temperature sensor, and heart-beat monitoring systems to support safe handling of trapped child. Karthik et al[4] proposed a design of a bore-well rescue mechanism which employs hydraulic arms and a locking mechanism which could securely hold the trapped child. The proposed mechanism enables to hold the child safely without any slippage. Jebakumari[7] proposed the design of a snake robot, which can crawl into small spaces thereby helping rescuers to monitor the status of the trapped child. Kaimal[8] proposed the design of a rescue mechanism which employs several methods of bore-well rescue. The proposed design comprised of an oxygen supplier, camera, lights, and employed the balloon technology and umbrella technique. Sriramireddy[9] performed a theoretical and practical analysis of bore-well rescue mechanism which involves inspection of bore-well conditions and rescuing mechanism.

Despite the various bore-well rescue mechanisms proposed, designed, and fabricated by researchers and patented technologies associated with bore-well rescue devices, there is a need to understand the conditions of the bore-well and the position of the trapped child prior selecting a rescue mechanism. According to Vivek[10], the first step in a bore-well rescue process is the determination of the depth of the trapped child and the position of the child, which is followed by the use of the actual rescue mechanism. Preliminary analysis of the bore-well conditions, such as depth, temperature, humidity, and oxygen levels inside the bore-well is also important which enables decision makers to quickly respond to the situation and select the suitable rescue mechanism.

However, performing such an analysis during an event of a bore-well trap might not be feasible as saving the child will be prioritized the most. In India, considering the increase in the number of child deaths due to unmanaged bore-wells, the authors of this paper recommend the need to inspect bore-well characteristics in different regions of the nation and store them in a public repository. The preliminary analysis of bore-well characteristics, such as depth, temperature, humidity, and oxygen levels inside a bore-well in specific regions during different time durations of a day can be used as a viable method to quickly select an existing rescue mechanism or fabricate an appropriate rescue mechanism. Against this backdrop, the authors of this paper propose a novel bore-well inspection and rescue framework. Figure 1 displays the proposed bore-well inspection and rescue framework.



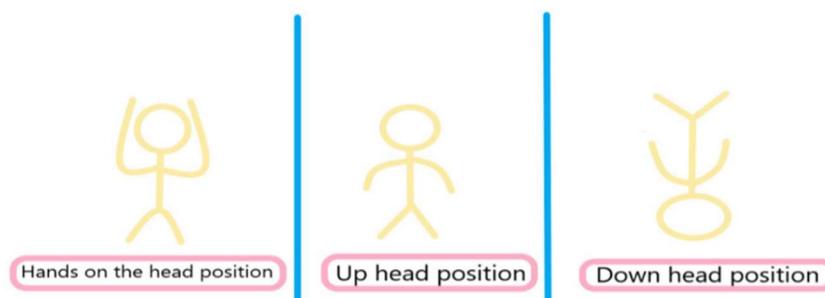
**Figure 1 - Bore-well Inspection and Rescue Framework (Source: Author (2021))**

The above framework works as follows:

1. Inspection Mechanism (Preliminary Analysis)
- Firstly, prepare a database to store bore-well conditions in different regions of the nation; when a database containing information such as air quality, humidity, and temperature against depth of bore-well across specific

regions of the country are available, rescuers can quickly access the data to select or fabricate a suitable rescue mechanism

- Secondly, rescuers should analyze the position of the child trapped in a bore-well. A child's position inside a bore-well could be – Up head, hands on head, or down head (Figure 2).



**Figure 2 – Child's Position inside a Bore-well (Source: Author (2021))**

## 2. Concept Design

Based on the bore-well characteristics and the position of the child inside the bore-well, rescuers can either select an existing rescue mechanism or propose a new mechanism.

### 3. Selection of Requirements

In both cases (existing rescue mechanism or new mechanism), rescuers must quickly fabricate required equipment.

### 4. Fabrication of the Mechanism

Rescuers must quickly fabricate the required mechanism to save the trapped child.

### 5. Conduct Test in Open Bore-Well

In scenarios where researchers develop a general bore-well rescue mechanism (one mechanism for all kinds of events), they must test the mechanism in an open bore-well to ensure its credibility for usage in real events.

When rescue mechanisms are fabricated for a specific event, conducting a quick test in an open bore-well holds good, this eliminates the chances of hurting the trapped child.

### 6. Assemble for Final Rescue Mechanism

In scenarios where researchers develop and test a general bore-well rescue mechanism, the final rescue mechanism must be assembled and kept ready for real events.

As per the proposed framework (Figure 1), step 1 which is the preliminary analysis must be made ready to quickly react to a bore-well accident. Steps 2,3,4,5 and 6 are generally followed during the design and fabrication of rescue mechanism and are extensively followed by researchers. No study exists which elucidates the procedure to perform a preliminary analysis of bore-well

conditions. In this regard, the authors of this paper attempt to collect data on bore-well conditions in a select region in India during different time durations. Based on the collected data, decision making charts are prepared which support the selection of a suitable rescue mechanism. In addition, the authors also attempt to simulate the position of the trapped child and propose methods to calculate the gap between the trapped child and the bore-well wall, thereby further providing more insights on selecting a suitable rescue mechanism.

## 2.0 Inspection Mechanism Components

The collection of data for preliminary analysis of bore-well conditions is segregated into two stages:

Stage 1 – Inspection of bore-well characteristics

Stage 2 – Inspection of child's position in the bore-well

### 2.1 Data collection components used in Stage 1

For the collection of bore-well characteristics, the authors selected Giddalur, Rajampeta, and Anathapuramin Andhra Pradesh, India as the study locations. The soil composition considered in Giddalur, Rajampeta, and Ananthapuramin includes clay, red and black soils respectively[11]. For the present study, the vital parameters to collect from a bore-well are humidity, temperature, and air quality[12]. Data on these characteristics should be collected against the depth of the bore-well. In this regard, the following components are used:

#### 1. Laser Distance Measurer Meter

Laster distance measurer meters are used to measure distances at a distance. These meters use laser light pulses to measure the time taken for the reflection to return[13]. Laser distance measurer

meter is used to accurately identify the depth of the bore-well.

## 2. Sensor Fusion System

Sensor fusion systems incorporate multiple sensors to collect data, such as humidity, temperature, and gaseous composition inside a bore-well. The status of a child trapped within a bore-well can also be monitored using a sensor fusion system[12,14] .

The sensor fusion system used by the authors in the present study includes two major components – air quality/gas detector sensor module and Rh-Temperature sensor. The air quality/gas detector sensor module senses conductivity in air. The higher the conductivity, the higher the concentration of gases and particles in air. The air quality sensor module used in this study is highly sensitive in detecting harmful gases. The Rh-Temperature sensor used in this study incorporates a thermistor and a humidity sensor to collect temperature and humidity data.

## 2.2 Child Position Simulation for Stage 2

Other than the collection of bore-well characteristics, rescuers must also analyze the

**Table 1 – Bore-well Parameters and Critical Values**

| Parameters  | Critical values of bore well | Condition of Child |
|-------------|------------------------------|--------------------|
| Air quality | >200 ppm                     | Abnormal           |
| Humidity    | <20 and >80 %                | Abnormal           |
| Temperature | <15 and >37°C                | Abnormal           |

## Case Study 1 – Inspection of Clay Soil Bore-well

Data is collected from a clay soil bore-well in Giddalur, Andhra Pradesh during different timings of a day as shown in Table 2. The results revealed that the deeper the child gets

**Table 2- Bore-well Characteristics in Clay Soil (Giddalur, Andhra Pradesh)**

position of the child trapped in the bore-well and the availability of the gap between the trapped child and the bore-well wall. In this regard, the authors of the present study simulated the bore-well environment with the trapped child in different positions using the ZEISS ZEN software. ZEISS ZEN is used to simulate the position of child inside the bore-well using image processing and segmentation technology[15].

## 3.0 Results

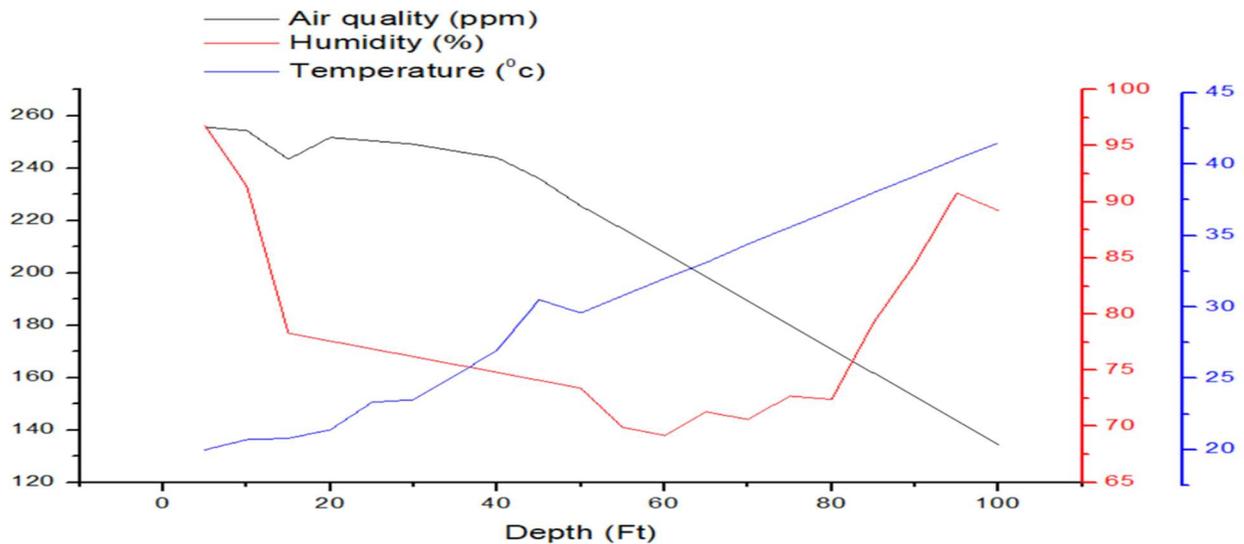
### Stage 1 – Collection of Bore-well Characteristics

The conditions inside a bore-well depends mostly on the type of soil and the timings of the day. Against this backdrop, the authors conducted cases studies by collecting bore-well characteristics in three types of soils (clay soil, red soil, and black soil) at two different timings (6AM to 9AM, and 12PM to 3PM) in three different bore-wells dug at Giddalur, Rajampet, and AnanthaPuram, Andhra Pradesh. A child trapped inside a bore-well is deemed normal or abnormal based on the values displayed in Table 1.

trapped in the bore-well, the more abnormal the child becomes as the air quality becomes poor, and the humidity and temperature values become critical.

| Depth(Ft.) | Morning (6am to 9am ) |              |                  | Afternoon (12pm to 3pm) |              |                  |
|------------|-----------------------|--------------|------------------|-------------------------|--------------|------------------|
|            | Air quality (ppm)     | Humidity (%) | Temperature (°C) | Air quality (ppm)       | Humidity (%) | Temperature (°C) |
| 5          | 255.69                | 96.8         | 20               | 275.24                  | 68.6         | 28.3             |
| 10         | 254.38                | 91.4         | 20.7             | 249.03                  | 68.4         | 28.9             |
| 15         | 243.44                | 78.3         | 20.8             | 240.82                  | 70.89        | 32               |
| 20         | 251.76                | 77.6         | 21.4             | 240.51                  | 77.7         | 33.3             |
| 25         | 250.45                | 76.9         | 23.33            | 233.95                  | 75.4         | 36.8             |
| 30         | 249.14                | 76.2         | 23.5             | 227.39                  | 76.3         | 38.28            |
| 35         | 246.52                | 75.5         | 25.2             | 220.83                  | 76.1         | 40.42            |
| 40         | 243.9                 | 74.8         | 27               | 214.27                  | 73.5         | 40.56            |
| 45         | 236.04                | 74.1         | 30.5             | 207.71                  | 72.8         | 41               |
| 50         | 225.56                | 73.4         | 29.58            | 201.15                  | 72.42        | 41.34            |
| 55         | 216.82                | 69.9         | 30.78            | 194.59                  | 71.62        | 41.7             |
| 60         | 207.65                | 69.2         | 31.98            | 188.03                  | 70.82        | 41.88            |
| 65         | 198.48                | 71.3         | 33.1             | 181.47                  | 71.02        | 41.96            |
| 70         | 189.31                | 70.6         | 34.4             | 174.91                  | 67.3         | 42.1             |
| 75         | 180.14                | 72.7         | 35.57            | 168.35                  | 72.14        | 42.5             |
| 80         | 170.97                | 72.4         | 36.76            | 161.79                  | 77.21        | 42.75            |
| 85         | 161.8                 | 79.2         | 38               | 155.23                  | 81.2         | 43.9             |
| 90         | 152.63                | 84.5         | 39.16            | 148.67                  | 86.8         | 45.14            |
| 95         | 143.46                | 90.8         | 40.35            | 142.11                  | 90           | 46.34            |
| 100        | 134.29                | 89.21        | 41.5             | 135.55                  | 90.15        | 47.53            |

- Data in Red represent values above accepted limits as displayed in Table 1



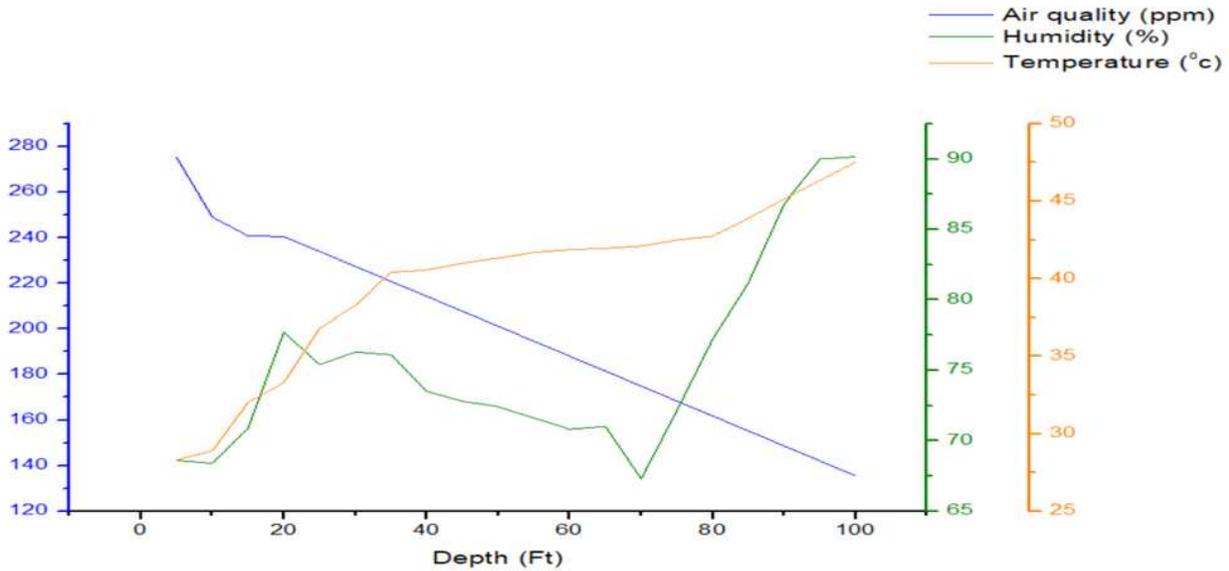


Figure 3 - Bore-well Characteristics in Clay Soil (Top-6AM to 9AM and Bottom- 12PM to 3PM) Case Study 2 – Inspection of Red Soil Bore-well Data is collected from a clay soil bore-well in RajamPet, Andhra Pradesh during 6AM to 9AM

of a day as shown in Table 3. The results revealed that the deeper the child gets trapped in the bore-well, the more abnormal the child becomes as the air quality becomes poor, and the humidity and temperature values become critical.

**Table 3- Bore-well Characteristics in Red Soil (Rajampet, Andhra Pradesh)**

| <b>Morning (6am to 9am )</b> |                          |                     |                         |
|------------------------------|--------------------------|---------------------|-------------------------|
| <b>Depth(Ft.)</b>            | <b>Air quality (ppm)</b> | <b>Humidity (%)</b> | <b>Temperature (°C)</b> |
| 5                            | 210.98                   | 91                  | 30.03                   |
| 10                           | 208.00                   | 88.1                | 31.5                    |
| 15                           | 206.00                   | 85                  | 34.1                    |
| 20                           | 200.10                   | 84                  | 36.1                    |
| 25                           | 196.00                   | 81                  | 37.9                    |
| 30                           | 195.40                   | 80                  | 40.0                    |
| 35                           | 190.00                   | 76                  | 40.7                    |
| 40                           | 188.06                   | 75                  | 40.9                    |
| 45                           | 186.00                   | 72.5                | 41.5                    |
| 50                           | 185.00                   | 68.9                | 42.22                   |
| 55                           | 182.30                   | 65.5                | 42.6                    |
| 60                           | 170.58                   | 61.2                | 42.6                    |
| 65                           | 172.00                   | 59.8                | 43.48                   |
| 70                           | 170.00                   | 74.3                | 44.0                    |

| Morning (6am to 9am ) |                   |              |                  |
|-----------------------|-------------------|--------------|------------------|
| Depth(Ft.)            | Air quality (ppm) | Humidity (%) | Temperature (°C) |
| 75                    | 163.00            | 76           | 44.6             |
| 80                    | 162.14            | 79           | 46.8             |
| 85                    | 150.90            | 80.5         | 47.0             |
| 90                    | 155.00            | 81           | 49.9             |
| 95                    | 151.00            | 85           | 50.5             |
| 100                   | 148.00            | 86.95        | 51.0             |

- Data in Red represent values above accepted limits as displayed in Table 1

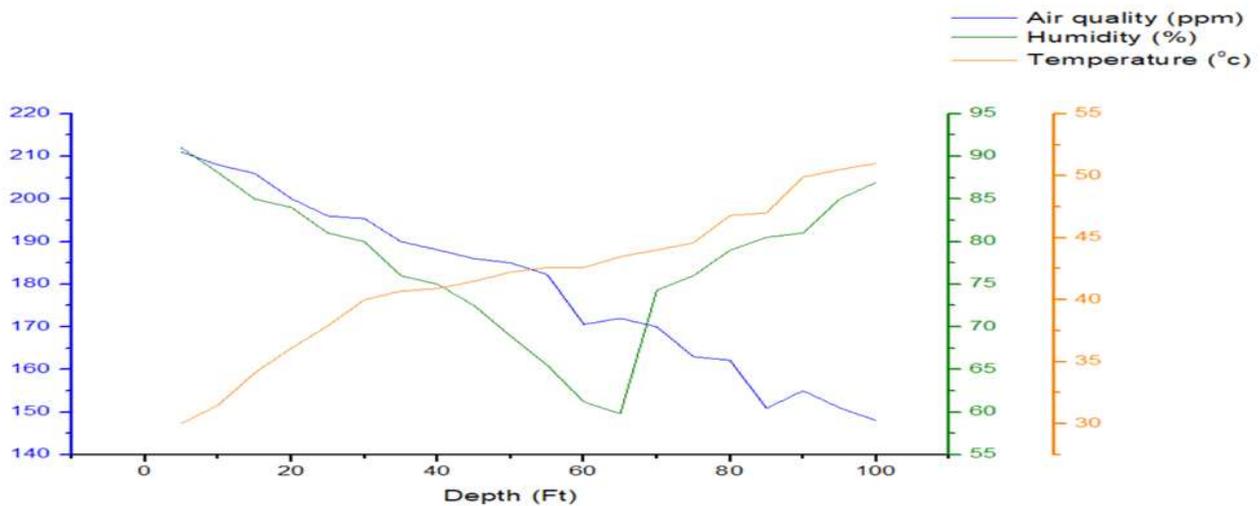


Figure 4 - Bore-well Characteristics in Red Soil (6AM to 9AM)

Case Study 3 – Inspection of Black Soil Bore-well

Data is collected from a black soil bore-well in AnanthaPuram, Andhra Pradesh during different durations of a day as shown in Table 3. The results revealed that the deeper the child gets

trapped in the bore-well, the more abnormal the child becomes as the air quality becomes poor, and the temperature value becomes critical. However, in the morning, the deeper the depth of the borwell, the better were the levels of humidity.

**Table 4- Bore-well Characteristics in Black Soil (AnanthaPuram, Andhra Pradesh)**

| Depth(Ft.) | Morning (6am to 9am ) |              |                  | Afternoon (12pm to 3pm) |              |                  |
|------------|-----------------------|--------------|------------------|-------------------------|--------------|------------------|
|            | Air quality (ppm)     | Humidity (%) | Temperature (°C) | Air quality (ppm)       | Humidity (%) | Temperature (°C) |
| 5          | 218.14                | 98.2         | 25.4             | 5                       | 228.23       | 89.9             |
| 10         | 213.27                | 96           | 25.9             | 10                      | 225.1        | 87.12            |
| 15         | 204.62                | 94.7         | 26.4             | 15                      | 222          | 88.14            |

|     |        |       |      |     |        |       |
|-----|--------|-------|------|-----|--------|-------|
| 20  | 198.26 | 92    | 26.9 | 20  | 218.6  | 85.1  |
| 25  | 196.15 | 89    | 27.4 | 25  | 209.9  | 82.32 |
| 30  | 192.68 | 87.25 | 27.9 | 30  | 206.14 | 78.15 |
| 35  | 185.35 | 84    | 28.4 | 35  | 201.1  | 76.4  |
| 40  | 180.06 | 81    | 28.9 | 40  | 199    | 73    |
| 45  | 174.77 | 79    | 29.4 | 45  | 198.75 | 70    |
| 50  | 169.52 | 78.9  | 29.9 | 50  | 195.11 | 68    |
| 55  | 164.21 | 77.1  | 30.4 | 55  | 192    | 66    |
| 60  | 158.91 | 76.84 | 30.9 | 60  | 189    | 63    |
| 65  | 153.64 | 75.6  | 33.7 | 65  | 188.23 | 61    |
| 70  | 148.3  | 74.3  | 34   | 70  | 186    | 70    |
| 75  | 143.06 | 73    | 38.2 | 75  | 182.5  | 72.1  |
| 80  | 137.77 | 70.4  | 40.3 | 80  | 177    | 76    |
| 85  | 132.48 | 70    | 42.6 | 85  | 176.66 | 80.1  |
| 90  | 129.53 | 69    | 45.4 | 90  | 175    | 79.3  |
| 95  | 127.2  | 68    | 46.5 | 95  | 171.5  | 85    |
| 100 | 122.93 | 66.5  | 49.9 | 100 | 169.99 | 89    |

- Data in Red represent values above accepted limits as displayed in Table 1

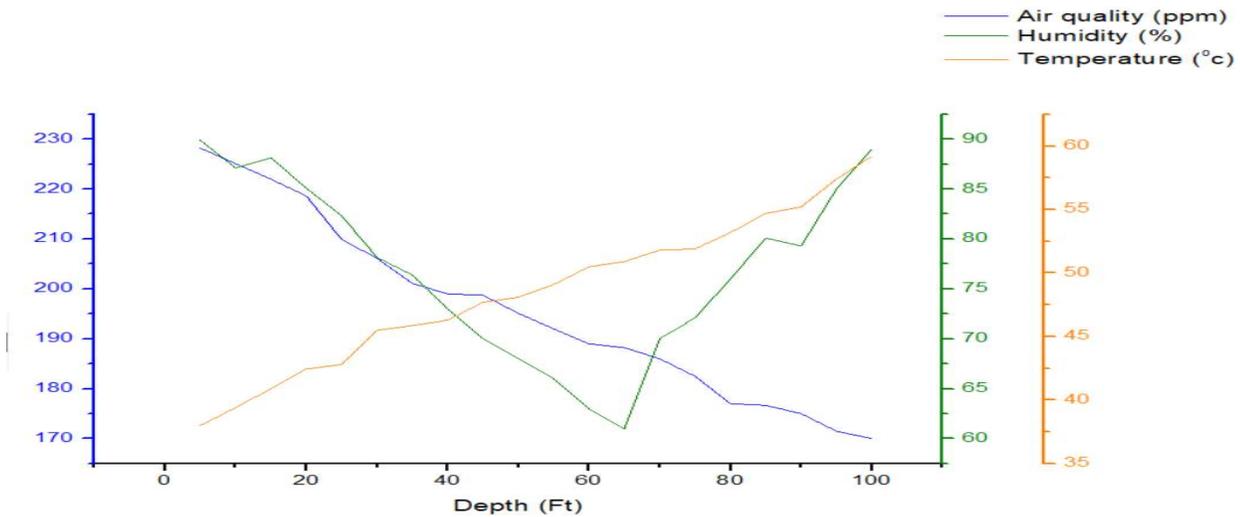


Figure 5 - Bore-well Characteristics in Black Soil (6AM to 9AM.)

**Stage 2 – Simulation of Child Position**

The position of the child trapped inside a bore-well is simulated using the ZEISS ZEN software. Simulations were performed for a trapped child in up head position and down head position. Simulation for the hands on the head position is not performed as both up head and hands on head

positions tend to have similar impact on rescue operations. Figure 6 displays a 5-Dimensional (5D) view of the child trapped in up head position and the gap versus distance measurement using ZEISS ZEN. Appendix 1 contains other representations of the simulation

and the code to measure the length between the child and the bore-well wall.

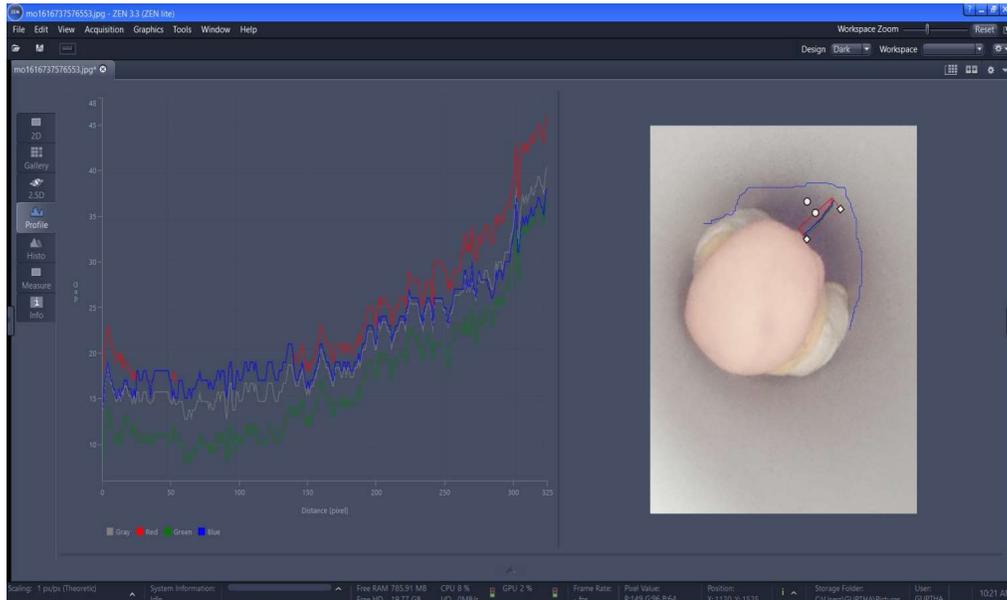


Figure 6 – View of Up Head trapped child and Gap vs. Distance measurement

Similarly, Figure 7 displays a 5D view of the child trapped in down head/legs up position and the gap versus distance measurement using ZEISS ZEN. Appendix 2 contains other

representations of the simulation and the code to measure the length between the child and the bore-well wall.



Figure 7 – View of Down Head trapped child and Gap vs. Distance measurement

#### 4.0 Discussion

Bore-well accidents, especially children getting trapped in unmanaged or abandoned bore-wells

are increasing every year. Many abandoned bore-wells still exist in the nation and the Government of India is taking stringent measures to close the

same. However, a need exists to create reactive bore-well rescue mechanisms to quickly react to such situations. Many rescue mechanisms available as proposed designs in literature studies tend to be tailor made for specific situations. If a child is trapped in a bore-well, rescuers look for data such as the position of the child and the conditions inside a bore-well. According to 'The Print' [16], several factors influence the success of a bore-well rescue operation, which include soil type, bore-well diameter and the depth at which a child is trapped. Furthermore, surfaces below the ground surface vary from region to region. For instance, in states such as Haryana and Rajasthan, the soil is found to be sandy and loose and hence a bore-well might collapse during a rescue operation. However, in hilly regions, the soil tends to be rocky and requires heavy machinery for rescue operations. While the position information of the trapped child is acquired during an event, bore-well conditions such as humidity, air quality, and temperature if known prior will provide good insights to rescuers in selecting a suitable rescue mechanism.

In the present study, the authors propose a bore-well inspection and rescue framework with an emphasis placed on performing a preliminary analysis of bore-well conditions in different locations of India. In this regard, the researchers considered bore-wells from three study locations in the state of Andhra Pradesh, India and data was collected from two different time durations. An analysis of the findings of the study revealed that in all the case studies performed in different locations, with increases in the depth of the bore-well, the characteristics of the bore-well such as humidity, air quality and temperature become poor. This infers the fact that the more the depth of the bore-well and

deeper the child gets trapped in a bore-well, the more abnormal it becomes. However, the collection of the data is purely based on a specific location and cannot be performed when there is an event of a bore-well accident. This necessitates the creation of a database by the Government by collecting data from bore-wells in different locations of the nation. Such data comes in handy during rescue operations. Furthermore, simulations of trapped child in bore-well using ZEISS ZEN tend to provide insights on the gap between the trapped child and the bore-well wall, thereby further facilitating rescuers to select or fabricate an appropriate rescue mechanism.

The propose framework is an extension of the normal rescue mechanism design procedures used by researchers. However, the authors in this paper recommend preliminary analysis of bore-well conditions across different locations in the nation. An idea is proposed in the present study and recommendations are put forth for the Government of the nation as well as the states.

## 5.0 Conclusion

The research paper is an attempt to explore bore-well conditions in select regions of Andhra Pradesh, India, as a means to populate preliminary data which can aid rescuers during a bore-well rescue operation. A bore-well inspection and rescue framework is devised; however, most steps in the framework are commonly adopted by researcher, except the need for a preliminary analysis not emphasized in almost all literature studies. While there exists no such preliminary bore-well data in the present day scenario, the authors of this paper recommend the need to create such data across different locations of the nation as bore-wells

serve as the prime mode of water supply to most of the population in India and bore-well trap incidents over the years are set in an increasing pace. The authors recommend the use of a sensor fusion system as the primary means to acquire bore-well conditions, such as air quality, humidity, and temperature inside the bore-well. If this information is collected and made public for access, rescuers can quickly respond to a bore-well trap. In addition, the authors also use ZEISS ZEN to simulate trapped child in bore-wells and provides solutions to measure the distance between the bore-well wall and the trapped child. The authors of the study collected data on bore-well conditions during two different time durations of a day; however, the authors recommend future studies to follow a similar approach as mentioned in the study and collect bore-well condition data during different seasons. The authors also recommend governmental and regulatory bodies to initiate the data collection of bore-well conditions from different regions of the nation so as to expedite a rescue operation in the future years, with a motive to improve the rate of success from such operations.

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