TACKLING THE HIGH WATER-TABLE PROBLEM AND DEVELOPMENT OF ASSURED WATER SUPPLY IN THE KARBONN MOBILES MANUFACTURING PLANT AT TIRUPATI INTERNATIONAL AIRPORT, CHITTOOR DISTRICT, ANDHRA PRADESH, INDIA

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Abstract: This paper describes how we solved the drainage problems faced by the Karbonn Mobiles Manufacturing Plant during its construction in 2007 at Chowtour Habitation of Renigunta Township within the Electronic Hardware Manufacturing Cluster abutting the Tirupati International Airport, Chittoor District, Andhra Pradesh, India. In addition, we helped the Plant to get assured water supply through a high-yielding bore well and thereby dispense usage of tanker water. We also described the adverse environmental effects caused by the release of treated sewage water by the Tirupati Municipal Corporation (TMC) from their Sewage Treatment Plant (STP) and how they could be remedied.

Keywords: Groundwater, Water Table Aquifer, Perched Aquifer, Artesian Aquifer, Assured Water Supply, Tirupati Sewage Treatment Plant.

DESCRIPTION OF THE STUDY AREA

Karbonn Mobiles Manufacturing Plant is located within the Electronic Hardware Manufacturing Cluster in Chowtour Habitation of Renigunta Township in a quadrilateral- shaped area of 15.28 acres (6.18 ha) north of the Tirupati International Airport in Chittoor District, Andhra Pradesh, India (Fig. 1). The climate is tropical sub-humid to semiarid with maximum and minimum air temperatures of about 40^o C and 28^o C in May, and 29^o C and 20^o C in December. The area receives rainfall both in the South-West Monsoon from June to September and in the North-East monsoon from October to December. The average annual rainfall is around 1126 mm with November usually recording a maximum of 249 mm and February a minimum of 5 mm. Cyclonic storms in the Bay of Bengal particularly during the North-East monsoon may bring heavy rains to the region causing flood damage. In their absence, rainfall is scanty resulting in drought damage.

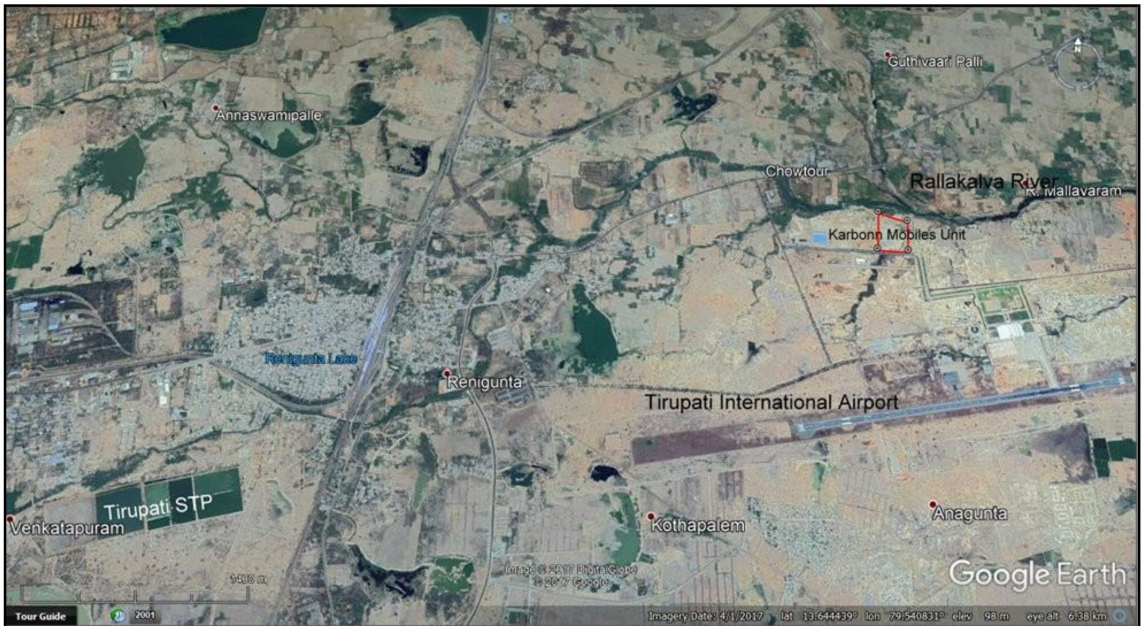

Fig. 1: A View of the Karbonn Mobiles Manufacturing Plant

The Plant area is nearly flat at an elevation of around 100 m (325 feet) above sea level to slope gently from southwest to northeast direction. It is bounded on the north by the Rallakalva River, a tributary of the Swarnamukhi River. The Plant area is covered by stiff clayey soils of alkaline nature mixed with boulders and cobbles underlain by pervious sandy soils for a depth of around 40 feet (12 m). The soils are underlain mostly by dolerite dykes intruded within granite of Archaean Age. These rocks were subjected to weathering and fracturing to result in soft disintegrated rock, followed by hard disintegrated rock and impervious sheet rock of granite with isolated thin gaps carrying artesian groundwater in varying amounts.

PURPOSE OF OUR STUDY

Construction of the Karbonn Mobiles Manufacturing Plant was taken up in 2017. In a bid to make available construction water, two bore wells (B1 and B2) were drilled at sites shown in Fig. 2 with B1 located in the southwest portion and B2 in the northeast corner of the Plant. As their yields were poor, they had to be abandoned and use tanker water for construction. Another problem relates to occurrence of groundwater at shallow depths of as low as 5 to 10 feet (1.5 to 3 m) all over the Plant area in monsoon, leading to water seepage into the basement of the buildings through gaps in the foundation and floor. The idea of closing the gaps completely was considered not desirable as it would develop water pressure causing instability to the structures in the long run. All the efforts taken to permanently lower the water table by continuous pumping of water in a large number of shallow pits excavated all over the Plant area failed to resolve the problem.

Fig. 2: A Close-up View of the Karbonn Mobiles Manufacturing Plant

Fig. 3: PQWT-W300 Prospecting Instrument Being Used in the Plant

The standard procedure followed throughout the world to tackle this type of problem consists in installing a drainage membrane or geotextile material inside the foundation walls under the concrete slab and direct the water collected into a storm drain or sump pump through a weeping tile disposal to a far-off drain. Various engineering uses of geotextiles including drainage water management are described in a technical manual by Departments of the US Army and the Air Force (1995). While implementing this procedure, the Plant Management felt the whole procedure to be highly cumbersome besides involving high capital and recurring expenditure.

In an effort to explore alternatives, the Plant Management consulted us in the local Geology Department of Sri Venkateswara University at Tirupati having good knowledge of the local hydrogeology (Jagadiswara Rao et al, 1978; Krishna Reddy, 1982). In view of our tackling large number of land- and water-related problems at several places in India and abroad using innovative and cost-effective methods, we readily took up the work. References to some such works include Jagadiswara Rao (1974, 1976a, 1976b, 1976c, 1976d, 1978, 2015, 2018), Jagadiswara Rao and Hanumanthu (2013), Jagadiswara Rao and Narasimha Rao (2008), and Ramanaiah and Jagadiswara Rao (2011).

OUR WORK IN THE PLANT AREA

Apart from reviewing the exhaustive work carried out by us and our colleagues in the past, we made further field work in and around the Plant area using multi-dated Google Earth Pro satellite images available in the public domain. In addition, we utilised the services of a local expert water diviner using the Pendulum method and a local geophysicist using China-Make PQWT-W300 Prospecting Instrument to understand the subsurface conditions (Fig. 3).

1. TACKLING THE HIGH WATER-TABLE PROBLEM

High water-table aquifers have their water table close to the ground overlain by a thin zone of aeration. This is common in high-rainfall regions or in regions close to perennial water bodies such as rivers and lakes (Fig. 4). In view of the Plant area's location in a semiarid drought-prone area with low and erratic rainfall with water shortages, water table at the Plant Area cannot be expected to be at such shallow depth even in monsoon. Based on our previous work and present studies we attribute this high water table to the widespread occurrence of shallow perched aquifers within the zone of aeration as shown in Fig. 5. These aquifers are formed because of wide-spread occurrence of aquiclude of stiff clay within the zone of aeration with equally wide-spread shallow perched water above it.

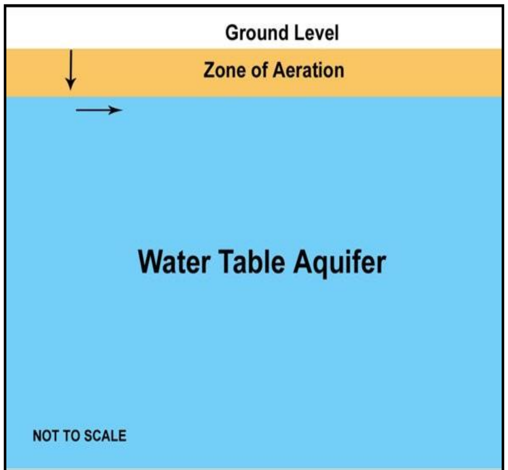

Fig. 4: Schematic Diagram of a High Water-Table Aquifer Capped by Thin Zone of Aeration

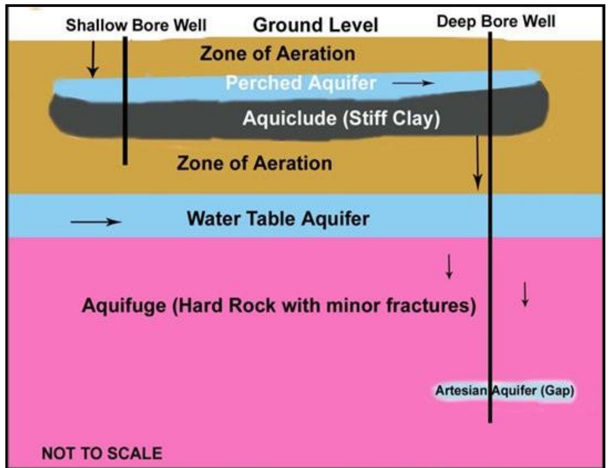

Fig. 5: Schematic Diagram of a Perched Aquifer Close to the Ground

The main source of this perched water is the large treated sewage water released round the year from the Sewage Treatment Plant (STP) of the Tirupati Municipal Corporation (TMC) (Fig. 6), flowing as a perennial stream (Fig. 7) in a northeast direction to join Rallakalva River via an irrigation tank close to the Plant Area.

Fig. 6: Treated Sewage Water from the Tirupati Sewage Treatment Plant (STP)

Fig. 7: Treated Sewage Water Flowing as a Perennial Stream

The best way this perched groundwater could be drained is not by pumping, but by puncturing the underlying clayey aquiclude to allow that water to percolate to fill the voids in the underlying thick zone of aeration. We demonstrated our methodology by arranging drilling from surface close to an existing pit at the southwest corner of the Plant area shown in Fig. 2 (Fig. 8). Using a truck-mounted heavy-duty down-the-hole (DTH) hammer rig that works on rotary percussion with compressed air, Sri Sai Ram Bore Wells of Chandragiri drilled to a depth of 40 feet (12 m) and cased the whole hole with a slotted-pipe of the type shown in Fig. 9. Once the Plant Management saw the rapid disappearance of water in the pit, they were convinced of our method and took up the construction of some ten more shallow bore wells spread over the entire area to permanently get rid of the high water- table problem both in the basement of the constructions and in the entire Plant area without the need to incur any further capital and recurring expenditures.

Fig. 8: Shallow Pit Exposing the Perched Water In the Plant Area

Fig. 9: Slotted-Pipe Type Used in the Construction of Shallow Bore Wells

DEVELOPMENT OF ASSURED WATER SUPPLY

Because of the failure of the two bore wells drilled earlier in the southwest corner (B1) and the northeast corner (B2) of the Plant area, we undertook the task of pinpointing the best site for construction of a new bore well (B). Fig. 2 shows all the locations. We selected the site for the new bore well (B) by using both indigenous water divining methods using pendulum and latest geophysical methods using China-Make PQWT-W300 Prospecting Instrument (Fig. 3). By probing the entire Plant area, we shortlisted a 14-m long line along the road divide in the central portion of the Plant for detailed investigation at one-metre interval to generate a Curve Map (Fig. 10) to pinpoint the best site for drilling and a Profile Map (Fig. 11) to determine the optimum depth of drilling to get the highest-possible yield. All this has led to selecting Site No. 10 along this alignment for drilling.

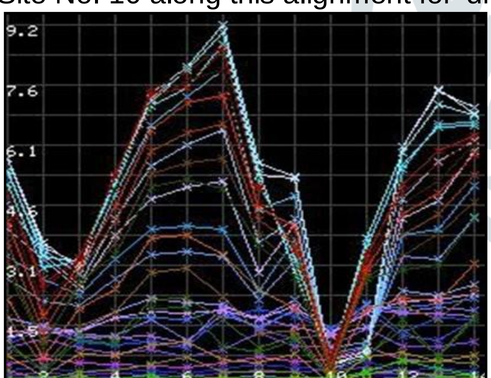

Fig. 10: Profile Curve Generated by the PQWT-W300 Prospecting Instrument

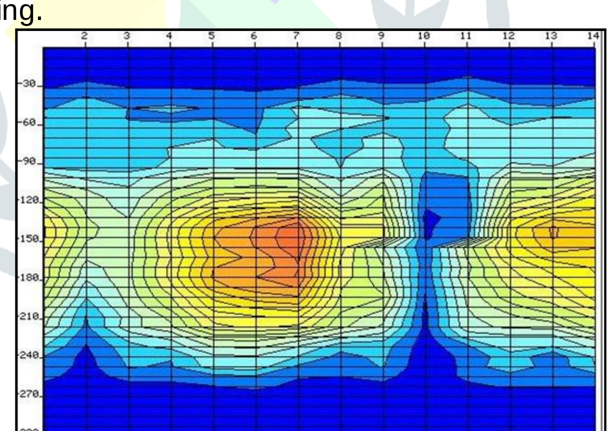

Fig. 11: Profile Map Generated by the PQWT-W300 Prospecting Instrument

The formations encountered during drilling were soil with perched water till 45 feet (14 m), soft disintegrated rock yielding 1-inch water from 45 to 120 feet (14 to 36.6 m), hard disintegrated dyke rock from 120 to 220 feet (36.6 to 67.1 m), moist rock slurry from 220 to 320 feet (67.1 to 97.5 m), hard impervious rock from 320 to 620 feet (97.5 to 189 m), hard rock with water-bearing gaps from 620 to 725 feet (189 m to 221 m) within hard granite to yield 2.5-inch water. Although more discharge would have been obtained by drilling deeper, the Plant Management decided to stop drilling as the yield obtained was more than adequate to meet even the ultimate water demand of the Factory.

TACKLING ENVIRONMENTAL POLLUTION CAUSED BY THE TIRUPATI SEWAGE TREATMENT PLANT (STP)

It is noted with concern that the Sewage Treatment Plant (STP) of the Tirupati Municipal Corporation (TMC) has been causing considerable environmental damage in the Tirupati- Renigunta area through release of large quantities of treated sewage water throughout the year (Figs. 1, 6 and 7). These waters flow in a northeast direction via an irrigation tank to join the Rallakalva River – a tributary of the Swarnamukhi River. Rallakalva River here is so much polluted that it is locally called "Tirupati *Murugu Kalva*". Although these waters find use to irrigate some local lands round the year, some of the farm workers there suffer from water-borne diseases. There can be also endemic health disorders in people consuming foods grown using these waters. We also find these waters to be the main source of perched groundwater in the Karbonn Mobiles Manufacturing Plant, which contributes groundwater through a small stream entering into the Plant. Our Environmental Impact Assessment (EIA) studies indicate that there should not be any difficulty to set right the environmental damage caused to the region in a cost-effective manner in a few years time, if only the Tirupati Municipal Corporation evinces interest.

CONCLUSION

We are happy to conclude that we could solve the two problems posed to us by the Karbonn Mobiles Manufacturing Plant to the full satisfaction of the Plant Management. Our work incidentally stresses on the need on the part of Tirupati Municipal Corporation (TMC) to set right the environmental damage being caused by their Sewage Treatment Plant (STP) on a permanent basis.

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