Rapid Investigations to assess impacts of Aquifer Recharge measures undertaken by BIRD-K in Sira and Pavagada tehsils of Tumkur district, Karnataka

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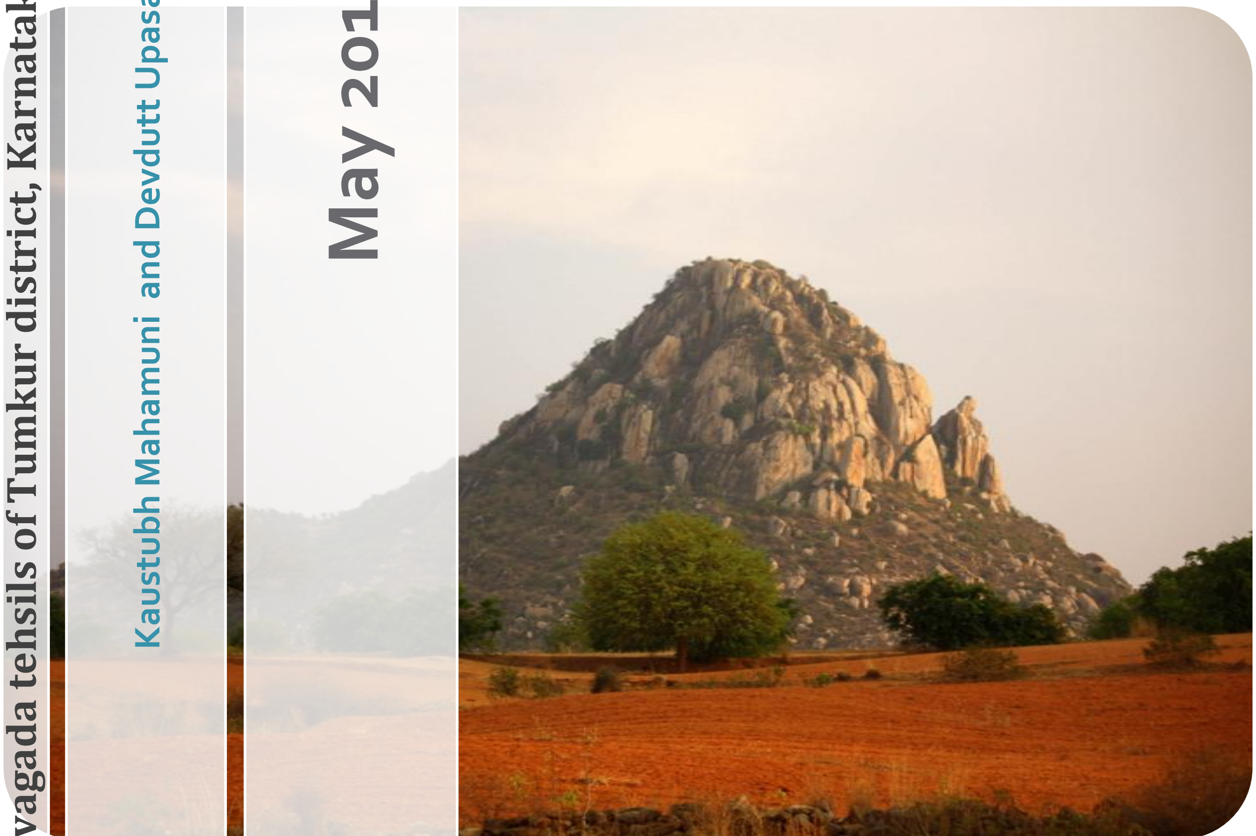

This report is a synopsis of the hydrogeological study carried out for Bird-K in Pavagada, Sira and Bagepalli areas, Tumkur District, Karnataka. The study aimed at an impact analysis of recharge through borewells as well as suggesting new sites for the same.

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Introduction

Groundwater forms the principle source for drinking as well as domestic use of water for large parts of rural India. The most reliable and ancient mode for obtaining this groundwater has been through dug wells. In recent times many of these wells are seen to go dry due to the increasing use and over abstraction of groundwater. Thus the present trend shows a shift from the use of traditional dug wells to drilling and pumping from deep borewells.

"An aquifer is a geologic formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs." The dug wells usually penetrate the shallow unconfined aquifer to obtain water while the borewells draw water from the deeply situated confined aquifers.

The recharge and discharge area of the aquifers are site-specific, based on the local geology. Thus a detailed hydrogeological study of an area is of prime importance before executing improved recharge through well or aquifer recharge, or even through a comprehensive watershed conservation, development and management plan.

Objectives and methodology

The principle objectives of the study were:

1. Impact analysis of aquifer recharge through borewells done by BIRD-K in Pavagada and Sira Clusters
2. Suggest new sites for aquifer recharge through borewells in Bagepalli cluster.

The methodology used comprised a background study of the area through Google images. A detailed geological fieldwork in the area was carried out. Various structural and hydrogeological measurements were made to map out the Aquifer systems within the area. Water levels in borewells and dug wells were measured.

Based on the above mentioned approach, impact analysis of aquifer recharge through borewells and suggestion of new sites for borewell recharge was done.

Location

The study area comprises seven watersheds and falls in two clusters namely Pavagada and Sira. Both these clusters are located in the Tumkur district of Karnataka.

Pavagada Cluster

Pavagada is located at 90 km northeast of Tumkur. The study areas in this cluster are four watersheds viz.

1. Mangalwada
2. Jangamarahalli
3. Kanameri
4. Jajurayanahalli

Sira Cluster

Sira is located at 50km north of Tumkur. The study areas in this cluster are three watersheds viz.

1. Nadur
2. Brahmasandra
3. Boppanadu

Hydrogeology and Groundwater System

Pavagada Cluster :

1. Mangalwada

The study area comprises of Granites. These granites show a viarition in grain size from medium to coarse. Felspathic veins are observed at various places. Porphyritic crystals of feldspars are also present. 2 -3 sets of fractures are observed within the granite of which those trending NE-SW are prominent.

A dyke, basic in composition is observed trending 80º-260º. This dyke forms the Northeastern boundary to the watershed.

Weathering is observed along the fracture zones. Granite with feldspar porphyry is also seen to weather at a higher degree. Weathering is restricted to the shallow depths and is observed in pockets.

These shallow, weathered pockets in the granite form the uppermost shallow unconfined aquifers. The water level in these unconfined aquifers is about ~10-12 feet from the ground surface.

Fractured granites form the deeper, intermediate, partially confined aquifer which is present below the shallow unconfined aquifers. This aquifer is present at a regional scale i.e. it has a lager extent than the unconfined aquifer. Water level in this aquifer is found to be at ~45-50 feet.

A third deeper aquifer confined in nature is present at ~ 300 feet which is tapped by some of the borewells.

Photo 1: Recharge borewell in a tank at Mangalwada

Probable Impacts of borewell recharge

- The effect of recharge through the borewell may be seen in the shallow unconfined aquifer. This can be observed as a rise in the water level of the dug wells tapping this unconfined aquifer.
- The intermediate partially confined aquifer has seemed to benefit from the borewell recharge. This effect can been visible in borewells located along the fracture zone.
- The deeper aquifer may not show a significant impact of the recharge through borewell.

2. Jangamarahalli

The geology of this area is similar to that observed in Mangalwada. The porphyritic granites are seen to weather more as compared to the medium grained variety. Fractures trending N-S and NE-SW direction are observed in the area. Isolated pockets of weathering are observed within the area.

Two dykes trending almost E-W mark the Northern and Southern boundary of the watershed.

The weathering which is observed in pockets is restricted to shallow depths, thus forming the shallow unconfined aquifers. These are tapped by most of the dug wells in the area. The water level in some of the wells was found to be at ~18-20 feet from the ground surface.

The fractured granites at intermediate depths form the second aquifer which is partially confined in nature. The water level in some of the borewells tapping this aquifer was found to be around 40-45 feet.

Probable Impacts of borewell recharge

- The effect of recharge through the borewell may be seen in the shallow unconfined aquifer. This can be observed as a rise in the water level of the dug wells tapping this unconfined aquifer.
- The intermediate partially confined aquifer is also seemed to benefit from the borewell recharge. This effect can been visible in borewells located along the fracture zones.

3. Jajurayanahalli

The study area comprises of Gneisses which show a foliation trend in the N-S direction. Felspathic veins are seen within the gneiss throughout the area. A gradation from granite to gneiss is also seen at places. Typical granitic fractures (sheet joints) are exposed in a dug well. The fractures trend N-S along the foliation and tend to dip in the East direction.

Thick lenses of biotite mica are seen concentrated at isolated places within the Gneiss. These lenses are thick in nature but have a small extent horizontally. They act as confining beds restricting further infiltration of groundwater, thus forming local, isolated, multiple unconfined as well as partially confined aquifers.

The shallow weathered profile of the gneisses over a regional extent forms the regional unconfined aquifer tapper by most of the dug wells.

Probable Impacts of borewell recharge

- The effect of recharge through the borewell will be observed in aquifers located at a depth of ~100-120 feet and would be of a local nature.
- A rise in water level of dug wells can be observed as a direct recharge from the tank.
- The borewells and dug wells located to the eastern part of the recharge borewell will favor the effect of recharge as the fractures in the gneiss tend to dip towards the east.

4. Kanameri

The area comprises of felspathic granite which is coarse grained in nature. Two prominent sets of fractures trending NW-SE and NE-SW are seen in the granite. The weathered zone in the granite forms the regional shallow unconfined aquifer.

Weathering at intermediate depths along the fractures form the partially confined aquifer over the area. A deeper aquifer of confined nature is present at depths below 350 feet.

Probable Impacts of borewell recharge

- The effect of recharge through the borewell will be observed in borewells located along the fractures in the downstream part.
- The deeper aquifer may not show any effect of the recharge done through the borewell.

Sira Cluster :

1. Brahmasandra

The area dominantly comprises of granite gneiss. At a few places it is seen to be rich in biotite mica. The granite has undergone intense weathering for a depth of ~18-20 feet. This weathered zone forms the shallow unconfined aquifer.

A second deeper, partially confined aquifer is present at a depth of ~60-90 feet. This is indicated by the water levels in some of the borewells. A few borewells show a shallow water level same as that of the unconfined aquifer. This is because the unconfined aquifer has not been cased out at various places indicating a leakage from the shallow aquifer to the deeper partially confined aquifer.

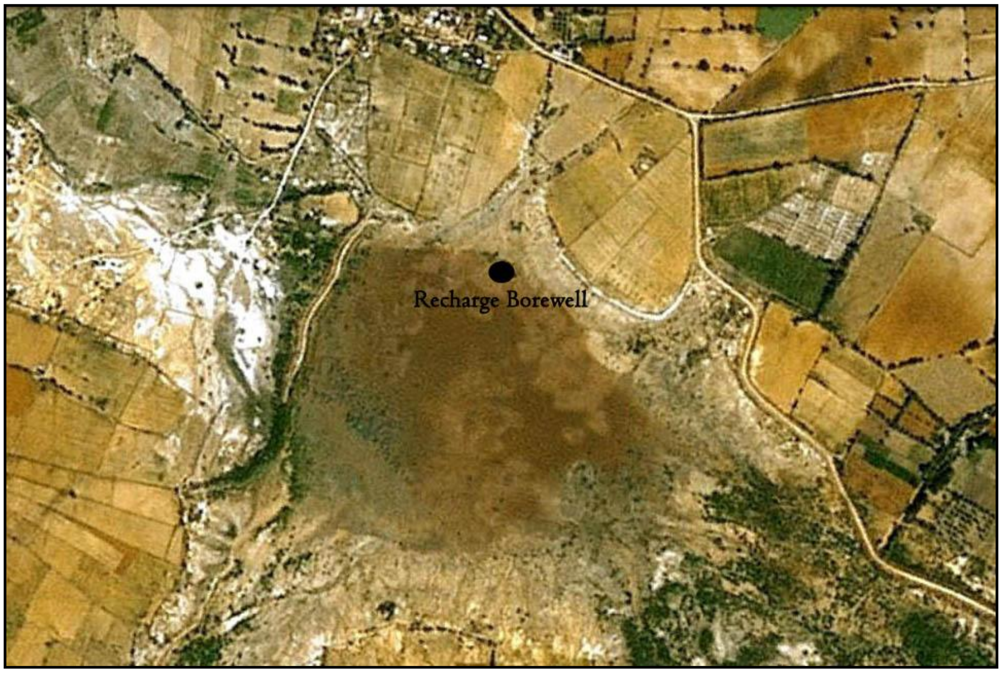

Photo 2: Recharge borewell in a tank at Brahmasandra

Probable Impacts of borewell recharge

- The effect of recharge through the borewell will be observed in borewells located in the downstream part.
- This effect would be mainly observed in borewells tapping the partially confined aquifer.
- No effect would be observed in the deeper aquifer present below 300 feet.

2. **Nadur**

The area comprises of biotite gneiss which is weathered to a depth of 18-20 feet. Fractures dipping in the NE directions are observed. A considerable soil thickness is observed over the area. The weathered zone forms the shallow unconfined aquifer which is dry at present.

Felspathic veins are observed within the granite throughout the area. A partially confined aquifer is present at a depth of ~60-80 feet as indicated by the water level in some of the borewells.

A deeper confined aquifer is present at a depth below 350 feet which is rarely tapped by the borewells.

Probable Impacts of borewell recharge

- No effect of the recharge borewells would be seen the shallow unconfined aquifer.
- A direct effect of the recharge will be seen in the intermediate partially confined aquifer which is tapped by most of the borewells.
- The borewells rarely tap the deeper confined aquifer, thus no effect of recharge would be observed in the confined aquifer.

Photo 3: Recharge borewell in a tank at Nadur

3. **Boppanadu**

The area comprises of biotite schist and gneiss. Felspathic veins are observed within the gneiss. The schist is weathered along fractures to a depth of ~18-20 feet. These weathered zones occur in pockets forming local unconfined aquifers.

Multiple aquifers at various depths of 250 feet, 350 feet are observed depending on the weathered zones. These are of a partially confined nature. A confined aquifer is present below 55o feet.

Probable Impacts of borewell recharge

- The effect of borewell recharge will be observed in the partially confined aquifers at a local scale.
- Dug wells in the downstream part may also exhibit the effect of recharge.
- The borewells rarely tap the deeper confined aquifer, thus no effect of recharge would be observed in the deeper confined aquifer.

Photo 4: Area typical granite outcrop from the area – *inselbergs and tors are common*

Photo 5: Incipient weathering – fresh granite overlying weathered granite.

Photo 6: Sub-horizontal sheet joints in granite exposed in a well

Photo 7: A Basic Dyke standing out as a ridge; these regional features clearly hold a control on the groundwater conditions

Photo 8: The structure of a recharge borewell located in a tank

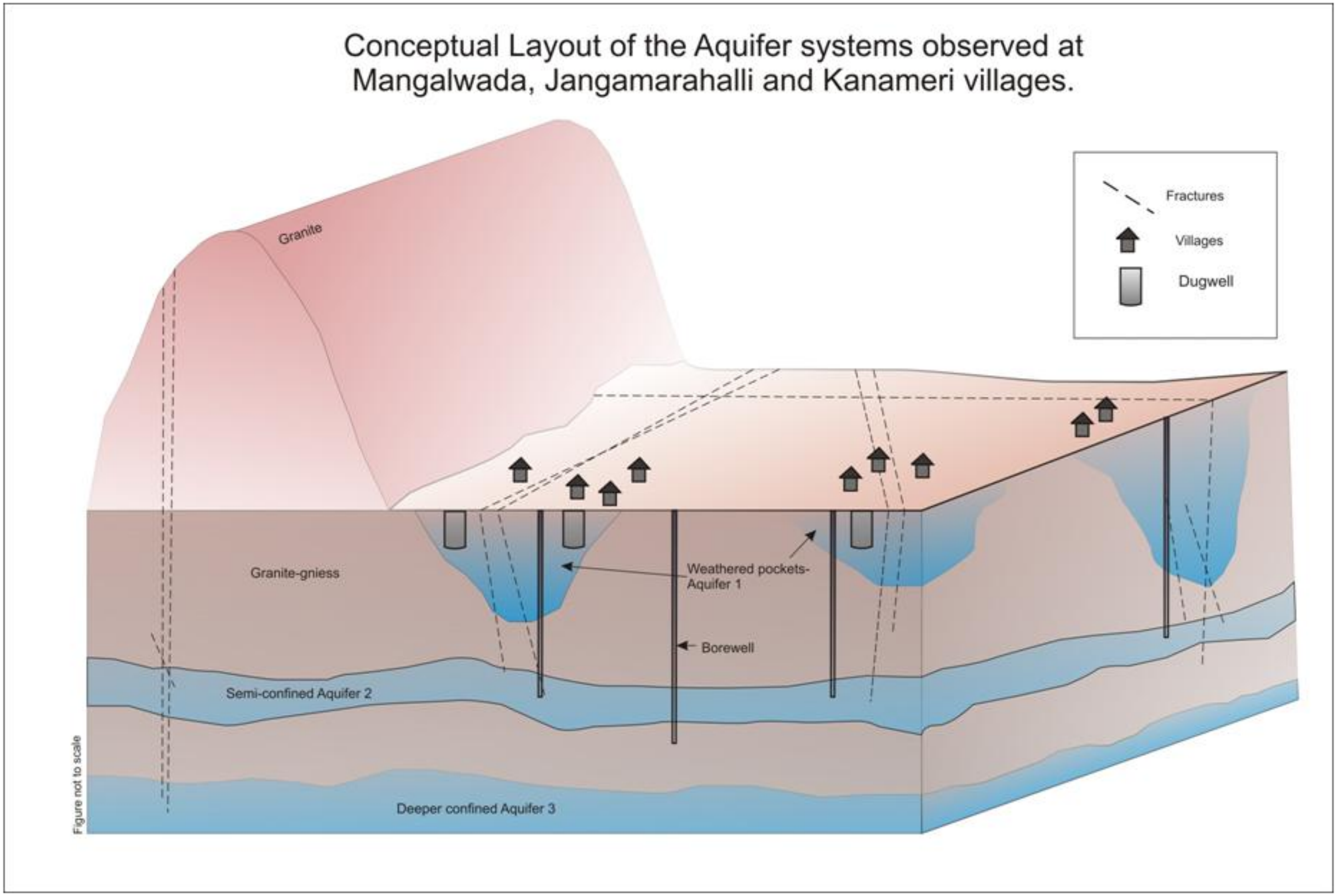

Figure 1: Conceptual layout of the Aquifer Systems observed at Mangalwada, Jangamarahalli and Kanameri villages

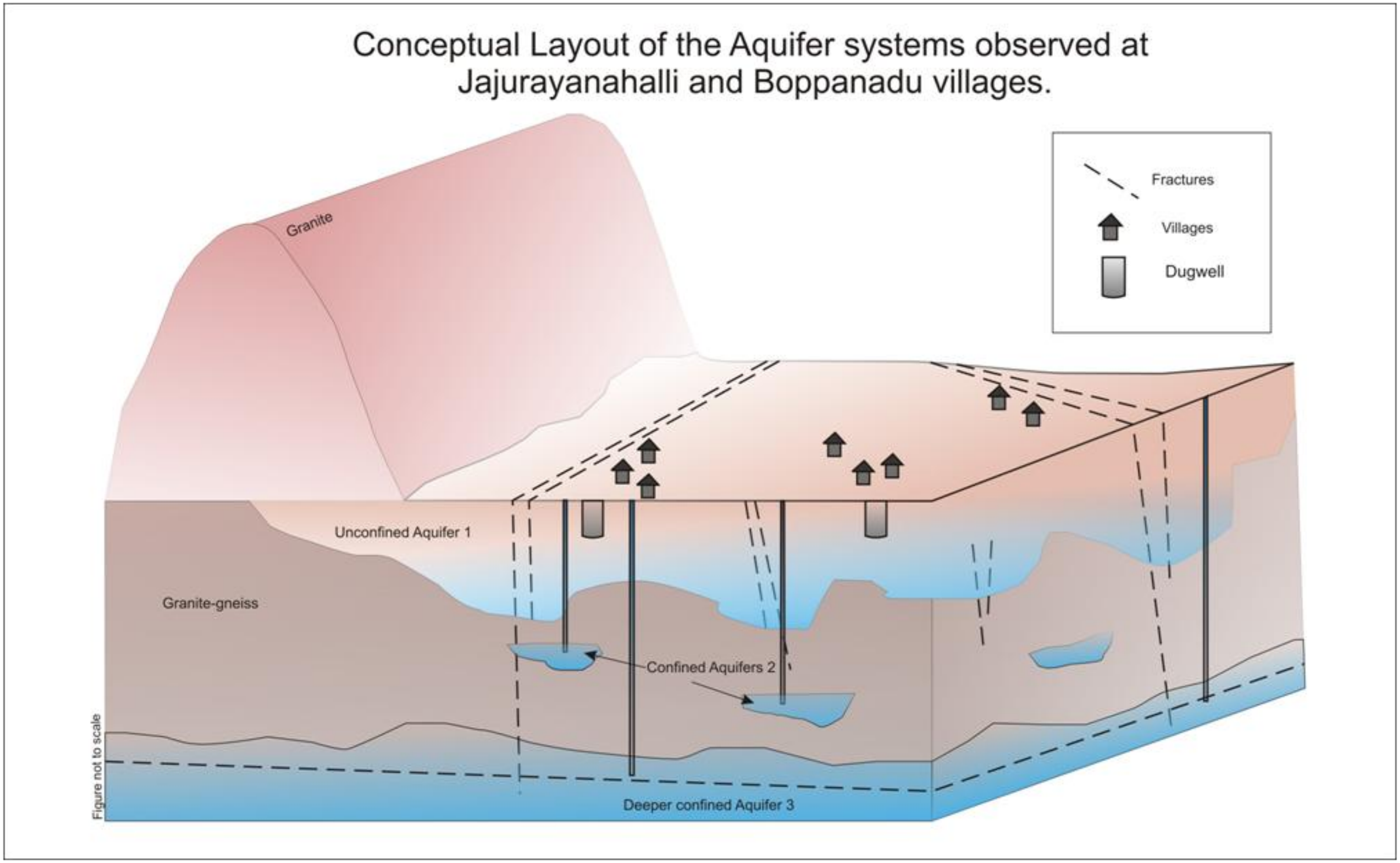

Figure 2: Conceptual layout of the Aquifer Systems observed at Jajurayanahalli and Boppanadu villages

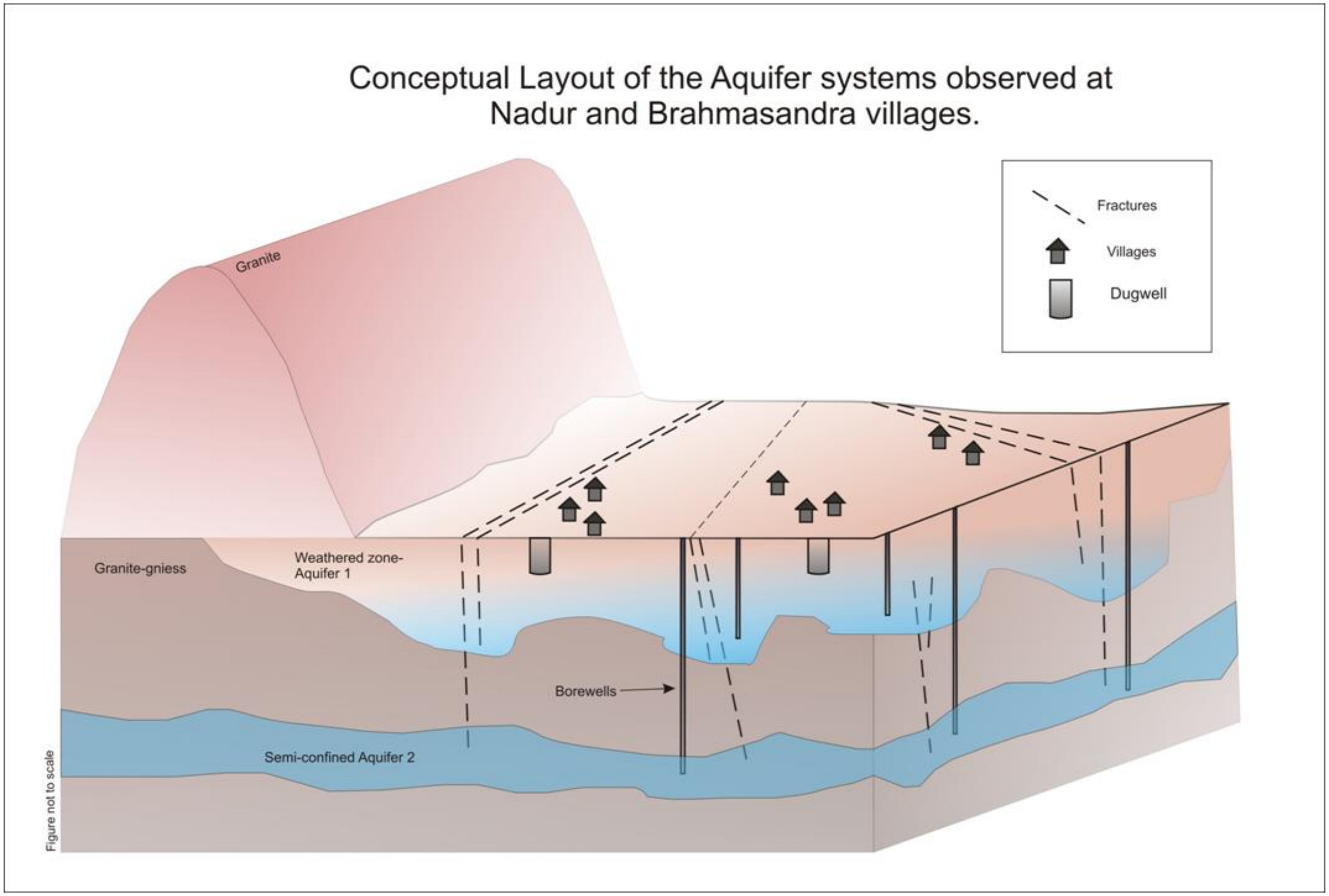

Figure 3: Conceptual layout of the Aquifer Systems observed at Nadur and Brahmasandra villages

A Note On Fluoride Entering Groundwater

Fluoride in groundwater is a natural phenomenon. Hence, the quantity of fluoride in groundwater depends upon the contact between groundwater and the rock medium through which it moves. Fluoride enters groundwater through chemical reactions with rocks that contain fluoride bearing minerals. The minerals apatite, fluorite and micas are common mineral sources for fluoride (Macdonald et al, 2005). This implies that suites of rock that include these minerals are likely to release fluoride into groundwater. It also implies that the chemistry of groundwater itself plays a significant role in the mobilization of fluoride. It is generally believed that fluoride from rocks enters groundwater through:

- The process of weathering of rocks and soils.
- Entry of chemical fertilizers into groundwater.
- Infiltration of existing fluoridated water
- Other sources, like effluents from certain industries.

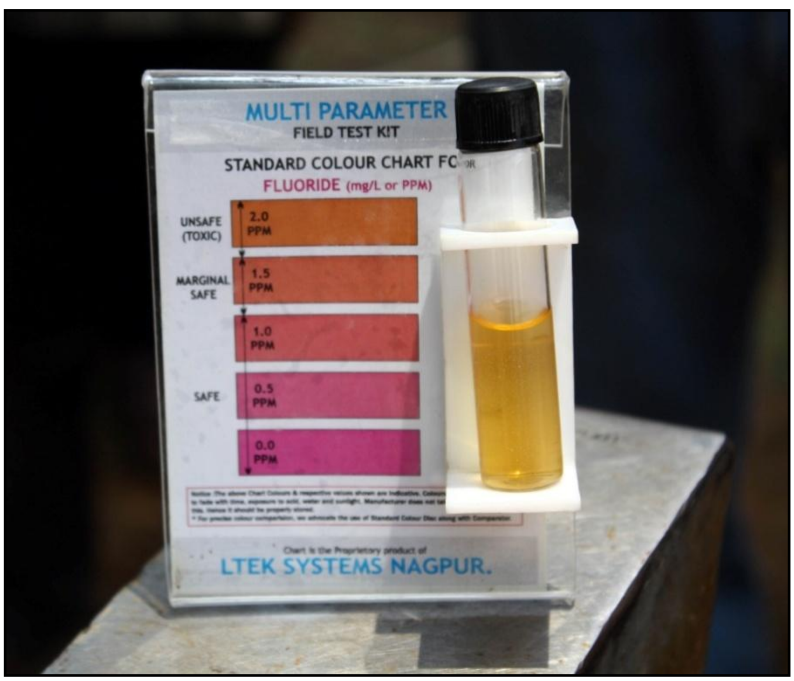

Photo 9: A water sample from a handpump showing a high fluoride content.

Persistent ingestion of fluoride above the guideline value of 1.5 mg/l is supposed to lead to dental fluorosis and in extreme cases, to skeletal fluorosis (BGS-Water Aid Factsheet on Fluoride). Given the fact that fluoride may enter water from a variety of sources, it becomes difficult to follow the spatial and temporal distributions of fluoride. Conventionally, it was believed that fluoride in drinking water would be restricted to regions underlain by granitic rocks and tectonic zones. However, as newer data becomes available, fluoride bearing groundwater is reported from other rock regions as well. Weathering of fluoride bearing minerals (fluorite, apatite and mica) releases fluoride to groundwater, rendered quite widespread because fluorine is the most reactive of all elements in nature. The amount of fluoride in groundwater can be quite area-specific, because it depends upon a set of factors, rather than just a suite of minerals or the type of rock. These factors can be summarized as follows :

- The geologic setting
- Contact time with fluoride bearing rocks
- The chemistry of groundwater
- Climatic factors

Groundwater from regions underlain by granitic gneiss is prone to a high fluoride count. The Fluoride count of the water samples tested in Pavagada area were within the permissible limits with an exception of Jangamarahalli showing a slightly higher value.

The water samples tested from the shallow unconfined aquifer in the Sira area showed a higher value of Fluoride contamination. A majority of the handpump water in the area was seen to be contaminated with fluoride.

Recommendations for Recharge augmentation and Fluoride mitigation

- A hydrogeological survey should be done before selecting the site for borewell recharge.
- Mapping of structural features in the area such as fracture zones, dykes etc, is important.
- The depth of the recharge borewell should not be considered the same for all areas. The depth to be decided after gaining some information about the geology and the nature of aquifers.
- The shallow unconfined aquifer should be completely cased out in the recharge borewell to avoid any leakage between different aquifers and also to prevent entering of fluoride from the shallow aquifer.
- If a geological log is made during the time of drilling a borewell, it would be helpful in interpreting the subsurface geology.
- In terms for impact assessment of the borewell recharge, it is important to measure the water levels in the surrounding borewells. The water levels should be taken accurately with a measuring tape.
- The surface elevation at the borewell is also to be noted.
- Periodic rainfall data of the area should be regularly collected.
- Mica (Biotite) rich granite/gneiss should not be used as a filter media in the recharge borewell. It might act as the source of fluoride in groundwater over the next years.

Site recommendation for borewell recharge in two areas near Bagepalli.

1. Boorgamadgu

Photo 10: Suggested site for borewell recharge

The study area is made up of Granites. A gradation from granite to gneiss is observed. Grain size varies from medium to coarse. The gneiss shows a foliation in the NW-SE direction. Isolated blebs of concentrated biotite are seen within the granite. These blebs are faulted along small fractures. A lot of fracturing is evident in the area. Two main sets of Fractures trending E-W and NE-SW are observed. Some of the fractures are filled by silica veins. These veins are also faulted at some places indicating different episodes of Fracturing.

The stream which flows towards West into the Boorgamadgu tank originates from an another tank located on the ridge on the Eastern side. This stream runs along a major fracture zone trending E-W thus exhibiting a linear nature. Evidences of fracturing such as dislocation, dense vegetation, closed spaced fractures etc, are observed along the fracture zone.

The site for borewell recharge was thus recommended along the fracture zone to facilitate recharge to the partially confined aquifer in the area. The depth of the recharge bore well should be between 200 to 250 feet. Proper care must be taken to case out the shallow unconfined aquifer to a depth of ~50-60 feet from the ground surface.

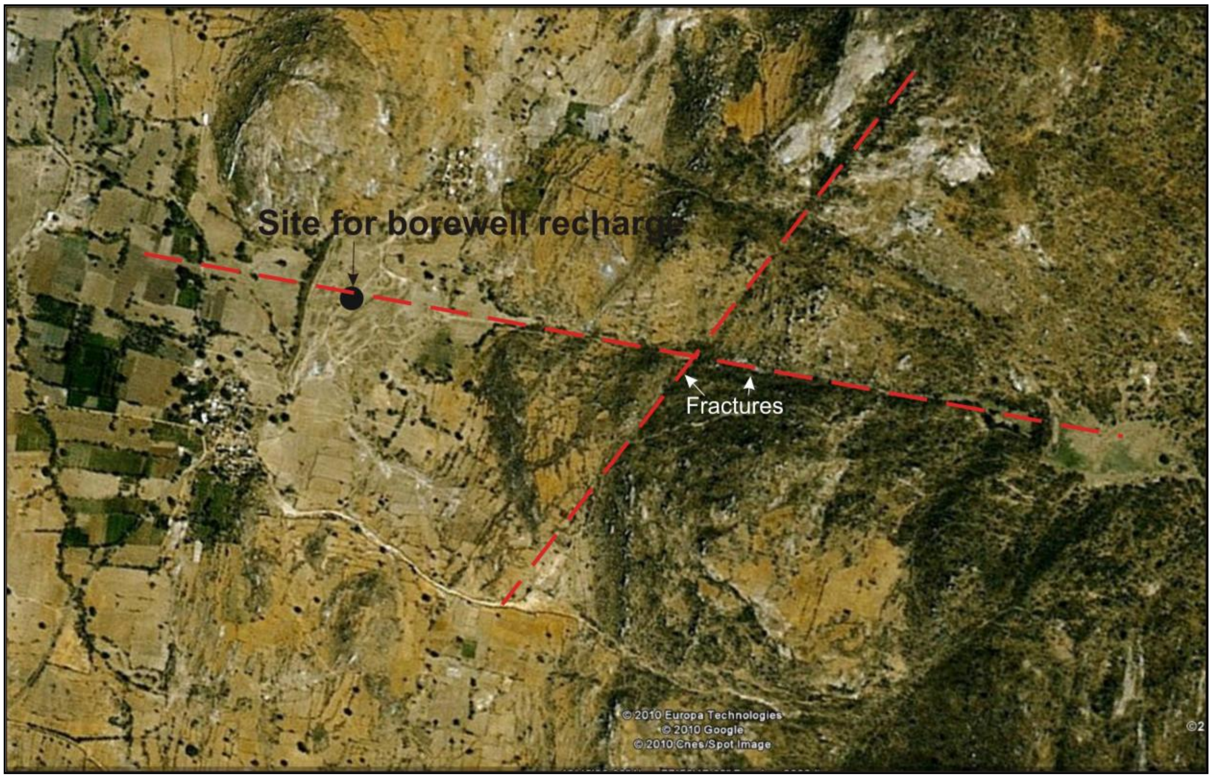

Photo 11: Suggested site for borewell recharge and fractures observed in the area

2. Lagumudhapalli

The study area is made up of Gneiss which shows a foliation trend in the N-S direction. A shift in the foliation direction towards E-W is also observed at some places. E-W trending fractures are evident in the area. Majority of the drainage in the area is controlled by these fractures.

The site recommended for recharge borewell also lies along the E-W trending fracture zone. Depth of the recharge borewell should ~300 – 350 feet. A high fluoride content was observed in the water sample from the dug well tapping the shallow unconfined aquifer. Thus the shallow aquifer should be completely cased out in the recharge borewell. Practices such as pumping out groundwater from the deeper aquifer and putting it in the shallow dug wells should not be carried out.

Photo 12: Suggested site for borewell recharge

Photo 13: Biotite rich blebs in a granite dislocated along a fault

References:

ACWADAM (2000) Strategy for Watershed development and Management: optimizing recharge and water management in the Kavalratti-Salparahalli, Arsikere taluka, Hassan district, *Karnataka. Report submitted to BAIF Development Research Foundation, Pune. ACWA /2000/H-3.*

ACWADAM (2001) Thematic Mapping of Adihalli-Mylanhalli watershed using Remote Sensing and GIS (With special emphasis on hydrogeological studies). *ACWA/2001/ H-1.*

Bhoite. M.K., 2008: Hydrogeological Study of Kalkeri-Virupapura Watersheds In Mundargi Taluka, Gadag District, Karnataka. M.Sc dissertation, Univ. Of Pune.

Chakabarti S., Reddy U. S. and Natarajan W. K. (1993) Sedimentary structures in the Archaean sediments of Gadag Schist Belt, Karnataka; *Jour. Geol. Soc. India 41*, 523–528.

Davis, S. N. and Dewiest, R. J. M. (1966) Hydrogeology. *John Wiley and Sons,*

Macdonald, D.M.J., Kulkarni, H.C., Lawrence, A.R., Deolankar, S.B., Barker, J.A. and Lalwani, A.B. (1995) Sustainable Groundwater Development of hard-rock aquifers : the possible conflict between irrigation and drinking water supplies from the Deccan Basalts of India. *British Geological Survey (NERC) Technical Report WC/95/52, 54p.New York, 463.*

Mahamuni.K.,2009: Understanding Geohydrological Systems In Hard Rock Areas Around Jamshedpur And Ranchi, Jharkhand. M.Sc dissertation, Univ. Of Pune.

Radhakrishna B. P. and Vaidyananadhan R. (1994) Geology of Karnataka. *Geological Society of India, Bangalore, 298p.*