

Report on
International Training Workshop
on
Surface Geophysics for Groundwater

(02nd – 12th December, 2014)

at

CSIR-National geophysical Research Institute, Hyderabad,



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1. Introduction of the course

An International training workshop was organized by CSIR-NGRI, USGS and Aarhus University, Denmark sponsored by the World Bank and Department for International Development [DFID]. The 10 days rigorous classes were arranged at CSIR-NGRI, Hyderabad from 2-12 December, 2014. The course was designed to provide practical training on the use of Electrical, Electromagnetic and Passive Seismic geophysical methods for groundwater exploration and to understand the physical parameters which govern the aquifer system.

2. Background of the course

In context with the Hydrology Project II programme, the World Bank has funded a collaborative project of “Aquifer Mapping on the pilot areas”. The project was taken up in June 2012 and mapping of all 6 pilot areas was covered in May 2014. This ambitious project has utilized the expertise of Geophysical community by the application of electrical and electromagnetic methods. After successful completion of the pilot areas, the World Bank aimed towards up-scaling the same programme on the national level. Thus there was a need to relay the hydrogeophysical capability from National to State level. In order to commute the expertise of hydro-geophysicist involved in the project to the state officers, the World Bank formulated this training program on Surface Geophysics. A part of the same program was designed for Borehole Geophysics and was taken up by Indian Institute of Technology, Kharagpur in 2014.

3. Objectives of the course

The broad objectives covered during the training course are

- Explanation of the basic theory of hydrogeophysical methods,
- Data acquisition strategy and layout of different electrical and electromagnetic instruments.
- Processing of the acquired data for different parameters, noise elimination and inversion modeling of the data acquired.
- Interpretation of the processed datasets with an aim towards groundwater exploration and delineation of aquifer.
- Explanation of various case studies in terms of success of geophysical methods as well as failure.
- Stressing over the necessity of the use of integrated methods towards accomplishment of the specified hydrogeological target.
- Illustration of the limitation and scope of individual methods and application of the same in purview of the target objective.

4. Preparatory phase

Dr. Shakeel Ahmed, Chief Scientist, NGRI was the coordinator of the workshop and the main nodal contact for the same. To make necessary arrangement towards field logistics, registration, accommodation and food, an internal committee was

formed at NGRI which includes, Mr. V.K.Somvanshi (Principal Scientist), Dr. Tanvi Arora (Scientist), Mr. Sateesh Chandrapuri (Scientist) and Dr. Sarah (Research Associate). Support was also taken by few students working at Indo-French Centre for Groundwater Research. This committee was also responsible to take care of necessary instruments for the field campaigns.

Various arrangements included the

- Site selection and preparation for 3 parallel profiles at NGRI campus towards the layout of Electrical Resistivity Tomography [ERT], Vertical Electrical Sounding [VES] and Gradient Resistivity Profile [GRP].
- Site selection and making necessary arrangements for Time Domain Electromagnetic method and passive Seismic stations.
- Availability of boreholes towards calibration and validation of acquired datasets. Preparation of well lithologs and make them available for the trainees.
- Arrangement of the venue , along with the availability of desktop computers, for hands-on exercise for individual trainees.
- Supply of registration kits including the printed copies of relevant lectures,
- Necessary arrangements for the evaluation of individual trainees along with the award of certificates upon completion.
- Necessary boarding and lodging facility within NGRI campus
- Arrangement of transportation for field campaigns; sightseeing; local shopping as well as pick-up and drop to airport for participants as well as faculty.

5. Faculty of the course

The faculty included experts from United States Geological Survey (USGS), Aarhus University, Denmark, NGRI and World Bank, listed below:

Dr. John W. Lane	USGS	USA
Dr. Eric White	USGS	USA
Dr. Jesper Bjergsted Pedersen	Aarhus University	Denmark
Dr. P. C. Chandra	World Bank	India
Dr. S. K. Verma	CSIR-NGRI	Hyderabad, India
Dr. D. Muralidharan	CSIR-NGRI	hyderabad, India
Dr. Subash Chandra	CSIR-NGRI	Hyderabad, India
Dr. Shakeel Ahmed	CSIR-NGRI	Hyderabad, India

TRAINING SCHEDULE

Day & Date	Time	Details	Instructor
Tuesday Dec. 2, 2014	10.00-10.30 hrs	Welcome & Registration (Room No. 115 GWB)	TA
	10.30-11.40 hrs	Opening Ceremony & Introduction of the faculty and participants	
	11.45-12.45 hrs	Visit to CSIR-NGRI: Seismic Observatory, Groundwater Projects & IFCGR	RR
	12.45-14.00 hrs	Lunch	
	14.00-15.00 hrs	Keynote Address - Applications of Surface Groundwater Geophysics in India: A Retrospective	PCC
	15:30-17:30	Course Overview and Intent; Physical Properties of the Earth; Conceptual Hydrologic models, Geophysical methods in Groundwater Exploration	JWL
Wednesday Dec. 3, 2014	09.30-11.30 hrs	1D Electrical Methods- Basics, Profiling, Soundings, GRP, Principle of Equivalence, etc.	PCC
	11.30-13.00 hrs	Examples and field Applications	DM
	14.00-17.30hrs	Electrical Resistivity Tomography (ERT) Basics: Forward and Inverse Modeling	JWL
Thursday Dec. 4, 2014	09.30-13.00 hrs	Electrical Resistivity Tomography (ERT) Basics: Forward and Inverse Modeling - Continued	JWL
	14.00-14.45 hrs	ERT Field Instrument and Survey Design	SC
	14.45-15.30 Hrs	Introduction to Field site in NGRI Campus	DM
	16.00-17.30 hrs	Passive seismic HVSr - theory and case studies	JWL + EW
Friday Dec. 5, 2014	09.30-13.00 hrs	ERT and HVSr field data collection- Layout, Collection, Data Transfer, etc: Group I	JWL,EW NCM+SS+ARD
	14.00-17.30 hrs	ERT and HVSr field data collection- Layout, Collection, Data Transfer, etc: Group II	JWL,EW TA+NVB+EN
	14.00-17.30 hrs	ERT and HVSr Data Processing	JWL, SC,EW
Saturday Dec. 6, 2014	09.30-13.00 hrs	ERT and HVSr field data collection II- Layout, Collection, Data Transfer, etc: Group-I & II	JWL,EW NCM+SS+ARD TA+NVB+EN
	14.00-17.30 hrs	ERT and HVSr Data Processing II - Integration of VES, ERT and Passive Seismic Data and Comparison with Borehole data	SC, JWL,EW
Sunday Dec. 7, 2014	Week-end Free		
Monday Dec. 8, 2014	09.30-13.00 hrs	Electromagnetic Methods- Basics	SKV
	14.00-17.30 hrs	Electromagnetic methods: FEM,VLF and TEM comparison with applications and limitations; India and International Case Studies	JBP+JWL
Tuesday Dec. 9, 2014	09.30-18.00	Full scale geophysical (TEM, Passive seismic, & ERT)data collection at Experimental Hydrogeological Park	JBP, SC
			JBP,SC
Wednesday Dec. 10, 2014	09.30-17.30 hrs	Field Cont....Spare alternate day.../ ERT and TEM data processing and discussion	JWL,JBP, SC
Thursday Dec. 11, 2014	09.30-13.00 hrs	ERT and TEM data processing and discussion	JWL, JBP, SC
	14.00-17.30 hrs	ERT and TEM data processing and discussion--continued	JWL, JBP, SC
Friday Dec. 12, 2014	09.30-13.00 hrs	Airborne and Surface Geophysics Case Studies	SC, JBP, JWL
	14.00-17.30 hrs	Exam, Suggestions/Recommendations, Result declaration, certificate distribution and Closing Ceremony	JWL, SA

Shakeel Ahmed-SA, John William Lane-JWL, Prabhat Chandra Chandra-PCC, Jesper Bjergsted Pedersen- JBP, Eric White –EW, Saurabh K. Verma-SKV, Subash Chandra-SC, D. Muralidharan-DM, Tanvi Arora-TA, NC Mondal-NCM, Sahebrao Sonkamble-SS, A Ramadevi-ARD, N Veerababu-NVB, E. Nagaiah-EN

6. Participants

There were total 43 trainees from different government organization of AP, Gujarat, Jharkhand, Karnataka, Maharashtra, Rajasthan, Tamil Nadu, Telangana, West Bengal and France. The list of participants includes:

Sr. Nr	Name	Organisation	Place
1	N. Veerababu	CSIR-NGRI	Hyderabad
2	Kanithi Chinnababu	AP GWD	Srikakulam
3	P. Harish	AP GWD	Karimnagar
4	Anuradha Mallarapu	AP GWD	Eluru
5	S. Sarah	CSIR-NGRI	Hyderabad
6	Somnath Paira	SWID-WB	Burdwan
7	Reddypogu Suvarna Kumar	APGWD	Ananthapur
8	Arun Mondal	SWID-WB	Coochbehar
9	E. Nagaiah	CSIR-NGRI	Hyderabad
10	Ratan Kumar Samadder	SWID-WB	Kolkata
11	Tanvi Arora	CSIR-NGRI	Hyderabad
12	Sandip Kumar Das	SWID-WB	Kolkata
13	Shamik Chaterjee	SWID-WB	Kolkata
14	N.C. Mondal	CSIR-NGRI	Hyderabad
15	K. Ravishankar	AP GWD	Medak
16	Anuj Kumar Agarwal	RGWD	Kota
17	Rhitwik Chatterjee	SWID-WB	Kolkata
18	Mousumi Neogi Adhikari	SWID-WB	Kolkata
19	Joy Chaudhary	CSIR-NGRI	Hyderabad
20	A. Ramadevi	CSIR-NGRI	Hyderabad
21	Nishat Ahmed	GSDA	Nasik
22	K Srinivasarao	GSDA	Amrawati
23	Rajinder kumar Rana	RGWD	Jaipur
24	Naresh Bhatia	RGWD	Jaipur
25	Animesh kumar N. Palchoudhary.	GWRD-Guj	Gandhinagar
26	Prakash Chandra Das	WRD-CG	Durg
27	Gautam Kumar	WAPCOS	Delhi
28	A. Suhail Ahmad	PWD-TN	Chennai
29	Virendra Kumar Upadhyay	UPGWD	Lucknow
30	Karnati Shankaraiah	TSGWD	Hyderabad
31	Sajal Kumar Das	SWID-WB	West Bengal

32	T.Raja Babu	CGWB	Hyderabad
33	G.Krishnamurthy	CGWB	Bangaluru
34	K.Ramesh Reddy	CGWB	Ranchi
35	Thomas Schwarz	IFCGR	France
36	Sateesh Chandrapuri	NGRI	Hyderabad
37	Farooq Ahmad Dar	NGRI	Hyderabad
38	Sahebrao Sonkamble	NGRI	Hyderabad
39	Ankita Chatterjee	NGRI	Hyderabad
40	Taufique Warsi	NGRI	Hyderabad
41	Md. Wajhiuddin	NGRI	Hyderabad
42	K.Swathi	NGRI	Hyderabad
43	K.Lohith Kumar	NGRI	Hyderabad

7. Knowledge Generation

The concept of the course was “Experiential Learning”, with a mixture of classroom lectures and field exercises. The focus was on the concepts, practical tools and applications. Keeping in mind the target participants of different specialization within Earthscience, theoretical equations were not included in the teaching material. The basic idea was to make participants learn from the practical examples, apply the basic principles of the physics, to gain confidence over the results acquired and also to recognize the limitations of every method.

The topics covered theoretical and as well as field experience of the application of Electrical, Seismic and Electromagnetic methods like Electrical Resistivity Tomography [ERT]; Time Domain Electromagnetics [TDEM]; Horizontal to Vertical Spectral Ratio [HVSr] to groundwater studies. A special emphasis was given on alluvial aquifer systems including sand/gravel aquifers or silt/clay aquitards. The complete transformation of conceptual model into computer model was illustrated in order to determine if a geophysical survey can locate freshwater in a hydrologic setting.

There were 2 days of rigorous field data acquisition, processing and interpretation in Choutuppal as well as within NGRI campus.

A clear need of geophysical methods was envisaged with objectives and solutions towards; formulation of a tractable problem in hydrological setting ; noticeable difference in physical properties emerges a need to be the presence of physical contrast; the contrast need to be detected through ground geophysics/borehole/Airborne; and the geophysical survey need to be logistically feasible in terms of time/cost/environmental conditions.

An overview of the geophysical property to be measured, relevant hydrologic parameter evaluated and the most practical acquisition method to be adopted is tabled below:

Method	Geophysical Property	Relevant Hydrologic Property/Parameter	Acquisition method (s)
DC Electrical Resistivity [ERT, VES, GRP]	Electrical Resistivity	Water content, salinity, pore fluid, porosity, lithology	Lab, borehole, crosshole, surface
Electromagnetic [EM]	Electrical Resistivity	Water content, salinity, pore fluid, porosity, lithology	Lab, borehole, crosshole, surface, airborne
Seismic refraction & reflection, HVSR	Seismic velocities & reflectivity (bulk & shear moduli)	Depth to bedrock, water table, aquifer boundaries	Lab, borehole, crosshole, surface

8. Field Campaign

Two sites were chosen for the demonstration of the geophysical instrument, one NGRI campus and another was Experimental Hydrogeological Park developed by NGRI at Choutuppal. The Experimental Hydrogeological Park (EHP) located in Choutuppal, 45 km south-east of Hyderabad. Vadose zone of EHP comprises an uppermost thin layer of red soil (<1m), sandy regolith (1m-3m), saprolite (10 m – 15 m), and then the a fissured layer until the bedrock (42 m). Both the sites are in the hard rock terrene. NGRI field site was prepared to measure 3 parallel ERT profile at the distance of 20 mts. Along the chosen site all VES, GPR, ERT and passive seismic data was acquired in subsequent timings. Whole of the class was divided into three groups for better understanding. Being in the urban environment TDEM data was all noisy.

The processes involved for interpretation of raw resistivity data were:

- Processing of 2D ERT datasets with various parameters along with
- Interpretation of 2D ERT datasets acquired in different terrenes
- Detailed knowledge about the theoretical background for Resistivity
- Hands on experience in 2D, processing and visualization of data

Similarly the HVSR Ambient-Noise Seismic method was used to acquire data at the location of electrodes along the ERT profiles. A special consideration was given to locations where the Borehole litholog data is already available. A low frequency 3C geophone or 3C medium period seismotmeter was employed from company called Tromino from US. A single-station measurements were recorded. This helped iin determining the resonant frequency of the site from which we can estimate the sediment thickness.

The basic approach towards single-station measurement of HVSR data was:

- Set up and level the seismometer
- Collect data (10-60 minutes)

- Calculate amplitude spectrum of vertical and horizontal components of seismic noise (windows)
- Average the spectrum of the two horizontal (N-S and E-W) components
- Calculate the ratio of the H and V spectrums
- Examine the resonance peak
- After calculating the peak, we calculate the depth-to-rock using local/regional regression equation relating resonant frequency to sediment thickness

9. Feedback

In general, there were few common suggestions from the participants, as below:

- The duration of training should be 15 days instead of 10 days and out of which 7-8 days to be mandatorily dedicated to field demonstrations and operations.
- Supply of sufficient reading material through email, before the commencement of the course.
- Considering the diversity of fields, more stress should be given to explain the basics of the course.
- A continuous field work in different terrene will be good enough to acquire more exposure of the data and its interpretation.
- The course should be repeated at frequent interval.
- National institutes such as NGRI should support the state offices for the detailed training and procurement of geophysical equipment.
- Such type of training are “A MUST” for hydrogeologist.
- The selection of students should commence in a more lenient way.
- A single person should be allowed to attend both surface as well as borehole geophysical training simultaneously. There should not be a bar to “ATTEND ONLY ONE”

10. Test hour

At the end of the training there was an examination conducted and top student award was conferred to 4 participants, along with certificate distribution. The students are:

1. Mr. Nishat Ahmed, GSDA, Nasik. Maharashtra
2. Mr. Rhitwik Chatterjee, SWID-WB, Kolkata
3. Mr. Anuradha Mallarapu, AP GWD, Eluru, AP
4. Dr. Farooq Ahmad Dar, CSIR-NGRI, Hyderabad

11. Light moments and snapshots



Inauguration by
Director NGRI



Glimpses from the Classroom



Field photographs

భూగర్భ జలాలపై పరిశోధన

మందోళ్లగూడెంను సందర్శించిన శాస్త్రవేత్తలు



యంత్రాల సహాయంతో భూగర్భ జల లభ్యతను మూల్యం

చౌటుప్పల్, మ్యూన్సిపాలిటీ : భూగర్భంలోని పొరల్లో దాగున్న నీటిజాడలను కనిపెట్టే పరిశోధనలు చేయడానికి వివిధ దేశాలు, రాష్ట్రాలకు చెందిన 50 మంది శాస్త్రవేత్తలు మంగళవారం చౌటుప్పల్ మండలం మందోళ్లగూడెం గ్రామానికి తరలి వచ్చారు. ఇక్కడ ఇండో- ఫ్రెంచ్ ప్రాజెక్టులో భాగంలో భూగర్భ జలాలపై పరిశోధన చేయడానికి ఎన్జీఆర్ఐఎ ఏర్పాటు చేసిన హైడ్రోజియాలజికల్ పార్కును వారు పరిశోధన క్షేత్రంగా ఎంచుకున్నారు. శాస్త్రవేత్తలు తమ పరిశోధనల్లో భాగంగా భూవిద్యుదయస్థాయి తరంగాలను, భూకంప తరంగాలను యంత్ర పరికరాల సహాయంతో ఇక్కడి వివిధ ప్రదేశాల్లో భూమి లోపలికి పంపారు. భూమిని తవ్వకుండానే భూగర్భంలోని నీటి జాడను కనిపెట్టారు. ఎక్కడ ఎంత పరిమాణంలో నీరున్నది అనే కచ్చితమైన సమాచారాన్ని సేకరించే పద్ధతులపై విశ్లేషించారు.

అంతర్జాతీయ కార్యశాల క్షేత్ర పర్యటన

-షకీల్ అహ్మద్, చీఫ్ సైంటిస్ట్, జాతీయ భూభౌతిక పరిశోధన సంస్థ
జలం జీవనాధారం. జలవనరులు తగ్గిపోతే చాలా నష్టం జరుగుతుంది. నీటి వనరులు ఎక్కడెక్కడ, ఎంత పరిమాణంలో ఉన్నాయనేది తెలుసుకునేందుకు జియోఫిజిక్స్ అధ్యయనం జరుగుతోంది. హైదరాబాద్లోని ఎన్ జీఆర్ఐఎలో ఈ నెల 2 నుంచి 12 వరకు ప్రపంచ వ్యాప్త సహకారంతో సర్వేస్ జియోఫిజిక్స్ ఫర్ గ్రౌండ్ వాటర్ పేరుతో అంతర్జాతీయ కార్యశాల జరుగుతోంది. దీనికి నేను సమన్వయకర్తగా వ్యవహరిస్తున్నాను. దేశవిదేశాల నుంచి వచ్చిన శాస్త్రవేత్తలు, పరిశోధక విద్యార్థులు ఆధునిక పరికరాల ఫలితాలను మందోళ్లగూడెంలో పరిశీలించారు.



విజ్ఞాన మార్పిడి చేస్తున్నాం

- ఎరిక్ వైట్, అమెరికన్ జియాలజికల్ శాస్త్రవేత్త
మేము ఉపయోగిస్తున్న పరికరాలు, డెన్మార్క్, భారతదేశంలో ఉపయోగిస్తున్న పరికరాల్లో పెద్దగా తేడాలేదు. పరిశోధించే విధానంలో తేడాలున్నాయి. ఈ కార్యకలాపాల్లో మా పద్ధతులను వీరికి నేర్పుతున్నాం. భూగర్భ జలాలపై విస్తృతంగా పరిశోధనలు జరుగాల్సిన అవసరముంది.

మరింత శోధించాలి - జస్పర్ పెడస్టెల్, డెన్మార్క్ శాస్త్రవేత్త

సిస్టిక్ మెథడ్, టెరామీటర్లను ఉపయోగించి ఇక్కడ భూగర్భ జలాలను నేలపై నుంచే కచ్చితంగా తెలుసుకునే పద్ధతులపై మందోళ్లగూడెంలో రోజంతా చర్చించుకున్నాం. ప్రయోగాత్మకంగా అందరూ తెలుసుకున్నారు. శాస్త్రవేత్తలు ఇంకా ఆచూకూస పెంచుకోవాలి. నిరంతరం శోధించాలి.

Research on groundwater

Scientists have visited Mondhollagudem

Choutuppall:

Around 50 scientists across International and national level from various organizations are visited Mondhollagudem village, Choutuppall Mandal for delineating the groundwater signatures in subsurface layers. Different methods like geomagnetic and seismic methodology were tested in this program for locating groundwater potential zones and its depth from the surface without drilling. They tested these methods in **Hydrgeological Park** established by NGRI under Indo-French project.

Field visit by International and National researchers -Dr Shakeel Ahmed, Chief Scientist, NGRI

Dr. Shakeel Ahmed said that water is life, if these resources are depleted there is no life. Ten days International training workshop organized at NGRI funded by World Bank for surface geophysics for groundwater. The aim of this workshop is to educate the researchers using modern surface geophysical instruments for delineating groundwater prospect zones. These studies are conducted in Mondhollagudem, Choutuppall.

Exchange of technology -Dr Eric White, USGS

Same instruments are using In USA, Denmark and India for delineating groundwater potential zones. But difference is in applying methodology. It is more important to study on groundwater resources. In this programme we are teaching our techniques to the researchers.

Still need to do research in groundwater -Jesper Bjergsted Pedersen, Denmark

Whole day we discussed regarding the importance of seismic methodology and Terameter in field of groundwater exploration at Mondhollagudem, Choutuppall. Experimentally we understand the same in this field. Researchers have to gain more knowledge on this research.

English translation of the news in Telugu newspaper

Acknowledgements: The most important contribution and genesis of this successful course has been from the World Bank and the special force behind the entire program has been Dr. Anju Gaur with her very dynamic efforts this very important event was possible. Of course, Profs. John Lane and Eric White from USGS and Dr. Jesper B. Pedersen from Aarhus University have come from out of India and spared their valuable time to complete the course. The course has run very smoothly with support of Director, CSIR-NGRI and his large team. Lastly the organizations who have sponsored the participants to reach Hyderabad with a short notice are also acknowledged.