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HYDROCHEMISTRY, GROUND WATER GEOPHYSICS AND WATER SUPPLY POSITION IN BIN BLOCK, PITHORAGARH DISTRICT (UTTARAKHAND)

DEBASISH BAGCHI & PUSHPRAJ SINGH*
Central Ground Water Board
Uttaranchal Region
Dehradun

****Geological Survey of India***
Western Region
Jaipur

INTRODUCTION

- **An area of about 160 sq. km was selected for deciphering the hydrochemical, hydrogeophysical &water supply position in parts of Bin block in Pithoragarh district, Uttarakhand**

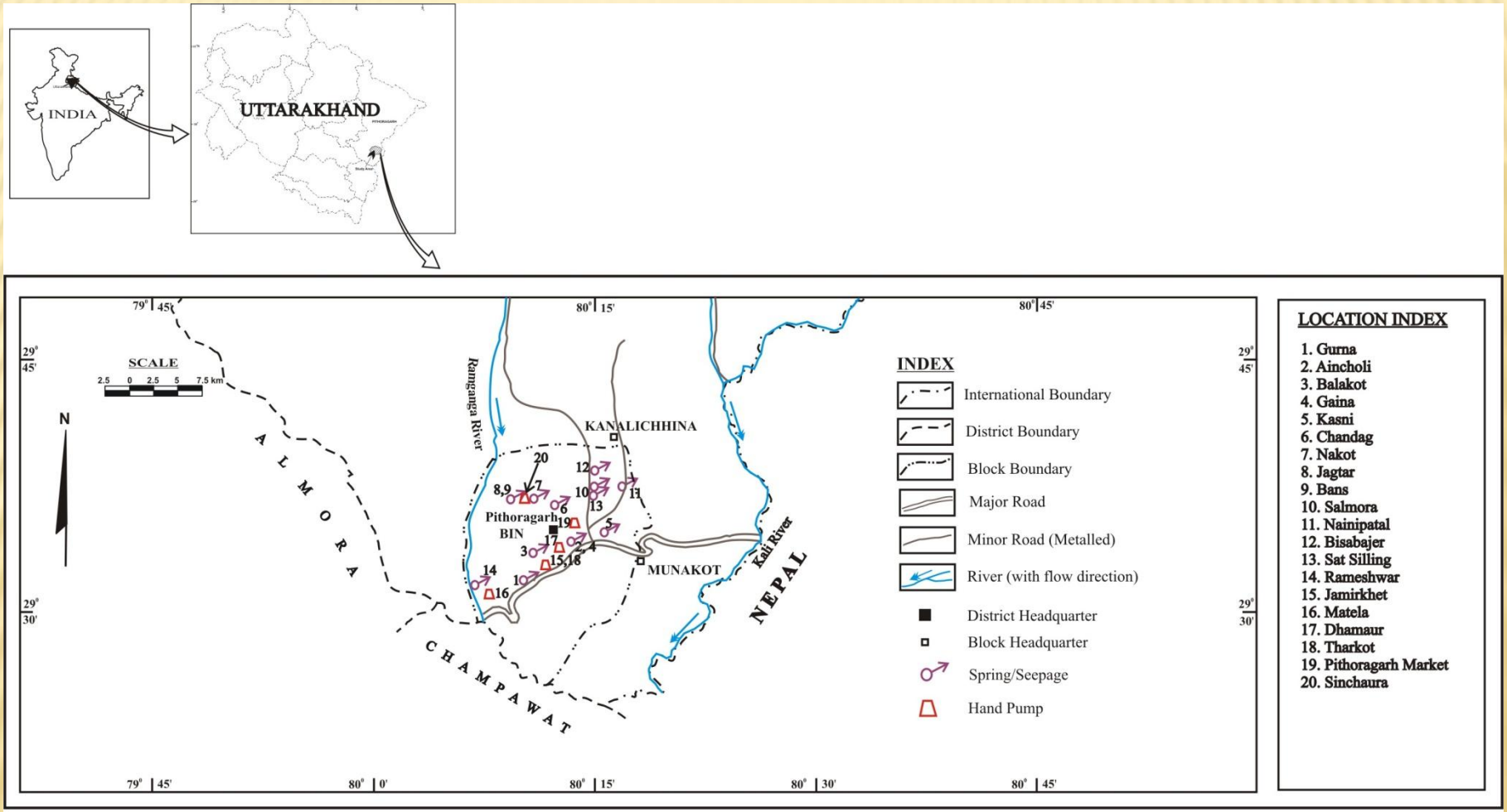
- **The area is a part of eastern Kumaon Himalaya which includes Pithoragarh Town, the district head quarter**

- **Ten VES with AB/2 ranging from 75 to 300 m were carried out to have an idea of potential aquifer zones within the fractured &fissured aquifer system of Lesser Himalaya**

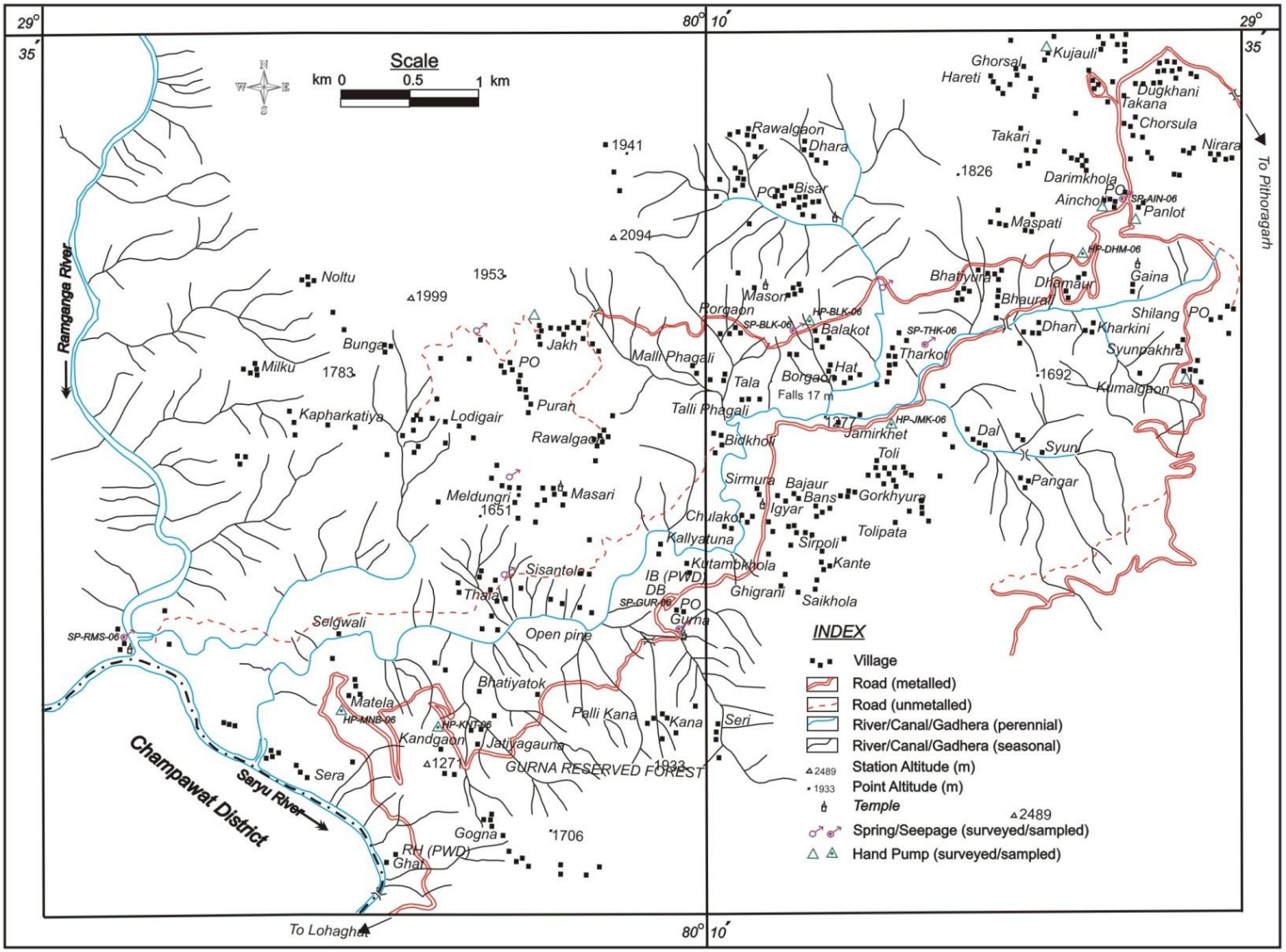
- **Urban water supply position of Pithoragarh Town & rural water supply position of adjoining areas have been documented based on water supply & demand, demographics &ancillary data**

GEOLOGICAL SET UP

- **Metasedimentary &metamorphic rocks of the Lesser Himalayan geotectonic zone constitutes the surface geology in the study area**
- **Geologically, the area is classified under Calcareous Zone of Pithoragarh (Valdiya, 1962) comprising Sor (Thalkedar) Formation &Rautgara Formation**
- **Rocks of Sor Formation includes slate (pyrite bearing, calcareous, carbonaceous), predominantly massive & less commonly jointed limestone (both calcitic & dolomitic) & dolomite. Thalkedar Limestone is exposed along Aincholi-Shilang-Syunpokhra area &along Meldungri-Jakh-Balakot section**
- **The Rautgara Formation comprises quartzite (fine to medium grained) of variable colour, slate & sparse lentils of conglomerate, intruded by basic sills & dykes & is exposed along Rameshwar-Matela-Gurna area**



Location of Springs and Hand Pumps in the Study Area, Bin block, Pithoragarh district



Detailed Study Area (parts of Bin block), Pithoragarh district

HYDROCHEMISTRY

- **Major element analysis of 17 groundwater samples has been done in the Chemical Laboratory, NWR, Chandigarh, which includes 12 samples from India Mark-II hand pumps & 5 samples from seepages &springs (locally known as Naula)**
- **Major element analysis was carried out by titration method, Spectrophotometer & Biotronic UV-flame Photometer**
- **Atomic Absorption Spectrophotometer (GBC-Avanta) was used for analysis of heavy metals**
- **The samples were collected during pre-monsoon period (May to June) from spatially well distributed key observation stations**
- **Complete chemical analysis has shown that 4 samples (23.53% of total) have Total Hardness (as $CaCO_3$) exceeding the Acceptable Limit (200 mg/L) as per revised BIS guidelines (BIS, 2009) with the maximum TH of 340 mg/L in a spring at Chandag. No sample has recorded TH beyond the Permissible Limit (600 mg/L)**

HYDROCHEMISTRY

- **High hardness in groundwater is positively correlated with high degree of mineralization, imparted by leaching of calcium (and magnesium) from calcite & calcitic dolomite/dolomite during rock-water interaction in the fractured aquifer system**

- **High magnesium is detected in 10 samples (58.82% of total), indicating leaching of magnesium from dolomite & dolomitic limestone of Sor Formation & from magnesite deposits in Chandag-Jagtar-Nakote-Bans section (Valdiya, 1980) during rock-water interaction**

- **This is supported by the fact that high magnesium was recorded in samples collected from Chandag (80 mg/L), Jagtar (39 mg/L), Nakote & Bans (36 mg/L)**

HEAVY METAL HYDROCHEMISTRY

- **Heavy metals like copper, iron, zinc, manganese, nickel, lead & chromium were analyzed from selected places like Kandgaon, Sinchaura, Jamirkhet, Matela, Dhamaur, Tharkot & Pithoragarh Market**
- **Analysis results reveal that except iron, manganese & lead, concentrations of other heavy metals are below the Acceptable Limit (BIS, 2009)**
- **High iron (> 300 µg/L with no relaxation) was found in hand pump samples at Pithoragarh Market (1254 µg/L), Dhamaur (1152 µg/L), Matela (1024 µg/L) & Jamirkhet (484 µg/L)**
- **High iron is attributed to rusted casing pipe and/or strainer zone, through which iron is leached into the shallow, fractured aquifer systems. Hence, iron contamination in the study area is anthropogenic**

HEAVY METAL HYDROCHEMISTRY

- **Manganese above the Acceptable Limit (100 µg/L) is found only in a hand pump sample at Dhamaur (108 µg/L)**
- **Positive correlation between high iron & manganese is not observed. This may be due to local groundwater regime (hard, fractured & fissured aquifers) & prevailing Eh-pH condition in the localized aquifers**
- **High lead was recorded in three hand pump samples at Matela (125 µg/L), Pithoragarh Market (21 µg/L) & Kandgaon (13 µg/L). The values exceed the Acceptable Limit With No Relaxation (10 µg/L), which is a matter of concern for the local populace**
- **Lead contamination due to geogenic source is excluded based on the local geology, as lead bearing sulphide minerals (galena, sphalerite, chalcopyrite) are neither reported nor observed in the study area**

HEAVY METAL HYDROCHEMISTRY

- **Groundwater with high lead is found only at selected villages, where the source of groundwater are inhomogeneous & anisotropic aquifers**
- **Hence, lead contamination in groundwater is of local nature & attributed to anthropogenic source**
- **Lead is leached into groundwater possibly from lead-bearing casing pipes. The casing pipes are made of galvanized iron which may have lead above the permissible concentration**
- **Metallurgical testing of casing pipes is required to conclusively establish a positive correlation between hand pump assembly & high lead concentration in groundwater**
- **Due to high toxicity of lead, it is advisable to avoid the hand pumps for drinking purpose**
- **A possible remedy to lead contamination is to utilize PVC pipes instead of the GI pipes. This has to be implemented by the concerned state government department (Uttarakhand Jal Sansthan & Uttarakhand Pey Jal Nigam)**
- **Report on action plan has been handed over to the State Government by the Regional Office, CGWB, UR**

GROUNDWATER GEOPHYSICS

- **A microprocessor based Resistivity Meter (Model: IGIS, SSR-MP-1) was used for carrying out ten VES in the study area with half electrode separation ranging from 75 to 300 m**
- **The VES sites were located at Pithoragarh, Dabri, Jakh, Naini Saini & Jajardewal**
- **VES data was interpreted manually by two-layer master &auxiliary curves. Manual results are processed &interpreted by Schlum Software for cross checking**
- **The data was also interpreted by Resistivity Factor method to decipher the depth range of fractures in the metasedimentary & metamorphic rocks of Sor (Thalkedar) Formation**
- **VES curves were carefully smoothened for constructing a realistic hydrogeophysical model for the study area**

VES SITES


Satsiling
Bansnakote R.F.
Jajurali
Sainkanla
Simalchora
Nakote
Devkatiya
Khatigaon
Jajardewal
Naini Saini Airstrip
Bajeti
DIBER
Dola
Pithoragarh
Gankot
Chaisar
Badlani
Maryura
Jakh, Uttarakhand, India
To Dabri & Bunga
Jakhpuran
Vishadn
Kharkini
Tharkot
© 2014 Google
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Image © 2014 CNES / Astrium
Google earth
2004
Imagery Date: 6/9/2014 29°35'10.71" N 80°11'38.55" E elev 5321 ft eye alt 45834 ft

- **Interpretation of true resistivity from VES reveals four to seven subsurface layers**
- **On the basis of true resistivity, the inferred subsurface geology has been correlated with groundwater potential**
- **Moderate groundwater potential is correlated with a) pebbles of phyllite/slate with clayey sand (Ω 15-120 ohm.m), b) weathered and/or fractured phyllite/slate (Ω 121-250 ohm.m) & c) semi-fractured phyllite/slate (Ω 250-500 ohm.m)**
- **Among ten VES, four VES sites have shown moderate groundwater potential in the study area**
- **The details of four sites (Jajardewal, Dabri, along the right bank of Rain Gad & west of Defence Institute for Bio-energy Research) are given in next slide**

VES RESULTS AT FOUR POTENTIAL SITES

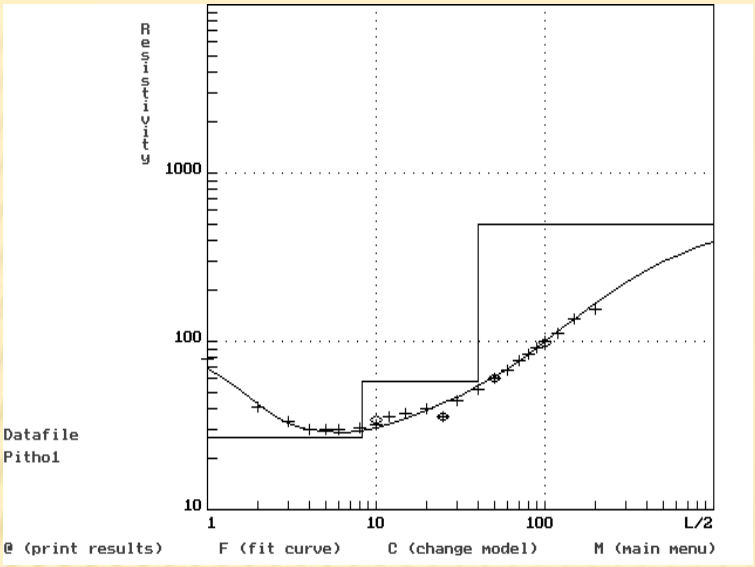
Location	True Resistivity (ohm.m)	Depth Range (m)	Layer Thickness (m)	Inference/Subsurface Geology
Jajardewal	90	0-0.64	0.64	Surface moist soil with pebbles of slate/phyllite
	27	0.64-8.32	7.68	Pebbles of phyllite/slate with clayey sand
	58	8.32-40.32	32.00	Weathered/fractured phyllite/slate
	500	40.32 --	--	Semi-fractured phyllite/slate
Eden Temple Public School, Dabri (Bunga)	220	0-0.68	0.68	Surface soil with dry pebbles of phyllite/slate
	66	0.68-2.87	2.19	Pebbles of phyllite/slate with clayey sand
	26	2.87-5.37	2.50	Weathered/fractured phyllite/slate
	108	5.37-16.17	10.80	Fractured phyllite/slate
	480	16.17-34.87	18.70	Semi-fractured phyllite/slate
	48	34.87-56.07	21.20	Fractured phyllite/slate
	4800	56.07 --	--	Compact phyllite/slate

VES RESULTS (CONTD.)

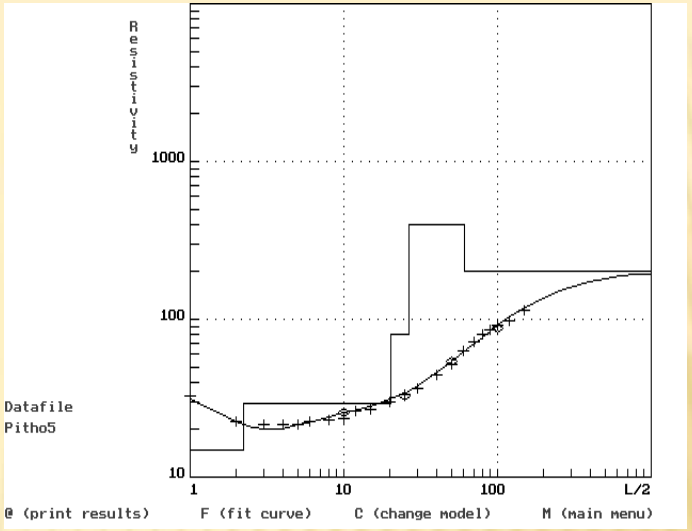
Location	True Resistivity (ohm.m)	Depth Range (m)	Layer Thickness (m)	Inference/Subsurface Geology
East of Rain Bridge, on the right bank of Rain Gad	600	0-0.60	0.60	Surface soil with dry phyllite/slate boulders
	120	0.60-1.80	1.20	Pebbles of phyllite/slate with clayey sand
	410	1.80-19.90	18.10	Weathered/fractured phyllite/slate
	1250	19.90-67.90	48.00	Compact phyllite/slate
	500	67.90 --	--	Fractured phyllite/slate
West of DIBER Field Station, in valley of Rain Gad	150	0-0.62	0.62	Surface soil with dry pebbles of phyllite/slate
	45	0.62-1.98	1.36	Pebbles of phyllite/slate with clayey s&
	120	1.98-7.38	5.40	Weathered/fractured phyllite/slate
	141	7.38-70.78	63.40	Compact phyllite/slate
	250	70.78 --	--	Fractured phyllite/slate

VES RESULTS (CONTD.)

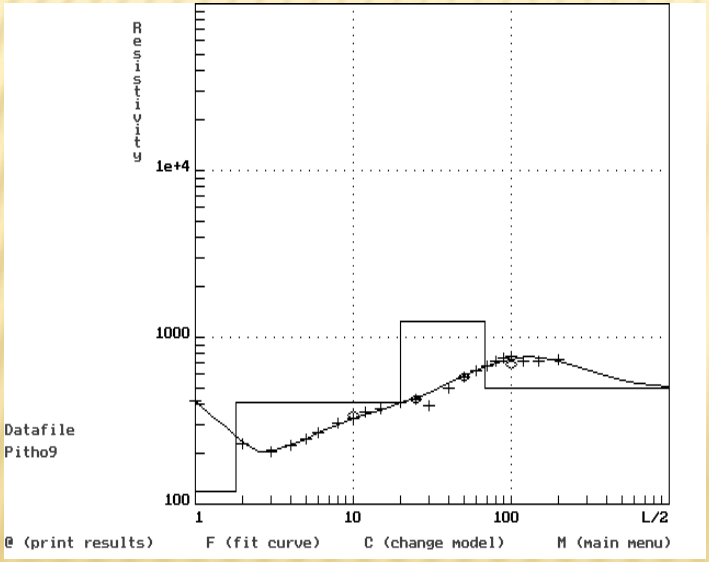
- **The VES sites to the east of Rain Bridge & west of DIBER Field Station are situated in the relatively well developed valley of Rain Gad, a perennial tributary of Ramganga River**
- **Zones having moderate groundwater potential occurs in the weathered & fractured rocks (phyllite and slate) of Rautgara Formation & Sor Slate Member of Sor (Thalkedar) Formation. However, limestone of Thalkedar Member may also form potential localized aquifers, particularly along the litho contact of weathered mantle & the bed rock**
- **Potential zones of groundwater are mostly confined to shallow depths in the range of 10-30 m bgl**
- **DTW in DIBER area is 20.32 m bgl (pre-monsoon, 2013) while that at Jajardewal is 14.69 m bgl (pre-monsoon, 2013)**



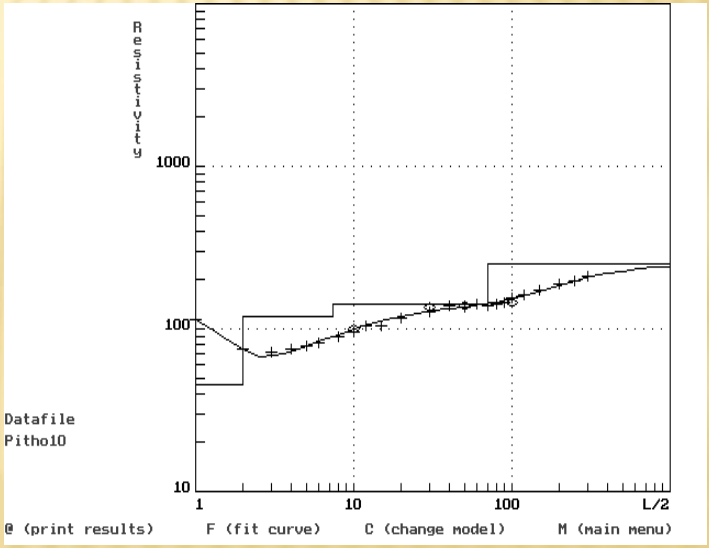
VES Field Curve, Jajardewal



VES Field Curve, Eden Temple Public School, Dabri (Bunga)



VES Field Curve, east of Rain Bridge



VES Field Curve, west of DIBER field station

WATER SUPPLY POSITION

- **Implementation of urban & rural water supply schemes in the study area is jointly done by District Project Management Unit & UPJN**
- **Municipal water supply schemes are funded under Rajiv Gandhi National Drinking Water Mission, MoRD**
- **Perennial springs & gadheras are tapped through gravity for water supply at Bans, Chainsar & Dumet**
- **Prescribed rate of water supply in Pithoragarh Town is 135 lpcd with 15% distribution loss. The effective rate of water supply is 114.75 lpcd**
- **Status of water supply position in the study area:**

  Fully Covered: 170 villages, Partially Covered: 263 villages, Not Covered: 120 villages (Source: UPJN)

WATER SUPPLY POSITION

- **Urban water supply of Pithoragarh Town is based on two gravity schemes (Nainipatal & Bhainlot) & three lift schemes (Rain Gad, Thuli Gad & Ghat)**
- **Supply through gravity schemes is 0.75 MLD & through lift schemes is 4.84 MLD (Period: 2007-08) resulting in total supply of 5.59 MLD against a total designed capacity of 5.92 MLD. There was a shortfall of 0.33 MLD, which has been revised to 0.28 MLD**
- **Actual rate of water supply in Pithoragarh Town is only 70 lpcd against the designed supply (135 lpcd)**
- **As per the latest data (Period: 2013-14), cumulative water availability in Pithoragarh Town is 5.64 MLD against the combined designed capacity (gravity & lift) of 9.75 MLD, with some proposed lift schemes based on Ramganga River &Thuli Gad under the PMRDP**

WATER SUPPLY POSITION

- **Shortfall in water supply (0.28 MLD) is bound to increase with time due to increase in population in & around Pithoragarh Town**
- **Resident Population: 54304, Floating Population: 13964 (Census, 2011)**
- **Projected Population: Resident – 74180, Floating – 19075 (2025 AD)**

  Resident – 99446, Floating – 25572 (2040 AD)
- **Total water requirement was 14.0 MLD (2010 AD), which will increase at a rapid rate – 18.75 MLD (2025 AD) & 25.0 MLD (2040 AD)**
- **Shortfall in water supply: 13.11 MLD (2025 AD)**

  19.36 MLD (2040 AD) assuming the existing rate of water supply (5.64 MLD) remains unchanged
- **An estimate suggests that 83% coverage of a sustainable water supply to every household is achievable by the year 2016**
- **Recently, Uttarakhand Government has sanctioned Rs. 5 Crore for proposed Awlaghat Water Supply Project (lift scheme based on Ramganga River), which will be implemented by the UDWC**

CONCLUSION

- **Major element &heavy metal hydrochemistry has revealed that except for high iron, manganese &lead at few places, groundwater is potable**
- **Due to high toxicity of lead, hand pump water at Kandgaon, Pithoragarh Market & Matela should be avoided for drinking purpose**
- **Lead contamination is possibly due to faulty metallurgy of hand pump assembly. Detailed metallurgical tests in accredited labs is required in this direction**
- **VES studies have revealed zones of moderate groundwater potential in the weathered & fractured slate/ phyllite of Rautgara Formation**
- **Four sites were identified to have moderate groundwater potential - Jajardewal, Dabri (Bunga), east of Rain Bridge & west of DIBER Field Station**
- **Data of rural & urban water supply position has indicated an ever increasing gap between demand & supply**

CONCLUSION

- **Three gravity schemes cater to 433 villages (FC: 170, PC: 263) whereas 120 villages are not covered under any water supply scheme**
- **Actual water supply is only about 70 lpcd in Pithoragarh Town against the norm (135 lpcd) coupled with a shortfall of 0.28 MLD**
- **The shortfall will increase to 13.11 MLD by 2025 AD & to 19.36 MLD by 2040 AD if prevailing schemes are not augmented and/or new schemes are not implemented**
- **There is an urgent need to adopt a holistic water management practice with participatory approach in the study area**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THANK YOU!