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RESEARCH ARTICLE

Integration of borehole electrical resistivity and lithological logs for hydrostratigraphic classification of the Kathmandu valley aquifer system, central Nepal

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ABSTRACT

Electrical resistivity logging and borehole lithological data provide important constraints for evaluating the hydrostratigraphic framework and groundwater potential of Kathmandu Valley. The Kathmandu Valley is an oval, fault-bounded intermontane basin in Bagmati Province, central Nepal, centred near 27.7°N, 85.3°E. The Kathmandu Valley population has grown roughly five-fold since the early 1970s to approximately four million residents today. This study integrates borehole lithologs, electrical resistivity logs, aquifer thickness, and spatial interpolation to characterize the subsurface distribution of aquifers from the southern to northern parts of the valley. A total of 22 borehole records were studied, with resistivity logging performed to identify variations in subsurface materials and their hydrogeological significance. The lithological logs of study area indicate spatial variation in hydro stratigraphy across Kathmandu Valley. Sand and gravel intervals form the principal aquifer materials, whereas clay and silty-clay units constitute the major aquitard horizons. The central part of the valley contains substantial clay-dominated sequences, although discrete higher-resistivity intervals indicate the presence of permeable sand and gravel layers at several depths. The generated hydrostratigraphic map delineate study area into aquifer, leaky aquitard, and aquitard zones. These findings have significant implications for the management of water resources in the region as they provide valuable information of groundwater resources for future use.

Keywords: ***Kathmandu valley, borehole logging, aquifer, aquitard classification, groundwater***

1. INTRODUCTION

The Kathmandu Valley population has grown roughly five-fold since the early 1970s to approximately four million residents today. Decades of over abstraction and over use of groundwater cause water table decline and consequently effects land surface across the valley (Gautam and Prajapati, 2014), and the pressure on the resource continues to grow with the built-up area. Effective management of this system requires hydrostratigraphic framework that identifies where permeable, water yielding material is concentrated, where it is confined beneath low permeability material, and how continuous these units are between individual wells.

The Kathmandu Basin fill is lithologically heterogeneous a Plio-Pleistocene sequence of fluvial, deltaic and lacustrine sediments deposited over a metamorphic basement (Sakai, 2001; Paudel and Sakai, 2008; Dhital, 2015) and different researchers have subdivided it into formations (Yoshida and Igarashi, 1984; Dongol, 1985, 1987; Shrestha et al., 1998; Sakai et al., 2001). Gautam and Rao (1991) classified the Kathmandu Valley into unconfined, confined, two aquifer, and rock aquifer zones. Unconfined aquifers occur mainly near the northern and western margins and consist of sand and gravel. Confined aquifers dominate the central and southern valley beneath thick Kalimati Clay. The central basin contains shallow and deep aquifers separated by clay. Fractured and weathered bedrock along the southern and southeastern margins also forms potential groundwater reservoirs (Gautam and Rao (1991). The Kathmandu Valley has been divided into six hydrogeological formations and three groundwater districts based on geological and groundwater characteristics. (JICA, 1990). The Northern Groundwater District contains highly permeable sand and gravel deposits and represents the most productive aquifer zone. The Central Groundwater District is dominated by thick, impermeable Kalimati Clay, with deep, low permeability aquifers containing old, poorly recharged groundwater. The Southern Groundwater District consists mainly of basal gravel beneath thick clay and has limited aquifer development. The reason, groundwater recharge and occurrence are strongly controlled by the distribution of permeable sediments and extensive lacustrine clay layers (JICA, 1990).

Downhole electrical resistivity logging provides a direct geophysical assessment of subsurface formations, with measured resistivity strongly influenced by porosity, clay content, pore fluid saturation, and fluid salinity (Archie, 1942; Keller and Frischknecht, 1966). It is therefore useful for identifying lithological variations, distinguishing aquifer and aquitard units, and characterizing groundwater-bearing formations. Comparison of resistivity logs with driller's lithological logs enables the discrimination of fine grained, confining units from coarser, groundwater bearing formations at the individual borehole scale (Keys, 1990; Hearst et al., 2000; Rubin and Hubbard, 2005; Binley and Kemna, 2005).This general approach calibrating resistivity against lithology, then using the calibrated signature to classify hydrostratigraphic units has been applied successfully to alluvial and intermontane basins elsewhere in the region and beyond, to resolve fluvial aquifer heterogeneity in general (Bowling et al., 2005), to trace fresh–saline interfaces in the Cholistan Desert of Pakistan (Arif and Khalid, 2023), and, in a tectonic and depositional setting closer to Kathmandu's own, in intermontane basins of the northwest Himalayan fold and thrust belt (Farid et al., 2017; Khalid et al., 2018).

This study investigates the hydrogeological characteristics of 22 boreholes distributed across the Kathmandu and Lalitpur groundwater districts studying drillers lithologs and performing downhole electrical resistivity logs. The specific objectives are to: (1) develop a Kathmandu Valley specific resistivity-lithology relationship for interpreting subsurface hydrogeological units; (2) classify logged intervals into aquifer, leaky aquitard, and aquitard units using lithological and well-completion information, with resistivity as supporting evidence; and (3) integrate borehole data to develop a spatial representation of aquifer distribution and evaluate the consistency of the classification through comparison with available hydrogeological information.

2. STUDY AREA

The Kathmandu Valley is an oval, fault-bounded intermontane basin in Bagmati Province, central Nepal, centred near 27.7°N, 85.3°E (Fig. 1). It measures roughly 30 km east–west by 25 km north–south, with a basin-fill area on the order of 650 km², and its floor lies at 1,300–1,400 m above sea level, ringed by hills that rise to 2,700–2,800 m along the southern rim. Drainage is centripetal: the Bagmati River and its principal tributaries the Bishnumati, Dhobi Khola, Manohara and Nakkhu Khola among others converge on the valley floor before the combined flow exits through the Chobhar gorge in the Mahabharat Range to the south.

The borehole network used for this study (Fig. 1; Table 1) spans this urbanized floor, from Ichangu and Balambu in the west to Kapan and Sukedhara in the northeast and Dhapakhel and Khokana in the south and includes sites in all three groundwater districts recognized by JICA (1990). Total drilled depths in the 22-borehols range from 90 m (KV19, Chovar) to 297 m (KV7, Ratnapark), reflecting deep confined aquifer wells that make up the valley's water supply infrastructure.

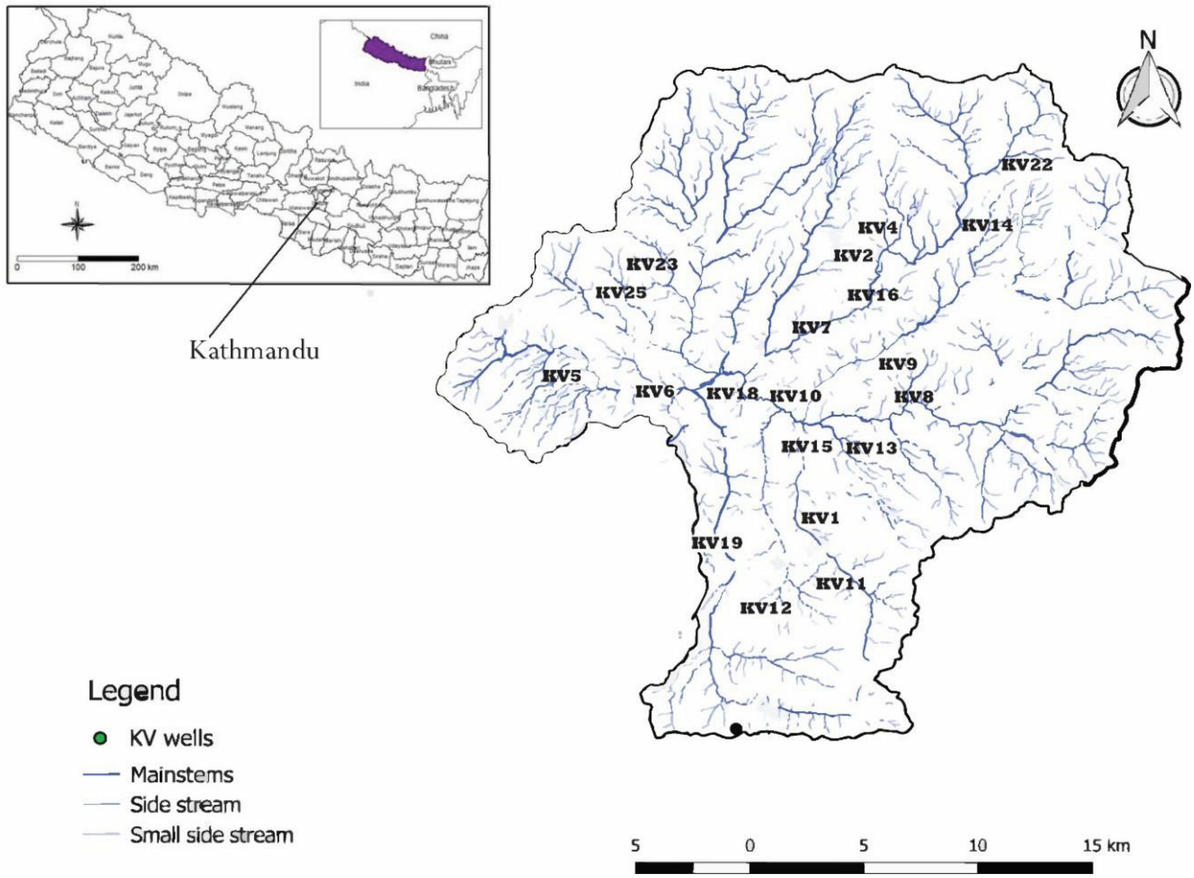

Fig. 1: **Location of the study area. Left: position of the Kathmandu district within Nepal. Right: the Kathmandu Valley basin, showing the Bagmati River drainage network and the 22 inventoried boreholes (KV1–KV25) compiled for this study.**

3. GEOLOGICAL AND HYDROGEOLOGICAL SETTING

3.1 Regional geological framework

The Kathmandu Valley basement forms part of the Kathmandu Nappe, a thrust sheet within the Lesser Himalayan tectonic composed of Precambrian to Devonian low-grade metasedimentary and metamorphic rocks (Stocklin, 1980; Stocklin and Bhattarai, 1977; Gehrels et al., 2006; Dhital, 2015). Around the valley margins this basement is mapped as the Chandragiri Formation (crystalline limestone and quartzite), the Tistung Formation (phyllite, sandstone and sandy limestone), and Augen and banded gneisses (Fig. 2; Shrestha 2012, DMG, 2010, Acharya and Paudyal, 2019), which together form the low-permeability "hydrogeological basement rock" that bounds the basin fill at depth.

The Kathmandu Basin developed through damming and reorganization of a former trans Himalaya drainage a "proto-Bagmati" river comparable in scale to the modern Koshi and Gandaki following uplift of the surrounding ranges during the Pliocene (Pokhrel et al., 2025), consistent with the broader pattern of foreland basin influenced Himalayan uplift documented further west (Decelles et al., 1998). Once impounded, the basin accumulated more than several hundred metres of fluvio-deltaic and lacustrine sediment, informally grouped as the Kathmandu Group and subdivided in different ways by successive workers (Yoshida and Igarashi, 1984; Yoshida and Gautam, 1988; Dongol, 1985, 1987; Shrestha et al., 1998; Sakai et al., 2001; Paudel and Sakai, 2008; Figure 3a. and Figure 3b).

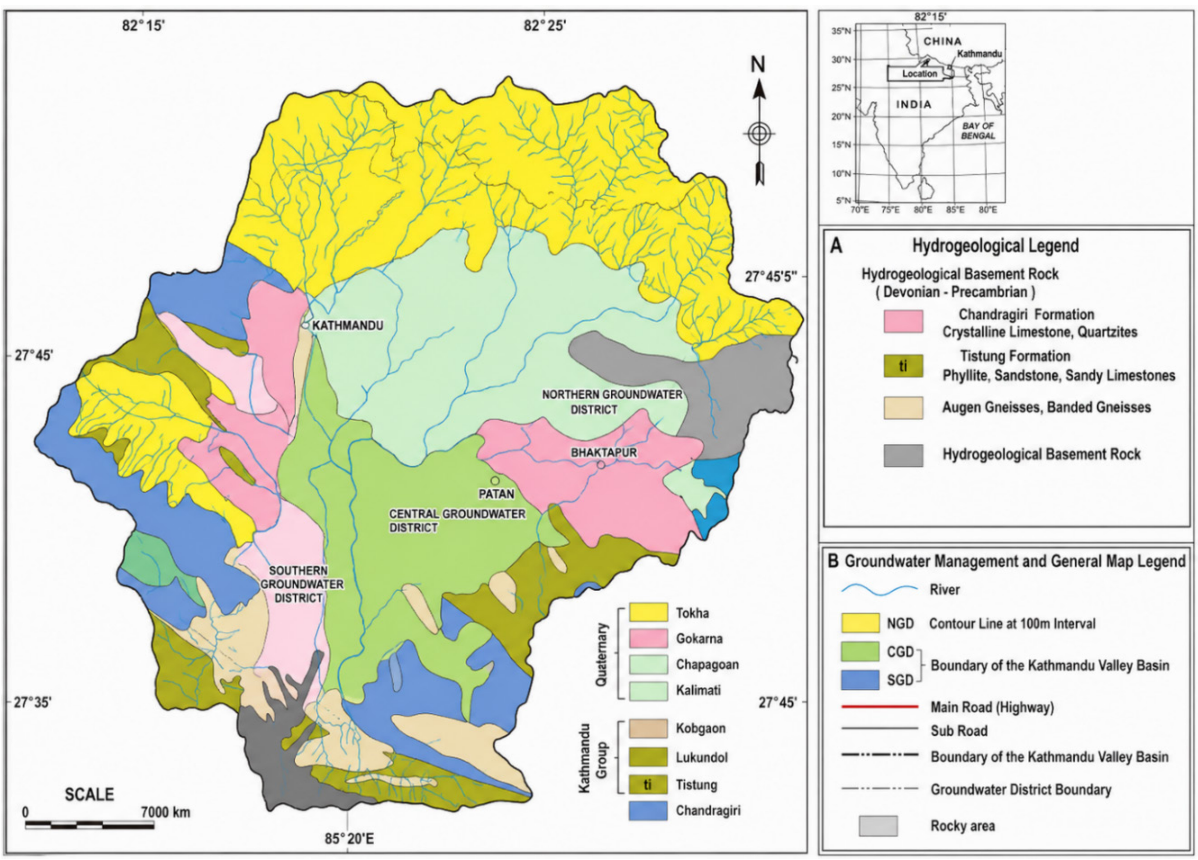

Fig. 2: Geological and hydrogeological map of the Kathmandu Valley, showing the Quaternary basin-fill units and the Kathmandu Group basement units (Shrestha et al, 2010) and the Northern, Central and Southern Groundwater District boundaries established by JICA (1990).

Depositional age (Ma)	Age (Ma)	Period	Yoshida and Igarashi (1984) Yoshida and Gautam (1988)	Member	Dongol (1985, 1987)	Shrestha et al. (1998)	Sakai et al. (2001) southern part	Sakai et al. (2001) central part	Paudel and Sakai (2008) southern part	Paudel and Sakai (2008) central part
0 – 0.01	0	Holocene	Patan Fm		—	Gokarna Fm, Takha Fm, Kalimati Fm & Chapagaon Fm	Terrace gravel deposits	Terrace gravel deposits	Terrace gravel deposits	Terrace gravel deposits
0.01 – 0.12	0.01	Late Pleistocene	Thimi Fm		Kalimati Clays		Lukundol Formation: Itaiti Fm	Kalimati Fm	Sunakothi Formation (Fluvial gravels with sandy and muddy interbeds) Thickness: 34 – 60 m	Kalimati Formation (muddy part)
			Gokarna Fm		Gokarna Fm					
			Boregaon Terrace Deposit		Champi-Itahari Gravel		Upper Member	Kalimati Fm	Kalimati Formation (muddy part)	
			Chapagaon Terrace Deposit							
			Pyanggaon Terrace Deposit							
0.12 – 0.78	0.12	Middle Pleistocene	Lukundol Fm	VII			Middle Member	Basal Lignite Member	Kalimati Formation (muddy part)	Kalimati Formation (muddy part)
				VI	Nakhu Khola Mudstone & Kaseri-Nayankhandi Lignite	Lukundol Fm & Kobgaon Fm				
				V						
				IV						
				III			Lower Member	Bagmati Fm	Lukundol Formation	Lukundol Formation
0.78 – 1.8	0.78	Early Pleistocene		II						
				I						
> 1.8	1.8	Pliocene and older	Tarebhir Basal Gravel		Tarebhir Basal Gravel	Basal boulder bed	Tarebhir Fm	Tarebhir Fm	Basal gravel / boulder bed	Basal gravel / boulder bed

Fig. 3a: The Kathmandu Basin stratigraphy (compiled after Yoshida and Igarashi, 1984; Yoshida and Gautam, 1988; Dongol, 1985, 1987; Shrestha et al., 1998; Sakai et al., 2001; Paudel and Sakai, 2008).

3.2 Hydrogeological framework

JICA (1990) divided the valley into three groundwater districts that remain the standard reference framework (Fig. 2). The Northern Groundwater District is characterized by unconfined conditions in relatively coarse, higher recharge fan and terrace gravels. The Central Groundwater District, beneath much of Kathmandu, Patan and Bhaktapur, is underlain by a thick regional lacustrine clay the Kalimati Formation or its local equivalent that confines a deeper multi-aquifer sand and gravel system. The Southern Groundwater District is more structurally complex and heterogeneous, grading toward the basement proximal, carbonate influenced margin of the basin. Subsequent syntheses have generally confirmed this first order pattern: sand and gravel beds in the northern and northeastern part of the valley form the principal unconfined aquifers, these are overlain by a thick lacustrine clay aquitard through the central and southwestern part of the valley, and lower permeability carbonate rocks characterize the south and southeast (Pandey and Kazama, 2011; Shrestha et al., 2018; Prajapati et al., 2021).

4. MATERIALS AND METHODS

4.1 Borehole inventory and data collection

We studied 22 boreholes distributed across the Kathmandu and Lalitpur districts. (Table 1; Fig. 1). The study includes borehole name, location, total drilled depth, static water level, dynamic water level during pumping, and drawdown, based on available well construction and hydrogeological records. Borehole coordinates are reported in UTM Zone 45N using the WGS84 datum.

Table 1. Regional borehole inventory used in this study (n = 22).

BH_ID	Locality	Lat (°N)	Lon (°E)	Depth (m)	SWL (m)
KV1	Khumaltar, Lalitpur	27.6541	85.3285	260	63
KV2	Lazimpat, Kathmandu	27.7217	85.3194	252	30
KV3	Bakundol, Lalitpur	27.6767	85.3112	265	24
KV4	Panipokhari, Lazimpat	27.7272	85.3240	252	35
KV5	Naikap, Balambu	27.6935	85.2515	250	–
KV6	Kalanki, Kathmandu	27.6937	85.2791	162	–
KV7	Ratnapark, Kathmandu	27.7067	85.3139	297	–
KV8	Buddhanagar, Kathmandu	27.6855	85.3322	245	–
KV9	New Baneshwor, Kathmandu	27.6905	85.3345	248	–
KV10	Sanepa, Lalitpur	27.6847	85.3013	198	–
KV11	Dhapakhel, Lalitpur	27.6347	85.3313	202	–
KV12	Khokana, Lalitpur	27.6363	85.3004	102	–
KV13	Lagankhel, Lalitpur	27.6679	85.3242	240	–
KV14	Sukedhara, Dhumbarahi	27.7249	85.3436	115	38
KV15	Bakundol, Lalitpur	27.6765	85.3118	231	–
KV16	NagPokhari, Kathmandu	27.7137	85.3232	253	–
KV17	Jawalakhel, Lalitpur	27.6719	85.3127	259	26
KV18	Balkhu, Kathmandu	27.6851	85.2990	115	15
KV19	Chovar, Kathmandu	27.6675	85.2849	90	28
KV22	Kapan, Kathmandu	27.7381	85.3640	212	–
KV23	Ichangu, Gairigaun	27.7267	85.2626	155	–
KV25	Sitapila, Kathmandu	27.7189	85.2680	216	–

4.2 Borehole electrical resistivity logging

Bore hole electrical resistivity logging has long been used to characterize subsurface lithology and groundwater-bearing formations. It helps distinguish permeable aquifer units from fine-grained aquitards and supports interpretation of borehole lithology and groundwater conditions. Electrical resistivity depends on both the lithologic makeup of the aquifer and upon the fluid contents of the aquifer. Archie, G.E. (1942). The methodology in this study involves existing data and the acquired data set. The acquired data comprised of Bore hole electrical resistivity logging upto 260 m depth (Table 1, Fig 1) at different locations of Kathmandu and Lalitpur districts. A normal resistivity probe is lowered into the borehole using a cable connected to a surface winch. The cable supplies power and transmits depth information to the probe. The measured resistivity signal is transmitted to the surface, processed, and recorded continuously with depth. (Keys, 1990; Hearst et al., 2000) as shown in Fig. 3. The normal resistivity configuration measures apparent resistivity using two standard electrode spacings, known as short normal and long normal. These configurations investigate progressively larger volumes of formation around the borehole. In this study, the long normal resistivity curve was used because it provides a greater radius of investigation and is less affected by borehole fluid and mud cake effects than the short normal curve (Keys, 1990).

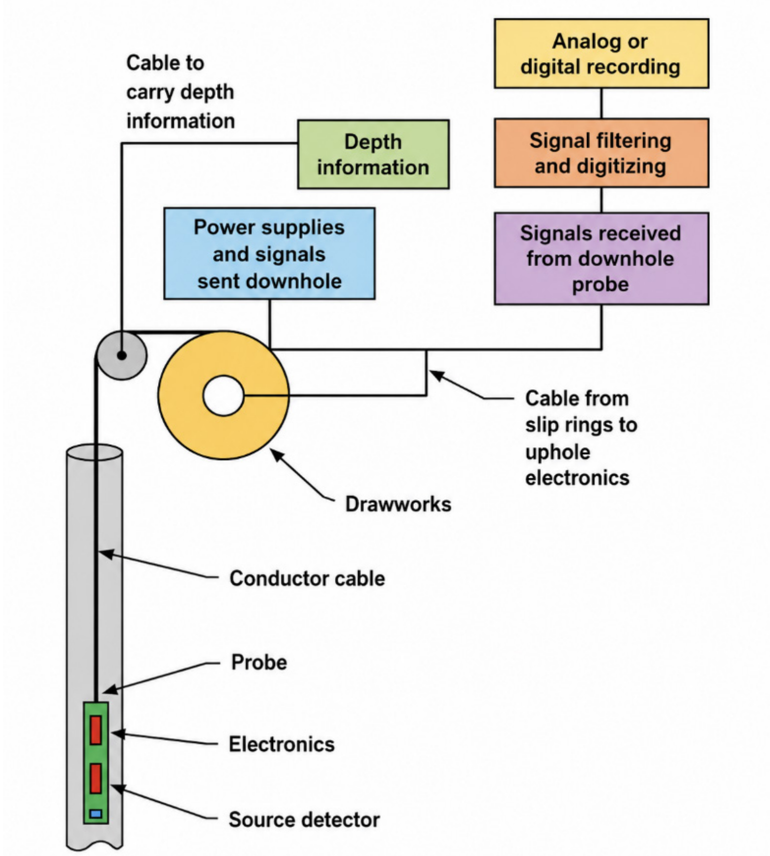

Fig. 3b: Electrical resistivity logging system (Keys, 1990, and Hearst et al., 2000).

Downhole electrical resistivity logging was conducted in 22 boreholes distributed across the Kathmandu and Lalitpur districts to characterize subsurface lithology and identify groundwater-bearing formations. The lithologs are prepared from sample logs prepared by drillers in each location of borehole drilling.

A resistivity lithology interpretation was done with standard hydrogeophysical practice for unconsolidated basin fill sediments (Keller and Frischknecht, 1966; Reynolds, 2011; Kirsch, 2006). We follow standard hydrogeophysical principles for unconsolidated basin-fill sediments (Keller and Frischknecht, 1966; Kirsch, 2006; Reynolds, 2011). The analysis of Resistivity values is difficult task and requires borehole lithology and established hydrogeophysical relationships. We prepared 22 borehole lithologs and performed Downhole electrical resistivity logging was conducted in 22 boreholes. We understand resistivity is influenced by lithology, porosity, saturation, clay content, and pore-water salinity, So, the resistivity ranges were treated as site-specific indicators rather than universal lithological thresholds (Keys, 1990; Keller and Frischknecht, 1966; Reynolds, 2011). The analysis software ARC GiS pro 3.4 is used for interpolation and data presentation. The transmissivity data is available from associated drilling company and complied 21 transmissivity data which are within the study area (Table 2). These Well locations are very close (0.5 to 1.6 Km) proximity from the studied bore hole locations.

Table 2. The transmissivity data from associated drilling company and complied 21 transmissivity data.

S.N	Well No.	Location	Latitude	Longitude	Transmissivity (m2/day)	GWD Zone
1	JW2	Bansbari	27.729	85.334	83	N
2	BB2	Golfutar	27.739	85.343	44	N
3	BAL1(b)	Balaju	27.728	85.311	94	N
4	JW1	Panipokhari	27.727	85.329	394	N
5	G13	Baluwatar	27.722	85.33	45.17	N
6	P9	Lainchaur	27.716	85.316	329	C
7	DK4	Ramhiti, Nayabasti	27.735	85.358	465	N
8	DK6	Kapan VDC-9	27.738	85.357	416	N
9	DK1	Mahankalchaur	27.734	85.358	1963	N
10	JP1	Jorpati	27.727	85.372	180	N
11	P25	PepsiCola, Manahora	27.706	85.357	860	C
12	P18	Soaltee, Tahachal	27.7	85.301	186	C
13	NA18	BishalBazar, Newroad	27.703	85.311	100	C
14	SRTH1	Teku Hospital	27.697	85.309	113	C
15	P37	Interknit Industry, Hattiban	27.653	85.311	6	C
16	B25	SurendraBhawan, Patan	27.677	85.325	28	C
17	ITECO	ITECO Nepal, Minbhawan	27.693	85.335	85.137	C
18	SP	Sports Council, Satdobato	27.66	85.328	27	C
19	JW3	Sundarighat	27.685	85.294	1.6	C
20	P20	Satungal	27.696	85.256	1	S
21	P35	Chobar	27.665	85.29	25	S

5. RESULTS AND DISCUSSIONS

Interpretation is made for four to five lithological and downhole resistivity profiles (Fig.4). The Bore hole electrical resistivity logging values and depth of each layer is distinctive. Resistivity values of each geo-electric layer can be implemented to characterize the probable underlying lithology. Higher resistivity values occurred (Fig.4) within sand, sand and gravel, and gravel dominated intervals, whereas lower resistivity values are associated with silty clay and clay rich units. The Southern portion of Kathmandu valley at Khumaltar area has relatively thicker and more frequent sand and gravel intervals interbedded with fine grained sediments. The KV1 borehole at Khumaltar shows relatively high resistivity in the shallow sand interval and higher resistivity occurs again within the deeper sand and gravel interval. The lithology and resistivity relationships provide clear knowledge of the lithology changes to coarse sand and gravel, accompanied by a progressive increase in resistivity. The central part of Kathmandu valley represented by KV16 demonstrates the importance of recognizing local heterogeneity. The borehole contains a substantial clay-dominated section, but discrete higher-resistivity intervals occur at several depths. These intervals correspond broadly to sandier or coarser-grained lithologies and represent localized permeable zones.

A spatial variation of subsurface lithology was shown in Fig 5. The deeper parts of boreholes contain substantial sand and gravel successions. Particularly notable coarse-grained intervals occur in KV6, KV8, KV9 representing southern and northern boreholes. The clay-rich succession is particularly prominent in boreholes such as KV3, KV7, KV8, KV9, KV16 representing central boreholes. The sub surface lithological variations indicate that coarse-grained sand and gravel occur at shallower levels. This spatial variability indicates that in Kathmandu Valley, aquitard is not a perfectly homogeneous regional layer but contains local sandy, silty and gravelly interbeds. This lithological variation explains the coexistence of shallow, semi-confined and deeper confined groundwater systems in Kathmandu Valley (Fig 5). This lithological association is consistent with the Quaternary fluvio-lacustrine sedimentary infill of the Kathmandu Basin, where fluvial channel deposits are intercalated with fine-grained lacustrine sediments (Shrestha et al., 1998; Sakai et al., 2001; Paudel and Sakai, 2008). The geological setting of the basin is also controlled by the surrounding bedrock and basin-margin structures. In particular, the Chandragiri–Chitlang range southwest of Kathmandu consists predominantly of low-grade metamorphic rocks, including metasandstone, phyllite, argillaceous limestone, quartzite and slate, and is associated with alluvial-fan deposits and Kathmandu Valley sediments toward the basin margin (Acharya and Paudyal, 2019).The Fig 5 therefore supports a generalized hydrostratigraphic subdivision into three major components as a relatively shallow, heterogeneous sand–gravel aquifer system; a laterally variable, clay-dominated aquitard; and deeper, discontinuous to semi-continuous sand–gravel aquifer units. This conceptual arrangement agrees with the hydrogeological framework established by JICA (1990) and subsequent studies, although the present borehole data indicate substantially greater local complexity than can be represented by a simple three-layer model. The aquitard thickness is expected to be greatest toward the central basin and to decrease toward the northern and northeastern margins, where coarse-grained deposits provide more favourable recharge conditions.

Transmissivity data compiled from previous hydrogeological investigations from the study area show a pronounced north–south gradient in aquifer hydraulic properties across Kathmandu Valley (Table 2). The Northern Groundwater District exhibits the highest transmissivity, with reported values of 44–1,963 m^2/day corresponds broadly to the high transmissivity zones shown in the JICA 1990 classification reflecting the dominance of highly permeable sand and gravel deposits. Transmissivity in the Central Groundwater District ranges from 1.6 to 860 m^2/day, indicating strong spatial heterogeneity associated with the interbedding of coarse-grained aquifer sediments and thick Kalimati clay. The Southern Groundwater District shows comparatively low transmissivity 1–54 m^2/day consistent with its poorly developed aquifer system and low-permeability basin-fill deposits. This regional pattern broadly supports the lithological and aquifer-thickness interpretation developed from the present borehole and resistivity dataset.

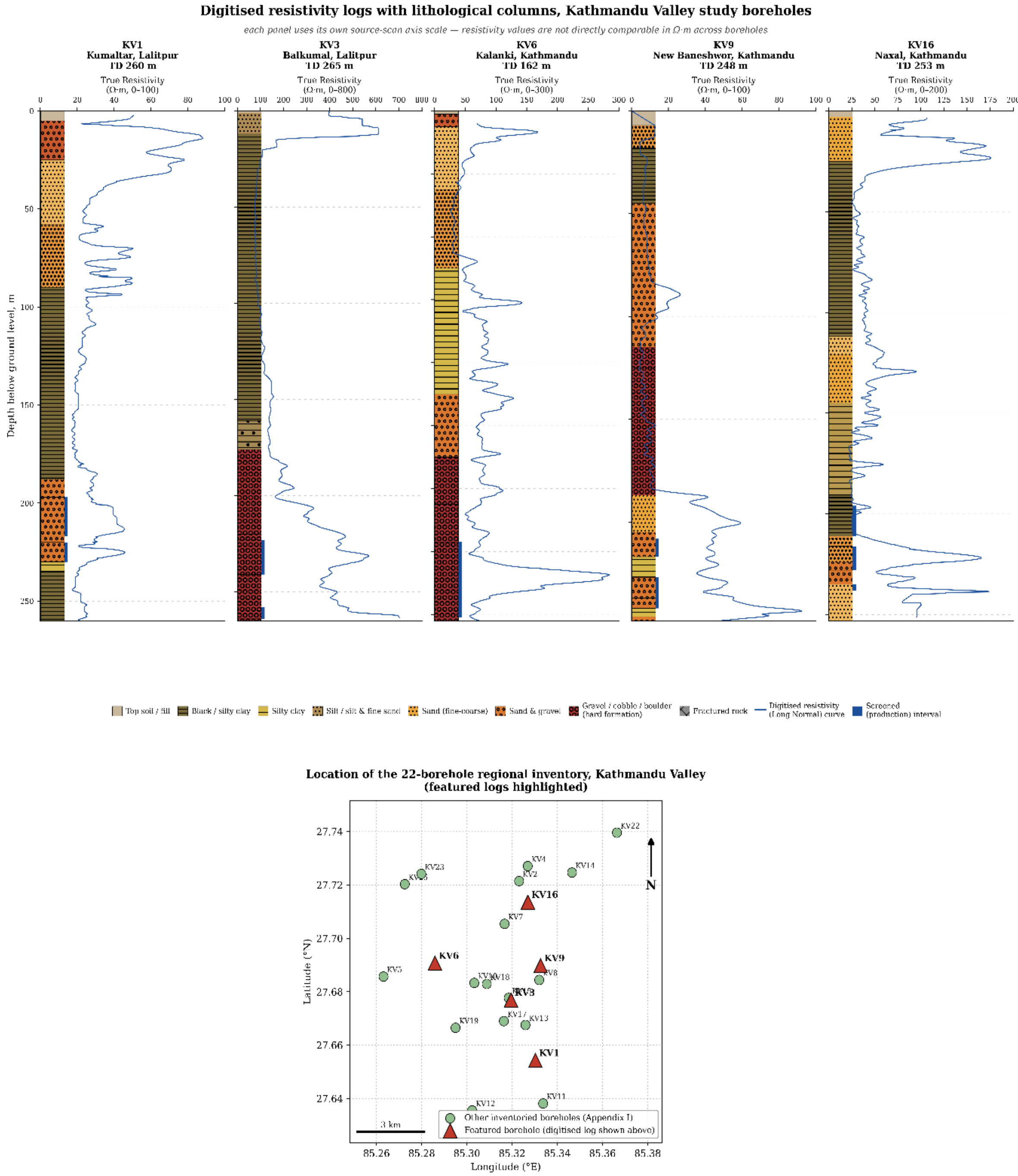

Fig. 4: Long-normal resistivity curves with corresponding lithological columns for five representative boreholes (KV1, KV3, KV6, KV9, KV16)

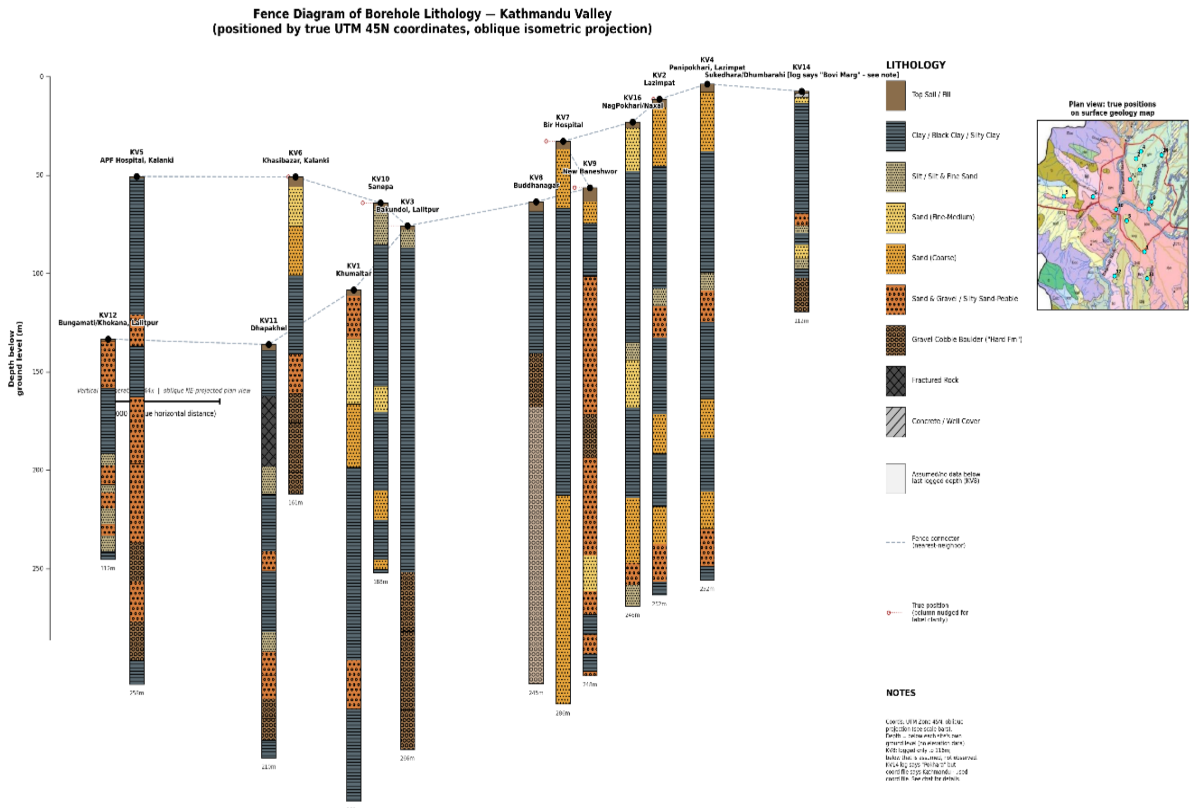

Fig. 5: **Boreholes in the study area representing deep subsurface geology lithology**

The spatial distribution of interpolated screened aquifer thickness shows considerable heterogeneity across the Kathmandu Valley, with estimated values ranging approximately from 0 to 60 m (Fig.6) The left panel represents IDW with power = 1 and gives a LOOCV RMSE of 19 m (n = 17), whereas the right panel represents ordinary kriging with a Gaussian variogram and a fixed 9 km range, producing higher LOOCV RMSE of 22 m. The interpolation surfaces indicate that aquifer thickness is not uniformly distributed but occurs as localized zones of relatively thick and thin screened intervals. Relatively high-thickness zones are seen toward the central–eastern and southern parts of the mapped area, whereas lower estimated thicknesses occur particularly toward the northwestern and some central locations. The observed borehole values, represented by filled circles, provide the primary constraints on the interpolated surfaces. The spatial pattern indicates that relatively thick aquifer intervals occur around boreholes such as KV2, KV8 and KV11, while comparatively thin intervals are associated with locations including KV23, KV12 and KV13 shown on Table 3. These contrasts demonstrate substantial spatial variability in the thickness of the permeable, screened aquifer units. Such variability is consistent with the heterogeneous fluvio-lacustrine sedimentary architecture of Kathmandu Valley, where coarse-grained fluvial/channel deposits are interbedded with fine-grained lacustrine sediments.

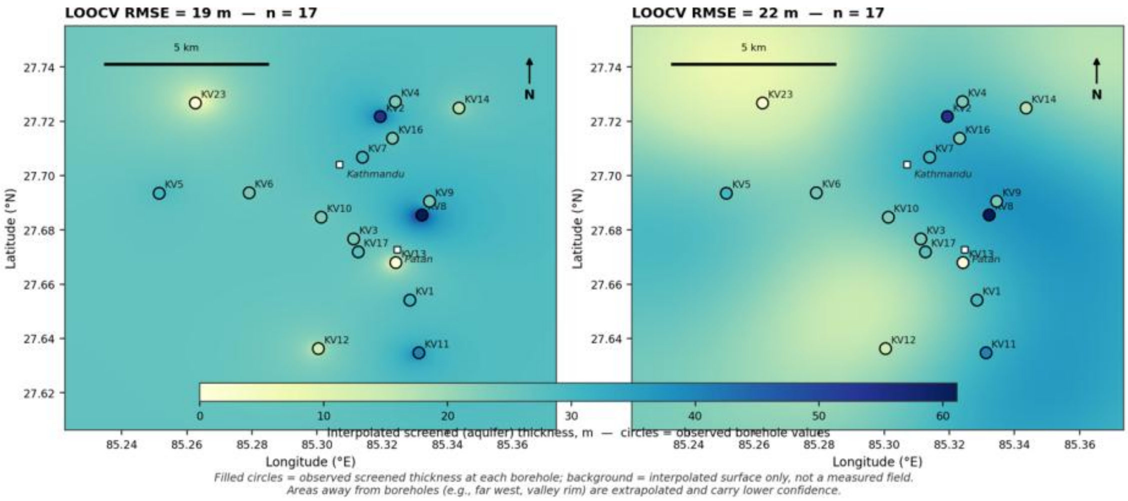

Fig. 6: Spatial interpolation of screened aquifer thickness across the Kathmandu Valley based on 17 borehole observations.

Table 3. Borehole screened thickness summary for the 17 logged boreholes.

BH_ID	Locality	Depth (m)	Screened thick. (m)	Mean aquifer resistivity (Ω·m)
KV1	Kumaltar, Lalitpur	260	30	32.4
KV2	Lazimpat, Kathmandu	252	54	119.2
KV3	Bakundol, Lalitpur	265	24	484.8
KV4	Lazimpat, Kathmandu	252	23	108.9
KV5	APF Hospital, Balambhu	250	30	178.4
KV6	Khasibazar, Kalanki	162	24	208.3
KV7	Ratnapark, Kathmandu	297	30	51.3
KV8	Budhanagar, Kathmandu	245	75	59.3
KV9	New Baneshwor, Kathmandu	248	24	58.1
KV10	Sanepa, Lalitpur	198	23	32.4
KV11	Dhapakhel, Lalitpur	210	40	36.3
KV12	Bungamati, Lalitpur	112	14	47.1
KV13	Lagankhel, Lalitpur	240	26	40.4
KV14	Sukedhara, Kathmandu	115	17	280.0
KV16	NagPokhari, Kathmandu	253	23	88.9
KV17	Jawalakhel, Lalitpur	259	27	38.4

The spatial distribution of hydrostratigraphic classes comprehends from the borehole lithology and screened intervals using two interpolation approaches using inverse-distance weighting (IDW; power = 2) and ordinary kriging using a Gaussian variogram with a fixed 9 km range (Fig 7). We use sixteen boreholes as the input observations. The classification distinguishes aquifer, potential aquifer, leaky aquitard and aquitard conditions. We classified the area as aquifer representing locations where lithology and screened intervals indicate relatively favourable permeable material, principally sand and gravel. The areas of bore holes KV1, KV13, KV9, KV8, KV6 have comparatively higher hydraulic conductivity and greater potential for groundwater flow (Fig 4, 5, Table 2). The potential aquifer class are classified as areas where permeable material is present, but the hydrostratigraphic interpretation is less certain, or the observations are spatially sparse. These areas should therefore be regarded as prospective rather than confirmed aquifer zones. The leaky aquitard class represents fine-grained units containing sufficient sandy or silty interbeds to permit limited vertical or horizontal groundwater movement. These units should not be treated as impermeable boundaries. Instead, they may permit leakage between shallow and deeper groundwater systems depending on their thickness, continuity and hydraulic conductivity. The aquitard class corresponds predominantly to clay- and silty-clay-rich intervals and represents the least permeable part of the interpreted groundwater system (Fig 4, 5, Tabel 2, 3). The major boreholes of central region KV10, KV7, KV16, KV 3 has thick layer of clay which act as a shallow depth aquitard. The occurrence of extensive low-permeability zones is particularly important in the central part of Kathmandu Valley, where thick lacustrine clay has historically been recognized as a major confining unit. The presence of localized permeable intervals within this fine-grained succession indicates that hydraulic connectivity may occur through discontinuous sand and gravel bodies. (Pandey, V.P., and Kazama, F., 2011).

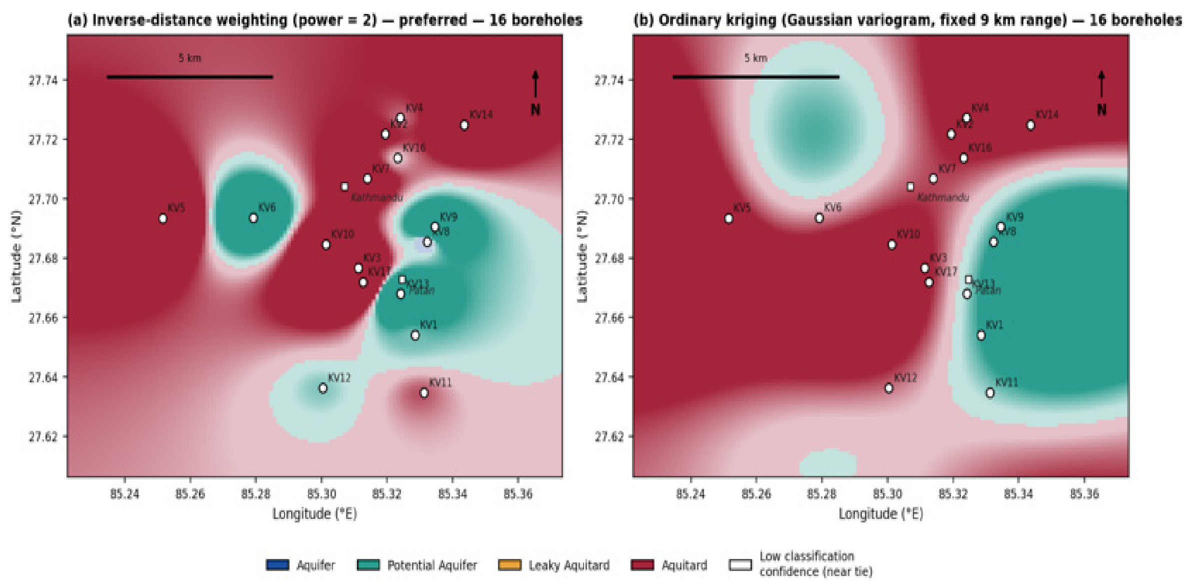

Fig. 7: Spatial distribution of interpolated hydrostratigraphic classes across the Kathmandu Valley based on 16 borehole observations.

CONCLUSION:

The electrical resistivity and lithological logs are very useful for studying the hydrostratigraphic of the particular region. In the study area, 22 borehole resistivity logging was carried out and lithologs are prepared form the drillers log. The sub surface distribution of sediments is determined from the study of sparsely distributed well lithologs from southern to northern region of Kathmandu valley. In the research area, 17 bore hole resistivity logging was done using resistivity logging instrument and collected data is used to identify the resistivity of materials and based on well log, resistivity and interpolation map, the study area is divided into aquifer, leaky aquitard and aquitard zone. The Southern portion of Kathmandu valley has relatively thicker and more frequent sand and gravel intervals interbedded with fine grained sediments. The central part contains a substantial clay-dominated section, but discrete higher-resistivity intervals occur at several depths. The Northern Groundwater District exhibits the highest transmissivity than Central and Southern Groundwater District. The study of aquifer thickness indicate that it not uniformly distributed but occurs as localized zones of relatively thick and thin screened intervals. Relatively high-thickness zones are seen toward the central–eastern and southern parts of the mapped area, whereas lower estimated thicknesses occur particularly toward the northwestern and some central locations. The study is classified as aquifer where the lithology and screened intervals indicate relatively favourable permeable material, principally sand and gravel. The leaky aquitard class represents fine-grained units containing sufficient sandy or silty interbeds to permit limited vertical or horizontal groundwater movement. The aquitard class corresponds predominantly to clay- and silty-clay rich intervals and represents the least permeable part. Thus, this study incorporates valuable research outcomes and useful for future research work.

AUTHORS' CONTRIBUTIONS

The first author and corresponding author conceived the study, conducted the field investigation, collected and analyzed the data, and prepared the initial draft of the manuscript. The second author, as the academic supervisor, provided scientific guidance throughout the study, contributed to the interpretation and discussion of the results, and critically reviewed and revised the manuscript. Both authors contributed to the development of the study and approved the final version of the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no financial, personal, or professional conflicts of interest that could have influenced the work presented in this study.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the first and corresponding author upon reasonable request through direct email communication.

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