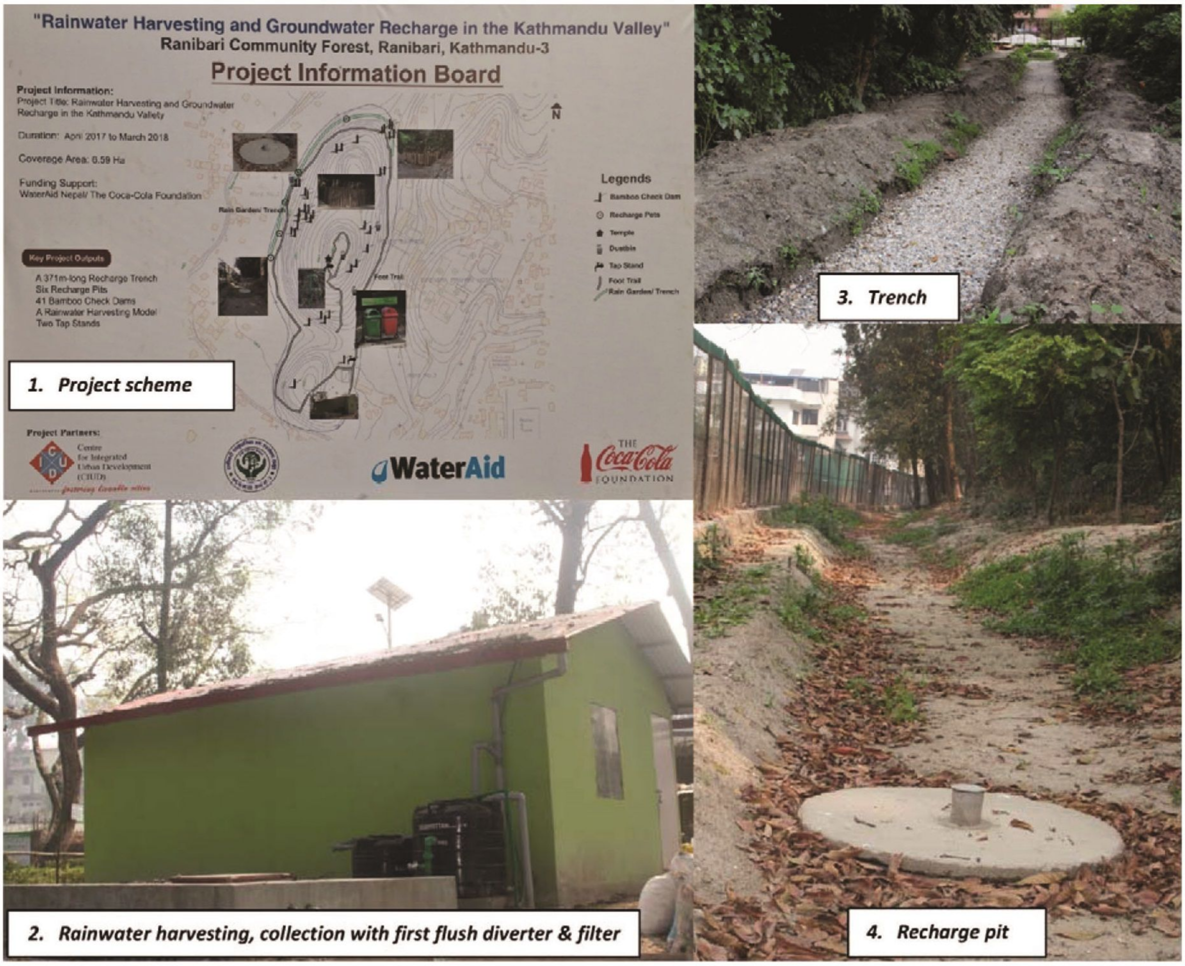
Proceedings of the 9th National Groundwater Symposium
"Challenges and Opportunities for Sustainable Management of Groundwater Resources in Nepal"

20th March 2018, Kathmandu



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Center of Research for Environment, Energy and Water (CREEW)
The Small Earth Nepal (SEN)
Environment and Public Health Organization (ENPHO)
Kathmandu Valley Water Supply Management Board (KVWSMB)
Groundwater Resource Development Board (GWRDB)

Co-organized by

WaterAid Nepal
SmartPhones4Water

In association and supported by

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Institute of Engineering (IoE), Tribhuvan University (TU)
Asian Institute of Technology (AIT), Thailand
Interdisciplinary Centre for River Basin Environment at University of Yamanashi (ICRE-UY), Japan
Kurita Water and Environment Foundation (KWEF), Japan

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Cover photo collage: Rainwater harvesting and groundwater recharge at Ranibari Community Forest, Ranibari, Kathmandu (Centre for Integrated Urban Development)

Back cover photo: Participants of 9th National Groundwater Symposium (CREEW)
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The organizers of the 9th National Groundwater Symposium would like to thank all the presenters for their contributions in the symposium.

The organizers take this opportunity to thank our distinguished dignitaries from various organizations during the inaugural session and would like to acknowledge the member of technical committee, chairpersons, rapporteurs and participants for their participation and providing expertise to the symposium.

The organizers express sincere gratitude for the support provided by WaterAid Nepal, Water and Energy Commission Secretariat (WECS), Asian Institute of Technology (AIT) Thailand, Interdisciplinary Centre for River Basin Environment at University of Yamanashi (ICRE-UY) Japan, Institute of Engineering (IoE) of Tribhuvan University (TU), Kurita Water and Environment Foundation (KWEF) Japan and SmartPhones4Water. Finally, organizing committee appreciates the suport of staff of CREEW, SEN, ENPHO, KVWSMB and GWRDB in making the symposium successful.

Organizers
CREEW, SEN, ENPHO, KVWSMB, GWRDB

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PREFACE

Groundwater plays significant role in fulfilling water demand of sectors like domestic, agriculture, industry as well as for the river e-flows in Nepal, while climatic as well as anthropogenic activities have altered the groundwater level and groundwater quality. Moreover, with growing recognition of the importance of groundwater storage in Terai as well as in the Mid-hills, attention has been drawn to enhance groundwater recharge and its sustainability. Therefore, timely study, research and its sustainable management is needed. Center of Research for Environment, Energy and Water (CREEW), The Small Earth Nepal (SEN), Environment and Public Health Organization (ENPHO) in collaboration with relevant government agencies like Kathmandu Valley Water Supply Management Board (KVWSMB) and Groundwater Resources Development Board (GWRDB) have been organizing National Groundwater Symposium that brings together the scholars, researchers, managers, policy makers and entrepreneurs to share the knowledge and discuss the various issues of groundwater.

The 9th National Groundwater Symposium on Challenges and Opportunities for Sustainable Groundwater Resources Management in Nepal was held on 20th March 2018 in the Radisson Hotel, Kathmandu to commemorate the Nepal National Water and Weather Week 2018 on the occasion of UN World Water Day 2018. This symposium was supported by WaterAid Nepal, Water and Energy Commission Secretariat (WECS), Asian Institute of Technology (AIT) Thailand, Interdisciplinary Centre for River Basin Environment at University of Yamanashi (ICRE-UY) Japan, Institute of Engineering, Tribhuvan University (IoE, TU), Kurita Water and Environment Foundation (KWEF) Japan. The symposium was attended by 77 participants from universities, government and nongovernmental organizations, water companies and media.

The thematic areas addressed in the symposium are as enlisted below;

- Groundwater science and innovations
- Groundwater energy and food nexus
- Groundwater utilization and management
- Groundwater in the face of disaster
- Groundwater quality and quantity and its associated impacts (social, economic, environmental, etc.)
- Groundwater and climate change
- Groundwater policy, regulations and governance

The symposium began with the inaugural session followed by three technical sessions. Altogether one keynote presentation, one plenary presentation, six oral papers and five posters were presented in three technical sessions that included various issues relating to household water security under pre and post Melamchi Water Supply Project case in Kathmandu Valley, assessment of the variation in citizen scientists' based monthly groundwater level observation, shallow aquifer potential mapping in the foot-hills of Chure, groundwater recharge through rainwater harvesting as case study, hydrogeological mapping of various parts of Kathmandu for groundwater recharge and resource assessment, and hydrogeological study of springs for potential recharge zones in sub-watershed.

We hope the papers presented in the symposium will be useful guide for sustainability of groundwater. We look forward to continue the symposium successfully next year as well.

Organizers

CREEW, SEN, ENPHO, KVWSMB, GWRDB

KEYNOTE PRESENTATION

Deep and Shallow Groundwater Potential within Kathmandu Valley

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Achieving water security is challenging for Kathmandu Valley, Nepal. Conjunctive use of ground and surface water is inevitable for the sustainable use of water within the valley. The focus of this study is to develop a robust groundwater model that can be used for better understanding surface and ground water interaction. For this purpose a three dimensional transient model is constructed using the U.S. Geological Survey (USGS) integrated model GSFLOW. This study tries to provide some insights on groundwater extraction volume. A pumping sensitive analysis of deep groundwater system in Kathmandu valley shows that the area near Dharmasthali, Dhapasi, Maharajganj Sankhu and Gokarna has a decline of 0.02 to 0.12m in head with per unit rise in pumping (m^3/s) whereas the area near Balaju, Samakhusi and Shywambu showed more decline of upto 0.12m to 0.23m. The proposed extraction rate map prepared through this analysis also indicates that the northern part of the ground water basin has more volume of water available per unit decline in head per year and the value of the extraction rate is decreasing as we move from northern part of groundwater basin to the southern part. Finally, a Village Development Committee (VDC) wise extraction rate map is prepared using the proposed extraction rate map which showed that Sangla, Baluwa and Danchi

VDC have higher value of proposed extraction rate where, Danchi VDC is showing highest extraction rate of up to 6273967 m^3/yr.

In case of shallow ground water present pumping rate is saturated in most locations whereas in some places still pumping rate can be increased as an alternate resource. Study also shows that there will be no significant drawdown problem with shallow groundwater till 2050 AD. Being very thin, it is replenished in each rainy season.

TECHNICAL SESSIONS

PLENARY PRESENTATION

Traditional Ponds of Kathmandu Valley: Concepts, Technology and Present Context

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With few exceptions all Newar settlements are located on the *tar* land with three of its sides slope down to the flood plain of rivers. If we explore how these settlements are possible in the water-scarce area immediately explains the story of Hiti System where ponds are the vital component. Stone spouts in the depressions (called Hities) and the dug wells are the primary sources of water in Newar settlements. These are served with shallow aquifers formed due to some hydro-geological conditions. To compensate continuous flow of water through these conduits ponds are dug to collect storm water and are further charged by Rajkulos that brings water from upstream rivers irrigating its command area. Furthermore, the concentrated monsoon downpour is buffered in these ponds so that it does not flood the downstream settlements nor demand larger water works to drain it out. Obviously the available water and the pond space not only provides water bodies to cool the surroundings and balance the ecosystem, it also provides auxiliary functions like washing, cleaning and duck farming. In the process of time many rituals and festivals were linked with these ponds. They have become an integral part of landscape of the Newar settlements, beautifying the neighborhood and providing open space to the clustered setting. As per their location and thus the use, they may be categorized into ponds upstream of the settlements, ponds within the settlements and the ponds downstream of the settlements. Upstream ponds, especially those located in the higher elevation to the settlements are meant for recharging the aquifer as well as serving as a buffer during heavy downpour and reservoir for feeding irrigation canals. These ponds are relatively larger in size. Rani Pokhari (Kathmandu);

Siddha Pukhu (Bhaktapur); and Jyawalakhyo Pukhu (Patan) are few examples of this type. Most of them were linked with *rajkulo* and some also have artesian wells to feed the ponds (like in Siddha Pukhu). These canals help to charge the aquifers through the ponds during dry season as well. The ponds inside the settlements are relatively smaller in size. Washing and cleaning are the visible functions they serve, but support the settlements by providing buffer to the down pours during rainy season; and more importantly, helps to recharge the ground water particularly to local aquifers. Duck farming, animal bathing, grey water treatment and fire-fighting are some of the auxiliary functions they serve to the neighbourhoods. Kathmandu already lost these ponds and Nagdaha Pukhu and Tekha Pukhu are the examples for such ponds in Bhaktapur. In Lalitpur, Pimbahal Pukhu is one of the conserved ponds at present time. Chyasa Pukhu, Guita Pukhu and Tyagah Pukhu in Patan are some of the examples of downstream ponds. Many of these ponds have been encroached at present. These ponds helps to recess the storm water during down pour thereby protect the settlements from slope scouring and landslides. These ponds also receives grey water from stone spouts and surface drains and serves dirty cleaning like animal bathing, animal feeding, etc. During dry season most of these ponds may be completely dried. The construction of pond was a skillful engineering work with the good knowledge of local hydro-geology. Clay liners are normally provided using one foot or more thick black cotton soil. These clay layers not only provide liners but also offer habitat for the floras and faunas that keep the pond healthy by recycling the resources. Moreover, where artisan wells are found like in Siddhi Pokhari or in Rani Pokhari perhaps, the water balance is maintained throughout the year even today after the loss of *rajkulos*.

Introduction of piped water system must be the start of the neglect to traditional water works. This became more prominent as the urbanizing forces started grabbing the ponds due to ignorance if not greed. The unattended ponds with filths and garbage, people started throwing waste and the surface drains that use to collect storm water now after the individual toilets, started discharging sewage in the ponds in several cases. Then politicians – local to central showed their 'creativity' by encroaching the ponds for public buildings if not private ones. For example, out of the 39 traditional ponds in Patan, only 16 are relatively in good condition from shape and size. Among the surviving ponds some were renovated by concreting the walls and the bed so that water do not infiltrate. This has ultimately converted these ponds into a dry concrete pit. Khapinchhen, Kuti Sauga, Prayag Pokhari, Bhailagaa and many more are the bitter examples of this. The recent case of Rani Pokhari has once again raised the issue of revitalization of traditional ponds once again. It has not only raised to protect the ponds but also challenged to rebuild using traditional knowledge and skills.

TECHNICAL SESSION I

Chair: Dr. Narendra Man Shakya
Professor, Institute of Engineering (IoE), Tribhuvan University (TU)
Rapporteurs: Palpasa Prajapati, Nischal Devkota

Household Water Security: Pre- and Post- Melamchi Cases in Kathmandu Valley

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Kathmandu Upatyaka Khanepani Limited (KUKL) has planned to harness off-the-valley source from Melamchi to supply water inside the ring road of the Kathmandu Valley (KV). The project called as "Melamchi Water Supply Project (MWSP)" is expected to complete by the end of September 2017 and 2023 to supply 170 MLD (Million-Liters-a-Day) and additional 340 MLD, respectively. Out of 370 MLD current water demand, KUKL's existing infrastructures are able to supply 19% (dry season) and 31% (wet season) in its service areas and facing sever water insecurity. In this background, this study aims to assess temporal trends in spatial distribution of household water security index (WSI) for basic human water requirement (50 liter-per-capita-per-day, (lpcd)) as demand and for economic growth (135 lpcd as demand) in pre- and post-MWSP scenarios to draw meaningful conclusions for securing water in the KV. WSI is defined as the ratio of supply and demand for domestic water use. For this purpose, the data on water demand and supply with infrastructure were used to map the spatial distribution of 'WSI' and per capita water supply using Arc Map. Results show severe water security condition in the year 2016 in all KUKL service areas (SAs), which is likely to improve after the completion of MWSP and year 2030. There could be in-equality in distribution of water within SAs with recent distribution networks and strategy. There is a possibility to re-distribute potable water by expanding their existing distribution network for the equitable distribution, which can serve additional 1.2 million people in the area. Service provider may have to develop strategies to strengthen a set of measures including improving water supply infrastructures, harness additional water from mountain, and water management in and out KUKL SAs in a long-run to cover whole KV.

Assessment of Variations in Citizen Science Based Monthly Groundwater Level Observations in the Kathmandu Valley

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The Kathmandu Valley, Nepal's capital city, is the most urbanized center of Nepal. With increasing population, the Kathmandu valley is hard hit by water crisis. Rapidly growing population has increased water demand to 320 million liters per day (MLD), but the water supplying agency (Kathmandu UpatyakaKhanepani Limited) can only provide 106 MLD and 76 MLD in wet and dry seasons, respectively (KUKL 2010). The present deficit is currently met through private groundwater pumping, traditional water spouts, wells, supplies from private vendors (through surface, spring, and groundwater), and bottled water industries. Groundwater has been a major source of dependable water supply for the Valley which is reflected by regular extraction of groundwater through ever increasing numbers of wells. Monitoring groundwater levels is useful to understand the impact of uncontrolled well drilling. Such studies provide early indicators of changes in the groundwater system and help to identify key actions to help protect it. Around 50 wells, distributed throughout the Valley, were selected for the study. At monitoring locations, monthly groundwater level data were collected with a smartphone by local citizen scientists using an open source Android data collection platform called Open Data Kit (ODK) Collect. Within ODK Collect, each observation requires the citizen scientist to enter the groundwater level reading, save the current date, time, GPS coordinates, and take photographs of the observation. The data are automatically transmitted to a centralized Google Cloud database via ODK Aggregate. Violin plot and heatmap plot were used to demonstrate the monthly groundwater level fluctuations of shallow monitoring wells from July 2017 to January 2018. Recharge of shallow groundwater level was more in monsoon season (i.e.July-August) whereas from September to March there was continue decline of groundwater level. The study shows that rainfall and land-use type has significant effect on seasonal groundwater level variations of shallow wells.

TECHNICAL SESSION- II

Chair: Dr. Suresh Das Shrestha
Professor, Central Department of Geology, TU
Rapporteurs: Madan Kafle, Anusha Pandey

Shallow Aquifer Potential Mapping in the Foothills of Chure: A Case Study in Saptari district, Nepal

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The foothills of Chure ranges are facing severe water security problem due to the limited access to surface water. The river passing through those areas are not perennial river and most of the river are Chure originated flash-flooded. There is extensive use groundwater through shallow tube well for domestic as well as agricultural purpose. Even though certain patches of land within our study area have limited.no water yield from shallow tube well. In addition to this aquifer response and information is not well known in foothills of Chure area. In this context, this research tries to answer the two pertinent question depth and thickness of groundwater aquifer potential and depth and thickness of aquifer layer (clay, sand, bedrock-limit depth of drilling) i.e. potential for shallow tube well development. The objective of this research is to identify the aquifer properties and access the groundwater potential at Kanakpati area of Saptari district using electrical resistivity method. Five 2D ERT profiles were carried out to collect information to a depth of around 40 m, employing the full length of profile of more than 240 m in each case. The minimum electrode spacing of 5 m was used in the survey procedure. The survey was carried out using Wenner, Schlumberger and Dipole-Dipole array of electrode configurations. The electrical resistivity data of true resistivity's (ñ) and thicknesses (t) of various subsurface strata from the values of recorded resistance (R) or apparent resistivity (ña) at electrode separations (a) were interpreted using RES2DINV software. This software provides output in the form of resistivity contours, and this inversion data were used to draw up the lithological and geological information presented as tomogram section. The result of the survey indicates that the good potential

area lies mostly along the southeast to central east parts of the study area. The study shows a patchwork of clay, silty-clay, sand, gravel and boulder materials, which provide for varied aquifer potentials. Installation of productive shallow tube wells has thus been a chance at locating the tube wells within productive patches/lenses of aquifer material. The reliability of any such well also depends on the extent of the aquifer, and hence the storage potential as well as the hydraulic conductivity of groundwater flow within the tapped aquifer material as well as the neighboring materials.

Groundwater Recharge and Rainwater Harvesting in Kathmandu Valley: An Approach of Climate Change Adaptation in Water Security

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The ever increasing population in Kathmandu valley with the high demand of water has caused the tremendous stress in the groundwater sources of the valley. With the rapid urbanization, Kathmandu valley is haphazardly encroached with various forms of physical constructions replacing agro fertile lands and public open spaces, thereby, leaving few spaces for the natural recharging of groundwater. Due to impervious paving of most of the urban area the surface runoff is increasing in Kathmandu valley causing urban flooding. On the other hand infiltration capacity is reduced and water table is depleting with the rate of approximately 2m annually. Historically valued water sources like stone spouts, shallow wells and springs are also drying up due to high exploitation of groundwater.

As the joint technical and financial collaboration among The Coca-Cola Foundation, WaterAid Nepal and Centre for Integrated Urban Development (CIUD), the project 'Rainwater Harvesting and Groundwater Recharge in Kathmandu Valley' was planned and designed to utilize the open spaces of the Ranibari Community Forest in Ranibari, Kathmandu for the recharge initiative activities and the promotion of rainwater harvesting. Ranibari forest is one of the very few community owned community forests of the valley. With the key objectives of increasing groundwater level of project site area, dissemination of information of rainwater harvesting and groundwater recharging in community level, the project was launched in July 2017 and completed in March 2018.

Throughout the project period, the key activities conducted were construction of a 341m-long recharge trench as the piloting of concept of rain garden where retention time of surface rainwater is increased to recharge groundwater. Additionally six recharge pits are constructed along the recharge trench for the groundwater recharge. Construction of bamboo check dams using simple technology to prevent possible soil erosion in the area has been practices within the project site. A full-fledged rainwater harvesting plant has been installed in two blocks within the forest area to promote rainwater harvesting in community and public level.

The structure for rainwater harvesting and groundwater recharge is sustainable with adaptation of minimum maintenance where graded media is applied to combat with clogging problem and in case of recharge pit removable cover was applied which requires periodic cleaning of geo-textile membrane to remove the clogging problem. At the same time operation and maintenance training was conducted to the users' community of peripheral area of the community forest.

It has been expected that with all these initiatives, the groundwater level will be maintained and that its direct beneficiaries will be the communities living around the forest area including the renters and the poor families. It has been considered a sustainable approach to combat climate change impacts in water sources and securing water for the valley and also as a model of a public private partnership to promote innovative solutions for water demand in the urban areas. This project has also been considered CIUD's continuation of 'Recharge Kathmandu Campaign'.

Hydrogeological Mapping of North-Eastern and South-Western part of Kathmandu Valley for Groundwater Recharge and Resources Assessment

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Groundwater has now become a major natural resource contributing to the water supply system in the Kathmandu Valley and people have been using groundwater for a long time through dug wells and stone spouts. Usually groundwater gets recharged during rainfall period through surplus monsoon runoff. Groundwater is stored in shallow (≤50m) and deep (>50m) aquifers. Shallow aquifers are easy to recharge as water from the surface easily penetrates there whereas deep aquifers are relatively hard to recharge as there are impermeable layers through which infiltration is not possible.

This study was carried out in the northeastern and southwestern part of the valley to meet the established objectives of the study; to evaluate the recharge potential of the shallow aquifer of the study area in three decades based on land-use/ land-cover (LULC) change patterns and to delineate the shallow groundwater potential areas of south west part of the Kathmandu valley. This is a part of hydrogeological mapping. LULC analysis was done for three decades; 1996, 2006 and 2017. The LULC map for 1996 was prepared using the digital layer provided by Department of Mines and Geology (DMG) and the LULC maps for 2006 and 2017 were prepared using high resolution Google Earth images transferred to ArcGIS 10. According to LULC analysis, the cultivable land was degraded and settlement increased due to the rapid population growth. This eventually led in the decrease in the areas for the groundwater recharge. The recharge area covered 20.32km^2 area during 1996 and it got degraded and now the recharge area covers only 15.71km^2 area. Hence, the recharge area is being decreased as 1.49%. For the delineation of groundwater potential zone, a weighted overlay method was used. Weighted overlay is a type of suitability analysis that helps to analyze site conditions based on multiple criteria. It allows to combine, weight and rank several different types of information and visualize it and can evaluate multiple factors at once. Shallow potential mapping is done through satellite image and different thematic layer prepared using ArcGIS 10. These layers were transformed to raster data using the feature to raster converter tool in ArcGIS 10. The raster maps were then reclassified and a rank and weighted was given to each individual layer. Each layer was computed to delineate the groundwater potential zones. The groundwater potential map was then categorized into three groups: high, medium and low. The groundwater potential map can be helpful in groundwater resource assessment.

By mapping the spatial distribution of geologic material with distinctive permeability, hydrogeologists can understand which geologic units will allow movement of groundwater and which units will restrict groundwater movement. Universities as well as government agencies lack the baseline data on the number, nature and capacity of aquifer systems of the valley. This study envisions to establish a hydrogeological map of the Kathmandu Valley giving a clear vision of groundwater conditions. The expected outcome will be greatly advantageous for the locals relying on those water sources as well as to the planning authorities for future planning to reduce the water scarcity problem.

Hydrogeological Study of Springs for Potential Recharge Zone using GIS in the Punyamata Sub-Watershed, Nepal

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In a mountainous country like Nepal that has young and subtle geological variations, it is imperative to know the hydro-geology. As the geological formation changes so does the movement of water in springs, wells and its potential availability in an area. The spatial and temporal variation of water resources is becoming highly vulnerable because of climate change, change in land use pattern, and population growth. As a result, natural springs are drying up in hard rock area where it could be the only source of water especially in mountain ecosystem. To fulfill their demand people are depending on ground water resources as an alternative source through wells and deep boring especially in per-urban area which are highly *agriculture urbanized*. Hence, the objective is hydro-geological study of springs of Punyamata Watershed, Kavre district, Nepal using weightage overlay index method in GIS. The contributing factors selected were precipitation, slope, geological formation, land use, hydrology and lineaments. The average precipitation from 1996-2015 A.D. was 1420 mm. The degree of slope varies from 0-34 degree. Geologically, quaternary deposit forms the valley floor and Markhu and Tistung formation can also be found in the watershed. The major land cover/land use types are cultivation area, forest, pine and shrubs and Built up area. Lineanment density ranges from 0-5.22 Km/km^2 while drainage density varies from 0-5.72 Km/km^2. The weightage is assigned within a thematic layer that is rasterized and rank is allocated based on its contribution on ground water recharge to produce a map of potential recharge zone. The watershed is dominated by moderate potential zone covering 41 % of the total area.

POSTER SESSION

Present Status of Stone Spouts in Kathmandu Valley: An Indicator of Groundwater Depletion

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Traditional water harvesting, and management techniques are either, in decline, or have been abandoned in many countries, regardless their efficiency and cost-effectiveness. Stone spouts were also one of the traditional water management techniques which served as primary water sources in the Kathmandu Valley from 550 C.E to the mid-1900s. These stone spouts (also known as "*dhunge dharas*") are channelized water spouts which uses shallow aquifers and springs as their source. These aquifers were recharged by precipitation and state canals (*Raj-kulos*). Stone spouts were once able to supply water in decent quality and quantity throughout the year due to proper maintenance of state canals, ponds, springs, and recharge areas. But the population of Kathmandu Valley has drastically increased over the last 50 years creating great stress on the water resources on the valley. excessive groundwater extractions, depleting groundwater table, destruction of state canals, and concretization of recharge areas due to increasing number of houses have collectively led towards drying up of these stone spouts. The main objective of our research is to analyze the present conditions of stone spouts in Kathmandu Valley.

Our study was conducted inside Kathmandu Valley which is situated around 1300 meters above sea level. Each measurement was recorded using Open Data Kit (ODK); an android phone application used by SmartPhones4Water team in their project. For discharge measurement, a measuring bucket was held under each spout with a timer and the time it took to fill the bucket was recorded.

Out of the 212 stone spouts analyzed inside Kathmandu Valley during October 2017, 40 percent had already dried, and 21 percent had significantly less flow rate. The flow rate varied between 0 lps to 42 lps. Stone spouts located in natural hills and forest had significant amount of flow while those located in city lowlands were dry or had comparatively very less flow.

From our study, we concluded that these traditional stone spouts are no longer capable of meeting the water demand of the Valley. This could be attributed to several factors such as; over-population, depletion of shallow groundwater aquifers, destruction of state canals, excessive groundwater extraction, concretizing sub-surface flow areas, decreasing recharge areas and so on. These stone spouts are losing its utilitarian value and are in the verge of disappearance or becoming a mere showpiece. These ancient heritages should be revived to preserve our historical ambience. Being a communal water source of the Kathmandu Valley, if managed properly, could still serve as one of the major water sources of Kathmandu Valley.

Spatial and Temporal Variation of Water Quality of Bishnumati and Dhodikhola Rivers in Kathmandu

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Water quality is termed as health of life. Rapid population growth and haphazard urbanization in Kathmandu Valley, had directly affected the river waters flowing across it The water quality of Bagmati river and its tributaries has deteriorated drastically in the few years due to waste water being directly dumped into the water resources, without adequate treatment. Both the aesthetic view as well as ecological balance of the river has been disturbed. The regular monitoring of river water quality parameters helps in database generation and support river basin management approach. The main objective of the study is to determine the status of river water quality throughout the river stream and also to visualize the trends of river water quality in terms of temporal and spatial variations.

For the study, four sampling points on Bishnumati and Dhobi khola rivers each were selected and water quality samples were collected thrice a year i.e. during pre-monsoon (April), monsoon (September) and post monsoon (November-December) seasons from year 2014-2017 A.D. The physical parameters of river water like pH, EC, DO and temperature were measured on site using instrument like Combo for pH, HANNA for EC, IIJIMA DOMETER ID-100 for DO and Garmin Colorado 300 for GPS measurement where chemical parameters like NO3-N, NH4-N, PO4 and COD were analyzed in laboratory with the help of instrument like UVmini-1240, SHIMADZU and Kyoritsyu Digital Water Analyzer respectively.

Temporal changes in water quality parameters like DO, NH4-N, COD and PO4 for sampling points of both river is plotted using average value of all three seasonal samplings for period 2014-2017 A.D. Spatial variations of water quality parameters for post monsoon season of 2017 A.D is shown using score normalization technique i.e. z- score, which is calculated using the arithmetic mean and standard deviation of the given data (Jain. et. al. 2005).The results from the graph showed the decreasing trend of chemical parameters on year 2017 as compared to 2015 and 2016, which could be due to public awareness, clean-up campaign, proper drainage system, etc. There is also a linear increment of BOD, PO4--- & NH4-N in downstream that might be due to disposal of domestic waste in river water. Due to less fertilizer runoff from agricultural land, the value of nitrate in 2nd sampling stations of both rivers could be less in comparison to 1st station. The overall graphs depicts that the river water quality at upstream of both rivers are relatively less polluted than at the downstream.

Current Status of Springs after 2015 Gorkha Earthquake in Bhusundi Catchment, Daraudi Sub-Basin

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Spring water is an important part of both water cycle as well as ecosystem. The large sections of population in mid hills of Nepal are benefited from the use of groundwater in the form springs or surface seepages. Nepal is one of the world's disaster prone country. The study emphasizes on the current status of the springs after 2015 Gorkha Earthquake in Bhusundi Catchment. The earthquakes of 25 April and 12 May 2015 have been a terrible calamity for Nepal as they affected almost half of its districts including hard to reach mountainous area. Kuncha Formation and Garnetiferous Schist are two different metamorphic terrains and Nepheline Syenite is a rare intrusive igneous rock body. In the present study an attempt has been made to identify spring water chemistry in and around the Bhusundi Catchment, which is branch of Daraudi Sub Basin. Among 44 springs, the physico-chemical parameters like temperature, pH, EC, DO, TDS and salt were measured insitu. Water samples from 10 typical springs were collected for laboratory analysis. For the hydrogeochemical assessments Piper Trilinear plot, Stiff patterns and Schoeller diagram were made with reference to major ionic composition, data obtained from laboratory analysis. Focus group discussions were conducted to know the people's perception about spring water discharge and water quality after earthquake. Physical and chemical parameters are below the maximum concentration limits of NDWQS except pH. The general order of major cations is Ca2+ > K+ > Mg2+ > Na+ and major anions is HCO3- > Cl- > SO42-. Springs water chemistry were assessed and hence obtained the natural mechanism controlling groundwater chemistry from the Gibbs plot that is rock dominance or rock water interaction mechanism. The prominent type of water is Ca-Mg-HCO3 in study area.

Despite the hardships the people had to face after earthquake, they showed tremendous resilience and community solidarity. In case of impact in spring water resources based on social survey and field visit, few springs were dried, most of them decline their discharge rate with changed groundwater chemistry, and some springs were buried after earthquake and were recovered from local efforts.

Status of Groundwater Quality in Kathmandu Valley: A Spatial Evaluation of the Valley's Dug Wells

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With the growing demand of drinking water in Kathmandu valley, people have been increasingly relying on the groundwater sources like dug wells and tube wells. As there does not exist a framework for construction, management, and utilization of these resources, concerns over the quality of the water have been looming. Some studies have tried to portray this degradation but their research have been centered mainly in the core areas. Through this study, we have attempted to provide an overview of the water quality of the dug wells in the valley. To accomplish this, we selected 34 dug wells, distributed throughout the valley with total depth between 4-13 m. Six parameters including pH, ammonia, nitrate, chloride, total harness and iron were measured using the Environment and Public Health Organization's (ENPHO) water test kit and electrical conductivity (EC) was measured using a handheld probe in the field itself. Total alkalinity and E. coli were analyzed in the lab within 8 to 10 hours of the sample collection. All of the data were recorded using an android app called Open Data Kit (ODK). The results were evaluated primarily using Inverse Distance Weighted (IDW) interpolation in QGIS. The obtained results were compared with the maximum concentration limits (MCL) set by the Nepal Government. Moreover, our study suggests a potential connection between land-use and water quality in dug wells. MCL exceeded for ammonia and nitrate mostly in the peripheries of the valley while for rest of the physio-chemical parameters, exceedance was observed mainly in the core areas. Iron levels were lower than the MCL in all areas. Among all the parameters too, E. coli had the greatest impact on the

groundwater as the values was over the MCL for 70% of the wells. If *E. Coli* contamination is not accounted, then the percentage goes down to 15%. Since degradation of water quality in dug wells might be related to their utilization and management, it is advisable that proper standards for management and construction of dug wells are developed to improve their water quality.

Ground Water Quality Analysis of Bhaktapur Municipality

Amber Thapa[1,*], Aalok Sharma Kafle[1]
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*(*Corresponding author. Email: thapaamber123@gmail.com)*

This research work "*Ground Water Quality Analysis of Bhaktapur Municipality*" was carried out in the month of January, 2018. A total of 40 representative wells (both public and private wells) of Bhaktapur Municipality were selected to cover entire study area considering human settlement and current usage of wells. Groundwater samples from these wells were collected and their physical, chemical and biological parameters were tested in the lab and analyzed in comparison with National Drinking Water Quality Standard (2062 BS).

The study aimed to assess the groundwater quality of public wells in Bhaktapur Municipality. In-situ quality parameters were checked on the spot while other parameters were measured with the help of Water Quality Test Kit along with chemical in laboratory. Water quality parameters include dissolved oxygen, chloride, total alkalinity, total hardness, ammonia, nitrate, phosphate, iron and coliform. Coliform was detected using P/A vials.

Finally, spatial variation of groundwater level as well quality parameters was analyzed by plotting in GIS. The spatial distribution indicated most of the parameters within innocuous quality as per standardization of NDWQS. However, nitrate and ammonia possess a major threat causing widespread environmentally unfriendly concentration. This issue dictates infiltration and leaching of organic pollutants and fertilizers. Hence, it can be concluded that water is consumable only after prior treatment.

ANNEX I: PROGRAM SCHEDULE

Date: 20th March 2018
Venue: Radisson Hotel, Kathmandu
Registration: 9:00 am - 9:30 am

GWRDB

Program Schedule **MC: Ms. Deepa Neupane**

INAUGURAL SESSION		
9:30 -9:35	Welcoming the dignitaries on dias	
9:35-9:40	National anthem	
9:40-9:45	Lightening of the traditional oil lamp by chief guest	
9:45-9:50	Welcome address	**Dr. Rabin Malla**, Executive Director, Center of Research for Environment, Energy and Water (CREEW)
9:50-10:15	Keynote presentation: **'Deep and Shallow Groundwater Potential within Kathmandu Valley'**	**Dr. Narendra Man Shakya,** Professor, Institute of Engineering (IoE), Tribhuvan University (TU)
10:15-10:35	Remarks by guests	**Dr. Moti Lal Rijal**, Assoc. Prof., Central Dept. of Geology/Member, President Chure-Terai Madhesh Conservation Development Board, Govt. of Nepal
		Er. Tejraj Bhatt, Director General, Department of Water Supply and Sewerage (DWSS
		Dr. Bhupendra Prasad, General Manager, Nepal Water Supply Corporation (NWSC)
		Er. Mahendra Bahadur Gurung, Chief Executive Officer, Pancheshwor Development Authority
		Er. Rajiv Joshi, Technical Director, Kathmandu Valley Water Supply Management Board(KVWSMB)
10:35-10:40	Remarks by chief guest	**Dr. Ramesh Pd. Singh**, Secretary, Water and Energy Commission Secretariat (WECS) & Chair of Nepal National Water and Weather Week 2018 (NNWWW 2018)
10:40-10:45	Vote of thanks	**Mr. Arun Bhattarai,** Program Coordinator, The Small Earth Nepal (SEN)
10:45-10:50	Closing remarks by the chairperson	**Er. Madhav Belbase,** Joint Secretary, Water and Energy Commission Secretariat (WECS) & Vice Chair of Nepal National Water and Weather Week

		2018 (NNWWW 2018)
Group photo session and tea break (10:50-11:05)		
TECHNICAL SESSIONS		
Plenary Speaker**: Er. Padma Sundar Joshi**, Habitat Manager, UN-Habitat Nepal Traditional Ponds of Kathmandu Valley: Concepts, Technology and Present Context (11:05-11:45)		
TECHNICAL SESSION- I **Chair: Dr. Narendra Man Shakya, Professor, Institute of Engineering (IoE), TU** **Rapporteurs: Ms. Palpasa Prajapati (CREEW), Mr. Nischal Devkota (S4W-Nepal)**		
11:45-12:00	Household Water Security: Pre- and Post- Melamchi Cases in Kathmandu Valley	**Dr. Bhesh Raj Thapa** and **Dr. Vishnu P. Pandey,**International Water Management Institute Nepal (IWMI-Nepal)
12:00-12:15	Assessment of Variations in Citizen Science Based Monthly Groundwater Level Observations in the Kathmandu Valley	**Er. Rajaram Prajapati,** Institute of Engineering (IoE), TU; **Er.Jeffrey C. Davids**, Delft University of Technology; **Mr.Aalok Kaafle,** Kathmandu Engineering College
12:15-12:25	**Questions and discussion**	
Lunch Break and Poster Viewing(12:25-13:45)		
TECHNICAL SESSION- II **Chair: Dr. Suresh Das Shrestha,** Professor, Central Department of Geology, TU **Rapporteurs:Mr. Madan Kafle** (CREEW), **Ms. Anusha Pandey** (S4W-Nepal)		
13:45-14:00	Shallow Aquifer Potential Mapping in the Foothills of Chure: A Case Study in Saptari district, Nepal	**Er. Surendra Raj Shrestha,** Groundwater Resource Development Board (GWRDB) and**Dr. Bhesh Raj Thapa,** IWMI-Nepal
14:00-14:15	Groundwater Recharge and Rainwater Harvesting in Kathmandu Valley: An Approach of Climate Change Adaptation in Water Security	**Mr. Sudarshan Rajbhandari**, and **Er. Sudeep Hada,** (CIUD); **Er. Dharma Ratna Chitrakar**, WaterAid Nepal
14:15-14:30	Hydrogeological Mapping of North-Eastern and South-Western Part of Kathmandu Valley for Groundwater Recharge and Resources Assessment.	**Ms. Jinita Shakya** and **Ms. Rasila Koirala** Central Department of Geology, TU
14:30-14:45	Hydrogeological Study of Springs for Potential Recharge Zone using GIS in the Punyamata Sub-Watershed, Nepal	**Mr. Kumud Raj Kafle**and**Ms. Susmina Gajurel** Kathmandu University (KU)
14:45-15:05**Questions and discussion**		
CLOSING SESSION		
15:05-15:10	**Closing remarks**	**Dr. Rabin Malla**, Executive Director, CREEW
HIGH TEA		

ANNEX II: LIST OF PARTICIPANTS

S.N	Name	Organization
Government Organizations		
1.	Dr. Ramesh Prasad Singh	Water and Energy Commission Secretariat
2.	Er. Madhav Belbase	Water and Energy Commission Secretariat
3.	Er. Mahendra Bahadur Gurung	Pancheshwor Development Authority
4.	Er. Surendra Raj Shrestha	GWRDB
5.	Mr. Manoj Khatiwada	GWRDB
6.	Raj Kumar Gumanju	GWRDB
7.	Er. Rajiv Joshi	KVWSMB
8.	Ms. Indira Sangraula	KVWSMB
9.	Arpana Shrestha	KVWSMB
10.	Mr. Kamal Bam	KVWSMB
11.	Mr. Bhaskar Khatiwada	KVWSMB
12.	Er. Bodhraj Dahal	KVWSMB
13.	Er. Nabin Tiwari	KVWSMB
14.	Mr. Kamal B. Bam	KVWSMB
15.	Mr. Anoj Khanal	KVWSMB
16.	Tika Shrestha	KVWSMB
17.	Mr. Niroj Bal Tamang	KVWSMB
Academic / Research Institutions		
18.	Dr. Motilal Rijal	Central Department of Geology, TU

19.	Prof. Dr. Suresh Das Shrestha	Central Department of Geology, TU
20.	Mr. Rajaram Prajapati	Institute of Engineering, TU
21.	Prof. Dr. Narendra Man Shakya	Institute of Engineering, TU
22.	Ms. Jinita Shakya	Central Department of Geology, TU
23.	Ms. Rasila Koirala	Central Department of Geology, TU
24.	Mr. Gunanidhi Pokhrel	Central Department of Geology, TU
25.	Mr. Amber Bahadur Thapa	Khwopa College
26.	Ms. Meera Prajapati	Khwopa College
27.	Mr. Kiran Gosai	Khwopa College
28.	Mr. Mahendra Prasad Uprety	Khwopa College
29.	Ms. Sanishya Shrestha	Scheme College
30.	Mr .Robert Dongol	Nepal Engineering College
31.	Mr. Nir Shakya	Tri Chandra Campus, TU
32.	Mr. Nawaraj Shrestha	CAS-N
33.	Mr. Shanker Pyakurel	CAS-N
34.	Dr. Dhundi Raj Phatak	Engineering Study and Research Center/ CREEW
International Non-Governmental Organizations (INGOs)		
35.	Dr. Vishnu Prasad Pandey	IWMI Nepal/CREEW
36.	Er. Bhesh Raj Thapa	IWMI Nepal
37.	Er. Padma Sundar Joshi	UN- Habitat
38.	Ms. Pramita Maharjan	WaterAid- Nepal
39.	Mr. Paras Pokhrel	WaterAid- Nepal
40.	Mr. Sonu Kumar Shah	WaterAid- Nepal

41.	Mr. Akira Nishikori	JICA/SATREPS
42.	Bidhya Pokhrel	JICA
43.	Mr. Jeffrey C. Davids	SmartPhones4Water-Nepal
44.	Mr. Saroj Maka	SmartPhones4Water-Nep
45.	Ms. Anusha Pandey	SmartPhones4Water-Nepal
46.	Mr. Nischal Devkota	SmartPhones4Water-Nepal
47.	Mr. Torgen Sodeslund	SmartPhones4Water-Nepal
48.	Mr. Sugam Dahal	SmartPhones4Water-Nepal
49.	Mr. Saroj Yakami	Meta Meta
Non-Governmental Organizations (NGOs)		
50.	Dr. Rabin Malla	CREEW
51.	Dr. Salina Shrestha	CREEW
52.	Er. Palpasa Prajapati	CREEW
53.	Mr. Sarad Pathak	CREEW
54.	Mr. Madan Kafle	CREEW
55.	Er. Deepa Neupane	CREEW
56.	Mr. Upendra Jung Sahi	CREEW
57.	Mr. Sujan Poudel	CREEW
58.	Er. Gautam Raj Karnikar	CREEW
59.	Mr. Kiran Prasad Bhatta	CREEW

60.	Er. Utsav Bhattarai	CREEW / BRBIP
61.	Binod Chhetri Bhandari	ENPHO
62.	Ms. Neha Basnet	JVS
63.	Mr. Niranjan Bista	SEN
64.	Mr. Arun Pd. Bhattarai	SEN
65.	Mr. Shankar Shrestha	NDRI
66.	Ms. Monica Maharjan	NDRI
67.	Er. Sudeep Hada	CUID
68.	Mr. Sudarshan RajBhandari	CUID
69.	Ms. Shovana Maharjan	CRT/N
70.	Shreya Bajimaya	RBMF
71.	Lal Prashad Jaishi	Karnali Samaj
Private Companies		
72.	Mr. Gokul Dangal	Best Paani
73.	Ms. Sajal Pradhan	Best Paani
74.	Mr. Ravi Poudel	JVNL
75.	Mr. Prabin Parajuli	Lifetime Eng. Solutions
Media		
76.	Ms. Radha Chalise	Gorkhapatra
77.	Mr. Umeswar Sharma	Photographer

ANNEX III: COMMITTEES OF THE SYMPOSIUM

Technical Committee

Assoc. Prof. Dr. Sangam Shrestha (AIT), Prof. Dr. Suresh Das Shrestha (CDG, TU),Prof. Dr. Narendra Man Shakya (IoE, TU), Assoc. Prof. Ishwor Man Amatya (IoE, TU), Er. Jeff David, S4W Nepal), Prof. Ashutosh Shukla (ISET Nepal), Asst. Prof. Dhiraj Pradhananga (CDHM/TU), Madhukar Upadhya (Water Expert), Dr. Divya Ratna Kansakar(DoI), Prof. Dr. Suresh Das Shrestha (CDG, TU), Dr. Vishnu Prasad Pandey (IWMI Nepal), Dr. Divya Ratna Kansakar (DoI), Er. Surendra Raj Shrestha (GWRDB), Prof. Futaba Kazama (ICRE-UY)

Organizing Committee

Dr. Rabin Malla (CREEW), Dr. Salina Shrestha (CREEW), Er. Bipin Dangol (ENPHO), Mr. Anoj Khanal (KVWSMB), Mr. Dilli Bhattarai (SEN), Mr. Niranjan Bista (SEN), Mr. Rajkumar Gumanju (GWRDB)), Er. Rajaram Prajapati (S4W Nepal)

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