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Full Length Research Paper

Assessments of drinking water supply quality at squatter and indigenous settlements of Bagmati River Corridors in Kathmandu

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This study made an attempt to acquire information on water availability and assess the drinking water quality level of Bagmati river corridors. It identified the different modes of water supply sources and then examined drinking water quality in 37 squatters and 5 indigenous communities which consists 3693 households within Kathmandu Valley. To assess the state of drinking water quality at sources and points of use (POU), the standard water quality indicators were obtained through different parameters. 90 representative water sources' samples for testing the water quality at point of use were carried-out through random sampling of households in the communities. The survey was conducted by visiting each community and gathered information through key informant interview (KII) and questionnaire survey in May that is, pre-monsoon season of the year 2015. The result shows that the maximum samples of the water consumed in the squatter settlements are poor in quality and unhygienic for drinking proposes which does not meet National Drinking Water Quality Standard-2006. Out of 90 source sample, 81 source samples are contaminated in one or many forms. Tube well source has been found contaminated both in biological and chemical form. Tanker source is also emerging as the second major water supply source supplying to a large number of households consists with coliform, and has been noticed in almost all type of sources. P/A vial test concludes that even Jar water, which is considered to be most pure and safe, is contaminated with coliform bacteria. 68% people are willing to pay higher cost for good quality water; so, it is recommended that water samples of every season should be tested even if it makes production cost higher. Water quality regulator should provide awareness program about maintenance of the minimum quality standards (MQS) of drinking water.

Key words: Water sources, willingness to pay, water quality assessment, Coliform, Escherichia coli, Kathmandu valley.

INTRODUCTION

Access to safe drinking water supply is fundamental to improve public health and to meet national poverty reduction objectives. Water supply services delivery in most urban areas within Kathmandu Valley is poor and inadequate (MOUD, 2014). The situation is even worse in slum and squatter settlements (Desar, 2013). Several government organizations and local bodies are working in this sector but are not being able to show significant improvement. The government of Nepal remains fully committed to provide basic level of water supply and sanitation service to all by 2017 acknowledging it as a fundamental human need and basic human rights (Nepal–WHO Country Cooperation Strategy, 2018). It has also envisaged a need to improve the basic level of water supply and sanitation services to medium and higher level to all by 2027 (MOUD, 2014). However, the provision of basic water supply and sanitation services for squatters and slum dwellers, the poor and marginalized group has largely been neglected.

Kathmandu city is facing a rapid population growth and the incensement of number of homes to many slum and squatter settlements (Dahal, 2011). There are 40 squatter and 5 indigenous settlements in the Kathmandu valley (GTZ and Lumanti, 2008). Another survey conducted by LICSU, KUKL in 2008 identified that there were 39 squatter settlements and 137 slums in the Kathmandu Valley, where a population of 40,237 live in 8,846 households. Of these, 22% had no access to piped water supply, and none had adequate sanitation (KUKL, 2015). They are facing acute problems of water in terms of quality and quantity (Acharya, 2010).

Although, many studies including Acharya (2010), Dhakal (2011), Little (2012), Desar (2013) have been carried out in the past it does not present water quality information of squatter settlements. WHO (2004) has remarked that microbial hazards continued to be the primary concern in both developed and developing countries – including Nepal. Hence, accurate and updated information is essential to develop and implement plans and programs for their efficient management. A few studies like Toffin (2010), Shrestha (2013) etc… in the past have identified the squatter settlements in the valley and provided their basic data, but there is a need to update this information from time to time. This paper contains information on water sources and its drinking water quality at squatter settlements in Kathmandu Valley.

The main goal of this study is to map the water sources and assess its quality at squatters and indigenous settlements along Bagmati River and its tributaries in Kathmandu Valley. During the study, numbers of assumptions were made in the light of the fact that ideal situation to carryout study is very difficult to achieve. Shallow well water in near proximity has more or less similar quality because ground water does not change its character in small areas. Tube wells in near proximity extract same groundwater as ground water storage is mostly huge enough and they are able to supply water for larger areas and hence a community withdraws same quality of water. Pipe supply along the community from same source has same quality because it is difficult to predict the contamination due to foreign substances in near areas. The study has determined the quality of water only in pre-monsoon season. Other seasonal variances in the quality are not considered and it is limited to squatter settlements and indigenous settlements of Kathmandu valley only.

MATERIALS AND METHODS

The study is based on primary source collected through key informant interview. However, secondary data was also used from different published and unpublished sources. To assess the state of drinking water quality at sources and points of use (POU), the standard water quality indicators were obtained through different parameters on the basis of National Drinking Water Quality Standard-2006 (NDWQS, 2006). Testing was done to characterize water quality and determine if there is any variability in the same source over different settlements at time of observation.

Data and sample selection

Identification of squatter settlements

The studied squatter settlements were selected based on the study report "Status of Squatter Communities along Bagmati River and its tributaries in Kathmandu Valley-2008" published by Lumanti and GTZ. The geographical map of the studied area was prepared using Google earth and Google map. Table 1 shows the names of the rivers and nearby squatter settlements.

Questionnaire survey

A set of questionnaire and geological map of the study area was developed in order to get the required information. The questionnaire as well as the study methodology was finalized in consultation with WaterAid Nepal. The survey team then visited each community and gathered information through key informant interview (KII). People who were knowledgeable in community issues such as community leaders, ward office personnel, community club leaders, women groups, local kiosks were selected as key informants. At least one respondent out of 50 households were interviewed based on the prepared questionnaire to gather sufficient information regarding water source. The sources were identified and mapped in Google map.

Sample selection

The types of sources were then ranked based on the number of households dependent on that source type. The major and the second alternate source type for that community were identified based on the first and second ranking respectively. The feature of Google Earth like Show Elevation Profile and Measure Area were used to plot elevation profile of the ground, probable effective area of the source types, etc. Representative samples were chosen from these source types assuming sources having similar elevation and ground water table have similar water qualities. Samples for testing water quality at point of use were carried out through random sampling of households, in communities where water supply through pipeline or sealed jar were available.

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Table 1. Name of river and nearby squatter settlements.

Nearby river	Name of squatter settlements
Bagmati River	Shanti Ngar, Bijaya Nagar, Jagriti Nagar, GairigaunTole, PragatiTole, Kalimati Dole, Bansighat, Kuriyagaun and Shankhamul , PaurakhiBasti
Bishnumati River	Squatter settlements- DhikureChouki, Kumaristhan, Buddhajyoti Marg, BalajuJagritiTole, SangamTole, Ranibari
	Indigenous settlements- Inyatole, Ramghat, Hyumat, Dhaukhel and Bhimmukteshwor
Hanumante River	Manohara Bhaktapur
Dhobikhola	Shanti Binayak, Devi Nagar, Bishal Nagar, Kalopul and Pathivara
Tukucha	NarayantoleMaharajgung and KhadipakhaMaharajgunj
Other Location	Palpakot, Anam Nagar, Maijubahal, Kumarigal, Radhakrishna Chowk, Mulpani, Kapan Dhungen, Subigaun, Ramhiti, Mahankal, Sukedhara and Mandikatar

Sources: Modified from various sources including Lumanti (2008), Little (2012) and Deshar (2013).

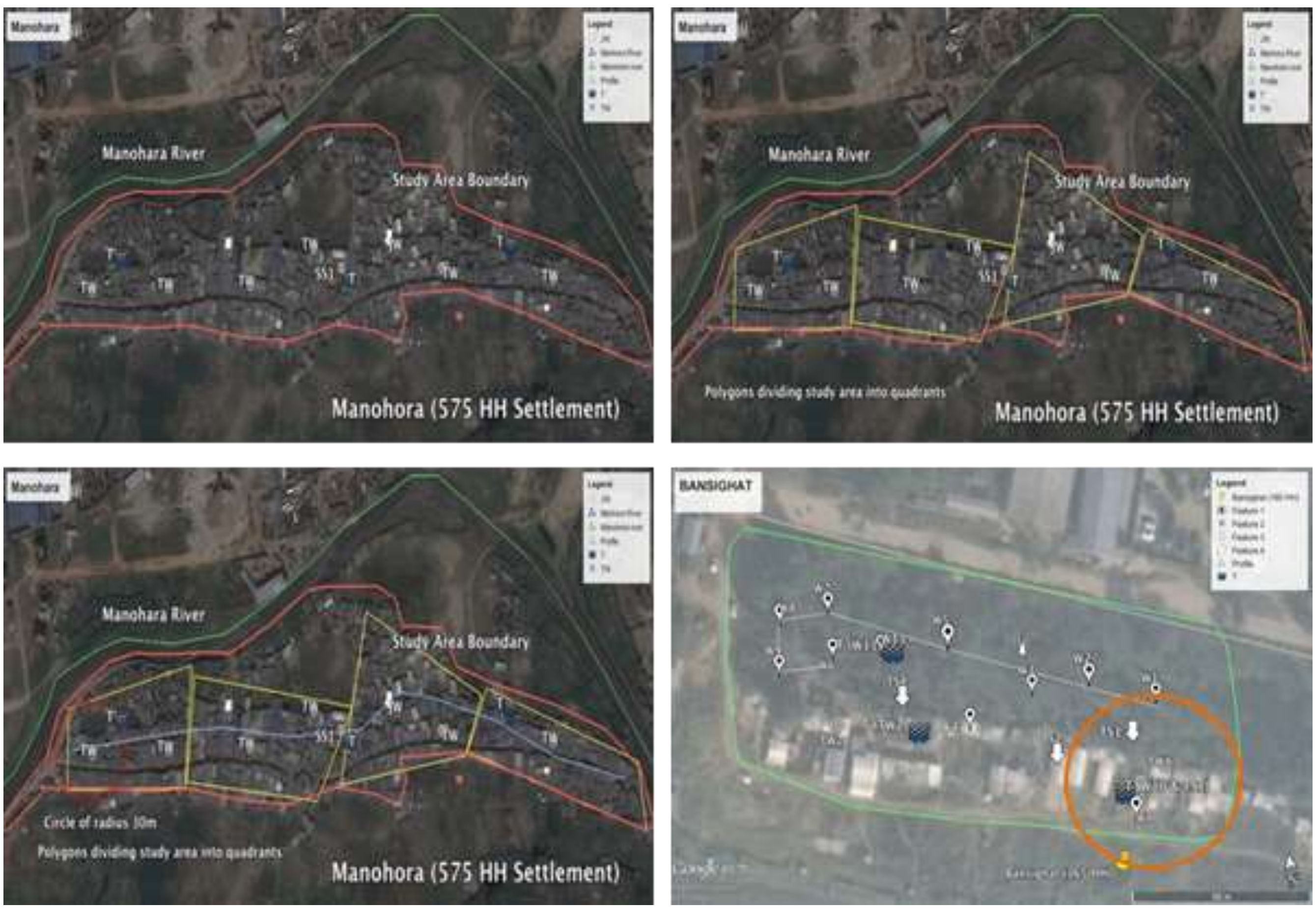

Figure 1. Area Map of Bansighat Settlement.

To developed the methodological framework, this study proceeds the following six steps as (i) preparation of geographic map (ii) marking boundary of the area and subdivide area into quadrants (iii) locating the sources (icons with names) (iv) drawing lines for profile (longitudinal line inside the area) (v) drawing circles from sources to find out near features (Red Circle of well of 30 m radius touches the river) and (vi) collect samples of sites predefined from desk work study. The chart and picture (in Figure 1) is an example of the process of selection of sample with the help of Google Earth and excel. The map (in Figure 1) shows the Bansighat settlement, near by the Manohara River. The sample selection was done based on the map using the methodology discussed. Different features were shown in the figure like green line polygon which denotes the area of study. Different types of place marks to represent the type of sources. Line feature along the shallow well place mark (W) represent the ground profile line. And red colour circle represent the radius drawn of the well source to check the radius of possible contaminating sources. The icons labelled with T are the possible source for sample collection.

All the water sources were mapped in Google map with the help of questionnaire survey. Superimpose different sources found representative source based on geography and other technical parameters like water table, tube well nature, pipe source and contamination. *Escherichia coli* test was also conducted in the sources which were nearby river site as there are high chances of contamination due to the river pollution. The graph shows out of 16 sources only 5 sources were selected as a sample. Two was from tanker supply, two was from tube well and 1 sample was selected from well.

Water quality assessments parameters

For water quality assessment the essential parameters recommended by NDWQS for drinking water purpose were considered. Most of the parameters are those that will effect adversely on the health with the lack or excess of it beyond NDWQS standard. The required parameters were chosen in such a way that every sample would represent the true nature of the water. The most essential physical, chemical test were done for all types of water sources like public stand post, tankers water source, tube well etc. The shallow wells that are prone to the faecal contamination were additionally checked for *E. coli* count along with the coliform presence/absence test. In case of water quality test for PoU, only P/A vial test and functional residual capacity (FRC) test were carried out. As like Kannel et al. (2007), Aryal et al (2013) and Gautam et al. (2013), the following parameters were tested for water quality assessment of water sources: (i) *Physico-chemical parameters:* 1. Electrical conductivity 2. pH 3. Turbidity 4. Colour 5. Temperature 6. Iron 7. Ammonia 8. Nitrate 9. Total Alkalinity 10. Total Hardness 11. Chloride 12. Calcium Hardness and 13. Magnesium Hardness and (ii) *Microbial parameters:* Coliform and *E. coli*.

Data analysis

This study is based on simple descriptive studies in which sophisticated statistical and econometrical tools have not been incorporated to analyse the outcomes. The gathered field information was entered into a customized database in a Microsoft Excel and spread sheet database were analyzed in Google earth. The paper is limited on measuring the quality of drinking water through Physio-chemical and Microbial parameters. However, this study can be extended for getting the information about willingness to pay (WTP) for improved drinking water to measure social welfare level in the study area. Contingent Valuation Method (CVM) would be one of the water users. Due to changes in income of water users or prices of water, consumer may be either better off or worse off. So, we can measure and examine ideal welfare when there is a fluctuation in willingness to pay in the study area.

RESULTS AND DISCUSSION

The study has been carried out in 37 squatters and 5 indigenous settlements. Some previous existing settlements “Dhumbarahi, Golfutar, Kialphat and Saranpur” were no more exists there and one new settlement has been identified named “Pauraki Basti” located at Bagamati river side, Thapathali. The population growth in the study area has been substantially increased from 2700 house hold to around 3700 house hold in the past seven years.

Water sources and household dependency

The survey has identified the different source types (such as pipe water, tanker, tubewell, well, stone spouts, public stand posts and jar water) as well as the number of each type of sources used by the communities in the study area. It has been found that the tube well source outnumbers all other sources. The total 1305 tube well sources are identified followed by 1101 Jar water, 56 well, 51 tanker, 33 public stand posts, 17 pipe and 12 stone spout. The households depends on the mentioned sources are 2128 (35%) on tube well sources followed by 1129 (19%) tankers, 1101 (18%) Jar waters, 645 (11%) public stand posts, 418 (7%) pipe, 391 (6%) stone spouts and 263 (4%) well sources respectively. This figure shows the water consumption pattern of the overall community. Based on this information further studies have been carried out such as number of sources to be tested of particular type. From this, tube well is found to be used hugely which is also the potentially vulnerable source of contamination among all other sources.

Drinking water treatment mechanism

It has been found that 59% of the households are using simple candle filter as water treatment mechanism. The second most popular treatment mechanisms are boiling (13%), followed by using bleaching powder or chlorination (4%). It was found that 24% of the households did not use any form of treatment mechanism. Results highlights that the water quality at squatter and indigenous settlements of Bagmati river corridors matters a lot in their health. As large number of settlement HH consumed water without taking full precautions, they are vulnerable from the water contamination.

Water sources and quality

Almost all communities are depending on a variety of sources for water. Tanker water supply and sealed jar water has been emerging as a new alternate source where municipal water supply and ground water is not sufficient. The settlements which belong to Bagmati River side are more dependent to tanker water. The sampled water collected from the study area was found both (i) Physico-Chemical Parameters and (ii) Microbial parameters. The details of the water quality are given in Annex Table 1.

Table 2. Summary of sources containing contaminants.

Sources	Bio chemical elements (Contaminants)						Total
	Iron	Ammonia	Nitrate	Turbidity	Coliform	*E. coli*	
Pipes	2	1	1	1	11	0	16
Public Stand Posts	3	3	0	0	5	0	11
Stone Spouts	0	0	1	0	4	4	9
Tanker	0	0	0	0	13	0	13
Tube Well	23	22	3	12	29	0	89
Well	5	6	2	3	9	8	33
Total	33	32	7	16	71	12	

Source: Authors' calculation.

Willingness to pay for quality water

People are increasing concerned about their health and their interest in the safety of drinking water has been increased (Kwak et al., 2013). Beaumais et al. (2014) in their study observed higher willingness to pay for better tap water quality in the countries with the highest percentage of respondents being unsatisfied with tap water quality because of health concerns. Our survey result shows that 68% people are willing to pay higher cost for good quality water. It indicates those people living in squatter and indigenous settlements of Bagmati River corridors are aware about water related health and other issues including water borne disease. It is similar with the result from Khan et al. (2011) which states people living with squatter area are willing to pay much higher than their current monthly bill charged.

Analysis of water quality assessment results

The results achieved through the water quality assessment of the samples are discussed in subsequent headings. Table 2 describes summary of water quality of all sources. Total 90 samples have been tested among them most contaminated source is tube well however it is free from *E. coli* other parameters are very high like high iron and ammonia. The well is other kind of source that contains all of the contaminants including *E. coli*. *E. coli* have been noticed in stone spout source and well only. In other source only coliform has been commonly notice. From figure, pipe supply sources can be considered the most safe source compare to all other as only coliform has been noticed which can be treating at house hold level.

Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. In drinking water, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases. This is especially problematic for immune compromised people, because contaminants like viruses or bacteria can become attached to the suspended solids. From the test, around 18% (16 out of 90 samples) have turbidity level higher than safe level (Figure 2).

Iron

Large amounts of iron in drinking water can give it an unpleasant metallic taste. Iron concentration is most commonly problematic in underground sources. As described above, around 30% (33 numbers) of the total samples contain concentration iron higher than national standards. Most of the samples which contain high iron are from tub wells. Among them 50% (15 numbers) samples had such high concentrations that it would be difficult to bring under limitation of NDWSQ if the treatment process is installed (Figure 3).

Ammonia

Ammonia is a chemical substance that is made by humans and by nature. The amount of ammonia manufactured every year by humans is almost equal to the amount produced by nature every year. However, when ammonia is found at a level that may cause concern, humans likely produced it either directly or indirectly. Ammonia is a corrosive substance and the main toxic effects are restricted to the sites of direct contact with ammonia (that is,, skin, eyes, respiratory tract, mouth, and digestive tract). Some people who use water-containing ammonia in excess could experience irritating effects to their eyes and nose, stomach discomfort and even cause cancer. Most of water sources in which high ammonia level found is from tube well and well. About 30% (32 numbers) of samples have excess of ammonia (Figure 4).

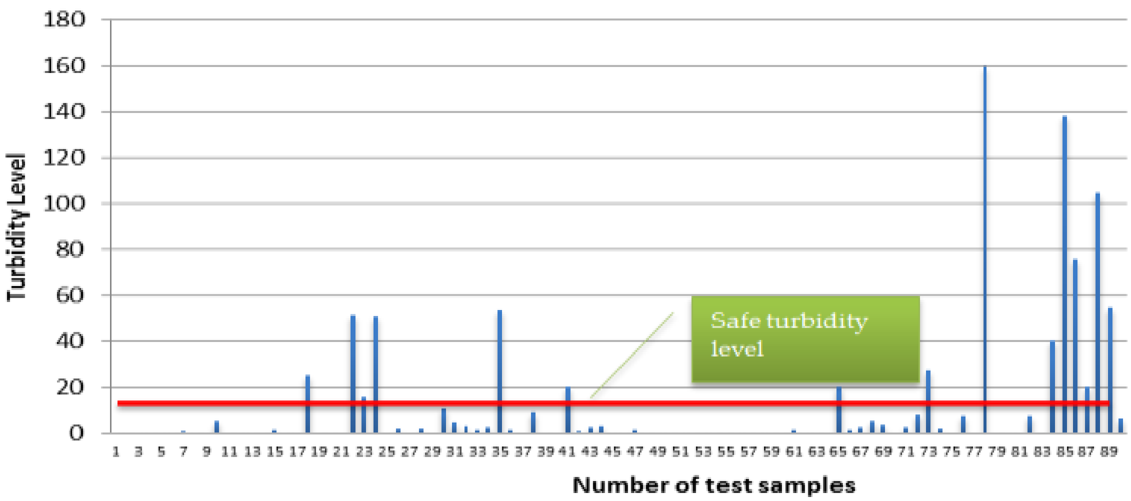

Figure 2. Turbidity level chart.

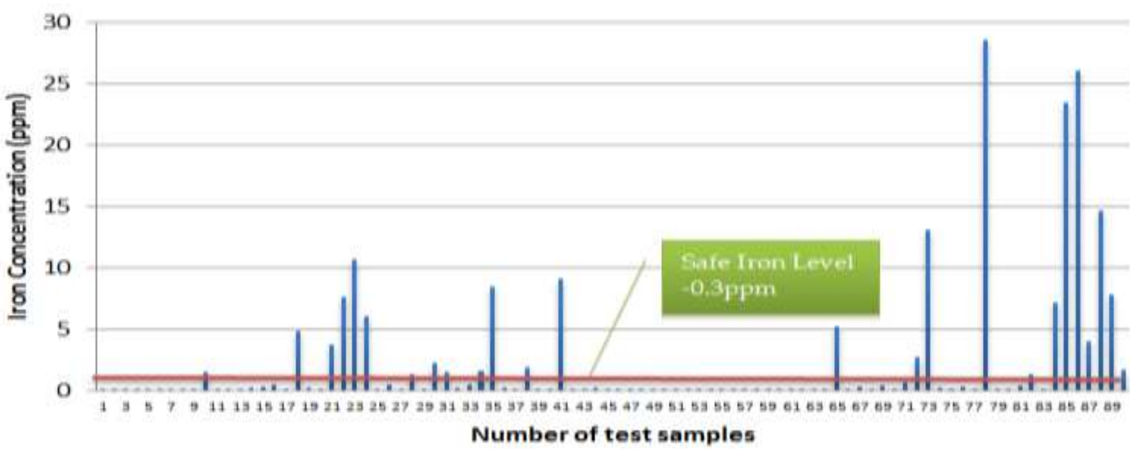

Figure 3. Iron concentration chart.

Nitrate

As shown by the graph, the excess nitrate is not observed in much sample. About 10% of the samples (7 numbers) have been found to have high nitrate concentrations. Nitrate has been found mostly in tube well and well sources. In one pipe supply source has also noticed high concentration nitrate located at Bishnumati river side, Hyumat (Figure 5).

Coliform

The presence of faecal coliform in drinking water is an evidence that human or animal waste has been or is present. This may be cause for concern because many diseases can be spread through faecal transmission. The presence of some faecal material in lakes, ponds and rivers is to be expected as part of the environment in which we live. In drinking water, presence of any coliform is a warning sign that action should be taken. The result shows that 79% (71 samples out of 90 samples) coliform contaminated. And these sources are tube well followed by tanker supply and pipe supply (Figure 6).

E. coli

E. coli is a type of faecal coliform bacteria commonly found in the intestines of animals and humans. *E. coli* is short for *Escherichia coli*. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination. Sewage may contain many types of disease-causing organisms. The number of coliform

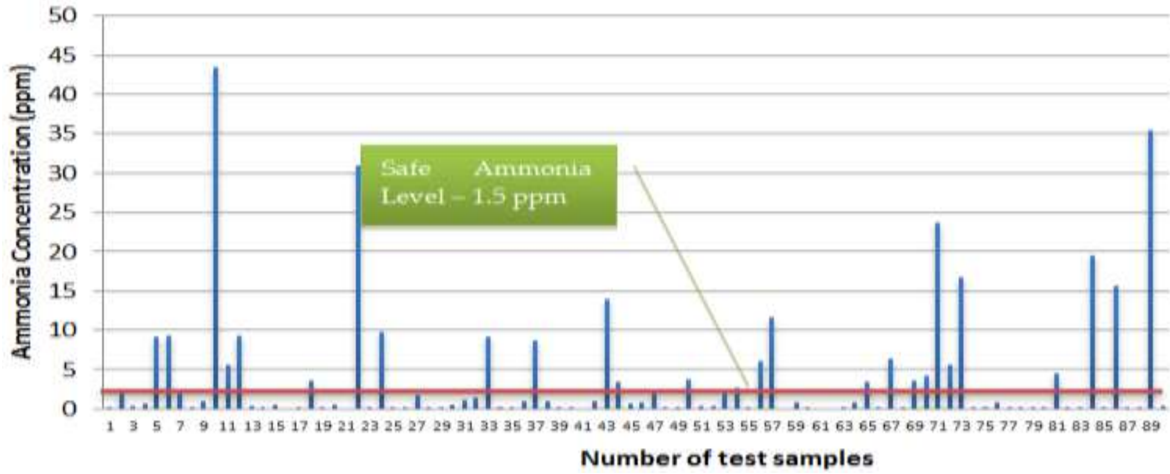

Figure 4. Ammonia concentration chart.

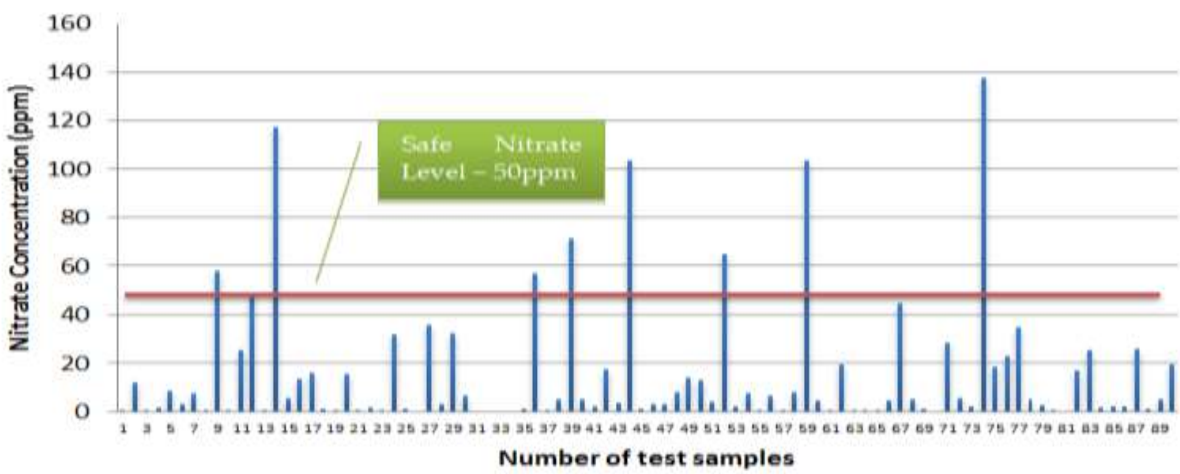

Figure 5. Nitrate concentration chart.

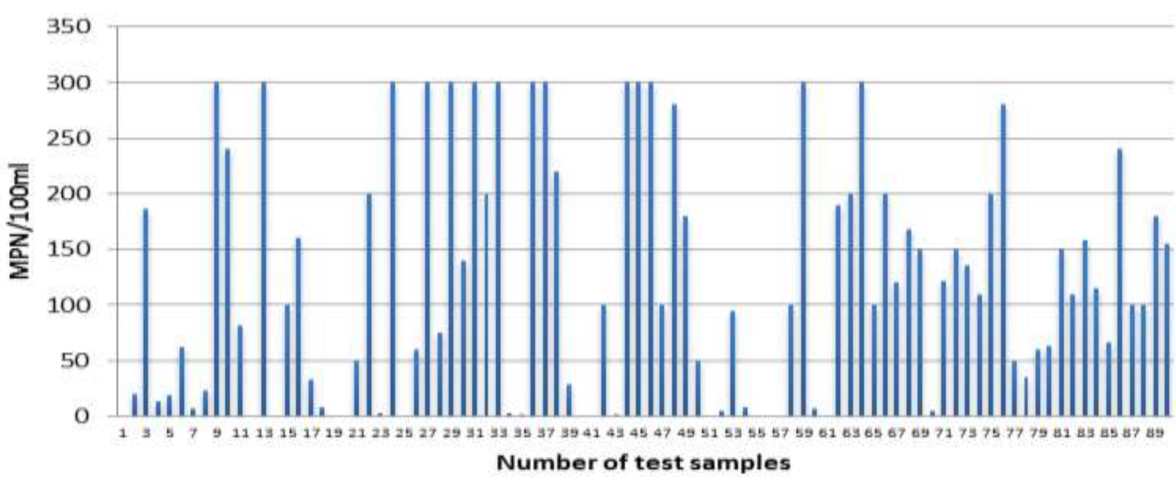

Figure 6. Coliform concentration chart.

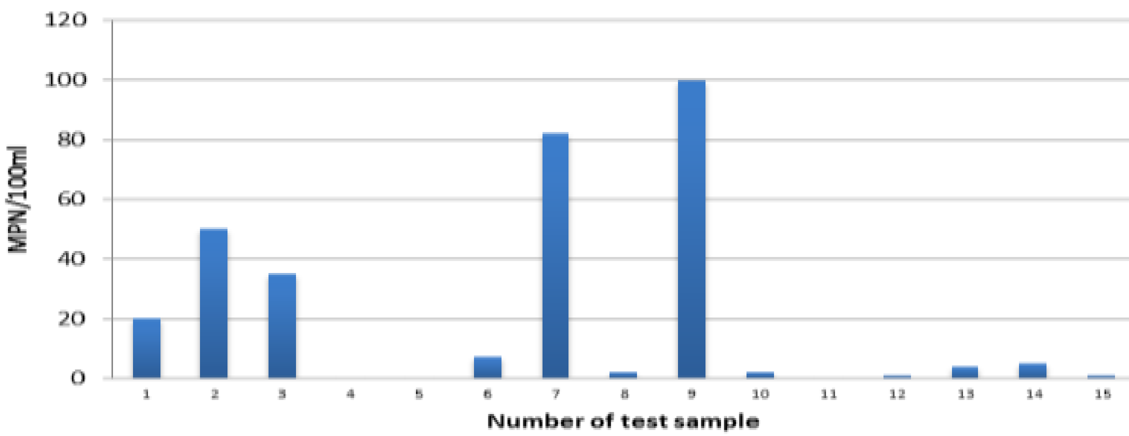

Figure 7. *E. coli* concentration chart.

Table 3. FRC value criteria.

Colour	Result	FRC value (mg/L)
Dark blue	High dosage	Above 0.5
Blue	Correct dosage	0.2-0.5
Light blue	Low dosage	0.1-0.2
No colour	Absence of chlorine	

bacteria is already indicated by the coliform test, which results in 90% contamination of total test. *E. coli* test has been done in some selected area where water sources are nearby river side and using for drinking purpose. Total 15 samples were tested for *E. coli* and 80% (12 samples out of 15 samples) has been found *E. coli* contaminated that sources are well and stone spout (Figure 7).

Summary of tests

The number of test samples were prepared to understand the the sample waters statues- whether it is contaminated or in good quality. Results show that the maximum samples are poor in quality which does not meet NDWQS-2006. Out of 90 source sample 81 source samples are contaminated in one or many forms. Only 10% of samples were free from objectionable constituents which meets NDWQS-2006.

Other tests

Random functional residual capacity (FRC) test

Random FRC test was done for PoU on almost all communities using piped and tanker water assuming they do chlorination for bacteria purpose (shown in Table 3). FRC test has been done using FRC test reagent developed by Environmental Conservation Camps for Awareness (ECCA). The FRC value can be observe through colour observation process (Presented in Annex Table 2). The result shows test result only 5% of water sources were found to have FRC (Table 4). Only in pipe source FRC was found. In one settlement “Bansighat” they are doing regular chlorination of community reservoir tank but found insufficient dosage.

P/A vial test

Along with FRC test, the P/A vial tests have been also done (Table 5). The P/A vial test also concluded that more than 50% of water consumed for drinking through sealed jar water is not good for drinking.

CONCLUSION AND RECOMMENDATIONS

The key motive of the study was to map the water sources and access its quality at squatter and indigenous settlements of Bagmati river corridors in Kathmandu valley. We tested several parameters under the heading of two broad prominent parameters (i) Physico-chemical

Table 4. FRC test result.

S/N	Community name	Source type	FRC status	SN	Community name	Source type	FRC status
1	JagritiTole	Pipe	Blue	16	Devinagar	PSP	No
2	JagritiTole	Tanker	No	17	Shantinagar	Tanker	No
3	BuddhajyotiMarg	PSP	No	18	Khadipakha	PSP	No
4	Ranibari	Pipe	No	19	Khadipakha	PSP	No
5	SangamTole	Pipe	No	20	Khadipakha	PSP	No
6	SangamTole	Jar	No	21	Khadipakha	PSP	No
7	DhikureChowki	Pipe	No	22	Khadipakha	PSP	No
8	ManoharaBhaktapur	Jar	No	23	Khadipakha	PSP	No
9	Bhimmukteshwor	Pipe	Blue	24	Bishalnagar	PSP	No
10	Dhaukhel	Pipe	No	25	Kalopul	Pipe	No
11	Ramghat	PSP	No	26	Kalimati Dole	PSP	No
12	Inyatole	Pipe	No	27	Bansighat	Pipe	Light blue
13	Inyatole	Tanker	No	28	ChadaniTole	Pipe	No
14	Hyumat	Tanker	No	29	Narayan Tole	Pipe	No
15	Anamnagar	PSP	No	30	KapanDhungen	Pipe	No

Source: Researchers' calculation.

Table 5. Vial test result.

S/N	Community Name	Source Type	Result
1	Pathivara	TW	Negative
2	PragatiTole	TW	Positive
3	Bishal Nagar	Jar	Positive
4	Maijubahal	Jar	Positive
5	Budhanilkantha	Jar	Positive
6	Devinagar	Jar	Negative
7	Shantinagar	Jar	Negative

Source: Researchers' calculation.

parameters and (ii) Microbial parameters. From the study it can be concluded that 90% of the water consumed in the squatter settlement is unhygienic for drinking propose which does not meet NDWQS-2006. The major contributing source is tube well. Tube well source has been found contaminated both in biological and chemical form. Tanker source is also emerging as a major water supply source supplying to a large number of households in the study area where municipal water supply and ground water is not sufficient. Coliform has been noticed almost all type of sources. Tube well source has been found most contaminated source in both physic chemical and microbial parameter. The major problem in tube well source is high amount of iron, ammonia, turbidity and coliform. *E. coli* have been noticed only in well sources and tube well. In tanker source only coliform has been noticed. To assess the quality of water at PoU random FRC test and P/A vial test have been conducted and result shows that there is no presence of FRC in pipe supplied water to prevent from further contamination. P/A vial test concludes that even Jar water, which is considered to be most pure form of drinking water, is contaminated with coliform bacteria. For clear judgement of the quality of water, it is recommended that water samples of every season should be considered and tested. More accurate result would be produced based on that.

(i) The findings already show that 90% of the domestic water usage is contaminated in both biological and chemical way (the health risks are not only posed in the case of drinking water, but also in other domestic usages like washing and bathing), which means majority of people living in this area are vulnerable to health hazards. So it is recommended to concern authority to implement water treatment process in those areas.
(ii) Almost all sources have been found coliform contamination so simple household treatment process

such as silver colloidal filter or chlorination could prevent from many water borne diseases as these solutions are cost effective and user friendly.
(iii) In terms of quality assessment most of underground sources such as tube wells and wells has been found more contaminated in both bio logical and chemical form. Based on its quality treatment plant should be design.
(iv) Tanker source has been emerging as a new source in many settlements where municipal water supply and underground water is not sufficient. Most of the tanker source has been found coliform contaminated. So it is recommended to any one HWTS before consumption.
(v) Awareness level on water quality has been found very poor. Public have concept that sealed water means safe but test result shows sealed jar water with coliform contamination, so necessary awareness program should be conducted so that they will take the steps of preventing themselves.
(vi) Based on the current water quality assessment report, the treatment system for safe quality of water should be studied in the details. To get the water quality of whole year similar kind of study should be conducted in different season such as rainy seasons and dry season as water quality varies season to season

In a nutshell, as awareness level found very poor in this area so awareness raising activities on water quality test at house hold level and introduction of house hold water treatment systems (HWTS) is very essential in this area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Annex Table 1. Water sources and quality.

S/N	Community Name	Total	Major sources (In terms of no. of HH)							Samples collected (Name and Nos.)	Nos.	Remarks
		HH	P	W	PSP	TW	SS	T	JW			
1	DhikureChauki	20	15					5		P-1	1	Good quality with reference of NDWQS
2	KumaristhanBuddhajyotiMarg	72		10	65	60			7	TW-1, W-1, PSP-1	3	High Iron, Ammonia and Coliform
3	JagaritiTole	300	60		50	200		240		P-1, TW-3, T-3	7	High Iron, Ammonia and Coliform
4	SangamTole	35	17			25		15	10	TW-1, T-1	2	Highly Turbid, Iron, Ammonia and coliform
5	Ranibari	52	10			20		5	37	T-1, P-1	2	Coliform only
6	Inyatole (indigenous)	55	44					11		P-1, T-1	2	High Coliform
7	Ramghat (Indigenous)	25	23					5		P-1	1	High Coliform
8	Bhimmukteshwor(Indigenous)	22	15	5				1	4	P-1, W-1	2	High Coliform
9	Hyumat (Indigenous)	8	8					4		P-1	1	Very high Ammonia, Nitrate and Coliform
10	Dhaukhel (Indigenous)	28	10	7				21		P-1, W-1	2	Iron, Ammonia (W), (Insignificant Coliform only)
11	ManoharaBhaktapur	107		42	8	41			37	W-1, TW-1, PSP-1	3	Very High Ammonia, Coliform and *E. coli*
11.1	Manohara Bhaktapur -2 (PragatiMarg)	575				300	60		517	SS-1, TW-4	5	Highly contaminated with all forms, *E. coli*
11.2	Manohara Bhaktapur -3 (Lokanthali)	45				3	45			SS-1	1	Nitrate, Coliform and *E. coli*
12	Palpakot	50				2	45	5		SS-1	1	Coliform and *E. coli*
13	Mandikhatar	75		10	30		75			SS-1, W-1, PSP-1	3	High Coliform, Iron andAmmonia
14	Shanti Binyak	45		30		4	40			TW-1, SS-1	2	High Coliform, E-coli, Iron and Ammonia
15	Kalopul	6	6	6						W-1	1	High Coliform and *E. coli*, Nitrate
16	Anamnagar	18			18	17				PSP-1, TW-1	2	High Iron in TW only
17	KhadkaBhadrakali	34		20	34					PSP-1, W-1	2	High Coliform, *E. coli* and Ammonia
18	Kumarigal	11				11			11	TW-1	1	Coliform only
19	Budhanilkantha	35				35				TW-1	1	Iron and Coliform
20	MaijuBahal	13		6	13					W-1	1	High Coliform, Iron and Ammonia
21	Bishalnagar	37			15	15			37	PSP-1, TW-1	2	High Ammonia and Iron
22	Devinagar	35			35				35	PSP	1	High Coliform
23	Khadipakha	300		10	300	150				TW-3, PSP-1, W-1	5	High Iron, Ammonia, *E. coli*, PSP good
24	Bansighat	165		10		110		110		T-2, TW-2, W-1	5	High *E. coli* in Well and Iron, Ammonia, coliform
25	Kuriyagaun	6				6			3		0	
26	PaurakhiBasti	211	100			211		211		TS-2	2	High Iron, Ammonia and Coliform
27	Sankhamul	110		35		110		110		T-2	2	Insignificant Coliform

Annex Table 1. Contd.

28	Shantinagar	421				300		200	240	T-2, TW-2	4	Very high Ammonia, Iron in TW only
29	Gairigaun	113				113	46	67		P-1, T-1, TW-1	3	Highly Turbid, Iron, Ammonia and coliform
30	Jagritinagar	120		60		60		60		W-1, T-1, TW-1	3	Highly Turbid, Iron, Ammonia and coliform
31	PragatiTole	15				15			3	TW-1	1	Very high Ammonia and coliform
32	Kalimati Dole	14			14	14				TW-1	1	Better Quality of Water
33	ChadaniTole	60	40			40				P-1, TW-1	2	Good Quality (Insignificant coliform only)
34	Bijaynagar	45				25		20	10	TW-1, T-1	2	Highly Turbid, Iron, Ammonia and coliform (TW)
35	Subigaun	42				42				TW-1	1	Coliform only
36	Ramhiti	119				119	80			TW-2	2	Coliform only
37	Pathivara	164			30	60			150	TW-1	1	High Ammonia only
38	KapanDhungen	14	14							P-1	1	Coliform only
39	Narayan Tole	33	33	10	33	4		33		T-1, W-1	2	Coliform and *E. coli* (TW)
40	Radhakrishna	15				15				TW-1	1	High Nitrate only
41	Hattigauda	6	6					6		P-1	1	Coliform only
42	Mulpani	17	17	2		1				P-1, W-1	2	High Iron, Nitrate, Coliform and *E. coli*
	Total household	**3693**	**418**	**263**	**645**	**2128**	**391**	**1129**	**1101**		**90**	

Annex Table 2. Quality assessment summary sheet.

S/N	Sample	Community Name	Color	pH	Turb	Temp	EC	T Hard	T Alk	Ca	Mg	Cl	NH_3	Fe	NO_3	Coliform	*E. coli*
1	2265	Anamnagar PSP	<5.0	6.4	<1.0	21.4	403	150	106	36.04	14.57	39.6	0.14	0.049	5.26	0	
2	2266	Anamnagar TW	<5.0	6.2	20.1	21.5	682	250	158	61.66	23.32	51.5	1.96	9.128	2.28	0	
3	2297	Bansighat T1	<5.0	6.7	1.2	22.7	161	198	44	36.04	26.23	14.9	0.36	0.06	4.62	200	
4	2299	Bansighat T	<5.0	6.8	5.4	23.4	162	60	58	14.41	5.83	11.9	0.65	0.16	4.99	168	
5	2308a	Bansighat TW1	<5.0	6.5	7.3	21.4	571	234	196	35	10.7	14.4	9.2	1.3	15.5	158	
6	2308b	Bansighat TW2	5	6.8	7.9	21.4	489	264	110	42	12.6	12.9	9.3	0.95	14.1	142	
7	2298	Bansighat W	<5.0	6.6	2.6	22	612	210	138	44.84	23.8	52.5	2.25	0.279	44.81	120	1
8	2268	Bhimmukteshwor P1	<5.0	6.5	1	21.4	561	236	158	56.06	23.32	41.6	0.02	0.082	17.34	100	
9	2336	Bhimmukteshwor W1	5	6.3	<1.0	22.2	954	322	240	73.67	33.52	43.6	1	0.114	18.68	200	
10	2384	Bijaynagar TW	<5.0	6.4	105	22.5	1133	122	396	28.03	12.6	53.6	43.43	14.66	1.11	100	
11	2256	Bishalnagar PSP	40	6.7	2.3	21.5	190	44	106	12.0	3.4	<1.0	5.65	1.6	<0.02	2	
12	2257	Bishalnagar TW	5	6.4	53.4	21.5	545	190	196	58.5	10.7	41.58	9.34	8.51	0.94	1	
13	2250	Budhanilkantha TW	<5.0	6.1	1.8	21.4	441	150.0	96	29.6	15.5	54.45	0.31	1.328	3.26	75	
14	2241	ChadaniTole P	<5.0	5.6	<1.0	21.3	32	10.0	16	2.4	1.0	6.93	0.13	0.186	0.77	0	

Annex Table 2. Contd

15	2239	ChadaniTole TW	<5.0	6.6	<1.0	22.5	674	234.0	222	17.6	46.2	41.58	0.46	0.047	16.04	33	
16	2262	Devinagar PSP	<5.0	6.3	<1.0	21.4	37	14	16	3.2	1.5	4	<0.02	0.054	0.34	300	
17	2269	Dhaukhel P1	<5.0	6.7	2.2	21.5	243	132	110	32.03	12.63	12.9	0.15	0.112	3.74	1	
18	2337	Dhaukhel W	10	6.5	7.3	22.1	1334	180	286	44.04	17	35.6	3.54	0.314	22.7	280	
19	2223	DhikureChauki P1	<5.0	6.8	<1.0	22.6	50	20.0	28	8.01	<1.0	4.95	0.19	0.043	0.27	0	
20	2240	Gairigaun P	<5.0	6.5	25.1	23.4	173	74.0	74	17.6	7.3	4.95	0.54	4.864	1.18	8	
21	2290	Gairigaun T	<5.0	7.1	<1.0	22.4	221	126	120	36.8	8.26	2	<0.02	0.123	0.55	200	
22	2385	Gairigaun TW	<5.0	6.5	54.6	22.4	830	194	292	48.05	17.97	40.6	30.95	7.84	5.27	180	
23	2230	Hattigauda P1	<5.0	6.6	<1.0	22.4	72	22.0	38	4.8	2.43	2.97	0.09	<0.01	0.63	23	
24	2270	Hyumat P	10	6.7	3	21.7	482	150	144	37.64	13.67	6.9	9.73	0.253	103.25	>300	
25	2272	Inyatole P	<5.0	6.7	<1.0	21.8	85	48	42	12.01	4.37	4	0.14	0.022	3.04	>300	
26	2273	Inyatole T	<5.0	7	1.3	21.9	275	166	136	40.04	16.03	3	0.11	0.139	3.33	100	
27	2277	JadiButi PSP	<5.0	6.2	<1.0	21.7	150	52	60	11.21	5.83	12.9	1.75	0.124	4.27	0	0
28	2229	JagritiTole P1	<5.0	6.9	1	22.5	213	74.0	104	22.42	4.37	6.93	0.18	0.15	7.56	7	
29	2340	JagritiTole T	<5.0	6.7	<1.0	22.1	297	160	144	40.84	14.09	3	0.08	0.07	2.88	60	
30	2228	JagritiTole T1	<5.0	7	<1.0	22.5	277	168.0	152	49.65	10.69	3.96	0.44	0.069	2.9	62	
31	2341	JagritiTole T2	<5.0	6.8	<1.0	22.2	306	168	152	38.44	17.49	<1	1.2	0.142	0.41	63	
32	2338	JagritiTole TW1	<5.0	6.3	<1.0	22.1	684	226	110	56.06	20.89	44.6	1.45	0.095	34.9	49	
33	2339	JagritiTole TW2	<5.0	6.1	160	22.1	864	264	182	50.45	33.52	28.9	9.18	28.55	5.27	35	
34	2342	JagritiTole TW3	<5.0	6.8	<1.0	22.3	337	178	170	41.6	17.97	2	0.23	0.402	<0.02	150	
35	2285	jagritinagar T	<5.0	6.5	<1.0	22.3	147	50	48	12.01	4.86	12.9	0.04	0.108	8.06	100	
36	2286	jagritinagar TW	<5.0	6.2	<1.0	22.3	768	226	140	53.65	22.35	47.5	0.94	0.16	103.72	300	
37	2383	jagritinagar W	15	6.4	20.1	22.5	842	144	236	30.43	16.52	50.5	8.69	4.022	25.7	100	
38	2242	kalimati Dole TW	<5.0	6.2	<1.0	21.3	393	156.0	144	36.8	15.5	44.55	0.92	0.065	15.45	0	
39	2258	Kalopul W	5	6.6	1.5	21.6	583	210	138	64.9	11.7	41.6	0.13	0.223	56.92	>300	82
40	2235	KapanDhungen P	<5.0	7	<1.0	22.9	33	10.0	14	2.4	0.97	1.98	0.28	0.016	0.67	300	
41	2247	Khadipakha PSP1	<5.0	6.7	<1.0	21	59	26.0	28	11.2	6.3	2.97	<0.02	0.094	0.97	0	
42	2243	Khadipakha TW1	<5.0	5.7	<1.0	21.4	150	34.0	42	8.0	3.4	19.8	1.03	3.734	0.38	50	
43	2244	Khadipakha TW2	<5.0	6	51.6	21.4	820	234.0	318	36.0	35.0	34.65	14.01	7.608	1.45	200	
44	2245	Khadipakha TW3	<5.0	5.9	15.6	21.1	490	128.0	126	37.6	12.6	49.5	3.51	10.695	0.55	2	
45	2246	Khadipakha W	<5.0	6.4	50.8	21.0	640	146.0	180	6.4	2.4	53.46	0.61	6.022	31.77	>300	50
46	2248	KhadkaBhadrakali PSP	<5.0	6.3	2.1	21	133	54.0	204	54.5	20.9	3.96	0.75	0.463	<0.02	60	
47	2249	KhadkaBhadrakali W	<5.0	6.3	<1.0	21.2	589	222.0	72	36.0	14.6	35.64	2.18	0.071	35.67	>300	35
48	2254	Kumarigal TW	<5.0	6.3	2.7	21.5	213	90	68	26.4	10.7	12.87	0.1	0.215	<0.02	200	
49	2227	Kumaristhan (BuddhaJyotiMarg) PSP	<5.0	7.2	<1.0	22.6	178	90.0	100	28.03	4.86	2.97	0.15	0.051	8.41	19	

Annex Table 2. Contd.

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50	2343	Kumaristhan (BuddhaJyotiMarg) TW	15	6.4	7.2	22.4	570	192	136	53.65	14.09	19.8	3.75	1.3	17.1	110	
51	2344	Kumaristhan (BuddhaJyotiMarg) W	<5.0	6.3	<1.0	22.3	602	226	122	54.45	21.86	37.6	0.35	0.127	25.19	158	
52	2278	Lokanthali SS	<5.0	6.4	<1.0	21.9	590	220	74	54.45	20.4	53.5	0.41	0.104	64.94	5	1
53	2255	Maijubahal W	<5.0	7	1.1	21.6	280	110	104	31.2	7.8	19.8	1.96	0.527	<0.02	300	7
54	2253	Mandikhatar PSP	5	6.4	4.6	21.4	234	74	116	21.6	8.7	4.95	2.7	1.474	<0.02	300	
55	2251	Mandikhatar SS	<5.0	6	<1.0	21.4	413	138	88	26.4	9.7	40.59	0.25	0.032	32.36	>300	Nil
56	2252	Mandikhatar W	15	6.2	10.6	21.4	301	106	42	23.2	3.9	33.66	6.02	2.227	6.72	140	Nil
57	2275	Manohara TW	<5.0	6.5	<1.0	21.5	1163	158	276	40.04	14.09	53.5	11.68	0.078	14.1	180	
58	2274	Manohara W	<5.0	6.6	<1.0	21.9	463	204	124	48.05	20.4	41.6	<0.02	0.107	8.21	280	100
59	2232	Mulpani P	15	6.4	5.4	22.4	93	34.0	52	9.61	2.43	1.98	0.89	1.515	0.44	240	
60	2231	Mulpani W	<5.0	6	<1.0	22.4	367	116.0	38	29.63	10.2	37.62	0.15	0.13	58.03	>300	20
61	2288	Narayan Tole T	<5.0	6.6	1.5	22.4	23	10	10	2.4	0.97	4.7	<0.02	0.101	0.58	0	
62	2289	Narayan Tole W	<5.0	6.9	<1.0	22.5	692	210	182	68.8	9.23	46.5	<0.02	0.07	19.46	190	5
63	2279	Palpakot SS	<5.0	6.5	<1.0	22	232	58	50	12.01	6.8	32.7	0.25	0.061	2.29	94	4
64	2287	Bijaynagar T	<5.0	6.5	<1.0	22.4	147	48	54	11.21	4.86	12.9	0.79	0.102	4.46	7	
65	2234	Pathivara TW	<5.0	6.4	<1.0	23	857	318.0	262	1.6	6.56	47.52	3.38	0.066	49.07	0	
66	2295	PaurakhiBasti T	<5.0	6.6	<1.0	22.7	15	6	6	1.6	0.49	1	0.03	0.021	0.39	300	
67	2296	PaurakhiBasti T1	10	6.4	20.4	22.7	796	56	104	15.22	4.37	36.6	6.39	5.228	0.6	100	
68	2276	PragatiMarg SS	<5.0	6.7	<1.0	21.5	589	216	72	50.45	21.46	44.6	0.17	0.085	12.99	50	2
69	2332	PragatiMarg TW1	30	6.2	2.4	22.2	875	286	107	69.67	27.2	33.7	3.55	0.695	28.39	122	
70	2333	PragatiMarg TW2	10	6.2	8.2	22.2	893	272	120	60.06	29.63	64.4	4.29	2.762	5.68	150	
71	2334	PragatiMarg TW3	40	6	27.5	22.1	846	174	196	39.24	18.46	65.3	23.71	13.055	2.1	135	
72	2335	PragatiMarg TW4	20	6	1.6	22.2	796	232	102	56.86	21.86	40.6	5.64	0.198	137.51	110	
73	2238	PragatiTole TW	<5.0	6.4	<1.0	23.2	774	210.0	272	71.27	7.77	75.24	16.68	0.461	13.53	160	
74	2236	RadhakrishnaChowk TW	<5.0	6	<1.0	23	492	126.0	56	23.22	16.52	47.52	0.23	0.244	117.42	0	
75	2271	Ramghat P	<5.0	7.1	<1.0	21.6	35	14	16	3.2	1.46	2	0.18	0.018	1.14	300	
76	2237	Ramhiti TW	<5.0	6.2	1.2	22.8	312	98.0	58	23.22	9.72	46.53	0.89	0.335	5.79	100	
77	2386	Ramhiti TW1	5	6.1	6.3	22.5	349	96	20	22.46	9.72	25.7	0.12	1.671	19.25	155	
78	2225	Ranibari P1	<5.0	6.5	<1.0	22.7	51	24.0	28	4	3.4	4.95	0.14	0.038	0.31	186	
79	2224	Ranibari PSP	<5.0	6.5	<1.0	22.6	122	50.0	40	15.22	2.91	11.88	0.09	0.013	12.13	20	
80	2226	SangamTole T1	<5.0	6.6	<1.0	22.7	297	184.0	168	5.65	41.27	4.95	0.2	0.067	1.42	13	
81	2345	SangamTole TW	15	6.3	40	22.3	594	192	226	47.25	17.97	33.7	4.49	7.213	1.66	115	
82	2281	Sankhamul T1	<5.0	6.5	<1.0	22.5	122	48	44	11.21	4.86	11.9	0.08	0.134	7.44	8	
83	2282	Sankhamul T2	<5.0	6.7	<1.0	22	29	12	16	2.4	1.4	2	0.06	0.058	0.67	0	
84	2382	Shanitnagar TW	<5.0	6.2	75.6	22.5	522	114	158	32.03	8.26	36.6	19.47	26.12	1.95	240	
85	2264	Shanti Binayak SS	<5.0	6.1	<1.0	21.5	486	138	74	36.0	11.7	49.5	0.19	0.054	71.53	29	2

Annex Table 2. Contd.

86	2263	Shanti Binayak TW	<5.0	6.2	9	21.6	734	226	266	71.3	11.7	79.2	15.62	1.918	5.03	220
87	2283	Shantinagar T1	<5.0	6.4	<1.0	22	144	58	56	14.41	5.34	13.9	0.06	0.105	6.84	0
88	2284	Shantinagar T2	<5.0	6.5	<1.0	22.2	32	14	14	3.2	1.46	4.9	0.08	0.137	0.12	0
89	2381	Shantinagar TW	<5.0	6.3	138	22.5	1037	184	268	48.5	15.55	31.7	35.44	23.46	2	66
90	2233	Subigaun TW	<5.0	5.9	<1.0	22.8	369	130.0	52	37.64	8.74	27.72	0.36	0.1	25.36	82

Related Journals: