Santosh Shrestha

MONITORING OF WATER QUALITY AND ESTABLISHING MAINTENANCE SYSTEM IN A RURAL COMMUNITY IN NEPAL

Bachelor's Thesis
Environmental Engineering

September 2014

MAMK
University of Applied Sciences

DESCRIPTION

MAMK University of Applied Sciences	**Date of the bachelor's thesis**
Author(s) Santosh Man Shrestha	**Degree programme and option** Environmental Engineering

Name of the bachelor's thesis

Monitoring of water quality and establishing maintenance system in a rural community of Nepal.

Abstract

This thesis is a part of the LEAP (Livelihood Environmental Awareness Project) Organized by CODEF (Community Development Forum) with the support of KEMA (Mikkeli- Kehitysmaayhdistys).

The study includes the water improvement systems and strategy to raise the awareness of water and personal hygiene for the community of Devichaur. The goal of this thesis is to minimize the number of diarrhoeal cases in the rural part of Nepal, Devichaur, situated in the Lalitpur district. The number of diarrhoeal cases observed in the Devichaur VDC is because of the drinking of contaminated water and poor personal hygiene. Analysis of water quality shows that water is contaminated with faecal pathogens. Likewise, faecal pathogen (*E.coli*) found from the hand hygiene test. The hand hygiene and water quality tests indicate that the source of water contamination is from contaminated hand of individuals. To assess the drinking water quality, Water quality tests for chemical, physical and faecal pollutants will be carried out with the help of available materials and methods. The result of the water quality tests will describe the need of water treatment methods to be adopted. The simplest way to find out the microbial alarming system for contamination of drinking water is one of the aim in this work.

The research target is to find out the most feasible technique to decontaminate the drinking water specially for the community residing in the rural part of Nepal. In addition, building the maintenance group to take care of the water management system is also important part in the study. After that, social, technical and environmental challenges for building the water treatment system is also studied. Besides improvement of the water quality, to educate the community about the effects on human health because of the poor drinking water and personal hygiene is major concern. Likewise, the information distribution about the safe sanitation to minimize the contamination of water source. In overall, this thesis will be helpful to assist socially and technically in setting up the pilot plant for water disinfection system and to replicate the system in other wards of the Devichaur VDC.

Subject headings, (keywords)		
Water, Hygiene, Contamination, Chotidanda		
Pages 39	**Language** English	**URN**
Remarks, notes on appendices		

Tutor	**Employer of the bachelor's thesis**
Maritta Jokela	Raimo Lilja KEMA (Mikkelin Kehitysmaayhdistys)

Acknowledgement

I would like to express my enormous gratitude to our mentor Aila Puttonen for encouraging me to apply for my thesis in Mikkelin Kehitysmaayhdistys. She has always supported during my all the study period and also provided counselling. I would also like to thank Project Coordinator Raimo Lilja for providing me an opportunity to do my thesis in the LEAP project assisted by KEMA Kehitysmaayhdistys.

I am extremely grateful to senior lecture Maritta Jokela for being my thesis supervisor and assisting and guiding me during my thesis. She has always advised me whenever needed. She has provided all the necessary equipments and tools for the practical work during my thesis work.

I would like to thank to Dharma Ratna Chitrakar, from the Engineering department of CODEF for assisting during my field work and providing useful data for my thesis.

Finally, I would like to thank to my parents for always being there for me.

Table of Contents

ABBREVIATIONS

KEMA - Mikkelin Kehitysmaayhdistys

CODEF - Community Development Forum

E.coli - Escherichia Coli

VDC - Village Development Committee

LEAP - Livelihood and Environmental Project

ENPHO - Environmental and Public Health Organization

NTU - Nepholometric Unit

FCHVs - Female Community Health Volunteers

WSUC - Water and Sanitation Users Committee

WUGs - Water Users Groups

SSF - Slow Sand Filtration

SODIS - Solar Disinfection

1 INTRODUCTION

Every year, about 2 million diarrhoeal deaths due to the unsafe water, sanitation and hygiene have been recorded, the deaths include the vast majority of children under 5 years[1]. Water born microbes are the major contaminants for many diseases harmful for the human beings. Such microbes are naturally present in our environment. Faecal contamination is one of the major sickness causing diarrhoea. Devichaur is one of the rural part of Nepal, where consumption of unsafe drinking water has caused sickness like diarrhoea, dysentery, typhoid etc to number of people every year.

Water contamination by *E.coli* and *Coliform* can be detected by different methods. Presence of faecal contaminants in drinking water can be verified by *E.coli* and *Coliform* test and other chemical indicators. To provide safe drinking water, those microbes should be treated in a way that the drinking water has minimal microbes which do not harm to people or the limit value according to the health standards are sustainable. To minimise the microbial contamination in water, the most suitable and cheapest water treatment and management system has to be implemented. Besides the water treatment, hand hygiene should also be taken into account. Although there are so many water decontamination techniques, the thesis will be useful to implement the cheapest water improvement system by analysing the proposed techniques.

1.1 Devichaur Background

Devichaur is one of the Village Development Committee (VDC) C situated in mountainous part of Lalitpur District (Fig.1). The VDC lies at longitudes 85^{o} 15'E and 85^{o} 19'E and latitudes at 27^{o} 32'E and 27^{o} 35'N. The VDC has 9 wards, one of them is Chotidanda. The elevated zone range from 960m to 2,340m above the sea level. The VDC is reach in water, forest, ethics, culture, natural beauty and so on. There is 28 households with 170 members, among them the number of male and female are 89 and 81 respectively. Devichaur can be reached in about 45 minutes by drive from the capital city Kathmandu.[2]

Devichaur VDC has 577 households with inhabitants of 2883 population. Ethnic habitants are Tamang which occupies about 80%. The major income source of the residents are farming and livestock and local wine production as well. [2]

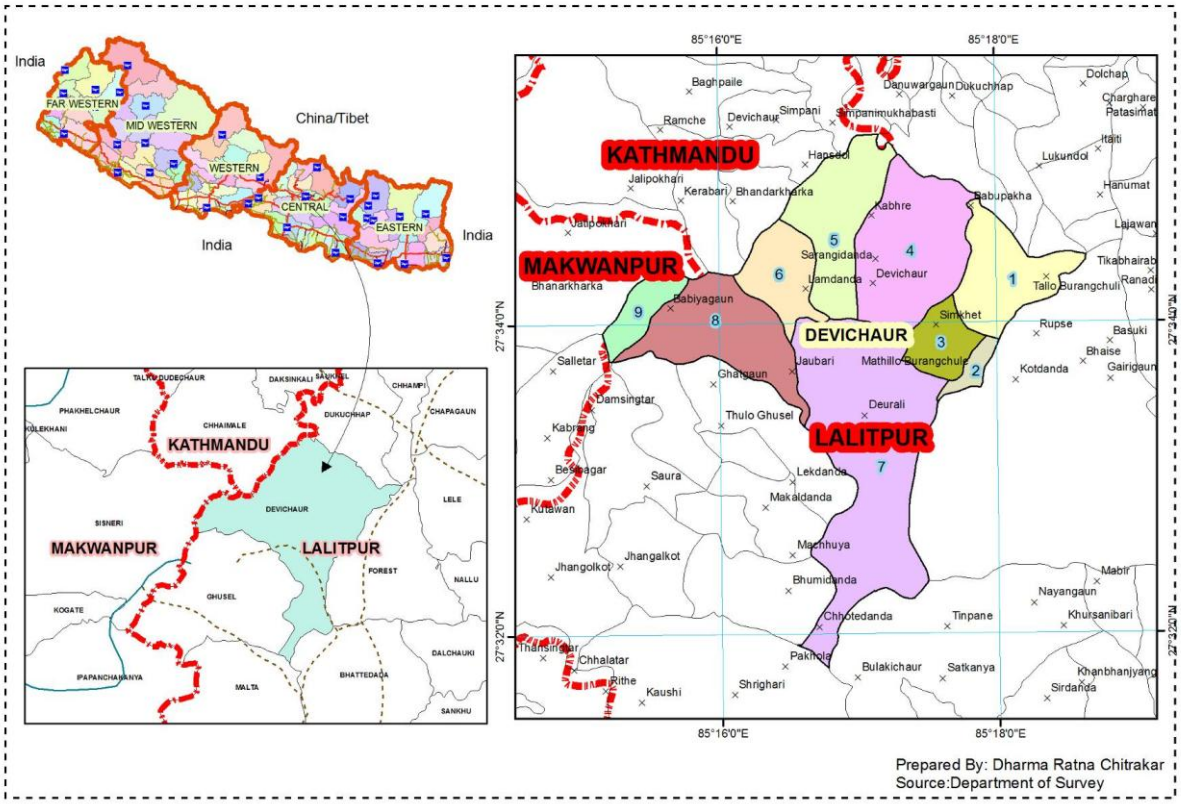

Figure 1. Devichaur Index Map [2]

1.2 LEAP

Livelihood and Environmental Awareness Project (LEAP) has been operating by Community development Forum (CODEF) with the support of Mikkelin Kehitysmaayhdistys (KEMA). This project started in 2010 in Devichaur VDC, Nepal. CODEF is non-governmental organization established in 1999. The Organization affiliation with Social Welfare Council and National NGO Federation was achieved in 2003 and 2004 respectively in Kathmandu. It has 9 years work experience in community development field through improvement of environmental sanitation at national level. It started the mission for the poor community to develop their living standards in a sustainable and environment friendly manner through public participation, awareness, advocacy and empowerment. [2]

LEAP started its mission in Devichaur with the objectives, to raise women by empowering them in household, community and in government authorities to improve the Devichaur society by providing institutional and practical knowledge for sustainable life through sanitation, portable water and better indoor quality. The aim is to improve the living standards

of ultra poor households women and capacity building of CODEF to improve the understanding with the partner organization KEMA. [2]

Figure 2. Chotidanda environment

1.3 Objective

The objective of this thesis is to assist the LEAP for finding the way to provide better environment to the people of Devichaur by improving the water quality and their personal hygiene so that the community doesn't suffer from the diarrheal cases. In details , the objectives are as follows:

- To address the alarming system for microbial water contamination with the help of chemical and microbial indicators.
- To develop the warning system for microbial contamination, mainly *E.coli* in drinking water

- To implement most feasible water treatment system for decontamination of *E.coli* and other faecal contamination.

- Also, the information distribution to the community of rural part of Nepal about the relation between contaminated drinking water and faecal contamination and hand hygiene related to the sickness.

- To build the maintenance system for the water decontamination and treatment so that the community get fulfilled the demand of portable drinking water.

1.4 Literature study

Literature study includes the observation and analysis of previously done research and article published by the LEAP. The previous collected data about the drinking water quality, number of toilets and situation of open defecation in Devichaur can be found in the thesis done by the Jari Koponen in 2010. Similarly, the baseline reports prepared by the CODEF has assisted in finding the updated data about the hygiene, water quality and the number of toilets built. Allocation of theoretical and practical reviews and reference materials has made the task more feasible. It shows that neither hygiene promotion and improvement of drinking quality has been promoted nor the education distribution to the community has been provided. I would like to write about a diarrhoeal case happened in remote districts of mid and western Nepal, killing around 200 people which forced government to set up emergency camps and health posts. Jajarkot, 375 km from the capital city Kathmandu, suffered through diarrhoeal cases killing more than 134 persons and effecting more than 15,000 individuals. [31]

1.4.1 Diarrhoeal Cases

The number of diarrhoeal cases observed during the year 2010-2012 from the Devichaur health post can be found in the table number 1. To indicate the diarrhoeal illness, International classification of diseases, ICD-10 was used. The data can be found in the baseline report prepared by the CODEF.

Table 1. Diarrhoeal cases in Devichaur [2]

Months/Year	**2010**	**2011**	**2012**	**Total**
Dec/Jan	11	15	18	44
Jan/Feb	8	16	35	59
Feb/Mar	14	20	9	43
Mar/Apr	16	39	86	141
Apr/May	14	10	18	42
May/Jun	13	32	59	104
Jun/July	19	55	49	123
July/Aug	20	41	38	99
Aug/Sep	16	0	26	42
Sep/Oct	12	16	8	36
Oct/Nov	11	23	22	56
Nov/Dec	21	16	14	51
Total	175	283	382	840

According to the table, it can be seen that the highest diarrhoeal cases observed during spring time in 2012 with total 86 where as next highest number of diarrhoeal cases occurred in summer time in same year. During the period, diarrhoeal cases have increased every year gradually. In the three year, total diarrhoeal cases recorded was 840. According to the project coordinator Raimo Lilja, the data was collected after the LEAP started and before the project, there was even more diarrhoeal cases which could not be found from the district health post since the registration of the diarrhoeal cases was not done.

1.5 Water and hygiene

During the field work, I observed the situation of water quality, water supply pipelines and the water sources from the Devichaur-1, Devichaur-2, Devichaur-3, Devichaur-4 and Chotidanda. The observation and findings are discussed below:

1.5.1 Water sources, supply and usage

Chotidanda (Devichaur-7) is rich in stream water having 5 open water sources. Out of 5 water sources, only one is in use nowadays. During the dry season, the water discharge rate is lower whereas it is higher in monsoon. The water sources are about 500m from the village. The exact distance may vary because of the variation in landscape.

The exact water demand is not known yet. The amount of water needed for households vary depending upon the number of family members and the domestic and pet animals. The water discharge rate from the source can be found from the table below:

Table 2. Water discharge rate from the water source

S.No.	Name of the source	Volume measured (l)	Observed time(Sec)	Velocity (m/s)	Mean Velocity (m/s)	Discharge (m3/s)	Mean Discharge (m3/s)	Mean Discharge (l/s)
1	Deurali Doman Dola	1	8	N/A	N/A	0.00013	0.00012	0.12
			8.8			0.00011		
			8			0.00013		
			8.5			0.00012		
			8.7			0.00011		

To measure the water discharge rate, we collected the running water in 1 litre bottle and set the time. The discharge rate was taken at the time when the one litre bottle was filled with water. The process was repeated for 5 times to get the mean value. According the measured data, per day water discharge rate is 10,368 litter. The existing water sources of Chotidanda can be found from the Figure 3.

Water supplies to the households straight from the water sources through the pipelines, which are open. Depending upon the water discharge rate, the supply pipelines are connected to the households.

Through thus connected pipelines, water is collected in small tanks for drinking. Every households in Chotidanda, store the drinking water in about 20-40 litters jar. People washes clothes and dishes with the water coming from the supply pipelines. The water is used for drinking, cooking, washing hands, domestic animals and other household purposes. Water storage tank for washing hand and dishes can be seen in Fig.4.

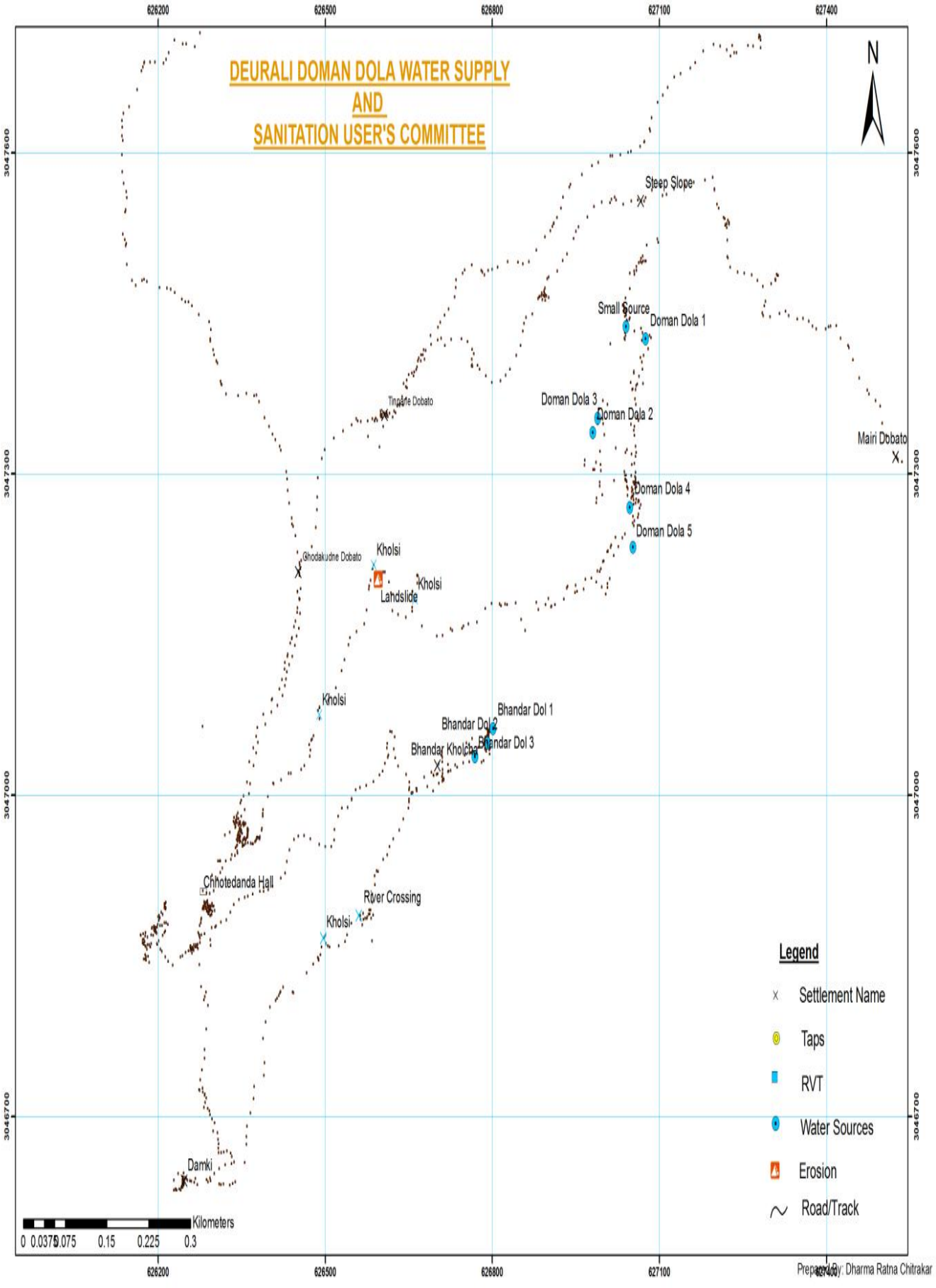

Figure3. Chotidanda water sources index map

Figure 4. Water storage tank for washing dishes and hand

1.5.2 Water Contamination

Since the Devichaur VDC is free of industries except stone mining, the major contaminants found are microbes, worms etc. In comparison with biological contaminants, physical and chemical contaminants are very low.

Devichaur VDC was declared open defecation free on 12th July 2014[3]. LEAP has claimed the 100% of households have toilet now. Still, the problem is about the maintenance system because the toilets which were built on previous year, found to be very dirty and people stopped using the toilets. There have been leakages from the toilets and waste water was discharged into the surrounding environment. The exact water sources are unknown but there are many water intakes around the VDC. The water sources are not protected. Some water sources found to be protected but not properly and the contamination by wild animals and household animals is common. The water goes to the households through the pipelines. Even in one water supply pipelines, many damages can be found. Since the road tracks are muddy, mud and worms enters the pipelines easily.

Each households own animals like goat, cow, buffalos and dogs etc. The animals are not placed in managed systems. They are kept in the same house separated with walls and door. People come to contact with the animals many times during feeding, milking and cleaning the

place. Households animals manure are often found on the road tracks and in house yards. The waste water produced from the households are discharged into the nearby small water stream and backyard.

E.coli (Escherichia coli)

E.coli is a rod shaped gram-negative bacterium commonly found in human and animals intestinal tract. The size of the bacterium cell is about 2.0 micrometer long and 0.25-1.0 micrometer in diameter. The optimal temperature for growth is 37^0C.The pathogenic *E.coli* cause illness like diarrhoea, dysentery etc. This pathogen can transmit through water, food and contact with animals or persons. Though most of the strains are harmless, some can cause severe food born disease. [4][5]

Giardia Lamblia

Giardia causes Giardiasis, also called gastrointestinal disease. The source of this parasite is faeces of infected persons and animals. Hence, the infection spreads from person to person by food contamination or by direct faecal-oral contamination. This pathogen exist in two forms, trophozoite and cyst. Trophozoite is responsible for causing the signs and symptoms of giardiasis and it cannot live outside the body for long time where the cyst can exit for long time outside the body. The infection can be seen even only if 10 cysts ingested. [6]

Cryptosporidium

This parasite found in the intestine of infected persons or animals and it transmit through faeces. It can spread into the drinking water through contact with food, soil or surfaces that have been contaminated with infected faeces. This microorganism can survive in the environment for long periods of time. The infected people suffer from diarrhoea, vomiting and dehydration.[7]

1.5.3 Water Contamination Transmission Pathway and Personal Hygiene

Mostly, the hand hygiene practice is very poor among the people. It is common to wash hands only with water. All the house members use same towel for drying their hands. Children play on the ground and eat with the dirty hand. The parents also don't care about washing the

children's hand before eating. Among the children, hygiene is even poor. People use same clothes and shoes while working in the agriculture field and cooking.

Even the water is safe for drinking, may become contaminated because of the poor personal hygiene. After the latrine, people normally wash hands only with water, which may cause the transmission of the faecal contaminants from hands to drinking water while handling, cooking and drinking.

Table 3. Degree of Contamination and Contaminants by source type

Contamination indicators	Source	Cause	Degree
pH	-	-	Low
Turbidity	Mud, Dusts, insects, Worms	Open Source, backyard agriculture	Low
Colour	Mud, Dusts	Open Source and road tracks	High(rainy season)
Ammonia	Decaying Animals, Human and Animal Manure	Open Source, forest, poor sanitation	High
Nitrates	Fertilizers	-	-
Phosphate	Fertilizers	-	-
***E.coli* and Coliform**	Animals and Human Manure	Improper Sanitation, Personal Hygiene, leakage in supply line	High

During the monsoon, water runoff from the surface washes out the mud. The water contains mud highly enters through the leakage in the water pipelines while raining. The source water also get contaminated because of the rain. In dry weather, mud enters the water supply pipelines through the leakage. The waste water produced from the households and animals are directly discharged on the house yard. After washing clothes and dishes, water discharged into the households yards. similar way, waste water resulted from washing domestic animals are also discharged on the ground. It has also been found that the toilets built in the households have not been maintained causing leakages from the tank. The possible contaminants and sources are categorized on the table 3.

1.5.4 Drinking Water standards in Nepal

According to the National guidelines for the drinking water for spring water source, the limit value for the *E.coli*, physical and chemical contaminants have been declared, can be found from the table 4.

Table 4. Drinking water standards in Nepal [8]

Group	**Parameter**	**Unit**	**Maximum Concentration Limits**
Physical And Chemical	Turbidity	NTU	5(10)
	pH		6.5-8.5
	Colour	TCU	5(15)
	Taste and Odour		Not objectionable
	Ammonia	mg/l	1.5
	Chloride	mg/l	250
	Nitrate	mg/l	50
	Sulphate	mg/l	250
	Free Residual Chlorine	mg/l	01-0.2
Microbial	*E.coli*	MPN/100ml	0
	Total Coliform	MPN/100ml	0 in 95% in Sample

2 MATERIALS AND METHODS

To find out the water quality and hand hygiene, different kind of materials and methods have been applied. The methods applied were water quality test which includes chemical and physical contaminants and fecal pathogen; specially *E.coli*. In addition, hand hygiene sample collection and test had also been done. The set of questionnaires had also been prepared to find out the personal opinion of the residents of Chotidanda about water quality and hand hygiene .

To collect the water and hand hygiene samples, sampling requirements were provided by the Mikkeli University of applied sciences whereas the lab experiment cost was covered by the LEAP project.

2.1 Faecal Pathogens and *E.coli* Test

To identify the presence of faecal contamination, *E.coli* as a microbial indicator count has been carried out in the lab. From randomly selected households, 5 drinking water samples had been collected. Thus collected water samples were sent to the Lab for the *E.coli* and *Coliform* test. Further microbial tests was carried out in the Nepal Environmental and Scientific Services in Kathmandu.

3M Petrifilm *E.coli/Coliform* Count (EC) Plates containing Violet Red Bile (VRB) nutrients, a cold water-soluble gelling agent, an indicator of glucuronidase activity, and a indicator that facilitates colony enumeration was used. Most *E.coli* (about 97%) produce □-glucuronidase which produces a blue precipitate associated with the colony. The top film traps gas produced by the lactose fermenting *Coliform* and *E.coli*. About 95% of *E.coli* produce gas, indicated by blue to red-blue colonies associated with entrapped gas on the Petrifilm EC plate (within approximately one colony diameter).[9]

2.2 Water sample test

In order to perform the quick water quality test ENPHO KIT was used. It is a device containing chemicals and equipments, designed for the water contamination test. This system is developed by the ENPHO, an Organization working in the field of Environment and research. The contamination parameters set by the ENPHO kit comprise with the standards set by the government of Nepal.

2.2.1 pH and Turbidity

pH test was proceeded by taking 5 ml water sample with the help of 5ml syringe in a vial. 2 drops of pH reagent was added to the vial and shaken well. Thus obtained colour was compared with the pH colour chat. The chart has different value for different colours.

Turbidity is visibility property because of the particles suspended in water. The water seems cloudy because of the light scattered and absorbed by the particles rather than transmitted in straight line. Turbidity measurement unit is NTU (Nepholometric unit). Turbidity should be

measured after the coagulation, flocculation and sedimentation process. The recommended turbidity for settled water before filtration is less than 10ntu. [10]

I did not measure the turbidity because of the lack of equipments but observed the water collecting in the transparent bottle with naked eye.

2.2.2 Temperature, Colour and Odour

Temperature effects the microbiological characteristics of drinking water through its impacts on water treatment processes, especially disinfection, and its effect on the growth and survival of micro-organisms. Disinfection is achieved by increased temperature. Temperature of the water samples could not be tested because of the lack of testing kit.[11]

Normally Colour change is not harmful unless it is associated with toxic chemical [12]. In case of Chotidanda, the changes in colour of water was observed mainly because of the mixing of mud during the rainy season which may indicate the mixing of microbes present in the mud. The odour may observe because of the decay of the organic materials and animals near by the water source. The odour and colour of all the water samples were observed with naked eye.[13]

2.2.3 Ammonia

The water can be considered to be contaminated by faecal contaminants if ammonia is found higher than the geogenic level. Upon the chlorination of water containing 0.2 mg of ammonia, taste and odour problems as well as decreased disinfection efficiency are to be expected. Cement mortar used in the construction of water storage tank, may release considerable amounts of ammonia into drinking water[14].

To perform the ammonia test, 5 ml drinking water sample was taken with the help of 5ml syringe and 1 drop of ammonia reagent 1 was added to the sample and shaken well. Then, 3 drops of ammonia reagent was added to the solution again and shaken well until the changes in colour of the solution was obtained. Thus obtained coloured solution was matched with the colour chart which have the changes in colour with the different value of ammonia concentration.

2.2.4 Nitrate

Nitrate test was done by taking the 5ml water sample in 50 ml test tube with the help of 5ml syringe. The sample was heated in the spirit lamp until all the water evaporated. The test tube was cooled and 8 drops of nitrate reagent was added and shaken well so that all the residue of the test tube was dissolved. Then, 2 ml of distilled water was added by the measuring dropper and shaken well. The test tube was cooled down and again 1 ml of nitrate reagent was added. After that, the tube was swirled and water was transferred to vial. 1.5 ml distilled water was added again and thus observed colour was matched with the colour chart which has different values of nitrate for different colour.

2.2.5 Faecal Pathogens and hand hygiene test

ENPHO kit was used to detect the presence of Faecal Pathogens also such as *E.coli* in water. The kit only provides the result of presence or absence of *E.coli*.

To analyse the *E.coli* contamination in hand, 52 hand samples have been collected. The swab sampling method was used to take the samples from the hand and sent to the lab. While collecting the hand samples swab was made wet by inserting into the tube containing 10 ml sterile 0.9 M (mole) sodium chloride solution. After that, the swab was rubbed on the hands of the individuals. The swab takes the microbes present in the hand , which was disposed into the tube containing sterile solution. The samples were taken in dry day during day after lunch time. However it was not assured that if people washed the hands with soap or without soap before taking the samples.

2.3 Questionnaire

1. Do you have toilet in your house?
2. Do you know what is Diarrhoea? How does it happen?
3. Where do you store the drinking water? Do you always wash your water storage container before filling it with drinking water?
4. Have you ever noticed either unusual smell or taste in drinking water ?
5. Do you still drink the water if you feel bad smell or taste in drinking water?

6. What do you know about water contamination? How does it happen?
7. What do you do to prevent drinking-water from contamination?
8. Do you always wash your hands with soap after toilet?
9. Do you always wash your hands before eating?
10. Do you always wash your hands before feeding your children?
11. Do all of your family members use same towel to dry hands after washing?
12. What do you know about water disinfection? Do you boil water or use chlorine or any other methods?
13. Do you know about solar disinfection?
14. What do you think about protecting your open water source from contamination by animals?
15. What do you think about paying a water user free to cover maintenance and repair?
16. What do you think about wastage of water through broken pipes?

3 RESULTS AND ANALYSIS

3.1 *E.coli* test result

Table 5. *E.coli* test result

Sample number	***HouseHolds***	***E.coli cfu/100ml***
1	*Choti Dada Water Tank*	*4*
2	*Sunita Bomjan*	*48*
3	*Gyani Maya Bomjan*	*4*
4	*Sancha Maya Bomjan*	*23*
5	*Dil Maya Bomjan*	*48*

The results obtained from the water sample test shows presence of *E.coli* in all the water samples. The lowest number of *E.coli* found in water sample was from water collection tank of Chotidanda. The tank has capacity of about 4,000 litter. In the rest 3 water samples, number of *E.coli* presence was higher, what was resulted may be because of the transmission

of *E.coli* owing to poor personal hygiene. Since all the water and hand hygiene samples were taken in same date, the variation in presence of *E.coli* in households water samples shows that poor personal hygiene has caused in transmission of *E.coli* in drinking water samples.

3.2 Water quality test result

Table 6. Water quality test result

Sample no.	***Location***	***Phosphate***	***Ammonia***	***pH***	***Nitrate***	***E.coli***
1	*Chotidanda, School*	*0*	*3*	*6,5*	*0-10*	*Yes*
2	*Chotidanda*	*0*	*1,5*	*6,5*	*-*	*Yes*
3	*Devichaur-1, Water Storage Tank*	*0*	*1,5*	*6,5*	*-*	*No*
4	*Samakhel*	*0*	*1,5*	*6,5*	*10*	*Yes*

The result shows that the pH, phosphate, ammonia and nitrate in drinking water is inacceptable level where as *E.coli* was found in three water samples.

3.3 Hand hygiene sample test result

The results obtained from the left(L) and right hand(R), hygiene test can be found from the table below:

Table 7. Hand hygiene test result

S.No.	***E.coli count/cfu ml (L)***	***E.coli count/cfu ml (R)***
1	*0*	*0*
2	*3*	*1*
3	*0*	*0*
4	*0*	*0*
5	*0*	*0*
6	*0*	*0*
7	*0*	*0*
8	*0*	*0*
9	*29*	*0*
10	*364*	*0*
11	*1*	*0*
12	*0*	*0*
13	*0*	*0*
14	*0*	*0*
15	*13*	*20*

16	*0*	*0*
17	*0*	*0*
18	*1*	*0*
19	*0*	*6*
20	*21*	*0*
21	*0*	*3*
22	$>10^8$	*0*
23	*0*	*0*
24	*0*	*5*
25	*0*	*0*
26	*0*	*2*

Similarly, presence of *E.coli* found in 12 hand hygiene samples out of 26 total samples. The hands were contaminated with *E.coli* because of the contact with human or animal faeces or from the field and raw vegetables. The result shows that, drinking water is not contaminated at source all the time. Either water has become contaminated after delivered to the house or through the leakages in the water supply pipelines.

3.4 Public Interview analysis

The set of questionnaires were designed to know the personal opinion of residents of Chotidanda about the water quality and hygiene. The interview was held among the FCHVs (Female community health volunteers), WSUC (Water and sanitation users committee) and WUGs (Water users group) in the different dates. The interview had been done personally to get the clear idea and personal knowledge of the interviewer.

During my first Devichaur visit, I met with the previous VDC president Mr. Nar Bahadur. During the meeting, We discussed about the ongoing situation about the water quality problems. The problem was mostly about the maintenance system because of the conflict between two communities about the water supply. The questionnaires were interviewed with the 9 FCHVs during the meeting. The meeting was about to share the state of sanitation in their respective wards. It also included to find out the peoples knowledge about cause and prevention of diarrhoea.

Almost all of the persons know about the cause of diarrhoea but they do not take any preventive action. None of the interviewer use chlorine to treat drinking water. The reason was still not intelligible that why people were not concerned about the diarrhoea and the

health hazard because of it. Similarly next interview held during the meeting of WUG's in Chotidanda where 7 people were interviewed. Out of 7, one member did not have toilet in her house. No any family had never applied any drinking water treatment system. The community was interested to build the safe water intake to protect the source. During the conversation with the Engineer of Drinking water division office, Lalitpur, He responded that they did not have any project plan for the water quality improvement, the division office is focussed on mainly on providing the water to the community as per their demand.

The problem with the interview was people did not want to talk about the water and hygiene in detail.

3.5 Uncertainty of Laboratory work and Sampling

The water samples were collected in the 100 ml sterile bottle leaving the top neck part empty. Similarly, the hand samples were collected in the 10 ml sterile bottle. Since, the distance between the water sampling site and the laboratory was about 30 km, it took about 5 hours to deliver the samples to the laboratory. Other physical and chemical contaminants of the water samples observation were done using the ENPHO testing kit at situ.

The hand hygiene samples collection would be more effective if the sampling were done before washing the hands with and without soap.

.

4 ALTERNATIVE STRATEGIES FOR IMPROVING WATER QUALITY

Only treatment of water is not enough for Devichaur VDC. To provide the safe drinking water, from the source prevention to the safe supply till household should be considered.

4.1 Water Safety Plan

Because of the unprotected water sources and poor hygiene, people of the Chotidanda have been suffering from the diarrhoea and other disease associated with the faecal contamination. Water safety is always connected with safe sanitation and water hygiene. The water safety plan can be brought into practice by involving the community, Water and sanitation user committee, Female community health volunteers, Water users group and government. Each participate should have different role. Community should understand the value and need of

water safety. The clear instructions should be mentioned in the water safety plan for each households so that they can learn and bring into practice. In certain interval of time, community should be gathered together for the education distribution. The group of people involved in the water safety plan should get the data of progress report. The household not following the water safety plan should be noticed and motivate them for taking the water safety precaution. The water safety plan should include safety principles from the source protection to the mouth. The reasons for not following the plan should be identified. The water safety plans are based on the field surveys that directly link water supply, hygiene and sanitation.

4.1.1 Safe Sanitation and Water Source Protection

Safe Sanitation mean building toilets for each and every households, school and other institution which leads to hygienically separation of human excreta from human contact [15]. In case of Devichaur, animal dung as well because each households have some domestic animals like goat, buffalo, cow etc, which are not placed in manage system their manure are found commonly on road tracks and households yards. Drinking water source can be protected from outside contamination particularly from faecal matter. It should be noted that, the location of toilets should about 100m far from the water source.

Though all the VDCs have been declared as the open defecation free, the open water sources should be protected from the faecal contamination. The faecal contamination from the open defecation and from households as well as forests animals should be stopped. Open defecation should be prohibited in nearby the water sources. In order to protect the water sources, a closed water intake system should be build up. One notice board , written "no defecation near by the water source" can be placed near by the each water source.

There are many water sources which should be protected from anthropogenic activities and biological pollution. The source must be protected from the forest animals and household animals. There are different kind of worms and leaches as well in the water. The simple way to protect the source is to build water intake in the water source.

4.1.2 Safe supply and water quality improvement

After building the water intake, the water supply pipelines should be checked. Wherever found leakage or damage in pipelines, should be fixed. This will protect the supplied water from the possible contamination. Any leakages in the water collection tank should be observed and maintained.

However there are many existing water supply pipelines, are broken and unmanaged. The mountainous landscape also disrupts the pipelines causing it to break. Some households disrupts the main water supply pipe by fixing the another pipe and leakage occurs. There should be one water supply pipeline from the water source to the storage tank. From the storage tank sub water supply pipelines can be connected to the households. All the pipelines should be buried under the ground to prevent from the breaking and damage.

Water quality should be tested in certain time intervals. The testing should be done in the water source and also from the water storage tank. In the pilot project, the testing should be carried out for many days to confirm the changes in the contaminants so that the proper water treatment methods can be adopted. The water quality treatment process will be discussed in detail, later in water improvement chapter.

4.1.3 Safe storage, handling and tap system in each households

Safe storage means the protection of drinking water from the contaminants. The water container should be clean before filling it with drinking water hence it is recommended to clean the water storage tank. To prevent from microbial growth, water should be drained and refilled every day. To avoid recontamination, small opening to allow easy and safe access to the water without entailing the contaminated hands or objects into the container.[16] Generally, each household has water storage tank for drinking water. The water is stored every day. The storage and safe handling of water is necessary to protect the stored water from contamination.

Tap system water supply is needed in Chotidanda in order to prevent from the misuse of water. The misuse of water results into the waste water that goes for no use and sometimes even contaminate the small water streams. Almost all the houses do not have tap water system, Water pipelines are often found to be blocked with small piece of wood which do not stop the water leakage. The tap system will also save lot of water from being waste. Tap

system will also reduce the contamination since the waste water would not be produced because of the discharge of water.

4.2 Water treatment

Water quality improvement is necessary for the community of Devichaur. Because of the poor sanitation and open defecation practice, water source and catchment easily get contaminated. There are number of water decontamination system but I have focused only on the most feasible system for the Chotidanda. Considering the landscape, water resource, community willingness to pay for safe drinking water and designing a maintenance system, The system has been proposed. The proposed water disinfection system can also be divided into 2 parts, household and community based. After the study of suitable water decontamination mechanism, the following systems have been selected:

Household based water treatment processes can be implemented to get the safe water because these treatment processes are effective and low cost. The demand of human resource is also minimum and can be easily implemented in households. Some of the household based water disinfection process needs guidelines and technical assistance too. Chlorine disinfection for water treatment can also be done in large scale. However this large scale water treatment system is relatively expensive and technical support is also needed.

4.2.1 Solar disinfection

Solar disinfection can be adopted to disinfect the drinking water for Chotidanda residents since the process doesn't cost for any chemicals and maintenance system. The simplest way is to collect the drinking water in a clean transparent bottle or tank and let it be in the sunlight for at least 6 hours. It should be noted that if the water contains high turbidity, filtration should be done before solar disinfection. [17]

Solar disinfection for the water treatment in Chotidanda had already been done during the previous thesis by Jari Koponen. The sample water was collected from the Dhungedhara (type of drinking water source) and let it be for 2 days in the sunlight. On the first day of the SODIS test, weather was partly cloudy where as on second day it was cloudy. The results can be seen from the table 18.

Table 8. SODIS test[18]

Date	***E.coli***	**Coliform**	**Total count**
14.07.2010	14	61	75
15.07.2010	0	6	6
16.07.2010	0	1	1

The SODIS test result shows that, there is effective decline in the *E.coli* and *Colifrom* in the water. It shows that even in the partly cloudy condition, SODIS method could be useful for the water treatment.

However this process is effective for the drinking water only since water demand for households animals, irrigation and other proposes is too high. SODIS methods can be useful during the sunny weather otherwise the disinfection time needs more than a day.

4.2.2 Boiling

Boiling the water can be considered as one of the effective method for drinking water treatment. It kills or inactivates viruses, bacteria, protozoa and other pathogens effectively.. About 99.99% of water borne microorganisms can be disinfected by boiling the water till the temperature reaches 100 degree Celsius. Boiling water for 1 minute and adding 1 minute per 1000 meters of elevation is considered to be effective to remove the pathogens.[19]

4.2.3 Chlorine disinfection

Chlorination is one of the cheapest and effective process for water disinfection. The cost of chlorine (bleaching powder) is about 50Rs/kg (40 cents/kg). According to the EPA and WHO, 02-0.4 mg/L residual chlorine is required to disinfect the water [20]. There are various factors needs to be examine before chlorine dozing. The factors are as follows:

- pH
- Temperature
- Turbidity

To get the effective result, turbidity of water should be below 20NTU for chlorination. Besides the factors, we also take into consideration about the chlorine demand, residual chlorine and chlorine contact time, so that the residual chlorine won't be enough to harm the

consumers. If, Chlorine disinfection water treatment is to implement in community based, The factors, should be considered are as follows:

The free residual chlorine can be calculated using the following formula:

Powder weight needed to make up a chlorine solution in a tank

Weight of powder required,

W = $\frac{1000*C*V}{S}$ (1)

V = volume of tank in litters

C = concentration of solution required in % (% by weight available chlorine)

S = strength of powder in % weight chlorine [21]

Free residual chlorine contact time,

C = Residual disinfectant concentration

T = Disinfectant contact time

If the free chlorine residual is 0.2mg/l after 10 minutes of contact time, the minimum required CT is 2mg-min/L (0.2mg/l * 10 minutes)

Theoretically, adequate contact time can be calculated with the equation written below,

$T = \frac{V}{Q}$ (2)

Where,

T = contact time

V = volume of storage facility or pipe in litters

Q = maximum flow rate in litters

For Pipes, contact time can be calculated as follows: $T = \frac{(0.785d^2)*(L)*(7.48)}{Q}$ (3)

Where,

T = Contact time in minutes

d = pipe diameter in feet

L = length of pipe in feet

Q = maximum expected flow rate in litters

For storage tanks, contact time can be calculated as T = $\left(\frac{V}{Q}\right) * BF$

Where ,

T = Contact time in minutes

Q = maximum expected flow rate through the tank in litters

BF = baffling factor from contact time

V = volume of tank at lowest normal operating water level in litters[21]

The estimated cost for the chlorine to disinfect the water storage tank of Devichaur 1 is suggested below:

Water needs to be chlorinated	100,000 l
Chlorine demand for water	0.5mg/l
Costs of Chlorine	50Rs/kg = 50/1000*1000 = 0.00005 Rs/mg
Total cost needs for the water chlorination	100,000*0,00005 = 5Rs (4 cents)

Chlorine disinfection for water is more effective in households basis. Since the drinking water are stored in the drum and the amount of water needs to be chlorinated is little consequently achieving the effective treatment.

4.2.4 Slow sand filtration(SSF)

Although this water treatment system is a traditional method, this has very efficient function. Theoretically, depending on the capacity to hold the water, tank should be build. About one meter of sand bed should be constructed in the tank. Below the sand layer, bed rocks are filled where the water supply pipe should be connected (Figure 5). The size of the bed rocks (gravel) varies on size depending on the position. A layer of biofilm developed on the top of sand bed. The biofilm traps the worms, bacteria and mud from the raw water and passes down to the bed rocks. Thus filtered water is cleaner however after the filtration, to achieve the lowest microbial contamination, chlorination should be done. Slower the rate of filtration, better the water obtained. To maintain the mechanism, about 1/2 inch of sand layer should be removed in certain interval of time, hence the water quality monitoring is necessary.. The time interval for removal of sand layer vary depending upon the deposition of mud on the top.

The flow rate of raw water to the sand layer should be appropriate so that the raw water doesn't disturb the biofilm. The depth of the water holding compartment on the top of the sand layer must be sufficient to drive through the biofilm. To avoid clogging, the turbidity of the

water should be tested. It should also be noted to avoid the formation of air pockets while feeding the sand during construction phase. [22][23]

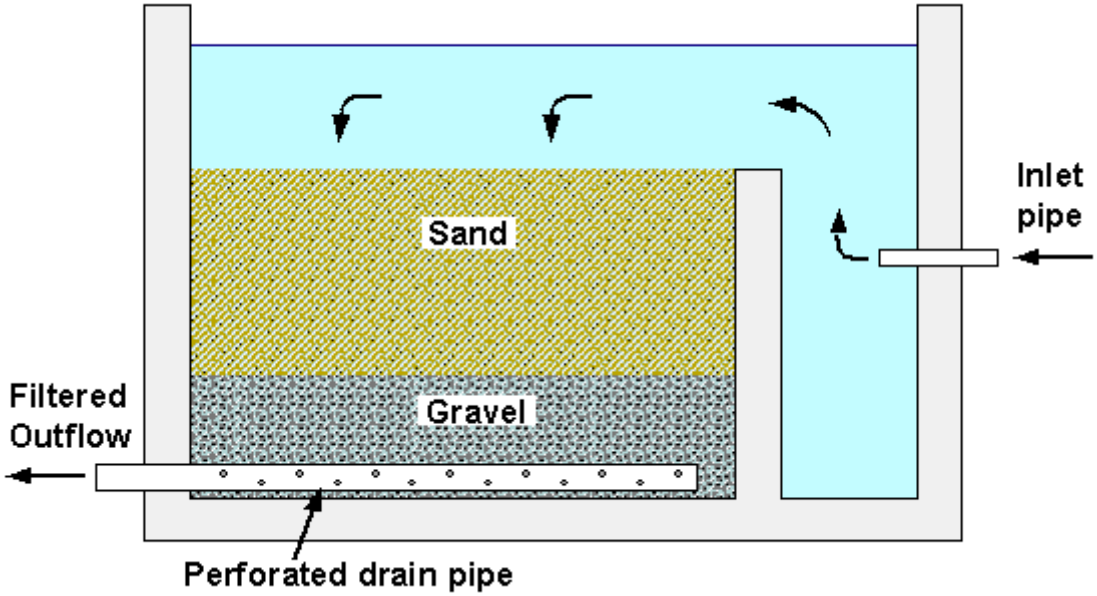

Figure 5. A typical slow sand filtration system [25]

The components of a typical slow sand filter are:

- The supernatant water reservoir
- The filter-bed
- The filter bottom and under-drainage system
- The filter box
- The filter control system[24]

The following parameters are calculated on the basis of size of the SSF are as follows

Table 9. SSF parameters for construction[26]

Total height of gravel bed	20cm
First gravel layer	0,05 mm
Second gravel layer	0,05 mm
Third gravel layer	0,15 mm
Height of the sand bed	1m
Effective diameter of the sand	0,15-0,4 mm
Height of the free border	0,2 m
Height of the supernatant layer	1m

The hourly quantity of water to be treated Q

Filtration rate Vf

The total filtration area A must be equal or greater than Q/Vf

Cost analysis

The cost analysis for building the slow sand filter in Devichaur-7 can be found in the table ... The rate of the materials are based on the District rate of Lalitpur for Civil Works for the fiscal year 2013/2014. Even the rates are mean to be proposed for the area inside the district and 3 km out of the ring road, same rate have been selected. The size of the bed has been calculated on the basis of the water discharge rate per day from the water source of Chotidanda.

Table 10. Cost volume analysis of SSF

Size of the SSF	m^3
Length	6
Breadth	4
Height	2

S.N	**Item**	**Quantity**	**Unit**	**Rate**	**Amount**
1	Bricks	4678	Pi	12000/1000 pi	56136
2	Cement	792.77	bag/50kg	690	10940.23
3	Sand	2.737	m^3	1834.95	5022.258
4	Sand (bed)(0.6m)	14.4	m^3	1834.95	26423.28
5	Aggregate (0.2m)	1.2	m^3	1799.65	2159.58
6	Perforated pipe 4"(Ø)	6	M	893.24	5359.44
7	Perforated pipe 2"(Ø)	24	M	298.22	7157.28
8	PVC pipes 4"(Ø)	1	M	746	746
9	Skilled Labour(7 days)	2	No	600	8400
				Total	122344.1
In EURO (approx.)					1000,00

For Chotidanda, building the slow sand filter plant is relatively expensive than the other proposed methods, because still chlorine disinfection may required after the filtration of contaminated water.

4.2.5 Flocculation and Coagulation

Flocculation and Coagulation effectively separates dissolved particles and suspended solids from the water. Commonly found flocculates in market is Aluminium sulphate. For the filtration, about 5 mg/l Aluminium sulphate is required. The particle settlement time is about 6-7 hours. After the sedimentation, All the clean water should be send to clean tank leaving the muddy water and sediments in the bed. Sediments can be collected through the outlet valve. To yield the better water quality, further chlorination is essential after this process also. The cost of aluminium sulphate is 100 Rs/kg.

4.3 Maintenance System

Devichaur needs maintenance system to keep the water management system sustainable. Even for the maintenance system, there are two people appointed by the Division office for drinking water, Lalitpur, but the maintenance group are not observed to be active. While observing the water supply pipeline, we found five water leakages which causes loss of water supplied to the community. The maintenance group get salary from the government office and The community also pay for the water use and some of the money goes for the maintenance too. The money collected per household is about 50Rs per month. To prevent the water loss and from contamination through leakages point, maintenance worker should be activated.

Before appointing the maintenance group, it should be taken into consideration that the maintenance group are aware of the water management system. They should be trained to handle the problems related with the water management system. In every ward, there should be 2 persons in maintenance group.

4.3.1 Alarming system for microbial contamination

Microbial contamination in drinking water is the major concern because of their pathogenic effect in human beings. The amount and type of harmful microbes should be assessed before

the treatment of water. There are many different kind of indicators which confirms the presence of such microbes. The alarming system would help in the identification of quality of drinking water. The indicators those can be used to develop the alarming system for microbial contamination in water can be done by using following indicators: pH, turbidity, colour and odour, ammonia, nitrate, *E.coli*/*coliforms.*

4.3.2 Cleaning the water source, storage tank and supply pipeline observation

The maintenance group should observe the water source in certain time interval. During the observation of the source, the contaminants, for example leaves, mud etc should be removed. The opposing stuffs should be removed from the water flow track as well. If there is water intake near by the source, the sediments should be taken out from the sedimentation tank.
To observe the water supply pipelines from the water source to household is also the task should be done by the maintenance group. if found, the broken and leakage in the supply pipelines, immediate action should be taken.

To avoid contamination by the previously held dirt and substance left in the tank, Water storage tank should be cleaned. The tank should be drained and make it empty before cleaning. All the internal surfaces of the tank should be scrub. To remove all the traces of detergent, the internal surfaces should be washed.

The maintenance team should also observe if there is any leakage in the tank. The wash out valve should also be checked for the leakage and proper function. The water storage tank should be cleaned at least in a year.[27]

4.3.3 pH measurement, Chlorine dozing and free residual chlorine observation

Some quick water contaminants indicator such as pH should be measured by the maintenance worker. pH measurement should be done at the intake and water collection tank. pH can be measured in situ by pH paper. Maintenance workers should know about the chlorine dozing. They should be trained for this water disinfection mechanism. The amount of chlorine required for the microbial disinfection should be determined. After the chlorination, residual

chlorine should be measured. Maintenance group should assure that the limit value for residual chlorine should not exceed.

4.3.4 Water quality test (pH, turbidity ,nitrate, ammonium, phosphate, *E.coli*)

Maintenance group should know how to use the device to test the contaminants in drinking water. In the beginning of the newly established water supply system, water sample collected from the water storage tank and household should be tested. The ENPHO kit can be used to test the water sample in situ.

If the contaminants found to have more than the limit value, further test should be carried out. The maintenance group should manage the timetable for the above mentioned tasks.

4.4 Public Participation

For Devichaur community, Public participation is important to aware the benefit of improved water quality and personal hygiene. Since the safe drinking water is co-related with the personal hygiene and safety, community should be aware of this issue. There are local public committee for the social and environmental aspects. However to increase the role of public in the participatory water and safety program would not be easy and short in terms of the Devichaur community but the strategic management for the community involvement is necessary. Female community Health Volunteers (FCHV), Water and sanitation users committee(WSUC) and WASH committee could be mobilized to enhance the public participation for providing education about need of safe drinking water and to improve personal hygiene.

4.4.1 Health and Hygiene education

Health and Hygiene education campaign could play important initiation for the community to promote health. The communication of information among the people of a community supports in the decision making about the health related activities. Health education should focus specifically with communicating for health that are related to sanitation, water supply, water consumption, water borne disease control and hygiene practice. Hygiene education is important for the transmission of contaminants and health risks associated with that.[28]

4.4.2 Female community health volunteers and Water and sanitation users committee

Female community health volunteers(FCHV) can be mobilized to educate the community about the disease associated with the contaminated drinking water and poor hygiene.

Role of FCHV

- Preparation of information distribution on drinking water and hygiene
- Identification of the source of health problems
- To Promote the good health practices in community
- Identification of the messages and communication methods
- Preparation for potential emergency health hazards
- Interact with the community about the diarrhoeal cases
- Motivate everyone to use soap for washing hands

In order to sustain the maintenance system for drinking water management system, financial support is necessary. However, Water users committee(WUG's) collect some money from every household for water usage, the money can be utilized for the maintenance of the water supply system and the water disinfection system. The most challenging part is the maintenance of the toilets build in the households.

4.4.3 Awareness about water quality and hygiene

In public participation, the agenda of the community discussion about the water and hygiene should focus on the following issues are as follows

- Disease associated with the poor water quality
- the factors responsible for the contamination of drinking water
- source of water contamination
- Water Safety
- Guidelines to stop the water from contamination
- How to deal when water is found to be contaminated, How to cope with the challenge

5 DISCUSSION

5.1 Water disinfection system challenges

To develop the technical skills for water treatment in household level is not so difficult for such a small community. The concerning matter is about how the community adapt to bring

the water treatment in practice. The challenge is to introduce the technology which is economically and culturally acceptable for the community. Before the installation of the system, it is important to educate the community about Water, Sanitation and hygiene so that the community understand the relation between them. The environmental challenge observation before installation of water treatment system is beneficial for the sustainability of the system.

5.2 Slow sand filtration(SSF) challenges

SSF works at the best when the filtration rate is maintained when the quantity of water treating at daily basis. During the dry season, when the quantity of water is low the rate might affect the system where as in the peak season - monsoon, the water level is high. Besides that, there should not be any damage in the water supply pipelines that goes to the SSF, which may decrease the amount of water goes to the households. The variation in water quality during the different season of the year may cause problem in the filter bed. While packing the sand in the system, air pockets may form if the procedure of filling which would create problem in the filtration.

Regarding the technical challenge to implement the water treatment system for the Devichaur VDC, The water disinfection system is proposed in section 4.2. It would be difficult to determine the water filtration rate from the filter bed of SSF. It would be challenging if the water filtration rate could not meet the demand and supply rate for the community. Even no additional chemicals are required, the maintenance task such as , removal of biofilm in certain interval of time is compulsory. Since the rate of filtration is slow, the leakage in water supply pipelines would result in the low supply of water to the community.

The water treatment system needs expertise in the field of water quality observation and treatment. Any technical problem or failure should be find out and solved as soon as possible. The maintenance group should observe the system in certain interval of time. The time interval of observation should be pre-planned. They should also be equipped with the equipments and tools and the fund necessary for the system maintenance. They should be able to understand the system of the SSF and the different components and their function. The persons appointed for the maintenance system needs training as well.

One of the challenging factor in Devichaur-7 is to allocate the location for the water treatment plant. For example, Slow Sand Filtration needs more space than for other water treatment process. The variation in landscape could disrupts water pipelines if they are not installed properly.

The cost to disinfect the water should be taken into account, so that the community pays the minimum cost and get the pure water in affordable price. The price for the maintenance system could be the potential challenge in long term. Every households in devichaur-7 can easily pay for the cost of chlorine needed for the water disinfection. In community base chlorine disinfection system, the amount of chlorine needed is higher since all the raw water needs to be treated. Besides that Water collection tank should be build which is extra cost. It would be cheaper to implement the chlorine to disinfect water in household level because the amount of chlorine needed is lower.

In case of SSF, the operating cost is higher because of the need to build the filter bed, consequently the cost becomes higher for the community.

Social aspects would be challenging in terms of Human resource. The number of households tend to work for maintenance system would not be so many, however the human resource needs the water management system is very low for Devichaur. While considering the Social influence, Cultural issue should not be neglected. Social influence would be challenging unless the community do not understand the importance of hygiene and need of water treatment.

Households based water system is challenging for the community because of the efforts need by themselves are necessary. Although boiling water treatment method is effortless process, household would not practice because there are many people who does not like the taste of boiled water.

5.3 Chlorination Challenges

There are several factors should be known before adopting the chlorination to disinfect the contaminated water. Before chlorination water quality should be tasted and the amount and concentration of chlorine should be known. Households using chlorine should be given information about using the disinfectant. Even though the disinfection process is simple and

easy to implement for households, it is more complex to execute in large scale. Tanks containing large amount of water needs a suitable mechanism for injecting the disinfectant. The contact time to disinfect the water may vary in different season consequently the amount of disinfectant may changes. Monitoring the free residual chlorine is important part, so trained person is required. It is rather challenging to determine the chlorine contact time during the period between chlorine injection and the chlorinated water reach to the household. Community should appoint the person who is responsible for chlorinating the water tank and the measurements and tests needed. The leakages in supply pipelines may leads to recontamination. For Chlorination, to determine the proper amount of chlorine needed to disinfect the water could be difficult for households unless they do not know about the process. The probability of formation of disinfectant by-products are also possible while chlorination of raw water which could be challenging. The excess residual chlorine in drinking water may cause irritation to eyes and nose and even stomach discomfort.[29]

The households would not hesitate to use chlorine to disinfect water unless the taste of water changes and gives unpleasant odour. For community based water treatment, amount of chlorine needed is relatively higher, so it would create the question that who would provide finance to buy the chlorine. It would still be difficult to monitor the water chlorination in household level whether people are using or not.

5.4 Solar Disinfection Challenges

Since solar disinfection process for water treatment do not require any chemical or physical requirements, it is the cheapest and one of the best method. The only requirement is clean and transparent bottles for this method. As the time needed to put the water in sunlight for at least 6 hours so drinking water should be disinfect and preserve in advance. In the rainy and cloudy weather, the time requirement is even higher. Since this process can be useful only for the drinking water, it would be challenging to disinfect large amount of water. This process is effective only when the water contains low turbidity as the particles present in the water obstruct the UV radiation from water penetration. Odour and colour of the water cannot be treated with this process.[30]

5.5 Boiling

Boiling is effective method to remove the faecal pathogens from the contaminated water. Since most of the Chotidanda households use fire woods for cooking It may increase the need of fire woods brought from the forests. Water needs to be filtered if it contains physical contaminants.

Besides the above mentioned challenges, to change the behaviour of the people for adopting the water quality and hygiene improvement are more challenging. The people are busy with their working life and taking care of children and they do not tend to improve these things. The behaviour change of washing hand with soap is important. People with low income may not pay for buying soap for washing hands.

6 CONCLUSION

After the field observation and water quality test, it can be concluded that water is contaminated with faecal contaminants where as other chemical contaminants such as ammonia, pH, nitrate etc are not at risk level. Residents of Chotidanda are susceptible for the sickness caused by faecal pathogens. Similarly, hand hygiene tests gave out the positive result. More than 50% of the hand samples contained *E.coli*. The pathogen transmitted either through the contact with contaminated water or because of the poor hygiene. It can be assumed that, water has been contaminated because of the poor personal hygiene. The other reasons for water contamination are leakages in water supply pipelines and forests and households animals which are not kept in safe place.

Despite the poor water quality and hygiene, people are not sick with diarrhoea all the time. It shows that, even the source is not protected, water is not contaminated all the time with faecal pathogens at source. Mostly , water has become contaminated at household because of the poor hygiene practice. The faecal pathogens pathway for water contamination are highly susceptible. Water treatment system is necessary to provide potable water for the community. Together with the water quality improvement, personal hygiene enhancement is also mandatory.

The community of Chotidanda are not aware of the links between hand hygiene and water quality. Even though people do not take any action to improve the water quality in household level they are positive about protecting the water source and for water quality improvement system in community level.

7 RECOMMENDATIONS

To minimise the diarrhoeal episodes in the Chotidanda, water quality and hygiene improvement is necessary. To improve the hand hygiene , people should be motivated to use soap as it can reduce *E.coli* by 3.10 log value with the non antimicrobial soap where as antimicrobial shop containing 70% ethanol advanced formula can reduce by 5.22-log reduction [32]. I would like to focus on the recommendations for the community of Chotidanda to improve the water quality and hygiene are as follows:
First of all, water source protection is necessary, so the water intake should be build in the water sources to protect drinking water from the anthropogenic and biological processes which leads to contamination.

After that, the maintenance team should be mobilized to take care of the water supply pipelines leakages and cleaning the water source. The water quality at household level should be tested after protecting the water source. If water found to be contaminated even after the source protection, water treatment is mandatory. Although, there is many water improvement process, I would like to propose chlorination in community level. As in household level, many people would not pay to buy chlorine and use it. Hence building the water tank and chlorinate the water and send to the household through supply pipelines. Community should collect certain amount of money for the maintenance system and the chlorine needed for the water disinfection. FCHV's should be activated to provide the health hygiene education to each household, which would raise the awareness of importance of hygiene. FCHV's should also collect the data of diarrhoeal incidents in the households which would help to analyse the situation of the water quality and hygiene. It would also help to take further steps and planning for the water quality improvement. It is also necessary to educate the people to use soap for washing hands after toilet, before cooking, working in the field and in contact with the domestic animals. Only water quality improvement will not decrease the diarrhoeal cases, hence hygiene promotion is also compulsory along with the water quality improvement. It would be more effective to give the hygiene and water quality education to the children in the school. FCHV's could provide education in school in certain interval of time. Prepare for the emergency cases, since the Chotidanda is the most remote part of the VDC, in emergency case it would be difficult to take the patient to the health post for the treatment hence every household should be able to treat themselves in such incident.

Future task and observation

During the conversation with Mr. Dharma Ratna Chitrakar and the Yubraj Shrestha (Manager at CODEF) about the water quality improvements, Yubraj Shrestha agreed to build water intake at source. We discussed with the WUG's of Chotidanda to build the water intake. We came up with idea that, CODEF will provide technical assistance, bricks, cement where as community will provide unskilled labour, stone and aggregate. If there will be water intake in near future, water quality should be tested again. The pipelines also needs to be repaired. It will definitely protect the contamination from anthropogenic process which may occur at source and in the pipelines. Still the question is about the hand hygiene promotion. It costs about 30 cents for a hand washing soap in local markets. For a family of 5-6 members, one soap is enough for one week. It costs 10 euro to provide soap for the 32 houses. Annual cost for soap is 490 euro. Hence, after building the water intake and providing soap, it may reduce the diarrhoeal cases in Chotidanda community. Providing shop to community may help to change the hand washing behaviour of the people.

REFERENCES

1. Household water treatment and safe storage. WHO 2014. WWW-published http://www.who.int/household_water/en/

2. Livelyhood and Environmental Awareness Project: 1st Quarterly Progress Report 2013-2015, CODEF, www.codefnepal.com

3. Livelyhood and Environmental Awareness Project: 6th Quarterly Progress Report April-June2014, CODEF, www.codefnepal.com

4. Singleton P 1999. Bacteria in Biology, Biotechnology and Medicine. WWW-published http://en.wikipedia.org/wiki/Escherichia_coli

5. Escherichia coli 2012, Centers for Disease Control and Prevention. WWW-published http://www.cdc.gov/ecoli/general/index.html

6. Jay W. Marks, Bhupinder Anand. Giardiasis: Giardia Lamblia. WWW-published http://www.medicinenet.com/giardia_lamblia/article.htm. Referred: 28/03/2014

7. Mellisa Conrad Stöppler, Jerry R. Balentine 2005. WWW-published http://www.medicinenet.com/cryptosporidium_symptoms_and_treatment/views.htm

8. Environment Statics of Nepal 2008. Government of Nepal. National Planning Commission Secretarat, Centrat Bureau of Statistics. Kathmandu, Nepal. WWW.published http://www.wepa-db.net/policies/law/nepal/st01.htm

9. 3M PetrifilmTM: E.coli/Coliform Count Plante. PDF-published. http://mb-labs.com/docs/spoilage/3M%20Petrifilm%20-%20TCC%20-%20ECC.pdf. Referred: 28/01/2014

10. Mellisa Christensen 2003. Principles and Practices of Water Supply Operation: Water Quality.WWW-published http://books.google.com.np/books?id=hUH0lb72K4EC&pg=PT158&dq=turbidity&hl=en&sa=X&ei=ZqRXU_jMHdH-8QWh0ILABg&redir_esc=y#v=onepage&q=turbidity&f=false

11. Environmental and Workplace Health: Temperature, 1995 Health Canada. WWW-published http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/temperature/index-eng.php#n5

12. World Health Organization 2011, Acceptability aspects: Taste, odour and appearance. PDF-published http://www.who.int/water_sanitation_health/publications/2011/9789241548151_ch10.pdf

13. Drinking Water Contaminants 2009, EPA. WWW-published http://water.epa.gov/drink/contaminants/#Inorganic

14. Marla Sheffer 2003, Ammonia in Drinking Water 1996, World Health Organization. PDF-published http://www.who.int/water_sanitation_health/dwq/ammonia.pdf

15. Sanitation: Progress on drinking water and sanitation , updated: 2014, WHO WWW-published http://www.who.int/topics/sanitation/en/

16. The Safe Water system: Safe Storage of Drinking Water 2011. PDF-document http://www.cdc.gov/safewater/pdf/safestorage_2011-c.pdf

17.Household Water Treatment 2011. PDF-document. http://www.cdc.gov/safewater/pdf/solar2011final.pdf

18.Jari Koponen 2010. Water Hygiene And Sustainable Development Of Water Resources In Devichaur VDC, Nepal, Bachelor thesis, MUAS, Referred: 25/02/2014

19.Household water treatment and safe storage 2011. WWW-published http://resources.cawst.org/asset/boiling-fact-sheet-detailed_en

20.Calcium hypochlorite, WHO. PDF- document. http://www.who.int/water_sanitation_health/hygiene/emergencies/fs2_19.pdf

21.Technical Guidelines For Determining Disinfection "CT" of Groundwater 2010. PDF-document. http://www.ct.gov/dph/lib/dph/drinking_water/pdf/Chlorination_Technical_Guidelines.pdf

22. L.Huisman, W.E, WOOD, F.I.C.E Slow Sand Filtration 1974. PDF-document http://www.who.int/water_sanitation_health/publications/ssf/en/

23.Art Ludwig, Slow Sand Filtration 1997-2014. Word-document http://oasisdesign.net/water/treatment/slowsandfilter.htm

24.Filter design and construction. PDF-document. http://www.who.int/water_sanitation_health/publications/ssf4.pdf?ua=1

25.Robert M. Svadlenka, Improving Local Water Supply in Rural Communities: Challenges, Techniques and Opportunities. WWW-published. http://www.whyhunger.org/frontend.php/overlay/simpleIndex?id=496

26.Cesar Marron, Slow Sand Filtration Water Treatment Plants: Design, Operation and Maintenance. WWW-published. http://practicalaction.org/slow-sand-filtration-water-treatment-plants

27.Davis, J and Lambert, R, Water Sanitation Health: Cleaning and disinfecting water storage tanks 2002. WWW-published. http://www.who.int/water_sanitation_health/hygiene/envsan/tn03/en/

28.Health promotion and community participation. 2002. PDF-document. http://www.who.int/water_sanitation_health/hygiene/emergencies/em2002chap15.pdf

29. Basic Information about Disinfectants in Drinking Water, updated 2013, EPA, WWW-published http://water.epa.gov/drink/contaminants/basicinformation/disinfectants.cfm

30. Melinda M. Foran 2007, An analysis of the time to disinfection and the source water and environmental challenges to implementing a solar disinfection technology. Master's Thesis. PDF-document. http://web.mit.edu/watsan/Docs/Student%20Theses/Ghana/Thesis-Final%20-%20Melinda%20Foran%205-18-07.pdf

31. Indra Adhikari 2009. Nepal: Diarrhoea outbreak kills hundreds. WWW-published. http://www.ifrc.org/ar/news-and-media/news-stories/asia-pacific/nepal/nepal-diarrhoea-outbreak-kills-hundreds/

32. Sarah L.Edmonds, Robert R. McCorMACK, Sifang Steve Zhou, David R. Macinga, Christopher 2012. Journal of Food Protection M. Fricker http://www.foodprotect.org/issues/packets/2014Packet/attachments/III_017_b.pdf