Jari Koponen

WATER HYGIENE AND SUSTAINABLE DEVELOPMENT OF WATER RESOURCES IN DEVICHOUR VDC, NEPAL

Bachelor's thesis
Environmental Engineering Degree Programme

November 2010

MIKKELIN AMMATTIKORKEAKOULU
Mikkeli University of Applied Sciences

DESCRIPTION

MIKKELIN AMMATTIKORKEAKOULU Mikkeli University of Applied Sciences	**Date of Bachelors thesis** 25.11.2010
Author Jari Koponen	**Degree programme** Environmental Engineering

Name of the Bachelors thesis

Water Hygiene and Sustainable Development of Water Resources in Devichour VDC, Nepal

Abstract

The main aim of this bachelor's thesis was to research and clarify the overall situation of drinking water and its related issues in Devichour VDC for project cooperators CODEF and KEMA in Livelihood improvement and environment-project. Aims also were to research possible options for improvement of the drinking water quality, to examine drinking water related diarrhea cases and other related diseases in the area, as well as research the relation between diarrhea occurrence versus dry- and monsoon season. Also to accompany Devichour to a more sustainable base regarding water resources and consumption, by researching viable options for water purification, as well as pursue the ways to enhance water management by local contribution. Main reasons for the study were, as most of rural areas in Nepal, that Devichour VDC was being reported to have plenty of drinking water related diseases, diarrhea amongst them. Diarrhea in rural areas is linked to poor sanitation facilities, agriculture, and with lack in common drinking water hygiene.

The research for this thesis was conducted in Devichour VDC in Nepal that lies about 20 km east from the capital Kathmandu during the period of three months from May to August 2010. During that time was carried out sampling of drinking water sources and water sample analyzes in Devichour VDC, most importantly for coliformic bacteria and *Escherichia coli* that are one of the most important markers for harmful fecal pathogens causing diarrhea. Also surveying local drinking water consumption habits and collection of relevant health data was performed in the local community.

The results for research show that poor sanitation facilities, habit of open-defecation and lack of general drinking water hygiene has big influence regarding the occurrence of diarrhea cases in the rural developing communities such as Devichour is. Results also show that amount of diarrhea cases are highly dependent on the season, especially on the monsoon season when there can be noticed an outbreak in diarrhea cases.

Subject headings (keywords)

Drinking water, *E. Coli*, coliformic bacteria, diarrhea, rural communities, water purification methods

Pages	**Language**	**URN**
61 p. + Attachments 10 p.	English	http://www.urn.fi/URN:NBN:fi:amk-2010121718631

Remarks

Tutor	**Bachelor's thesis assigned by**
Pia Haapea	Mikkelin Kehitysmaayhdistys Ry

KUVAILULULEHTI

MIKKELIN AMMATTIKORKEAKOULU
Mikkeli University of Applied Sciences

Opinnäytetyön päivämäärä

25.11.2010

Tekijä

Jari Koponen

Koulutusohjelma

Ympäristöteknologia

Nimeke

Water Hygiene and Sustainable Development of Water Resources in Devichour VDC, Nepal

Tiivistelmä

Tämän opinnäytetyön tavoitteena oli tehdä peruskartoitus juomavesitilanteesta Mikkelin Kehitysmaayhdistyksen ja Community Development Forumin ”Livelihood Improvement and Environment” yhteistyöhankkeeseen Devichourin kylässä Nepalissa. Tutkimuksen pääkomponenttina oli tutkia koliformisten bakteerien määrää juomavesissä, ja niiden suhdetta kylässä esiintyvien ripulitapausten määrään. Tämän lisäksi tutkin kyläyhteisöön sopivia veden laadun parantamis- ja puhdistuskeinoja, sekä yhteyttä kuivan- ja sadekauden välillä esiintyvien ripulitausten määrässä. Asettaessa tavoitteita, päällimmäisenä kuitenkin oli keinojen selvittäminen Devichourin kyläyhteisön veden kulutuksen saattaminen omaehtoiselle ja kestävälle pohjalle. Pääsyy tutkimukselle oli, kuten maalaisyhteisöissä Nepalissa yleensä, myös Devichourissa raportoitiin olevan paljon ripulitapauksia. Ripuli vastaavanlaisissa kehitysmaa-maalaisyhteisöissä usein liitetään heikkoihin saniteettioloihin, maatalouteen, sekä yleiseen vesihygienian puutteeseen.

Tutkimuksen suoritin Devichourin kylässä Nepalissa, joka sijaitsee noin 20 kilometriä maan pääkaupungista Kathmandusta, kolmen kuukauden ajanjaksolla Toukokuusta Elokuuhun 2010. Tänä aikana suoritettiin juomaveden laadulliset mittaukset paikallisissa vesilähteissä, sekä vesinäytteiden analysoinnit koliformisten bakteerien ja *E. colin* osin, jotka ovat tärkeimpiä indikaattoreita suolistoperäisille bakteereille. Näiden lisäksi tutkimukseen kuului paikallisten juomaveden kulutustapojen tutkiminen, sekä aiheeseen liittyvän terveystilastoinnin suorittaminen ripulin ja muiden aiheeseen liittyvien tautien osin.

Tutkimuksen tulokset kertovat heikkojen sanitaatio-olosuhteiden ja tottumusten, sekä yleisen vedenkäsittelyhygienian vaikuttavan selkeästi alueella esiintyvien ripulitapausten määrään. Tuloksista on myös havaittavissa selkeä syy-seuraussuhde kuivan ja sadekauden kauden, sekä niillä esiintyvien ripulitapausten määrässä.

Asiasanat, avainsanat

Juomavesi, *E. Coli*, koliformiset bakteerit, ripuli, kehitysmaa kyläyhteisöt, vedenpuhdistusmenetelmät

Sivumäärä	Kieli	URN
61 s. + Liitteet 10 s.	Englanti	http://www.urn.fi/URN:NBN:fi:amk-2010121718631

Huomautuksia

Ohjaavan opettajan nimi	Opinnäytetyön toimeksiantaja
Pia Haapea	Mikkelin Kehitysmaayhdistys Ry.

LIST OF CONTENT

1 INTRODUCTION..1

2 DRINKING WATER RELATED DIARRHEA WORLDWIDE..........................3

2.1 Source of diarrhea..3

2.2 Fecal pathogens 4

3 NEPAL..5

3.1 Geography of Nepal..5

3.2 Zones, regions and districts 6

3.3 Issues related to drinking water in Nepal 6

4 LIVELIHOOD IMPROVEMENT & ENVIRONMENT- PROJECT COOPERATION...7

5 DEVICHOUR 9

5.1 Devichour society 11

5.2 Health, well-being and prevalence of diarrhea in Devichour 13

6 METHODOLOGY...16

6.1 Data collection methods 16

6.2 Interviews 16

6.3 Sampling and analyzing methods 19

6.3.1 Sampling Petrifilm (3M) *E. coli* and Coliform Count Plates..........20

6.3.2 Phosphate Test and Ammonium Test sampling..............................21

6.3.3 Analyzing E. coli & coliformic bacteria 22

6.3.4 Analyzing phosphate & ammonia..24

7 DRINKING WATER RELATED ISSUES IN DEVICHOUR VDC 24

7.1 Toilets and open-defecation practices 25

7.2 Drinking water facilities 26

7.3 Water consumption habits 27

7.4 Water distribution 29

7.5 Wards & water sources 31

Collection tanks, natural water sources and taps in Devichour VDC..........32

7.5.1 Reservoir tank, Ward 1 33

7.5.2 Main source, Dhungedhara, Ward 1 33

7.5.3 Main source, Ningrodol, Ward 2 34

7.5.4 Main source/ water tank, Zurili, Wards 2/3 35
7.5.5 Main water source, Kartiki, Ward 3 36
7.5.6 Main source, Okhare, Ward 3 37
7.5.7 Dhungedhara and water collection tanks, Ward 4 38
7.5.8 Water source, Ward 7 40
8 RESULTS OF THE ANALYSIS 41
8.1 *E. coli* and Coliforms 41
8.2 Ammonia and phosphate 42
8.3 Temperature and pH 43
9 SOLAR WATER DISINFECTION – SODIS 43
10 IMPROVING WATER MANAGEMENT IN DEVICHOUR 44
10.1 Improvement by local contribution 44
10.1.1 Water users committee and water watchers group 44
10.1.2 Filtration 45
10.1.3 Environmental education 45
10.1.4 Rainwater harvesting 46
10.2 Relevant house water treatment and purification methods for rural communities 46
10.2.1 Boiling and thermal (heat) technologies 47
10.2.2 Chemical disinfection 48
10.2.3 Granular media filters – Slow-sand and bio-sand filtration 49
10.2.4 Membrane, porous ceramic or composite filters 52
10.2.5 UV technologies and Solar Water Disinfection 54
10.2.6 Coagulation, precipitation and/ or sedimentation 56
10.2.7 Combination (multi-barrier) treatment approaches 56
11 SUGGESTIONS FOR FURTHER STUDIES 57
12 CONCLUSION 59
LIST OF REFERENCES 61

ATTACHMENTS

ATTACHMENT 1: Lalitpur District map

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066

ATTACHMENT 3: Sampling result table

1 INTRODUCTION

This study concerns drinking water and sanitary problems in the rural community of Devichour VDC that is located about 25 km from the capital Kathmandu in Nepal. Thesis research was done for Mikkeli Association for Sustainable Development (Mikkelin Kehitysmaayhdistys - KEMA) joint project with Community Development Forum (CODEF), based in Kathmandu, Nepal – for Livelihood Improvement and Environment - project (LEAP).

During the period of three months; from 2 of May to 2 of August 2010, I researched the baseline situation for drinking water; the water related diseases, problems and noteworthy improvement options for the matter. Main reasons for the study were, as most of rural areas in Nepal, that Devichour VDC was being reported to have plenty of drinking water related diseases, such as diarrhea amongst them. Diarrhea in rural areas is linked to poor sanitation facilities, agriculture, and with lack in common drinking water hygiene.

The aims of the thesis are:

- Clarify the overall (baseline) situation of drinking water and its related issues on the area for project co-operators CODEF and KEMA
- Research possible options for improvement of the drinking water quality in Devichour VDC
- Examine drinking water related diarrhea cases and other related diseases in the area, as well as research the relation between diarrhea occurrence versus dry- and monsoon season
- Increase community's readiness to avoid drinking water related diseases by community's own effort by interviewing and executing small scale water hygiene education in Devichour

The problems related to drinking water were surveyed through everyday life of local people in Devichour VDC, by causation of the diseases, water source sampling and analyzes, and as a result the drinking water and other relevant problems can be linked between. Other related problems are women issues in the project area, such as inequality between male and female community members. Also health issues and other environmental problems are related due to the lack of education and knowledge of the issues. The improvement plans are reflected to achieving sustainable level in the usage of drinking water. They are targeted for female group activities, to activate male community members, and in overall to achieve the community's interest for their own drinking water and its clean hygienic usage.

NOTE: In project proposal and official project documents project area is referred as Devichaur VDC, but in this thesis it's referred as Devichour VDC (as it's known officially, and also by community locals and world-wide organizations e.g. United Nations).

2 DRINKING WATER RELATED DIARRHEA WORLDWIDE

Worldwide, the most common contamination of raw water sources is from human sewage; in particular from human fecal pathogens and parasites. In 2006, estimated 1.8 million deaths were caused by waterborne diseases, while about 1,1 billion people lack access to a proper drinking water. [1] In many parts of the world, especially in developing countries, the only sources of water are from small streams of water, often directly contaminated by sewage or fecal pathogens [2].

Pathogenic micro-organisms are directly transmitted when contaminated fresh water is consumed. Contaminated fresh water, used in food preparation, can be the source of food-borne disease through consumption of the same micro-organisms. [2]

According to WHO, diarrhea occurs worldwide and causes 4% of all deaths and 5% of health loss to disability. Most commonly it is caused by gastrointestinal infections that kill around 2.2 million people globally each year, mostly children in developing countries. Cholera and dysentery can cause severe and sometimes life threatening forms of diarrhea and is the passage of loose or liquid stools more frequently than is normal for the individual. Depending on the type of infection, the diarrhea may be watery or passed with blood. [2]

2.1 Source of diarrhea

Diarrhea is a symptom of infection caused by a host of bacterial, viral or parasitic organisms that can spread through contaminated water. It is more common when there is a shortage of clean water for drinking, cooking and cleaning; and in general basic hygiene is important factor in its prevention. Water contaminated with human feces, for example from municipal sewage, septic tanks and latrines is of special concern. Animal feces also contain micro-organisms that causes diarrhea. [2]

Diarrhea can also spread from person to person, aggravated by poor personal hygiene. Food is another major cause of diarrhea when it is prepared or stored in unhygienic conditions. Water can contaminate food during irrigation. Fish and seafood from polluted water may also contribute to the disease. [2]

Diarrhea generating pathogens include e.g. *Cryptosporidium* and *Giardia lamblia* parasites, *Legionella* and *Coliformic bacteria*, as well as several virus classes such as norovirus and rotavirus. Coliformic bacteria have several classes and are naturally present in the environment as well as in feces. Fecal coliforms and *Escherichia coli* only are transmitted from human and animal fecal waste. [3]

2.2 Fecal pathogens

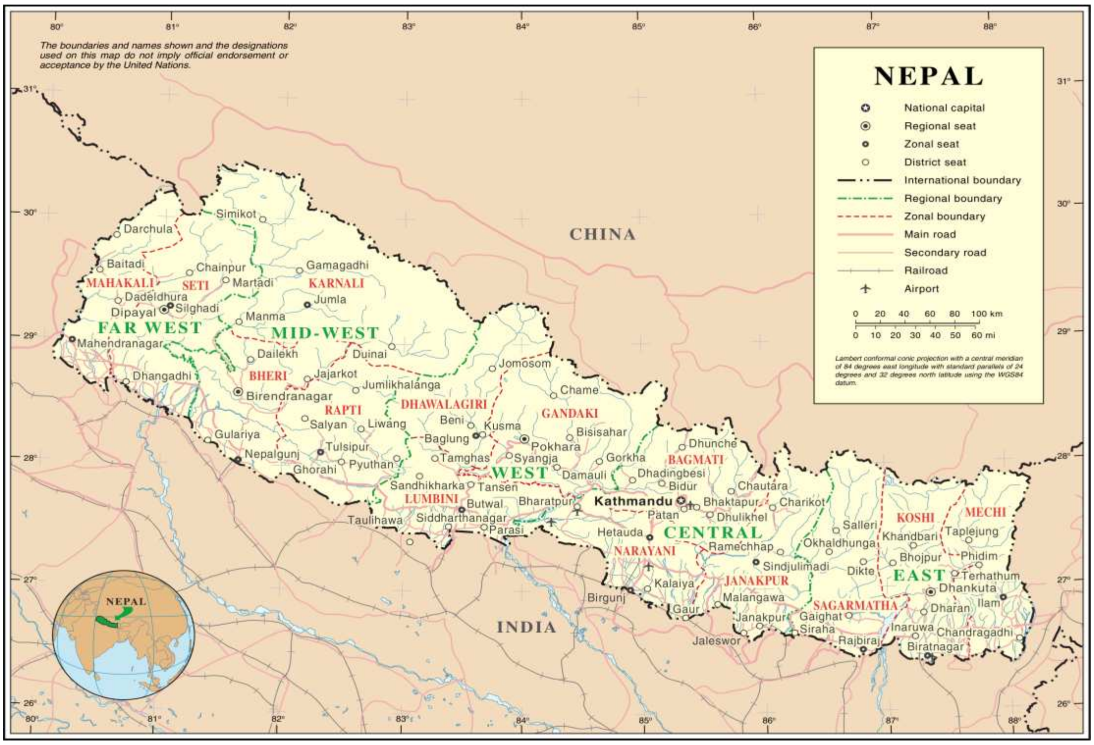
Fecal pathogens fall under microbiological parameters that include Coliformic bacteria, *Escherichia coli* (*E. coli*) and other specific pathogenic species (such as cholera causing *Vibrio cholerae*), viruses as well as protozoan parasites. In general, fecal contamination is determined with the presence of coliform bacteria, a convenient marker for a class of harmful fecal pathogens. The presence of fecal coliforms (e.g. *E. coli*) serves as a good indicator of contamination by sewage and feces. Microbiological pathogenic parameters are in general the greatest concern for their immediate health risk. [3]

Large numbers of *Escherichia coli* are present in the normal intestinal flora of humans and animal, where it in general does not cause harm. However in other parts of the body, *Escherichia coli* can cause serious disease, such as urinary tract infections, bacteraemia and meningitis. Limited number enteropathogenic strains can cause acute diarrhea. [4]

Several classes of enteropathogenic *Escherichia coli* have been identified on the basis of different virulence factors, including enterohaemorrhagic *Escherichia coli* (EHEC), enterotoxigenic *Escherichia coli* (ETEC), enteropathogenic *Escherichia coli* (EPEC), enteroinvasive *Escherichia coli* (EIEC), enteroaggregative *Escherichia coli* (EAEC) and diffusely adherent *Escherichia coli* (DAEC). More is known about the first four classes named; the pathogenicity and prevalence of EAEC and DAEC strains are less well established. According to WHO (2008), the objective of zero *Escherichia coli* per 100 ml of water is the goal for all water supplies and should be the target even in emergencies. [4, p. 107.]

3 NEPAL

Nepal (officially Federal Democratic Republic of Nepal) in South Asia is a landlocked country between India in south-southwest and China in north-northeast (see picture 1). Area of Nepal is 147,181 square kilometers and its population approximately 30 million, a number that is increasing at the rapid rate of 1,4 % annually. [5]



PICTURE 1 Map of Nepal [6].

3.1 Geography of Nepal

For a small country, Nepal has great physical diversity, ranging from the Terai Plain in Southern Nepal at about 300 meters above sea level, to the almost 8800 meter high Mount Everest in the north part of the country. From the lowland of country's Terai belt, landforms rise in consecutive hill and mountain ranges, including the Himalayas, ultimately reaching the Tibetan Plateau beyond the Inner Himalayas. This rise in elevation is punctuated by the valleys situated between mountain ranges. [5]

Commonly Nepal is divided into three physiographic areas; the Mountain Region, the Hill Region, and the Terai Region. All three parallel each other, from east to west, that are occasionally bisected by the country's river systems. These ecological regions were divided by the government into development sectors within the framework of regional development planning. [5]

3.2 Zones, regions and districts

Nepal consists of 14 zones and 75 districts that are grouped into 5 development regions that are [6]:

- Eastern region (Purwanchal)
- Central Region (Madhyamanchal)
- Western Region (Pashchimanchal)
- Mid-Western Region (Madhya Pashchimanchal)
- Far-Western Region (Sudur Pashchimanchal).

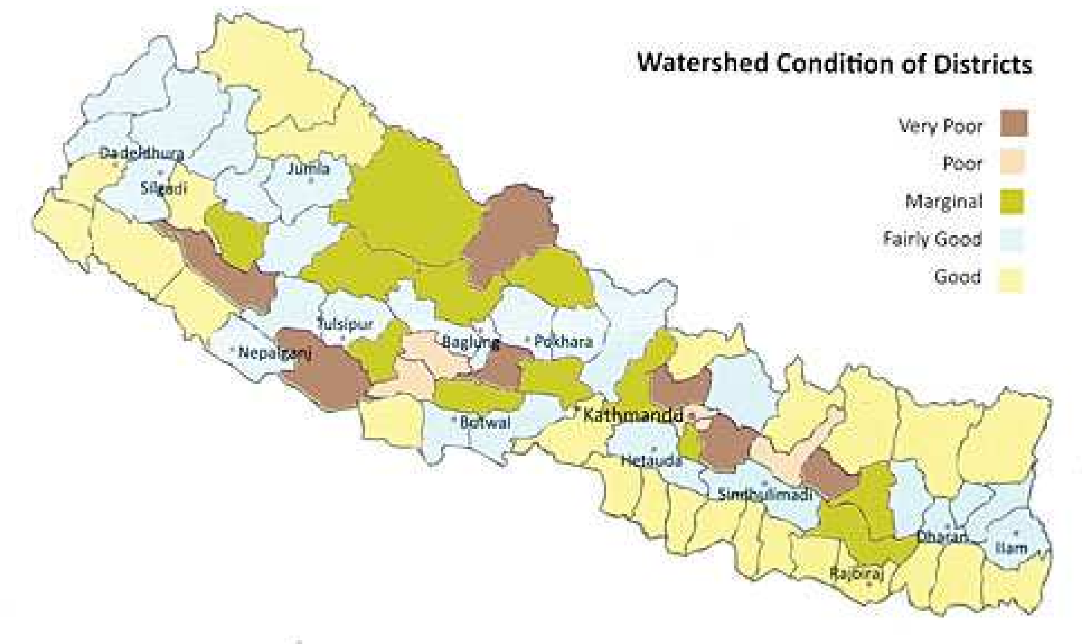
Below the district level is the VDC (Village Development Committee) level, and in total there are 3913 villages (VDC's) in the country. Each village is divided into 9 wards. Every district has a permanent chief district officer, which is responsible for maintaining law and order, and coordinating the work of different field agencies of various NGO's and governmental ministries. [7]

3.3 Issues related to drinking water in Nepal

Drinking water related diarrhea has gained lots of national and also worldwide reportage. According to Nepali Times (2010) and a study by Indian Strategic Foresight Group's The Himalayan Challenge - Water Security in Emerging Asia, the four countries of the Himalayan sub-region (Nepal, India, China and Bangladesh), will have to make with 275 billion cubic meters less water over the next 20 years due to changes in the behavior of monsoon. This number is greater than total number of water in Nepal at present. [8]

As the Himalayan river basins are home to 20 % of the world's population, water depletion in the region is in such scale, therefore it even has serious social, economic and political percussions worldwide. Around 80 % of Nepal's annual rainfall falls between June and September, many people in the hills have to survive on less than five liters of water per capita per day. The monsoon is characterized by heavy precipitation, culminating in flooding across the country. The rest of the year is marked by long spells of drought. During recent years, there have been noted changes in the behavior of monsoon, and therefore in availability of water in Nepal. Aid agencies have been urging Nepal to implement stronger water and sanitation measures to prevent diarrhea outbreaks, which claims hundreds of lives every year in the country. Especially during monsoon seasons, there is noticed to be an outbreak in diarrhea related deaths. [8]

In 2009, there were more than 370 cases in diarrhea deaths, according to Nepal government's Epidemiology and Disease Control Division (EDCD). Over 67,000 diarrhea cases were reported last year, most of them in 18 of the country's 75 districts. These districts that does not have proper health care, and have improper water and waste management, are included in these figures. See picture below for watershed conditions in Nepal. [8]



PICTURE 2 Watershed conditions of districts in Nepal [9]

4 LIVELIHOOD IMPROVEMENT & ENVIRONMENT- PROJECT COOPERATION

Livelihood Improvement and Environment- project is implemented by Community Development Forum Nepal (CODEF) in Devichour VDC of Lalitpur district in Nepal from January 2010, with an aim of community development through environmental management and livelihood improvement. Women mobilization and strengthening of its institution by increasing equality between male and female community members are the main objectives of the project.

CODEF is a non-governmental and non-political non-governmental organization (NGO) registered in FY 2055/56 (1998/999 AD) and has been affiliated with the Social Welfare Council in Kathmandu since 2003. CODEF provides services in the field of rural infrastructures, environment, agro-forestry, water supply and sanitation, school and community sanitation and hygiene, health and nutrition, resettlement of people, human resource development and other various activities for the sustainable development of the country. It has a national office at New Baneshwore in Kathmandu and several project offices around the country. [10]

CODEF has worked several years in improvement of environmental sanitation at national level. At present, it is also a member of Steering Committee of National Sanitation Action Plan of the Government of Nepal. CODEF developed the proposal of Livelihood Improvement and Environment Project with aim to develop the Devichour VDC community through capacity building on preventive health care; focusing on child health, reproductive health, sanitation and waste management; as well as implementing small scale environment friendly technologies, by mobilizing local resources and increasing environmental awareness in the community. [11]

Mikkelin Kehitysmaayhdistys Ry (Mikkeli Association of Sustainable Development, KEMA) is a local association based in Mikkeli, Finland. It is a civic organization, which aim is increasing fairness in trade between Finland and development countries worldwide, as well as adding quantity and quality of Finnish development cooperation [12]. The association is a part of KEPA, Finnish Service Centre for Development Co-operation, a service base for Finnish NGOs interested in development work and cooperation [13].

The project co-operation started in January 2010, when KEMA was granted support from Ministry of Foreign Affairs in Finland for Livelihood Improvement & Environment development project for 2010-2012 with CODEF. KEMA’s co-operation partner in Finland is Mikkeli University of Applied Sciences (MUAS), with whose grants

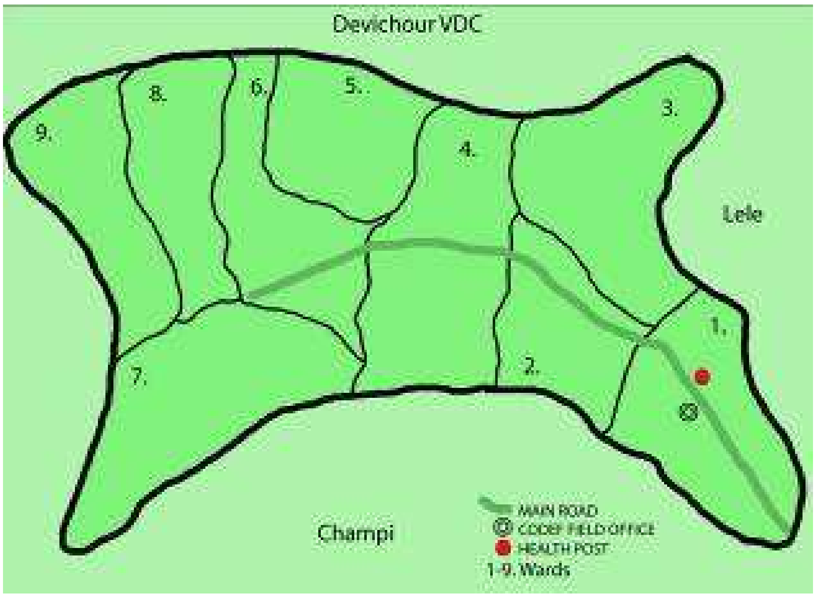
KEMA is committed and is able to send two student interns for the project yearly during the project period. As for the project, KEMA has also been granted national fundraising permit, as the funds are needed to cover projects share of self-financing. [12]

5 DEVICHOUR

Devichour is one of the 42 VDC's in the area of Lalitpur. Devichour VDC lies at the Central Region of Nepal (picture 3). Surrounding villages are Champi, Lele, Dukuchhap and Ghusel. Devichour is located about 25 km from Kathmandu (attachment 1, Lalitpur district map) [15]. Devichour VDC area consists of nine wards with an area of 1036.96 ha and highest elevation about 5000 m above sea level [16].

PICTURE 3 Location of Devichour [14]

During the time of research, e.g. hiking from ward 1 to ward 7 took about seven hours per way. Distance between these two wards is approximately 6km (picture 4).



PICTURE 4 Devichour Ward map [17]

Wards 1 – 3 are more developed than rest of the wards. The development on these wards can be noticed by more tolerable living conditions and in general income on these wards is higher than in rest of the wards. There are also services available for locals, such as shops, local tea shops and a health post. CODEF field office is located in ward 1 (see picture 4 for location in Ward map, picture 5 for ward 1).

PICTURE 5 Local shops and houses in Devichour ward 1 [18]

Further in the area of Devichour, the terrain gets harder and more difficult to travel. Road (that is suitable for driving) reaches ward 6, although major parts of wards 5 and

6 are only reached by walking. Travelling on the road becomes difficult during monsoon season as the road gets muddy and landslides are common. The standard of living gets relatively lower further the area you get. In the furthest wards (5-9) locals need to go long distances to have same goods as locals in wards 1-3, and are more dependent on their own outcome of their farm and crops.

PICTURE 6 Terrain in Devichour [19]

5.1 Devichour society

Majority of Devichour locals are Tamang, who forms about 6 % of the population in Nepal, which makes it largest ethnical group in the country [20, p. 47-48]. Most of them live in the northern side of Kathmandu, while many move to Kathmandu for work and better standard of living. This originally animistic culture has taken its influences from Tibetan Buddhism, as well as from the main religion of Nepal, Hinduism. Their native language is Tamang dialect as many do speak Nepali as well. See picture 7 for regular family in Devichour.

PICTURE 7 Regular family in Devichour [21]

According to CODEF Baseline Report (conducted from June to July 2010), the total population of Devichour is 2733, female 1347 (49,3%) and male 1386 (50,7%). The total population in Devichour consists of Tamang 80,1 %, Brahmin and Chettri 19,5%, while 0,2% are Dalit, and 0,1% others. Most recent number of households in Devichour VDC is 524 and average family size is 5,2. [16, p. 8-9.]

In Devichour VDC there are five government schools, which two are secondary schools, and three are primary schools. School-aged children (6-15 years old) in Devichour are around 20 %, though it is not reported how many of them attend school. Primary level educations have 57.1 % of the total population, where 27.4% have secondary level education, 8.2 % are Intermediate and 2.3 % are Bachelor. Total literacy rate in Devichour VDC for male is 56,6 % and for female 43,4 %. [16, p. 9-10.]

According to the Devichour locals, average monthly income for a household varies between 3500-4500 NRP (income in general gets lower, further in the area you get). In CODEF Baseline Report 34 % of the community falls under 4000 NRP per month income category that is considered to be ultra poor and do not meet the calorie requirement of the family members [16, p. 13]. And in general monthly expenses exceed the income level and locals need to rely on loans.

NOTE: During the time of research, currency rate for Nepalese rupee (NRP) was around 0.01 €, where 100 NRP is about 1 €. Prices stated here and further in the thesis are referred to this rate.

5.2 Health, well-being and prevalence of diarrhea in Devichour

According to CODEF Baseline Report, 73 % of the total population of Devichour suffered from different kind of sicknesses; such as diarrhea, typhoid and dysentery, during the year 2009 [16]. Diseases that existed (and was reported by households) in 2009 are presented in the table 1 below.

TABLE 1 Diseases in Devichour, 2009 [16, p. 15-16]

Name of disease	Number of households	Percentage
Diarrhea	112	16.9%
Dysentery	39	5.9%
Worms	10	1.5%
Typhoid	50	7.5%
Cholera	7	1.1%
Skin diseases	26	3.9%
Malaria	-	-
Jaundice	13	2.0%
Others	406	61.2%

Other notable and not officially registered diseases in the area are asthma and uterus prolapse. Latter one was reported by local female community members to have over 20 cases, and is due to heavy work load performed by female community members. Also notable diseases according to health post data are amoebic cysts and jaundice, which occurred few cases in Devichour during 2009. Both of these are drinking water related diseases.

Majority of the locals rely on health post/ hospital (40,1 %) or a traditional healer (37,6 %) when seeking treatment for sicknesses [16, p. 16]. See table 2.

TABLE 2 Methods of treatment in Devichour [16, p. 16]

Methods of treatment	Number of households	%
Home Treatment	190	16.4%
Traditional Healer	436	37.6%
Village health promoter	10	0.9%
Health post/Hospital	465	40.1%
Medical shop	54	4.7%
Others	4	0.3%

As for diarrhea, 182 locals visited local health post for treatment during February 2009 – March 2010. Most of the health post visitors are from Devichour wards 1-3, but usually in case of more serious cases, also visitors from further wards (5-9) seek treatment from health post. These numbers does not include the locals who did not get treatment at all, and did self-treatment, or the most serious cases that need hospital care. Health post also had few visitors because of diarrhea from the villages of Champi and Lele. Nearest hospital is located few kilometers outside the village in Tikabhairav. See chart 1 Diarrhea cases by age in Devichour (February 2009 – March 2010) below and chart 2 for overall diarrhea cases in Devichour (2009-2010):

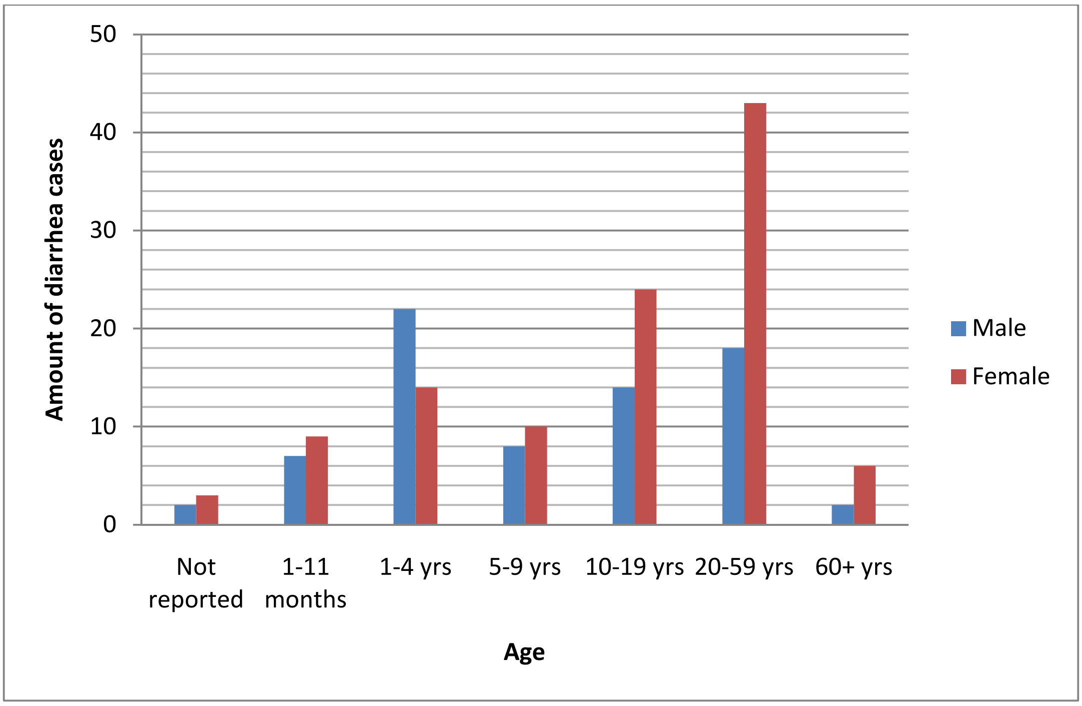


FIGURE 1Diarrhea cases by age in Devichour (February 2009 – March 2010) [22]

In the figure 1 can be seen that most diarrhea cases are in the age group 20-59 years. When studying the data for diarrhea cases and proportioning children in age groups 1-11 months, 1-4 and 5-9 years to these numbers, can be noted children in these ages suffering relatively lot of diarrhea compared to rest of the population.

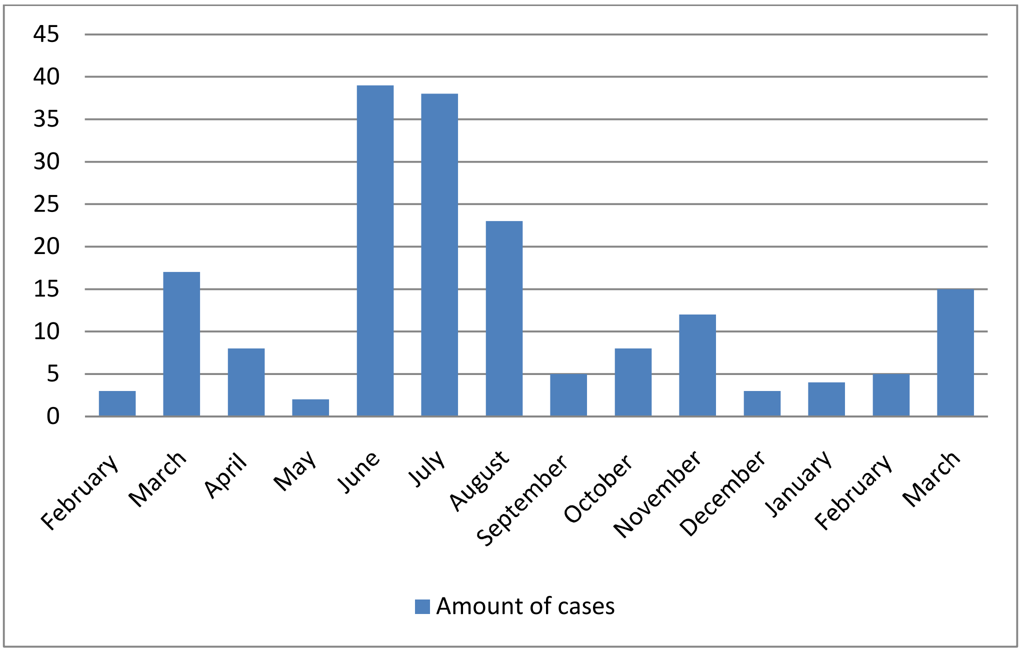


FIGURE 2 Diarrhea cases in Devichour (2009–2010) [23]

As for overall diarrhea cases, (see figure 2) a clear spike can be noted on diarrhea incidents during June, July and August. Cases can be associated with monsoon and its relevance with the overall condition of drinking water in the area at the time period. Due to heavy rains, it is more probable that drinking water is contaminated with surface waters than in the dry season. Monsoon in Nepal usually appears from June until September.

In Devichour VDC, there is one health post for use of locals. According to the CODEF Baseline Report, it was found out that more than 73 % of people said they have health facilities and almost 27 % say that they do not possess health facilities [16, p. 15].

6 METHODOLOGY

Methodologies of this thesis are dealt by reviewing methods used for interviewing and analyzing the results, as well as implementation of the sampling executed in Devichour VDC.

6.1 Data collection methods

The data and information regarding demographics presented in the study are based on CODEF's reports on Livelihood Improvement and Environment- project, such as CODEF Baseline Report that was conducted during the time of my thesis research (first published in October 2010). Information on Devichour VDC's health data and diarrhea cases were collected from VDC's health post data with a help of translator. To be exact on the matter, village health post does not have electricity in use most of the time, let alone a computer. Health data is upheld by simple book-keeping method by the local doctor. Numbers of cases are self-calculated, as well as charts, tables and figures regarding Devichour VDC health data and prevalence of diarrhea in the research area are done by person undersigned. If news reportage related to the subject from local newspapers from the time period is referred, they are mentioned in the list of references.

6.2 Interviews

Interviews and samplings for the study were carried out with great help of translator/ field worker Bikash Shrestha, and local community mobilizers Manju Tamang and Bimlah Bajgain. Also project coordinator Yaba Shrestha, was a great help understanding culture related customs and habits in Devichour VDC, and also a good information source of common problems in the area. Field coordinator Hari Buddhathoki, person in charge in field and female committee activities in Devichour VDC, was source of local information, as well as help on coordinating sampling activities in the field.

Interviewees mostly were local female community members with whose help I was able to understand local water consumption habits and problems related to drinking water in Devichour VDC. As for female community members, CODEF conducted and organized female group meetings and activities around project area, where consumption habits of drinking water could be surveyed, as well as gathering more detailed information on the subject was possible. The drinking water related issues were also discussed with women during the women committee meetings. Also local male community members who were responsible for water distribution on their area were interviewed. More detailed information regarding water distribution on wards 1-3 was given by; Indrajit Llama who carried out monitoring wards 1-3 water sources, and Narabbhadchur Tamang who was person in charge for water distribution system in wards 1-2, as well as in small scale water user committee activities. ENPHO representative Suman Shakya was inquired repetitively for company's projects and activities in the rural communities of Nepal.

CODEF conducted baseline survey for each household on the project area, its target to gather general information on the households; caste/ ethnic, characteristic, socio-economical, health, water and sanitation, natural resources, institutional, skills and training related information (see attachment 2) (Results of CODEF Baseline Survey in Baseline Report that are referred). During visits to the households, I was able to perform more detailed questions and consumption habit research for water and sanitation related issues.

NOTE: CODEF Baseline Survey Form is originally in Nepalese, but due to Finnish stakeholders also translated into English as presented in this thesis as well.

Besides the questions presented on the Baseline Survey Form regarding water and sanitation (see attachment 2, p. 4-6), matter was discussed and questions asked are presented and summarized below:

1. *Most common problems with the drinking water?*
    a. *Diseases (if referred person relates drinking water with possible diseases)*
    b. *Other problems (with fetching, consuming etc.)*

2. *What do you do for drinking water before consuming?*

3. *Have you become sick out of consuming drinking water?*

4. *How many visits have you had to do to the pharmacy/ health post/ hospital because of diarrhea (past year/ during lifetime)?*

5. *How do you understand diarrhea?*

6. *Do you consider it as a sickness?*

7. *Do you consider it as drinking water- or food hygiene related (do you know why it is happening)?*

8. *How do you protect your water sources (natural water sources/ water tanks/ distribution system) or upkeep general water hygiene in household?*

9. *What do you usually do to treat diarrhea (medication, purification; boiling, or others, etc.)?*

As for water distribution system and related subjects, the person in charge Mr. Narabbhadchur Tamang, was a help to locate main sources of water and do the generalized map of distribution system. Mr. Indrajit Llama, person monitoring distribution system in wards 1-3, in addition with locals present in the, were interviewed for the matter with questions below:

1. *Who is responsible for building the water distribution system in Devichour VDC?*

2. *How much do locals use natural water sources as their main source of water (in general, if household not connected to the water distribution system)?*

3. *Are you aware of the fact that locals are linking their household by themselves to the water distribution system?*

4. *Is there any surveillance on the matter (by you, government, anyone)?*

5. *Are there water user group activities performed in Devichour VDC (if so, in which wards)?*

6. *Who has funded the building of water distribution system in Devichour VDC?*

7. *Budget for it? Where does the funding for maintaining the water distribution system come from?*

8. *What are the problems with the water distribution system?*

9. *What are the water purification/ upkeep methods used (overall/ in tanks/ reservoir tank)?*

6.3 Sampling and analyzing methods

The methods for quality monitoring were selected through most appropriate and user-friendly options to be used in such rural conditions that Devichour has, and by the knowledge and research I made on field sampling conditions before field research period in Nepal.

For hygienic quality observation of drinking water, indicator organisms are used, such as coliformic bacteria, as actual determination of pathogens is troublesome and expensive. The presence of indicator organisms shows that the water is potentially contaminated with feces, while presence of disease causing organisms is possible. Most commonly used indicator for quality of household water (drinking water) is coliformic bacteria. Among coliforms, only *Escherichia coli* are found in high concentrations from human and animals' guts. [24] As Devichour VDC was reported to have plenty of drinking water related diarrhea and also widespread practices regarding open-defecation were these indicators for contamination the most obvious ones to settle in.

Ammonium ions are a waste product of the metabolism in animals, as well as from agricultural and industrial processes. Natural levels of ammonia in ground and surface water are usually below 0, 2 mg/l. Intensive rearing of farm animals can give rise to much higher levels in surface waters. Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution. Toxicological effects are observed only at exposures over 200 mg/kg of body weight. [4, p. 304.] As for phosphate, its man-influenced sources also include untreated sewage and runoff from agricultural sites.

The methods that were settled were Petrifilm (3M) *E. coli* and Coliform (EC) Count Plates that can be used to track coliformic bacteria and *E. Coli* from water or other samples (such as food). Ammonia and phosphate were assessed by quick-sampling-methods from the water sources by Phosphate Test (by Merck) Test Ammonium (by Aquamerk ®), to find possible remnants of animal feces. In addition temperature and pH were assessed, as well as sensory (smell and general appearance) analysis.

Sampling sessions were carried out during dry- and monsoon season, on-site. Dry season samplings were done during 10 - 30 of May, and for monsoon season during 10th of June – 14th of July. For accurate places and times see attachment 3, Sampling Result Table.

6.3.1 Sampling Petrifilm (3M) *E. coli* and Coliform Count Plates

The 3M Petrifilm *E. coli* / Coliform Count (EC) Plate kit includes:

- Instructions of use
- 25 (*2) count plates
- Plastic spreader

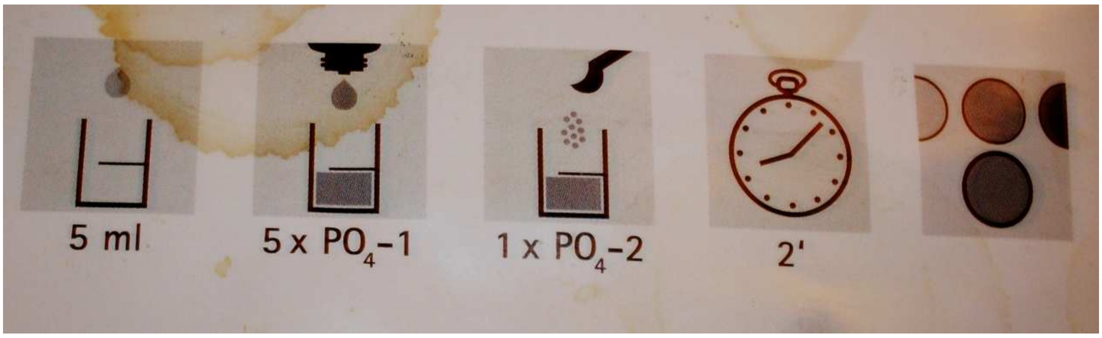
Plating of EC plates is carried out by placing the plate onto a flat surface; in general in the field plate was placed either on a flat rock or surface. The top film of EC plate is lifted, where sample by 1 ml pipette is placed onto the center of the bottom of the film. The top film is rolled down onto the sample to prevent trapping air bubbles. The plastic spreader is placed with the flat side down onto the sample, and pressed gently on the center of the spreader to distribute the sample evenly. The inoculum is spread over the entire Petrifilm plate growth area, before the gel is formed. The spreader is removed, and plate left undisturbed for at least one minute to permit the gel to form. In general this took at least two EC plates, due to uneven surfaces or difficult circumstances.

Count plates on the field were collected to a plastic case, where they were held during the sampling round while hiking at maximum of 8 hours. Bacteria growth was carried out in a longer time period that was 5 days (120 hours) and the growth of bacteria was monitored daily, and happened in “home-laboratory”, after which bacteria counting was performed. If staying overnight in the field, count plates were held in the field office. The count for sample incubation time started at the time of placing the sample on the count plate. In the field office or “home-laboratory”, contamination of samples (count plates) was possible, as it is anywhere in such conditions as Nepal has and without laboratory conditions, though improbable have an effect on the general out-come of sampling results.

6.3.2 Phosphate Test and Ammonium Test sampling

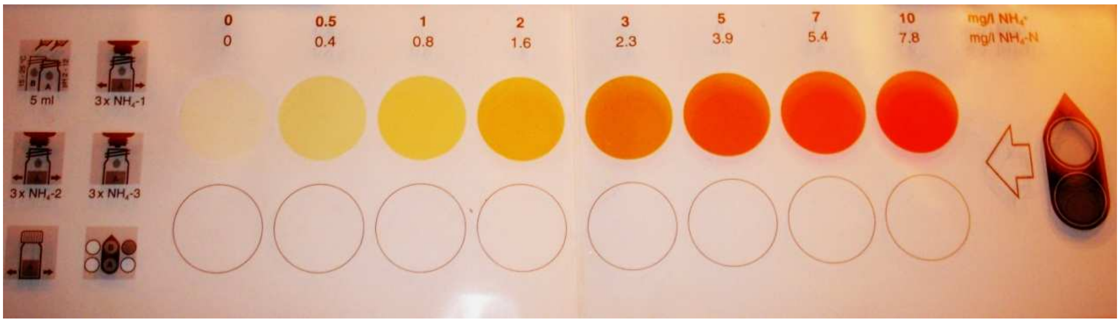
Sampling of phosphate was carried out in five phases (see picture 9), where:

1. The test vessel is filled to the 5 ml mark
2. Addition of 5 drops of PO_4^{-1}
3. Addition of 1 micro-spoon of PO_4^{-2} and dissolved.
4. 2 minute reaction time
5. The color is compared with the scale provided and result read off.



PICTURE 8 Manual for Phosphate field test kit [25]

Procedure of ammonia sampling starts rinsing the both test tubes. The measurement sample volume (test syringe) is 5 ml, and test tubes are filled with sample water to the5 ml marker line. Other test tube is the blank sample (no reagents added); whereas measurement tube is added with reagents NH_4-1, NH_4-2 and NH_4-3 in different phas-es. Reagent addition of each substance is 3 drops. After reagent addition, the test tubes are inserted into the sliding comparator (blank sample to the upper place facing the color scale, measurement sample lower place facing the blank scale) (see picture 10). The comparator is slided along the color scale until the closest possible color match is achieved between the two open tubes when viewed from above. The result is read off in mg/l NH_4^+ from the color card indicated by the pointed end of the sliding compara-tor, or if necessary, estimated an intermediate value.



PICTURE 9 Manual for Ammonium field test color scale for concentrations of 0-10 mg/l NH_4^+ [26]

Both applications, Ammonium Test and Phosphate Test, can be used for sampling materials, such as ground- or surface waters, waste water, fertilizers or process waters.

6.3.3 Analyzing E. coli & coliformic bacteria

The 3M Petrifilm *E. coli*/ Coliform Count (EC) Plates are a sample-ready-culture-medium system which contains Violet Red Bile (VRB) nutrients, a cold-water-soluble gelling agent, an indicator of glucuronidase activity, 5-bromo-4-chloro-3-indonyl-b-D-glucuronide (BCIG), and tetrazolium indicator that facilitates colony enumeration. Petrifilm EC plates are used for enumeration of *Escherichia coli* and coliforms in the food and beverage industries and plate components are decontaminated though not sterilized. 3M Microbiology is certified ISO (International Standardization Organization) 900.1. [27, p. 1.]

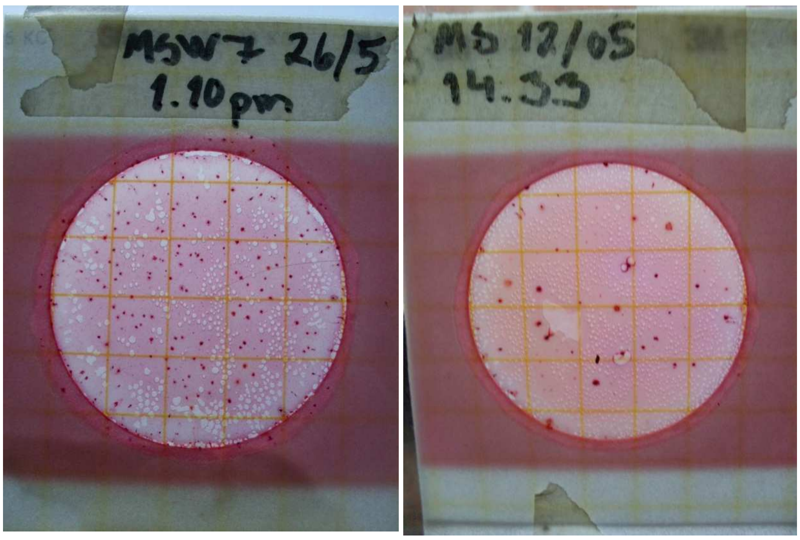
In general bacteria growth for Petrifilm count plates is carried out by 24 hours (+/- 2 hours) incubation time in 35 Celsius degrees (+/- 1 Celsius degree) (AOAC Official Methods) [27, p. 4]. Before departure to Nepal, the method was evaluated by help of MUAS Environmental Laboratory personnel to be used in such conditions. We came up to a conclusion that incubation is possible to conduct in a "room temperature" (that is during the research period 25-34 Celsius degrees in Nepal), by lengthening the incubation time to 3-5 days (depending on the temperature), while monitoring the overall *Escherichia coli* and coliform count throughout the period.

Counting of colonies can be done by using a standard colony counter or other illuminated magnifier [27 p. 4-5], in case of this research neither of mentioned was used.

During the time of analyzes, photos of sample plates were taken, as counting was easier on laptop screen. Colonies on EC plate foam dam are not included to calculations, since they are removed from the selective influence of the medium [27, p. 5]. Neither artifact bubbles are not counted that were present.

The interpretation of *Escherichia coli* colonies varies by method, but for this research AOAC Official Methods (998.08 and 991.14) are used. In the method blue to blue-red colonies associated with entrapped gas are enumerated, regardless of their size or intensity of color, as confirmed *Escherichia coli*. Blue colonies without gas are not counted as *Escherichia coli*. Other coliform colonies are red and closely associated, within one colony diameter, with entrapped gas. Colonies not associated with gas, with a distance bigger than one colony diameter between colony and gas bubble, are not counted as coliforms. The total coliform count consists of both the red and blue colonies associated with gas at 24 hours. Anytime within the method incubation period that a blue colony associated with gas appears, it is a confirmed *Escherichia coli*.

As the *Escherichia coli* and coliform counts for this study are self calculated, small variation to real counts is possible. Because the field tests are not as accurate as laboratory conducted tests, can the results given be used for directional information on water sources condition very well. To clarify sampling methods regarding Petrifilm count plates, there is an example of two sampling results below that were carried out during the time of research (picture 10).



PICTURE 10 Petrifilm EC count plates [28]

6.3.4 Analyzing phosphate & ammonia

Phosphate was researched by Phosphate Test (by Aquamerk®) to be used in fresh and seawater. This method is colometric with color card provided in the test kit for concentrations of 0,25-0,5-0,75-1,0-1,5-2,0-3,0 mg/l phosphate (PO_4^{3-}). [29]

To research ammonia concentrations in water, the method used was Ammonium Test (by Aquamerk®) for concentrations of 0-10 mg/l NH_4^+ or Ammonium Test (by Merkoquant®) for concentrations of 10-400 mg/l NH_4^+. The method for concentrations of 0-10 mg/l NH_4^+ is based to a reaction between ammonium ions and Nessler's reagent that forms a yellow-brown compound. The concentration of ammonium is measured semi-quantitatively by visual comparison of the reaction zone of the test stripe with the fields of color scale provided in the test kit (see picture 9). [30] Concentrations of NH_4^+ being below 10 mg/l, the Ammonium test for concentrations of 10-400 mg/l was not used in many occasions in the field (see results).

7 DRINKING WATER RELATED ISSUES IN DEVICHOUR VDC

Although 47% of total population in Devichour are literate, lack of awareness level on environmental sanitation and conservation are nearly absent. According to locals and CODEF field workers, secondary school levels 9-10 teaches a course that relates to environmental issues such as health and sanitation in Devichour VDC. While visiting local Bhimsen secondary school, local youth seemed to be aware of environmental problems on the area, and are at least eager to learn more about these and related issues. Local practices and knowledge can be considered to have major influence to the drinking water quality in Devichour VDC. Also highly elevated terrain and ground matter has significant effect to surface waters and their runoff streams, therefore to the quality of drinking water. In this chapter issues with drinking water in the area are dealt primarily through man-made issues that are toilets and local open-defecation practices, drinking water facilities, consumption habits and generalized view of the water distribution system in the area.

7.1 Toilets and open-defecation practices

As a result of poor sanitation and open-defecation, improper solid waste management, unhygienic drinking water facilities and the lack of drinking water treatment, there is a higher risk of contamination of water borne diseases. According to CODEF Baseline Report, it is reported that 41 % in the community have access to a toilet. “Pucci” latrines are typical Nepalese ‘squat’ toilets with a possible water-wash. Pit latrines can be minimally defined as ‘a pit in the ground’. (See table 3).

TABLE 3 Access to a facility of latrine [16, p. 19]

Existing toilet	**Number of house-holds**	**Percentage**
Yes	215	41.0%
No	309	59.0%
Total	**524**	**100.00**
Type of toilet		
Pucci latrine	168	78.1%
Pit latrine	46	21.4%
Other	1	0.5%
Total	**215**	**100.00**

Especially in the older generation and in the furthest wards of Devichour, people are oblivious with relation between drinking water and diarrhea, and the habits regarding open-defecation are rooted in the behavior so strongly, that these are challenging to change. See table 4 for open-defecation practices in Devichour.

TABLE 4 Open-defecation practices among community members who do not have access to a toilet facility [16, p. 20]

Practice of defecating	**Households**	**Percentage**
Open Field	36	12 %
Nearby Forest	271	87 %
Others	2	0.6%
Total	**309**	**100.00**

7.2 Drinking water facilities

Overall 507 (97 %) households in Devichour VDC have tap water in use [16, p. 17]. These water taps are mostly in communal use, and only few have their own taps in use. However it is quite common to link a household by self-made junctions to the water distribution pipes. So far it has not been under any regulations in the community. Rest of the community, about 20 households (3,6 %) does not have water taps in use, and they depend on the natural water sources, such as ponds and wells in the area (see table 5) [16, p. 17].

TABLE 5 Types of water facilities in use in Devichour VDC [16, p. 17]

Type of facilities	Households	Percentage
Tap	507	96.8%
Well	5	1.0%
Stream	4	0.8%
Natural	1	0.2%
Pond	6	1.1%
Others	1	0.2%
Total	**524**	**100.00**

When it comes to hygienic sanitary practices e.g. washing hands, majority of locals (61 %) uses water and soap while washing, and 19 % uses only water (see table 6) [16, p. 21].

TABLE 6 Means of washing hands [16, p. 21]

Means of washing hands	House-holds	Percentage
Only Water	97	18.5%
Ash	53	10.1%
Water and Soap	321	61.3%
Others	53	10.1%
Total	**524**	**100.0**

7.3 Water consumption habits

The general knowledge in Devichour with relation between diarrhea and contamination through drinking water is relatively poor. Within the community, diarrhea is mostly associated with spicy food, or in some cases with food contamination. Especially in the older generation, beliefs are animistic and habits behind generations. See picture 11 for typical water tap in Devichour.

PICTURE 11 Typical water tap in Devichour [31]

It is women's duty to fetch the water (either from the further natural sources, or near-by communal taps) along with other household and farm work (see table 7). In average it takes around 10 minutes, affecting on whether it is dry or monsoon season, the fetching distance and terrain on the fetching way [16, p. 18].

TABLE 7 Responsibility of fetching the water in the family

Responsibility	No. of households	%
Female	350	67 %
Male	174	33 %
Total	**524**	**100.00**

Water consumption pattern in Devichour VDC shows that in general 50 % of the total number of households uses less than 30 liters of water per day (see table 9).

TABLE 9 Quantity of water required per day in a household [16, p. 18]

Quantity of water required per day	Households	Percentage
Up to 30 l/day	260	49.6%
31 lit/day to 75 l/day	131	25.0%
76 lit/day to 150 l/day	77	14.7%
Above 151 l/day	56	10.7%
Total	524	100.00
Total	**524**	**100.00**

Locals find problems sometimes with water distribution pipes, as they get stuck or broken. Few times a crusher (there is mining practiced in the area) has broken pipelines. Community fixes the pipes by themselves; though mining company so far has paid the expenses. Water usually becomes dirty during the monsoon season, still they consider overall quality fine, and no purification methods are considered to be needed (household boiling, filtration or clorification). In some households they use cloth (fabric cotton or mixture, sari cloth) for filtration, to separate bigger particles from drinking water. In overall, local people do not like to use chlorine in the drinking water because of its taste and smell, and attitudes towards other cleaning methods (such as filtration) were considered to be not needed, and were considered more as a nuisance.

Also leeches are considered as a problem during monsoon season when their quantity increases high as the rains start and terrain gets wetter and moister. Leeches are able to get to the water distribution system via sources and pipes, from where all the way to the water taps. During monsoon season, most of the water sources surrounded by dense vegetation and forests were filled of leeches. Leeches lurked in the bushes, and did interfere the samplings quite a lot as they are able to literally jump on bypasser from the bushes and get inside the clothes.

In case of locals having diarrhea, most common self-treatment method is to have mixture of salt, sugar and other minerals that are available from nearby shops and pharmacy (wards 1-3), or making mixture by own effort. And while having diarrhea, they usually do boil the water to disinfect it.

The water is collected to general type plastic buckets. Inside the household, as it is common for the Nepalese culture they use common shared vessel for drinking while dining. In case of ‘special’ quests, at times a private mug is offered. They do wash their hands before and after having a meal (though it depends on the household habits) (see table 6), as the food is eaten by your hand (right one) as in common in Nepalese culture. Self-wash after toilet happens by water, and in most of the cases, there is not soap in use (see table 6).

7.4 Water distribution

The water distribution system in Devichour is primitive by western standards. It was not surprising to see self-made junctions to these on-ground pipelines (see picture 12), to join households to the distribution system. Many of the natural water sources were strained by animal feces and practices of open-defecation. These can easily be traced back to the amount of diarrhea cases in the area. Animal and human feces can easily contaminate the water sources via surface water flooding

The water distribution system in Devichour has been financed by several different non-governmental organizations. It has been put together in different phases, basically at times when there has been need from the community. By community pressure, different organizations had taken part at times, and therefore it has been created hastily, and with a quite poor quality.

PICTURE 12 Water distribution pipes in Devichour [32]

For irrigation there was not any system in a common use. About 20 households in Devichour had a canal facility in use, but mostly community depends on the rainfall [7]. To gather drinking water, there was not any rainwater harvesting in use. Amongst locals, the changes in the behavior of monsoon had been noted, and therefore in the availability of water in Devichour. Devichour depends heavily on rainwater for irrigation. This year's (2010) delayed and scattered monsoon made shortage in water for irrigation, as well as in drinking water.

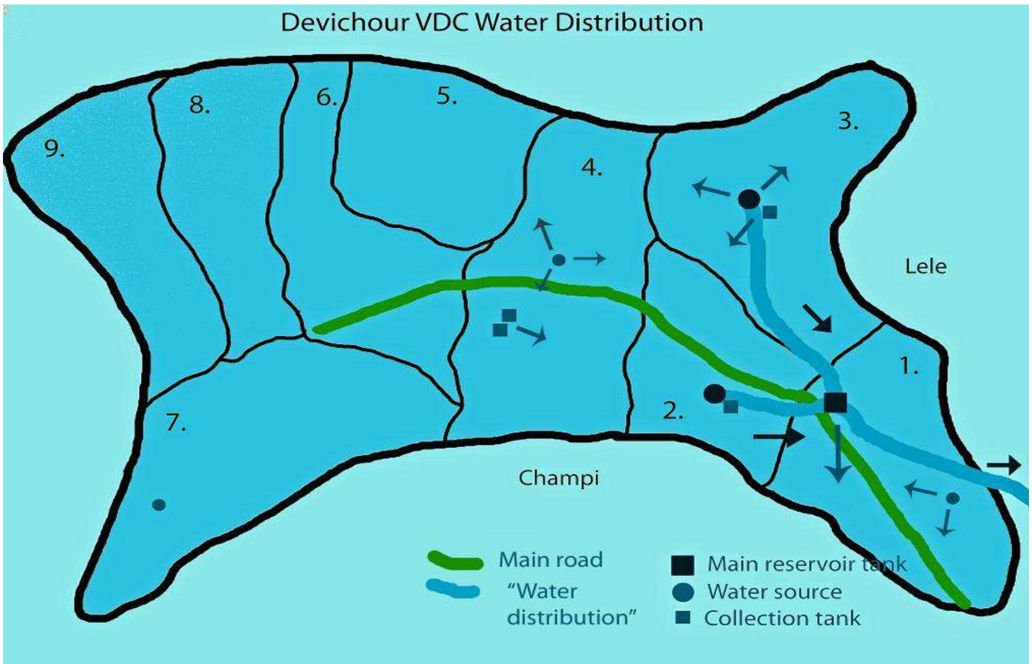
In Devichour, there was not anyone to manage or to train people for maintenance of the water distribution system. Wards 1-3 were told to have a water users group, but they did not seem to be in operation. At the time of research, Mr. Indrajit Llama was responsible for guarding the water sources and tanks, and monitoring the condition of the sources, and he was paid by locals (see picture 13).

PICTURE 13 Mr. Indrajit Llama cleaning the water sources [33]

There are water user committees formed in some villages in Kathmandu valley (such as Gundu, in Bhaktabur district), by a non-governmental organization ENPHO with the help of Water Aid Nepal. These committees are formed to survey and monitor drinking water situation in the village. Each ward has two persons in the committee, and these persons do the monitoring in their own ward, and make sure that the community follows the rules given to maintain drinking water quality. Also these people are allowed to give penalties for people in case of not following certain regulations, e.g. in case of habitual open-defecation or un-allowed self-made pipeline connections. [34]

7.5 Wards & water sources

Water distribution system in Devichour consists of natural water sources, water reservoir and collection tanks, and distribution pipes. Collection tanks are built of cement and distribution pipes in general are plastic. The distribution system comprehends wards 1, 2 and 3 in Devichour (see picture 14).



PICTURE 14 'Generalization' of the Devichour water distribution system. Arrows represent waters destination area from its source, small sources or households aren't included. [35]

For mapping the water distribution system in Devichour, I encountered some problems since I did not have the general map of the area (Devichour area has not been mapped properly by anyone so far). Locations of water tanks, water sources, households and piping would make the work easier in future. The map above was conducted by help of Bikash Shrestha and Narabbhadchur Tamang. Locations on the map are not absolute.

Collection tanks, natural water sources and taps in Devichour VDC

Sampling locations e.g. collection tanks, natural water sources and taps (separated in results, see attachment 3) are explained more accurate in this chapter, by the sources in common use amongst community. The sources are considered to be open (open-source), if the source is not covered (e.g. lid or plastic spread). The type of the source, whether it is open or closed, natural or a collection tank or if there are any chemicals used for disinfection affect to the quality of the drinking water. The type and location of the water source might be affected by surface run-off waters. Overall water source appearances were generally good, although each of the sampling results contained coliformic bacteria and most of them *E. coli* as well.

7.5.1 Reservoir tank, Ward 1

In ward 1 there is one bigger scale water collection/ reservoir tank (vol. 100 000 l), that is used to collect water supply from wards 1, 2 and 3. The excess water from ward 1 is distributed to other surrounding villages, such as Champi. The location was sampled several times during the research period, and there were not detected any big changes in the drinking water quality. Collection tank was reported to be chlorinated every one or two months. Tank is locked and closed by wooden doors. See picture 15 for the reservoir tank.

PICTURE 15 Ward 1 Reservoir Tank [36]

7.5.2 Main source, Dhungedhara, Ward 1

Dhungedhara (common Nepalese name for a water source, a ‘faucet’ type) in ward 1 is mainly used by community members living in the surrounding area, for washing clothes and fetching water (see picture 16). The water source is surrounded by farmland where crops were mostly rice or corn. Overall appearance of the water source was good, and in the surrounding area open-defecation was not practiced, although there could be found water buffalo and goat feces. Source is open-water source (not covered by plastic spread or cement lid, to prevent access of e.g. pests or rodents).

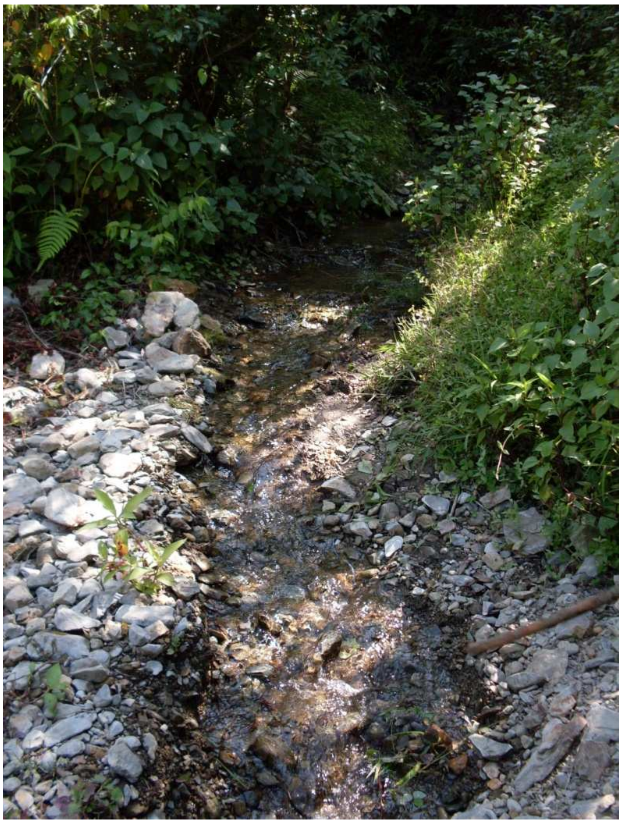
PICTURE 16 Ward 1 Dhungedhara & typical local ' faucet' [37]

7.5.3 Main source, Ningrodol, Ward 2

There are two larger scale natural water sources in ward 2, Kartiki and Ningrodol, which are connected to the Devichour VDC water distribution system. The water source of Ningrodol (see picture 17) is the biggest one in Devichour VDC area, and it collects water from several surrounding sources.

PICTURE 17 Ningrodol water source [38]

Overall appearance of water in the source was slightly muddy during monsoon season, but the general appearance of the source was good (see picture 18). It is an open-water source.



PICTURE 18 General outlook of the Ningrodol water source [39]

7.5.4 Main source/ water tank, Zurili, Wards 2/3

Zurili water source is located on a steep hill. About 20 meters below the water source lies collection tank for the source. Water source (see picture 19) is located between wards 2 and 3. The tank and water source are surrounded by thick bushes and forests, where during monsoon season lies masses of leeches that get also via distribution system all the way to the household water taps. Water source is open and tank below the source is covered with cement lid.

PICTURE 19 Zurili water source [40]

7.5.5 Main water source, Kartiki, Ward 3

Kartiki water source/ tank is surrounded by hills and difficult terrain to travel. Water tank is connected to the Devichour VDC water distribution system, and it gathers water supply from surrounding hills and streams (see picture 20).

PICTURE 20 Surroundings of Kartiki water source with Manju Tamang [41]

Overall appearance of the source is good, although during the period of research it was mostly empty due to drought (see picture 21). During monsoon season it is also inhabited by masses of leeches. There is no cement lid in use to cover the source.

PICTURE 21 Kartiki water source is empty due drought [42]

7.5.6 Main source, Okhare, Ward 3

In ward 3, there is Okhare water source that is also connected to the distribution system. It is a natural and open-water source (see picture 22). Overall appearance was below average; every sampling time source was filled with leaves and trash.

PICTURE 22 Okhare open-water source in Ward 3 [43]

7.5.7 Dhungedhara and water collection tanks, Ward 4

In ward 4, main water source is known as Dhungedhara (see picture 23). In July 2010 ward 4 Dhungedhara was polluted by a latrine waters from a broken toilet (see sampling results for Dhungedhara W4). The owner of latrine (male) at the time refused to clean the water source. It is an open-water source that gathers water from surrounding hills and forest.

PICTURE 23 Ward 4 Dhungedhara [44]

Ward 4 also has two water collection tanks and other scattered water sources that are also used as a direct source for household water. Past year locals have found carcasses in the water tanks and a dead frog was found in the other tank in May 2010 (see picture 24).

PICTURE 24 Inside the ward 4 water tank [45]

The frog carcass polluted drinking water for a brief time, but the overall condition of drinking water improved after locals removed the carcass, and cleaned the tank properly. As locals were told about my sampling results for the tank they seemed to learn about it, and were eager to keep on cleaning the tanks regularly to keep the water quality good. Both water tanks are covered with cement lid, and overall condition of drinking water was the best ones in Devichour VDC area (see picture 25).

PICTURE 25 Water tank in ward 4 with local community members [46]

7.5.8 Water source, Ward 7

While visiting ward 7 for water sampling, the condition of water sources could be detected by sight to be in very poor condition. Person guiding was not willing to let me sample the main water source due to drought and other unclear reasons. The sampling was carried out for a water source that was told to be used in these emergency cases (drought, pollution etc., see picture 26).

PICTURE 26 Ward 7 water source [47]

Human feces could be detected surrounding the water source. In the same ward, overall knowledge of open-defecation and of all its side effects was poorer than on other areas of Devichour in general. People seemed to open-defecate all around in the area, not much concerning whether there is a drinking water source nearby or not (see picture 27).

PICTURE 27 Open-defecation practices in ward 7 [48]

In general the further wards 5-9 in Devichour are even more primitive regarding to the drinking water system than the other wards. On these wards there are only minor pipelines that connect households and communal taps to water sources and tanks lying in the surrounding area.

8 RESULTS OF THE ANALYSIS

The results for field sampling and their analysis are covered in this chapter. These include counts for *E. coli* and coliforms, ammonia and phosphate, as well as temperature and pH. Results for SODIS (Solar Water Disinfection) method that was performed in Kathmandu are covered in the chapter 9.

8.1 *E. coli* and Coliforms

The main aim for sampling was to research the drinking water quality in Devichour, by carrying out water quality tests (*Escherichia coli* & coliformic bacteria, total ammonia and phosphate, pH), and to discover monsoons effect on the overall water quality. Especially important variable for water quality is the *E.Coli* and coliformic bacteria count, which represents remnants of human and/or animal feces. According to WHO guideline values for verification of microbiological quality; all water directly intended for drinking, *E. coli* or coliformic bacteria must not be detected in any 100 ml sample.

In the figure 3 are presented *Escherichia coli* and coliform total counts (sample size 1 ml); in comparison with dry and monsoon season, at main natural water sources in Devichour VDC. The sampling results from randomly sampled sources are not included. For all results see attachment 3.

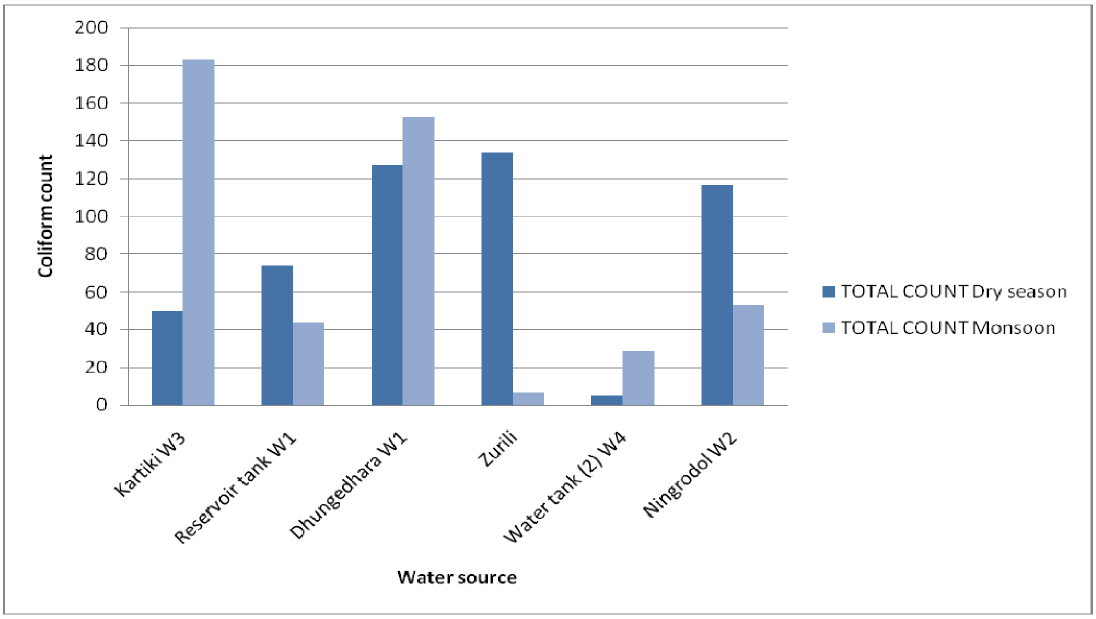


FIGURE 3 Count for coliformic bacteria, on-location

As for comparison of the effect of monsoon rains to the overall water quality, there were not distinct differences between the two seasons. The main factor for this most possibly is monsoon season and its rains being delayed this season. To coliform count affects the location of the water source, whether is it on effect of surface water runoff areas, possible other contamination sources (e.g. human or animal feces, farmland) or what type of source is about, e.g. open-water source, covered/protected source (covered with cement lid or plastic cover) and whether water in the source has current or if it is still.

8.2 Ammonia and phosphate

In general results for ammonia or phosphate concentrations were small and non-significant. Majority of the sampling locations was located further distances from farmland, where runoff waters including these substances could affect the results. Results for ammonia and phosphate are shown in attachment 3.

8.3 Temperature and pH

Temperatures were assessed with general thermometer. Temperatures for sampling waters varied between 12 – 16^{o}C depending on the location. PH was assessed with pH-indicator paper stripes (Merck). The results for temperatures and pH are separated in attachment 3.

9 SOLAR WATER DISINFECTION – SODIS

SODIS-method (Solar Water Disinfection) can be considered effective, at least when it comes to disinfecting coliformic bacteria from drinking water. I made my own small scale research regarding the SODIS method. For water sample I used drinking water from ward 4 water source Dhungedhara that was polluted by latrine waters of a nearby household. In the beginning of the test, the sample contained 14 *E. coli* units and 61 coliformic bacteria units, where overall count was 75 units. The test was conducted in Patan of Lalitpur District and started on 14 of July, and for the test period I took two days, while taking samples in between (every 24 hours). The weather for the first day of the test was half cloudy, and for second day weather was cloudy. Overall coliform count in the sample decreased to 1 unit during the period. See table 11 below for results:

TABLE 11 Results for SODIS experiment, 14th – 16th of July 2010

SODIS EXPERIMENT			
Sample from Dhungedhara W4 14.7.2010			
DATE	***E. coli***	**Coliform**	**Total count**
14.7.2010	14	61	75
15.7.2010	0	6	6
16.7.2010	0	1	1

NOTE: For more on UV-radiation based purification methods and SODIS, see chapter 10.2.5.

10 IMPROVING WATER MANAGEMENT IN DEVICHOUR

Ways to create a more sustainable water management system to Devichour can be easily executed by local contribution, management and regulations. Water quality in natural water sources can be enhanced by ending the habit of open-defecation. To achieve this, community needs education regarding the relation between open-defecation and cases of diarrhea. Also different types of water purification methods need to be brought up for locals and general environmental education, starting from local children and education given in local schools. Also in this chapter are dealt relevant water purification methods to be used in rural communities in developing countries.

10.1 Improvement by local contribution

In this chapter, such improvement options are dealt that can be done by community's own effort and contribution. These include creating a functional and active water users committee and groups monitoring the drinking water quality, pursuing the simplest methods of filtration for the use of the community and households, increasing environmental education and its quantity and quality in Devichour, as well as increasing local water supply by rainwater harvesting.

10.1.1 Water users committee and water watchers group

Creating a functional and active water users committee, to work for community's good, is a way to a more sustainable water management and to improve the drinking water quality in Devichour VDC. Although there are now some activities by few community members in wards 1 and 2, these activities should be introduced to each ward of Devichour.

By creating "water watcher"-groups from female committee members, who would monitor and upkeep the water sources and distribution system in their designated ward or area, could repairing necessities done more accurately and systematically. The upkeep would increase the quality of drinking water in the sources and distribution system remarkably when performed regularly. And reason why targeting the female community members is that during the time of research, generally females were much more active regarding the matter and more interested in improving the overall water quality than the males in the community.

Water users committee should be formed to survey and monitor the drinking water situation and practices affecting it. They could also make local level regulations and rules that should be followed in the community. Regulations would maintain the drinking water quality and committee members could perform penalties for persons not following them (e.g. un-allowed self-made pipeline connections or cases of open-defecation). As the chief district officer is responsible for activities in their own district, could committees and officer cooperate and have more proper and functional system in general. These types of committee and group activities need voluntary effort from the community members and trust between them. Local funds might be insufficient for this type of activities or if money is included it can cause jealousy or trust issues between the community members.

10.1.2 Filtration

Even the simplest methods of filtration should be pursued and taught for community, such as cloth filtration. Most bacteria and pathogens are attached to bigger particles in the water. The method can be easily executed by using cotton cloth such as sari cloth, folded to four or more layers. To decontaminate the cloth, it should be rinsed and washed every couple days, and dry out in the sun for few hours. To decontaminate cloth properly, cheap disinfectants or boiling for the cloth can be used. The simple method of cloth filtration would also work against leeches bothering during the monsoon seasons.

10.1.3 Environmental education

Locals should be made aware why not to defecate in some areas. Especially during the monsoon season, when farmers are out in the field and far away from the toilets, open-defecation is quite common. To enforce new sanitation practices, community members could be fined as a penalty, but as a forcing method it might not be strong enough to change people's habits. In this case awareness campaign for community members would be a useful method, educating them door-to-door or in common meetings. Also children, even in young ages, can be considered even more receptive than adults when initializing and forcing new practices

10.1.4 Rainwater harvesting

To increase water supply in Devichour, rainwater harvesting should be taken into a consideration to increase the water supply. And after water supply is not a problem anymore, the next big issue regarding the water is securing enough water for irrigating the fields. At the moment, community solely relies on the monsoon rains.

Overall, Devichour to achieve a sustainable level on drinking water management, it has to improve the overall drinking water quality, improve the water pressure at tap stands, and have toilets on everyone's use, whether by CODEF/ KEMA promoted Eco San toilets or typical latrines with proper drainage system. In addition, it would be suggested Devichour to have proper health and hygiene training program in the community and at schools, improve solid waste management in the area, and increase general awareness of the locals on water and sanitation related issues. This way local government can take over, once CODEF has completed the project in the area.

10.2 Relevant house water treatment and purification methods for rural communities

Non-piped water supplies, such as roof catchments (rainwater harvesting), surface waters and water collected from wells or springs, may often be contaminated with pathogens. Such sources often require treatment and protected storage to achieve contaminant-safe water. Many of the processes used for water treatment in households are the same as those used for community-managed and other piped water supplies e.g. pretreatment, micro-straining, off-stream/ bankside storage, bankside infiltration, conventional clarification, high-rate clarification, dissolved air flotation, lime softening, granular high-rate filtration, slow sand filtration, precoat filtration, membrane filtration, nanofiltration and reverse osmosis, chlorine, monochloramine, chlorine dioxide, ozone as well as UV irradiation. However, there are additional water treatment technologies recommended for use in non-piped water supplies at the household level that typically are not used for piped supplies. [4, p. 137-140/ 141.]

Suggested and recommended house water treatment technologies according to WHO, are chemical disinfection; membrane, porous ceramic or composite filters, granular media filters, solar disinfection, UV lights using lamps, thermal heat technologies; coagulation, precipitation and/ or sedimentation, combination (multi-barrier) treatment approaches. [4, p. 141a-d.]

Not all house water treatment technologies are highly effective in reducing all classes of waterborne pathogens such as bacteria, viruses and protozoan. For example, chlorine is ineffective for inactivating oocysts of the waterborne protozoan *Cryptosporidium parvum*, whereas some filtration methods, such as ceramic and cloth or fiber-filters, are ineffective in removing enteric viruses. Therefore, careful consideration of the health-based target microbes to be controlled in a drinking-water source is needed when choosing among these technologies. [4, p. 141a.]

In this chapter, relevant water purification methods and technologies are reviewed that can be considered to be taken into a use in Devichour VDC, by considering the stage of development, geography/ terrain/ environment, and suffiency of possible funding need or need of special expertise.

10.2.1 Boiling and thermal (heat) technologies

Boiling (100^{o}C) as a water purification method is easy, simple and effective. In Devichour, boiling drinking water before consuming to avoid water related diseases e.g. diarrhea is not a common habit. Locals know relatively well its disinfecting effects, but boiling is not done due to its need of fuel (wood), work and time. Basically vigorous boiling for three minutes kills bacteria, including disease-causing organisms and giardia cysts. Boiling the water used for drinking or washing vegetables should be taken into a consideration. The recommended procedure for water treatment is to raise the temperature so that a rolling boil is achieved, removing the water from the heat and allowing it to cool naturally, and then protecting it from post-treatment contamination during storage. Other thermal technologies are pasteurization (typically heating to minimum of 63^{o}C) [4, p. 141c].

Spores are more resistant to thermal inactivation than are vegetative cells. To effect properly in the reduction of spores, there must ensure sufficient temperature and time for boiling. [4, p. 141f]

Boiling on a bigger scale or longer time span purification method is not advisable or suggested in poor rural communities, since the amount of wood required does not make the method most sustainable or long-lasting in the area and in its forests.

10.2.2 Chemical disinfection

Chemical disinfection of drinking-water includes chlorine based technologies, including chlorine dioxide, as well as ozone, some other oxidants and some strong acids and bases [4, p. 141a]. In this chapter I only review chlorination as a water treatment method.

Method of chlorination is the process of adding chlorine to water to make it fit for human consumption as drinking water. Water that has been treated with chlorine is effective in preventing the spread of waterborne diseases. According to WHO (2004), improvements in drinking-water quality through household water treatment, such as chlorination at point of use, can lead to a reduction of diarrhea episodes by between 35% and 39% [49].

For immediate results, to have clean and safe drink water for use, it is suggested that households use chlorination for water purification. In markets in Nepal, there is a broad scale of choices and cheap options in water purification solutions and chlorine products. For example, a 240 ml bottle of ‘Water Guard’, water and sodium hypochlorite solution costs 35-50 NRP. It is used by adding few drops to a bucket of water, and thus provides safe drinking water. People in Devichour should be made aware of this, but not to encourage using it for a longer period of time. It is an easy solution, but it should not be in everyday use, as the drinking water should achieve the sustainable level of consumption. Government already promotes chlorination as a purifying method in the area (see picture 28).

PICTURE 28 Government promotion for household water chlorination [50]

There are studies that show that residual chlorine in drinking water increases individual's risk of developing certain diseases since excess chlorine is thought to combine with certain organic water pollutants to form toxic chemicals and carcinogens. According to Acu-Cell, several epidemiological studies linked the chlorination of drinking water individuals' increased risk of developing bladder cancer, with some studies also claiming a higher incidence of Hodgkin's disease, colorectal, esophageal and breast cancer. Based on these claims, women with breast cancer have 50-60 % higher levels of organo-chlorines (byproducts of chlorine) in their breast tissue, compared to women without breast cancer. It has been also associated with declining sperm counts, male infertility, and circulatory disturbances according to some animal studies. [51]

Anyhow WHO states that the health risks from these by-products are extremely small in comparison with the risks associated with inadequate disinfection, and it is important that disinfection not be compromised in attempting to control such by-products [4, p. 6-7]. Turbidity and chlorine demanding solutes inhibit this process [4, p. 141d].

10.2.3 Granular media filters – Slow-sand and bio-sand filtration

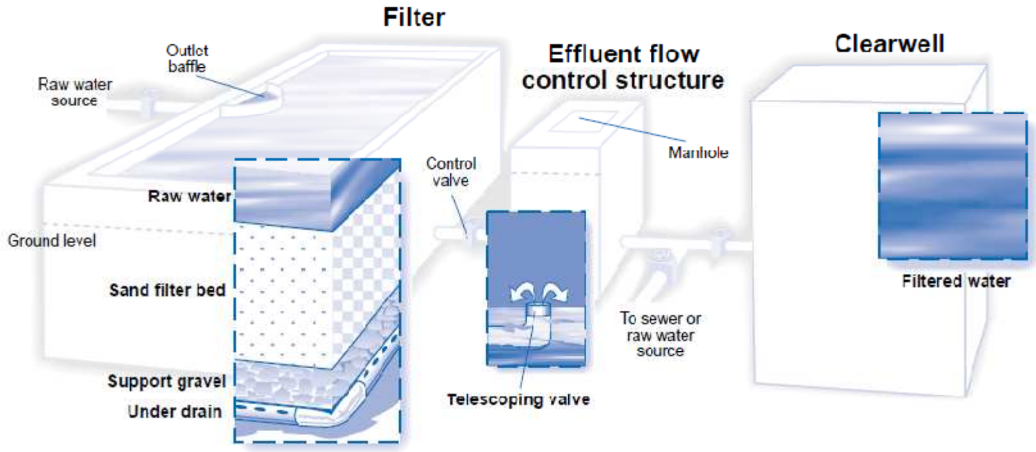
Granular media filters are those containing sand or diatomaceous earth or others using discrete particles as packed beds or layers of surfaces over or through which water is passed (e.g. slow-sand filtration and bio-sand filtration). [4, p. 141b.]

Granular media filters retain microbes by a combination of physical and chemical processes that include physical straining, sedimentation and adsorption. Some may also use chemically active antimicrobial or bacteriostatic surfaces or other chemical modifications. Other granular media filters are biologically active because they develop layers of microbes and their associated exopolymers on the surface of or within the granular medium matrix. This biologically active layer, called the *schmutzdecke* in conventional slow sand filters, retains microbes and often leads to their inactivation and biodegradation. A household-scale filter with a biologically active surface layer that can be dosed intermittently with water has been developed. [4, p. 141b.]

Reductions of bacteria, virus and protozoa are influenced by media size, flow-rate and operation conditions; some options are more practical than others for use in developing countries [4, p. 141e]. In this chapter are dealt methods of slow-sand filtration process for communal use and a bio-sand filter for household water treatment.

Slow-sand filtration

Slow sand filtration is quite simple and reliable process, and easy and inexpensive to build and also to initialize in household use. In the process, untreated water is percolated slowly through a bed of porous sand, with water poured over the surface of the filter, and then drained from the bottom. Usually, when properly constructed, the filter consists of a tank, a bed of fine sand, a layer of gravel to support the sand, a system of under drains to collect the filtered water, and a flow regulator to control the filtration rate. No chemicals are added or needed to aid the filtration process. [52]



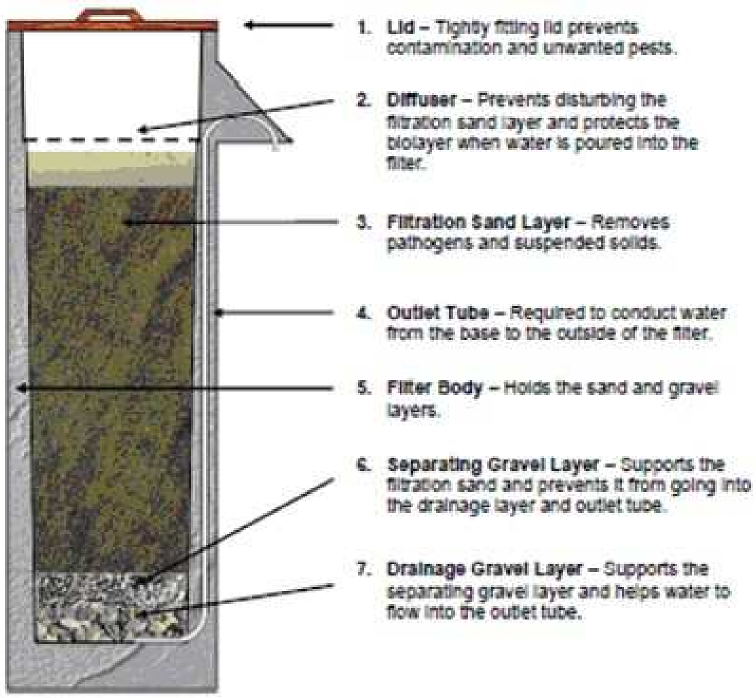
PICTURE 29 An example of slow sand filter (picture by NESC) [52]

Under suitable circumstances, slow-sand filtration may be not only the cheapest and simplest but also the most efficient method of water treatment. Its advantages have been proved in practice over a long period, and it is still the chosen method of water purification in certain highly industrialized cities as well as in rural areas mid small communities. It has the great advantage over other methods that it makes better use of the local skills and materials available in developing countries, and it is far more efficient than rapid filtration in removing bacterial contamination. [53]

Initialization of slow-sand filter might be difficult due to elevated terrain in Devichour, although filter construction and attachment to the water tanks and distribution system could work out perfectly.

Bio-sand filtration

The bio-sand filter is an adaptation of the traditional slow sand filter. The bio-sand filter is smaller (about 1 m tall and 30 cm wide) and more adapted for occasional use, making it more suitable for households. The filter container can be made of concrete or plastic and is filled with layers of specially selected and prepared sand and gravel. The sand layer removes pathogens and suspended solids from contaminated drinking water. [54]



PICTURE 30 Typical structure of bio-sand filter [54]

The treatment of water is carried out by the sand inside the filter. The water passes through the diffuser and percolates down through the bio-layer, sand and gravel. Treated water naturally flows from the outlet tube. [54]

In bio-sand filter, the filter container can as well be made of concrete, plastic or any other water-proof, rust-proof and non-toxic material, though concrete has several advantages. For example to build an outlet out of cement is most probable for Devichour, as one bag of cement in Nepal costs around 580 NRP.

10.2.4 Membrane, porous ceramic or composite filters

Membrane, porous ceramic or composite filters are filters with defined pore sizes and which include carbon block filters, porous ceramics containing colloidal silver, reactive membranes, polymeric membranes or fiber/cloth filters. They rely on physical straining through a single porous surface or multiple surfaces having structured pores to physically remove and retain microbes by size exclusion. Some of these filters may also employ chemical antimicrobial or bacteriostatic surfaces or chemical modifications to cause microbes to become adsorbed to filter media surfaces, to be inactivated or at least to not multiply. Cloth filters, such as those of sari cloth, have been recommended for reducing *Vibrio cholerae* in water. However, these filters reduce only vibrios associated with copepods, other large crustaceans or other large eukaryotes retained by the cloth. These cloths will not retain dispersed vibrios or other bacteria not associated with copepods, other crustaceans, suspended sediment or large eukaryotes, because the pores of the cloth fabric are much larger than the bacteria, allowing them to pass through. [4, p. 141b.]

Most household filter technologies operate by gravity flow or by water pressure provided from a piped supply. However, some forms of ultra-filtration, nano-filtration and reverse osmosis filtration may require a reliable supply of electricity to operate. [4, p. 141b.]

To bacteria, virus and protozoa reductions with porous ceramic and carbon block filtration influences pore size, flow rate, filter medium augmentation with silver or other chemical agents [4, p. 141d]. With membrane filtration reductions influences membrane pore size (micro, ultra, nano and reverse osmosis filters), integrity of filter medium and filter seals, as well as resistance to chemical and biological degradation [4, p. 141e].

With fiber or fabric filters, reductions are influenced by particle or plankton association that increases removal of microbes, notably copepod-associated guinea-worm *Dracunculus medinensis* and plankton-associated *Vibrio cholerae*. Larger protozoa (bigger than 20µm) may be removed, though it is ineffective for viruses, dispersed bacteria and protozoa (e.g. *Giardia intestinalis*, 8-12 µm, and *Cryptosporidium parvum*, 4-6 µm). [4, p. 141e.]

In Nepal, and especially more developed areas e.g. Kathmandu, have membrane/ ceramic porous filters in household use as a tap water treatment method. It is common and acknowledged as a good method of filtration. These types of membrane filters are locally manufactured in a ceramic/ clay filter body, and price range is from 400 to 5000 NRP and is available in local bazaars and supermarkets. It is supposed to purify water 80 % of the bacteria. Common habit is to use chlorination/ boiling in addition, to get the purification effect to the full 100 %.

10.2.5 UV technologies and Solar Water Disinfection

There are few considerable UV (Ultra-violet radiation)-based options for water purification. At the moment, Nepal based association ENPHO, is the leading local company to promote water purification applications for the use of rural communities. At the moment, they are promoting four options i.e. boiling, filtration, chlorination and SODIS in the rural communities of Nepal [34].

Solar water disinfection - the SODIS method - is a simple procedure to disinfect drinking water. The method is based on the combined action of the UV radiation of the sun, oxidative activity associated with dissolved oxygen and heat [4, p. 141b-c]. Contaminated water is poured into a transparent soap-cleaned PET-bottle or glass bottle and exposed to the sun for at least 6 hours. During this time, the UV-radiation of the sun kills diarrhea generating pathogens. Important points to consider when applying SODIS method are material, color and shape of the bottle; turbidity of the water and weather (cloudiness affects the strength of solar radiation and thus also the effectiveness of the method). In order to prevent contamination of treated water, it should be kept in the bottle and drunk directly from the bottle, or poured into a cup or glass immediately before it is drunk. In this way, it is possible to prevent the treated water from becoming contaminated again. [55] See picture 31 for use of the application.

PICTURE 31: Promotion of SODIS for treating drinking water by ENPHO [34]

As I interviewed a representative from ENPHO Mr. Shakya, besides promoting SODIS-method for rural areas in Nepal as a water purification method, they are currently doing research for similar method called Solvatten from a Sweden based company that manufactures Solvatten application for household water treatment. The application makes unsafe water drinkable by using solar energy (UV-radiation). Solvatten states that it is used by putting Solvatten in a sunny place, giving it 2-6 hours and the water will be drinkable [56]. Basically method is the same as SODIS, only application is different (see picture 32).

PICTURE 32 Solvatten application for household water treatment [56]

A number of drinking-water treatment technologies use UV light radiation from UV lamps to inactivate microbes. For household- or small-scale water treatment, most employ low-pressure mercury arc lamps producing monochromatic UV radiation at a germicidal wavelength of 254 nm. In general, these technologies allow water in a vessel or in flow-through reactors to be exposed to the UV radiation from the UV lamps at sufficient dose (fluence) to inactivate waterborne pathogens. [4, p. 141c.] These may have limited application in Devichour because of the need for a reliable supply of electricity, cost and maintenance requirements.

To bacteria, virus and protozoa reductions with SODIS method are influenced by oxygenation, sunlight intensity, exposure time, temperature, turbidity and size of the water vessel (depth of water). With UV-technologies using lamps, results vary in result of excessive turbidity and certain dissolved species inhibiting the process. The effectiveness of the method depends on fluence (dose) that varies with intensity, exposure time and wavelength. [4, p. 141e.]

10.2.6 Coagulation, precipitation and/ or sedimentation

Coagulation or precipitation is any device, application or method using a natural or chemical coagulant or precipitant to coagulate/ precipitate suspended particles, including microbes, to enhance their sedimentation. Sedimentation is any method for water treatment using the settling of suspended particles, including microbes, to remove them from the water. These methods may be used along with cloth or fibre media for a straining step to remove the floc that are the large coagulated or precipitated particles that form in the water. [4, p. 141c.]

This category includes simple sedimentation, or that achieved without the use of a chemical coagulant. This method often employs a series of three pots or other water storage vessels in series, in which settled water is carefully transferred by decanting daily. By the third vessel, the water has been sequentially settled and stored a total of at least two days to reduce microbes. [4, p. 141c.]

To bacteria, virus and protozoa reductions are influenced by settling of particle-associated and large (sedimentable) microbes. Results vary with storage time and particulates in water. [4, p. 141f.]

10.2.7 Combination (multi-barrier) treatment approaches

These are any of the previously mentioned treatment methods for household used together, either simultaneously or sequentially (e.g. coagulation/disinfection, media filtration/disinfection or media filtration/ membrane filtration.). [4, p. 141c.]

Some of these combination systems are commercial products in the form of granules, powders or tablets containing a chemical coagulant, such as an iron or aluminium salt, and a disinfectant, such as chlorine. When added to water, these chemicals coagulate and flocculate impurities to promote their rapid and efficient sedimentation and also deliver the chemical disinfectant (e.g., chlorine) to inactivate microbes. [4, p. 141c-d.]

These combined coagulant/ flocculant/ disinfectant products are added to specified volumes of water, allowed to react for floc-formation, usually with brief mixing to promote coagulation/flocculation, and then allowed to remain unmixed for the floc to settle. The clarified supernatant water is then decanted off, usually through a cloth or other fine-mesh medium to strain out remaining particles. The recovered supernatant is stored for some period, typically several tens of minutes, to allow for additional chemical disinfection before use. [4, p. 141d.]

11 SUGGESTIONS FOR FURTHER STUDIES

As far as my study is concerned; proper mapping of the area would have made this research much easier, also locations of water sources and distribution system mapping could have made discovering hazard points more effortless. In developed countries these in general are covered, but while missing regulations on the matter or proper funding for setup and maintenance of water distribution system it is more difficult task. Bigger scale water treatment plant and other bigger scale applications are sort of disregarded in Devichour VDC, since even the more developed areas of Nepal e.g. Kathmandu has lot to improve in that field. Country such as Nepal, terrain with high rises in elevation, makes initialization of any kind of bigger scale treatment plants is a difficult task, especially in its densely populated mountainous regions.

The initialization of recommended water treatment methods in this thesis is appropriate subject of research. There are broad scale of applications and methods available for rural and developing communities that are successfully initialized and researched, and mostly they are based on active community training and education, though many require expertise for introduction and initialization. This thesis covers only the methods that I considered viable and as most suitable ones.

In general, developing rural communities worldwide lack the education and knowledge, regarding environmental subjects and issues. Old habits and customs of the culture strain the environment, while missing the more advanced and modern procedures and habits. By increasing quantity and quality of environmental education, by adding practical and easy practices that are easy to initialize are generally needed to better environmental conditions in this type of communities.

Also briefly covered in this thesis, the SODIS method has a lot to prove as good and sustainable water treatment method for rural developing communities. It has gained discussions with its pros and cons, and it is obvious that method is effective when it comes disinfecting the drinking water from *E. coli*, coliformic bacteria and other contaminants. However the method needs developing on the plastic bottle need that are not in general supplied in the rural areas of Nepal or in rural communities worldwide. The fact that locals need to remove the habit of throwing trash and rubbish in the nature that comes into a question in excess and used plastic bottles as well. Life span of a plastic PET-bottle is not too long, as method loses its effectiveness in broken and non-clear bottles. Excess non-usable bottles need a place of relocation or recycle.

12 CONCLUSION

As far as my research for the project is concerned, the results for my fieldwork were often more complicated as I previously had imagined. First I came to Nepal thinking that I could cover the entire issue of Devichour water management, with all stakeholders and politics included that came in. But in reality, I ended up focusing on the water quality in the area, locals’ perceptions on water management and usage, and to a brief scratch on overall water management politics in Nepal and in the community of Devichour. Not to mention, that the aspect of water supply is a whole other issue.

The first two weeks after arrival to Nepal was strained by Maoist strikes that delayed the initiation of the research. When research started, it was hampered by misunderstandings between CODEF and KEMA communication, as well as lack of planning when it came to sampling the water sources or attending community meetings. Sampling was not in the beginning systematic as it came to doing exact and on-time monitoring of the water sources. Either way, my main objective of the research was not the general water quality, just having directional information on the overall drinking water quality of Devichour VDC. But overall research came out smoothly after rough start and after everyone project and research related reached the same page.

I consider the aims of the thesis to be fulfilled, as the baseline situation for drinking water and viable options for improving drinking water hygiene in Devichour VDC are covered. Also important findings for this thesis and subject were the cases of diarrhea and their relation versus dry and monsoon season. I was hoping to find same correlation in the drinking water quality and amount of coliformic bacteria in Devichour water sources, although results are easily explained by the longer-lasting dry season and untypically dry monsoon season.

Equality between female and male community members are still a challenge, but are properly dealt with long-span enlightenment, since culture related habits and customs are challenging to change. Also health education has its barriers, but is dealt as far as community gets more aware by on-going committee meetings and education classes. For younger generation, environmental education is the way to avoid the current environmental problems in the future.

In general the time of research and living in Nepal was such mind-opening time for me, and after been able to visit and work in such many cultures in Asia, I easily can claim that Nepal is the most nicest, richest and one the most unique culture around the continent with its pros and cons. While it may seem that issues with water management and supply issues have easy or obvious solutions, in reality they are quite complicated, and influenced with backdoor politics and international donors, that for a western person might find difficult to understand. All the different governmental or non-governmental organizations that have had their hands on “developing” Devichour VDC, have not obviously always had the best consequences.

I hope the project report provided after research period and this thesis works as a good base for CODEF and KEMA to continue the work I started on water hygiene and sustainable development of drinking water resources in Devichour VDC. And I genuinely hope that the people of Devichour to have taken even a slight knowledge I distributed at our field meetings and also the results, suggestions and notes on this report to work as directional and good source of information for the people involved with this project. I hope I avoided the unnecessary technical, regulation and politics oriented talk in this thesis, and it to have achieved an easy and humane approach to the subject.

LIST OF REFERENCES

[1] U.S. Centers for Disease Control and Prevention. Atlanta, GA. Safe Water System: A Low-Cost Technology for Safe Drinking Water - Fact Sheet. World Water Forum. March 2006. Web document. Available at: http://www.cdc.gov/safewater/publications_pages/fact_sheets/WW4.pdf. Updated March 2006. Read: 1.10.2010.

[2] World Health Organization, WHO. Water related diseases, diarrhea. Web document. Available at: http://www.who.int/water_sanitation_health/diseases/diarrhoea/en/. Updated in 2000 (ref. Global Water Supply and Sanitation Assessment 2000 Report). Read 2.11.2010.

[3] United States Environmental Protection Agency, EPA. Drinking water contaminants. Web document. Available at: http://water.epa.gov/drink/contaminants/index.cfm#listmcl. No update information. Read 24.10.2010.

[4] World Health Organization, WHO. Guidelines for drinking water quality, 3rd edition [Electronic resource]. Web document. Available at: http://www.who.int/water_sanitation_health/dwq/fulltext.pdf. Read 24.11.2010. Updated 2008.. Read 19.11.2010.

[5] Central Intelligence Agency (CIA). The World Fact Book. Nepal. Web document. Available at: https://www.cia.gov/library/publications/the-world-factbook/geos/np.html. Updated: Bi-weekly. Read: 24.10.2010.

[6] United Nations, UN. Map of Nepal. Picture. Web document. Available at: http://www.un.org/Depts/Cartographic/map/profile/nepal.pdf. No update information. Read 2.11.2010.

[7] Shrestha, Yaba. Interview 25.7.2010. Project coordinator. CODEF Nepal. 2010.

[8] Mahato, Rubeena. Troubled Waters. Nepali Times. Issue #510. 9.-15.7.2010. Read 13.7.2010. (Also available at: http://www.nepalitimes.com.np/issue/2010/07/09/Nation/17239.)

[9] Nepali Times. Watershed condition of districts. Picture. Available at: http://nepalitimes.com.np/imgbank/article/2010/nt3120.jpg. No update information. Read 1.11.2010.

[10] Community Development Forum, Nepal (CODEF Nepal). Web document. Available at: http://codefnepal.com/index.php. No update information. Read 20.09.2010.

[11] Shrestha, Yaba. Livelihood Improvement & Environment- Project Proposal. CODEF Nepal. 2010.

[12] Mikkelin Kehitysmaayhdistys Ry (KEMA). ”Mikkeli Association for Sustainable Development”. Nepalin projekti. Web document. Available at: http://kemamikkeli.fi/nepalin_projekti.php. No update information. Read 1.10.2010.

[13] Service Centre for Development Cooperation (KEPA). Web document. Available at: http://www.kepa.fi/international/english. No update information. Read 24.10.2010.

[14] Google Maps. Nepal Map Layout (Devichour location self-added). Web document. Available at: http://maps.google.com/. No update information. Read 10.8.2010.

[15] United Nations, UN. Lalitpur District Map. Web document. Available at: http://www.un.org.np/maps/district-maps/central/Lalitpur.pdf. No update information. Read: 2.11.2010.

[16] Community Development Forum, CODEF. Baseline Report of Devichour VDC, Lalitpur. 2010.

[17] Koponen, Jari; Buddhathoki, Hari & Shrestha Bikash. Picture of Devichour Ward Map. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[18] Koponen, Jari.Picture of Local shops and houses in Devichour ward 1. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[19] Koponen, Jari. Pictures of Terrain in Devichour. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[20] Bindloss Joey, Holden Trent & Mayhew Bradley. Lonely Planet, Nepal. 8th Edition. Lonely Planet. 2009.

[21] Koponen, Jari. Picture of Regular family in Devichour. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[22] Koponen, Jari. Figure of Diarrhea cases by age in Devichour (February 2009 – March 2010). Devichour VDC Health Post Data. Feb 2009- Mac 2010.

[23] Koponen, Jari. Figure of Diarrhea cases in Devichour (2009–2010). Devichour VDC Health Post Data. Feb 2009- Mac 2010.

[24] Health Canada. Significance of *E. coli* in drinking water. Web-document. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/escherichia_coli/significance-importance-eng.php. Updated 16.4.2009. Read 1.11.2010.

[25] Koponen, Jari. Picture of Manual for Phosphate field test kit. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[26] Koponen, Jari. Picture of Manual for Ammonium field test color scale for concentrations of 0-10 mg/l NH_4^+. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[27] 3M™ Petrifilm ™ E. Coli/ Coliform Count Plate. User Manual (provided in sampling kit). ©3M. 2004.

[28] Koponen, Jari. Picture of Petrifilm EC count plates. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[29] Aquamerk® Phosphate Test 0,25 – 3,0 mg/l PO_4^{3-}. User Manual (provided in sampling kit).

[30] Aquamerk® Ammonium Test for concentrations of 0-10 mg/l NH_4^+. User Manual (provided in sampling kit). 2008.

[31] Koponen, Jari. Picture of typical water tap in Devichour. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[32] Koponen, Jari. Picture of Water distribution pipes in Devichour. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[33] Koponen, Jari. Picture of Mr. Indrajit Llama cleaning the water sources. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[34] Shakya, Suman 2010. Email discussion. 28.7.2010. ENPHO representative. 2010.

[35] Koponen, Jari; Shrestha, Bikash & Tamang, Narabbhadchur. Picture of 'Generalization' of the Devichour water distribution system. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[36] Koponen, Jari. Picture of Ward 1 Reservoir Tank. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[37] Koponen, Jari. Picture of Ward 1 Dhungedhara & typical local ' faucet'. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[38] Koponen, Jari. Picture of Ningrodol water source. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[39] Koponen, Jari. Picture of General outlook of the Ningrodol water source . Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[40] Koponen, Jari. Picture of Zurili water source. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[41] Koponen, Jari. Picture of Surroundings of Kartiki water source with Ms. Manju Tamang. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[42] Koponen, Jari. Picture of Kartiki water source is empty due to drought. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[43] Koponen, Jari. Okhare open-water source in Ward. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[44] Koponen, Jari. Picture of Ward 4 Dhungedhara. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[45] Koponen, Jari. Picture of Inside the water tank in Ward 4. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[46] Koponen, Jari. Picture of Water tank in ward 4 with local community members. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[47] Koponen, Jari. Ward 7 water source. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[48] Koponen, Jari. Open-defecation practices in ward 7. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[49] World Health Organization, WHO. Water, sanitation and hygiene links to health. Web document. Available at: http://www.who.int/water_sanitation_health/publications/facts2004/en/. Updated November 2004. Read 2.11.2010.

[50] Koponen, Jari. Picture of Government promotion for household water chlorination. Mikkeli University of Applied Sciences. Student of Environmental Engineering.

[51] Acu-Cell Nutrition. Fluroride & chloride. Web document. Available at: http://www.acu-cell.com/fcl.html. No update information. Read 2.11.2010.

[52] National Environmental Services Center, NESC. Slow-sand filtration. Web document. Available at: http://www.nesc.wvu.edu/pdf/dw/publications/ontap/2009_tb/slow_sand_filtration_dwfsom40.pdf. Updated June 2000. Read 2.11.2010.

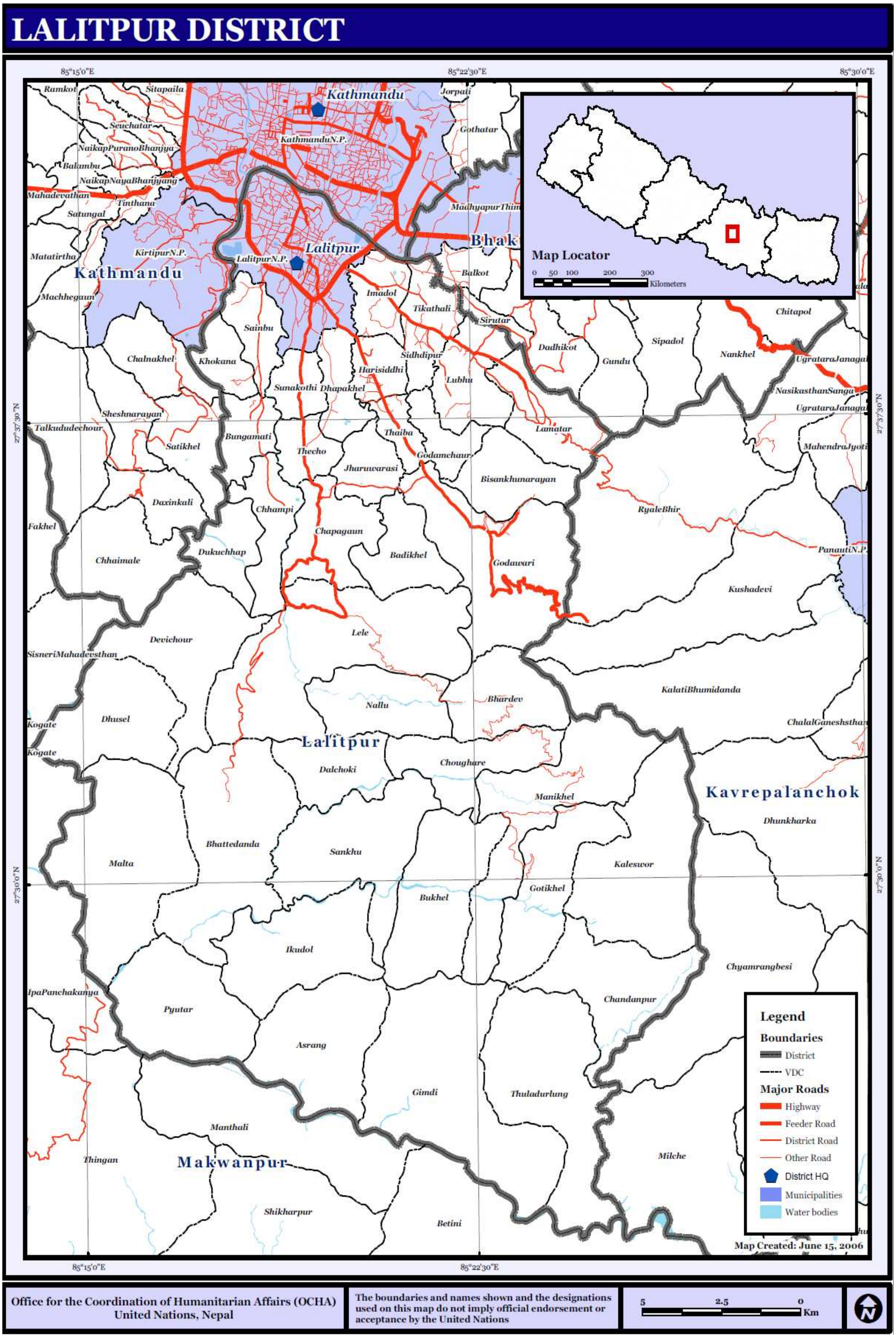
[53] World Health Organization, WHO. Slow sand filter. Web document. Available at: http://www.who.int/water_sanitation_health/publications/ssf/en/index.html. No update information. Read 2.11.2010.

[54] Centre for Affordable Water and Sanitation Technology, CAWST. Biosand filter. Web document. Available at: http://www.cawst.org/en/themes/biosand-filter. No update information. Read 2.11.2010.

[55] Safe Drinking Water for All – SODIS. How does it work?. Web document. Available at: http://www.sodis.ch/methode/anwendung/index_EN. Updated 22.2.2010. Read 2.11.2010.

[56] Solvatten. About Solvatten. Web document. Available at: http://www.solvatten.se/aboutaboutsolvatten/about-solvatten/. No update information. Read 2.11.2010.

ATTACHMENT 1: Lalitpur District map



Picture 33 Lalitpur District map [15]

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 1(8)

Community Development Forum

Livelihood and Envirinmental Awareness Project

Baseline Survey-Household) Form2066

1. **General Information:**

1.1 District: 1.2 VDC 1.3 Ward No.:

1.4 Cluster:

2. **Household Information:**

2.1.Name of household head :

2.2. Sex:

1. Male 2. Female

3. **Caste/ Ethnic Information:**

3.1.Brahmin 3.2. Chhetri 3.3. Gurung 3.4. Newar 3.5. Tamang 3.6. Limbu

3.7. Magar 3.8. Muslim 3.9. Sherpa 3.10. Rai 3.11. Damai 3.12. B.K. 3.13. Sarki

3.14. Other ....

4. **Household Characteristics :**

S.NO.	Name of Family members **(Name of the respondents should be written in serial no 1)**	Female	Male	Age	Education	Literate	Illiterate	Dropped or Running	Profession/ Occupation

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 2(8)

5. Socio-economic Characteristics:

5.1.Do you have your own land?

1) Yes 2) No

5.2.If yes, provide the following information(In Ropani):

Own land		Tenant	
Total cultivated land (paddy field)	Total high land (Bari)	Total Low land (paddy field)	Total high land (Bari)

5.3.How many months the produced food supports your family?

1) Up to 3 months 2) 3 to 6 months 3) 6 to 9 months 4) whole year 5) Surplus

5.4. What is your monthly income & expenditure ?

1) Less than 4,000
2) Between 4001 to 5,500
3) Between5,501 to 8, 500
4) Between 8,501 to 11,000
5) More than 11,101

5.5. What are the main sources of income ?

1) Agriculture 2) Animal husbandry 3) vegetable farming 4) Business 5) Service
6) Abroad employment 7) Self employ 8) Other

5.6. Have you taken loan ?

1) Yes 2) No

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 3(8)

If yes,

Purpose of loan	Rs.	Interest rate	Institution	Individual
Agriculture				
Udyog				
Daily household expenditure				
Social work				
Medical treatment				
House repairing & construction				
Education				

5.7. What are the means of communication that you use at home?

1) Television 2) Radio 3) Computer 4) Telephone 5) Other

6. **Health Information :**

6.1 Is there any health post facility in your village?

1) Yes 2) No

6.2 During last 1 year, have any of your family members have suffered from sickness?

1) Yes 2) No

6.3 If yes, what is the name of disease & how did you treat it?

S.No.	Cause of sickness	Number of People Suffered	Method of treatment

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 4(8)

6.4 Whom did you consult for treatment?

1) Home
2) Traditional Healer
3) VHP
4) Health Post/ Hospital
5) Medical Shop
6) Others

6.5 Do VHP or TBA visit in your village?

1) Yes 2) No

6.6 In pregnancy period , have any women of your family visited the health post for treatment?

1) Yes 2) No

6.7 Do you know about family planning measures?

1) Yes 2) No

6.8 What are the various types of family planning measures?

1) Condom 2) Laparoscopic surgery 3) Pills 4) Mini-laparotomy(lap)

5) Sterilization(Vasectomy) 6) Others

7. Information regarding Water and Sanitation

7.1 What are the sources of Water ?

1) Tap 2) Well 3)Stream 4)Natural 5) Pond 6)Others

7.2 Who bears the responsibility of fetching water?

1) Female 2) Male

7.3 What quantity of water per day is required for your family ?

1) 1to 2 water vessels 2) 3 to 5 water vessels 3) 6 to 10 water vessels 4)Above 11

1 water vessels =

7.4 Time taken to fetch water

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 5(8)

1) Time taken..................... in rainy season 2) Time taken........................in dry season

7.5 Is there any latrine facility in your house?

1) Yes 2) No

7.6 If yes, then what are the types of latrine facility in your house?

1) Water Sealed 2) Pit 3) Others

7.6 If no ,then where do you go for open defecation?

1) Cultivable land 2)Nearby Forest 3) Others

7.7 Do you have any idea about Eco –San latrine?

1) Yes 2) No

If yes, from where you came to know about it?

7.8 Where do you dispose your household garbage?

1) Near by Pit 2) Road 3) Kitchen Garden 4) Haphazardly

5) Dung Pit 6) Others

7.9 How do you utilize the waste water ?

1) In Kitchen Garden 2) Throw in Fixed Place(Platform) 3) Used for pig

4) Diverted into Drain 5) Others

7.10 Where do you wash and clean your Utensils?

1) In Platform 2) Inside home 3) Haphazardly 4) Others

7.11 What are the different materials used for handwashing?

1) Water Only 2) Ash 3) Soap and Water 4) Others

7.12 Do you have Improvished Stove(Smokeless Stove)?

1) Yes 2) No

7.13 Reasons for not making Improvising Stove

1) Lack of Knowledge 2) Technological Constraints 3)Financial Constraints

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 6(8)

4) Others

7.14 Do you have Kitchen Garden?

1) Yes 2) No

7.15 If yes, then how do you provide irrigation facility in Kitchen Garden?

1) Tap 2) Canal 3) Others

7.16 What type offertilizers do you use in Kitchen Garden?

1) Chemical fertilizers 2) Animal Dung (Compost) 3) Others

8 <u>**Information Regarding Natural Resources**</u>

8.1 Is there any forest nearby your village?

1) Yes 2) No

8.2 If yes, then what are the types of forest?

1) Community Forestry 2) Individual Owned Forest 3) Government Owned Forest

4) Others

8.3 If it is the community forestry, then do you have the membership?

1) Yes 2) No

8.4 What are the benefits that you are taking from the forest?

1) Fodder 2) Firewood 3) Bamboo 4) Wood

5)Foodstoop 6)Amrishoo 7)Allo

8) Herbal medicine 9) Lokta 10) Others

8.5 How much do you have to pay for utilizing forest products?

....

8.6 Sources of light used in your house at night

1) Kerosene 2) Deyalo 3) Electricity 4) Solar 5)Bio Gas 6)Others

8.7 What are the sources of fuel used for cooking purpose?

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 7(8)

1) Firewood 2) Kerosene 3) Gobar Gas 4) Bricket 5) Others

9 Institutional Information

9.1 Do any of your family members are enrolled in any institutions?

1) Yes 2) No

If yes in which they are enrolled

1) Saving Group 2) Mothers group(Ama Samah) 3) Saving and Credit Group

4) Community Forestry

9.2 Who are enrolled?

1) Female 2) Male

9.3 Do they have habit of saving ?

1) Yes 2) No

9.4 If yes, how much per month

============

9.5 Who supported to form the group?

============

10 Skills and Training Related Information

10.1 Have any of your family membersare into income generating activities?

1) Yes 2) No

If yes

S.NO.	Name of trained personnel	Age	Sex	Types of Skills	Utilization of skill is there or not

ATTACHMENT 2: Livelihood and Environmental Awareness Project: Baseline Survey (Household) Form 2066 8(8)

10.2 Do any of your family members have indigenous knowledge?

1) Yes 2) No

If yes

S.NO.	Name of trained personnel	Age	Sex Types of Skills	Utilization of skill is there or not

Name of the Enumerator...

Signature...

Date...

ATTACHMENT 3: Sampling result table

Date/ Time	Location	Type	Status	Temp. C (T)	pH	NH^{+}_{4} mg/l	PO^{3-}_{4} mg/l	E.Coli Count	Coliform Count
12.5.2010 2.33pm	Main Water Source, Kartiki, Devichour	Natural water source	Active	12	6,5	0	0	15	35
12.5.2010 3.22pm	Tap, Household (near Kartiki), W3 Devichour	Household tap	Active	15,5	6,5	0	0	35	37
12.5.2010 4.24 pm	Reservoir tank, W1 Devichour	Communal water tank	Active	14	6,5	0	0	20	54
13.5.2010 12.55 pm	*Tap, Village (community)* ***outside Devichaur area*** .	Household tap	Active	16	6,5	0	0	24	50
20.5.2010 1.00pm	Main Source, Dhungedhara (near field office), W1 Devichour	Natural water source	Active	15,5	6	0	0	46	81
20.5.2010 3.05 pm	Main source/ Water tank,Zurili, W2/3 Devichour	Main water source/ Water tank	Active	13	6,5	0	0,25	25	109
21.5.2010 10.25 am	Water tank, Devichaur W4, Devichaur	Communal water tank	Active	17	6	0	0	0	29
24.5.2010 11.52 am	Household (next to the codef field office), Water Vessel, W1 Devichaur	Household, Vessel	Active	16	6,5	0	0.5	9	4
26.5.2010 7.54 am	Main Source, Okhare, W3 Devichour	Natural water source	Active	11	6,5	*Measuring devices not available*	*Measuring devices not available*	0	4
26.5.2010 1.10 pm	Water Source, Ward 7	Natural water source	Inactive, used in "emergencies"	13	6	*Measuring devices not available*	*Measuring devices not available*	*246 (estimated total count)*	*246 (estimated total count)*
10.6.2010 11.18 am	Main Source, Okhare, W3 Devichour	Natural water source	Active	14	6	0	0	6	46
10.6.6010 1.45 pm	Main Water Source 2, Okhare, W3 Devichour	Natural water source	Active	13	6,5	0	0	0	94
10.6.2010 2.20 pm	Main water source, Zurili, W 2/3Devichour	Natural water source	Active	13	6	0	0	*150 (estimated total count)*	*150 (estimated total count)*
10.6.2010 3.15 pm	Main source, Ningrodol, W2 Devichour	Natural water source	Active	13	7,5	0	0	29	88
10.6.2010 4.42 pm	Reservoir tank, W1 Devichour	Communal water tank	Active	15	6,5	0	0	20	47
2.7.2010 9.30 am	Main Source, Dhungedhara, W1 Devichour	Natural water source	Active	14	6	0	0	66	87
2.7.2010 11.20 am	Main water source, Ningrodol, W2 Devichour	Natural water source	Active	13	6,5	0	0,25	5	48
2.7.2010 12.40 pm	Main water source, Zurili, W2/3 Devichour	Natural water source	Active	13	6	0	0	0	7
2.7.2010 1.45 pm	Main water source, Kartiki, W3 Devichour	Natural water source	Active	14	6,5	0	0	12	171
14.7.2010 10.24 am	Dhungedhara, W4 Devichour	Natural water source	Non-active, polluted	13	6,5	0,4	0,25	14	61
14.7.2010 12.00pm	Water tank (2nd, upper) W4 Devichour	Collection tank	Active	14	6,5	0	0,25	6	23
14.7.2010 1.25pm	Reservoir tank, W1 Devichour	Collection tank	Active	13	6,5	0	0	9	67