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Total Coliform Removal Efficiency in Slow Sand Filter

by

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A THESIS

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING

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The undersigned certify that they have read, and recommended to the institute of engineering for acceptance, a final thesis report entitled **"Total Coliform Removal Efficiency in Slow Sand Filter"**, submitted by Mr. Arjun Adhikari in partial fulfillment of the requirement for the degree of Master of Science in Environmental Engineering.

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ABSTRACT

Slow sand filtration is an ideal technology for developing country's drinking water treatment options. Slow sand filter is a simple option to remove the microorganisms as well as turbidity and the study was to demonstrate the total coliform removal efficiency in slow sand filter using coarse sand.

This research work was carried out by developing a 0.22 m*0.22 m*2.75 m fiber glass filter model and set up at Institute of Engineering. During the study different parameters like total coliform, turbidity, pH, temperature, discharge and head loss developed on the filter were analyzed in three cycles of filter run. Total coliform removal efficiency varied from 35.9% to 100% .Total coliform removal efficiency was dependent with Hydraulic loading rate as the efficiencies were 99.58%, 97.34%, 95.45%, 90.32%, and 89.81% for HLR <0.1m/hr., HLR 0.1 m/hr. – 0.2 m/hr., HLR 0.2 m/hr. – 0.3 m/hr., HLR 0.3 m/hr. – 0.4 m/hr., and HLR >0.4 m/hr. respectively.

With proper operation of slow sand filter upto influent turbidity of 50 NTU, water becomes drinkable with effluent water turbidity below 5 NTU, total coliform removal upto 100% and pH also within the limit of National Drinking Water Quality Standards, 2005.

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TABLE OF CONTENTS

Title	Page
Cover page	1
Copyright	2
Approval page	3
Abstract	4
Acknowledgements	5
Table of contents	6
List of tables	8
List of figures	9
List of abbreviations	10
CHAPTER ONE : INTRODUCTION	**11**
1.1 Background	11
1.2 Removal mechanism in slow sand filter	13
1.3 Rationale of the study	14
1.4 Objective of the study	15
1.5 Limitations of the study	15
1.6 Organization of the report	15
CHAPTER TWO : LITERATURE REVIEW	**16**
2.1 Total coliform bacteria	16
2.1.1 General description	16
2.1.2 Indicator value	16
2.1.3 Source and occurrence	16
2.1.4 Application in practice	17
2.1.5 Significance in drinking water	17
2.2 Working of slow sand filters	17
CHAPTER THREE : METHODOLOGY	**21**
3.1 Experimental setup	21
3.2 Flow regulation	21
3.3 Collection of sample	21
3.4 Analysis of sample	26

3.5 Composition of the media 26

CHAPTER FOUR : RESULTS AND DISCUSSIONS 28

4.1 Performance of slow sand filter 28

4.1.1 Total coliform removal with respect to media depth 28

4.1.2 Turbidity removal 30

4.1.3 Total coliform removal with respect to hydraulic loading rate 32

4.1.4 Turbidity removal with respect to hydraulic loading rate 33

4.1.5 pH change in slow sand filter 34

CHAPTER FIVE : CONCLUSIONS AND RECOMMENDATIONS 35

5.1 Conclusions 35

5.2 Recommendations 35

REFERENCES 37

ANNEXES 38-81

LIST OF TABLES

Table	Title	Page
2.1	Guideline for design of slow sand filter	19
2.2	Typical treatment performance of conventional slow sand filter	20
3.1	Description of SSF	22
3.2	Gradation of base material	24
3.3	Gradation of filter material	24
3.4	Characteristics of filter material sand	25
3.5	Method of analysis	26
3.6	Media composition	27

LIST OF FIGURES

Figure	Title	Page
3.1	Experimental setup of slow sand filter	23
3.2	Gradation of filter material	25
4.1	Total coliform removal efficiency on 1st cycle	28
4.2	Total coliform removal efficiency on 2nd cycle	29
4.3	Total coliform removal efficiency on 3rd cycle	29
4.4	Turbidity removal efficiency on 1st cycle 1st phase	30
4.5	Turbidity removal efficiency on 1st cycle 2nd phase	31
4.6	Turbidity level with respect to depth at 2nd cycle	31
4.7	Turbidity level with respect to depth at 3rd cycle	32
4.8	Total Coliform removal efficiency with respect to HLR	33
4.9	Turbidity removal efficiency with respect to HLR	33
4.10	pH change in slow sand filter	34

LIST OF ABBREVIATIONS

BGS	-	British Geological Survey
cm	-	centimeters
CFU	-	Colony Forming Units
DWSS	-	Department of Water Supply and Sewerage
ECD	-	Examination Control Division
HDPE	-	High Density Poly Ethylene
H_f	-	Head loss
IOE	-	Institute of Engineering
ltr	-	liter
m/hr.	-	meter/ hour
NPC	-	National planning commission
NDWQS	-	National Drinking Water Quality Standards
ppm	-	parts per million
pvc	-	poly vinyl chloride
SSF	-	Slow Sand Filter

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Groundwater should be of good microbiological quality at origin, but can be contaminated due to unsanitary practices at the source and handling of it. Microbiological quality of shallow groundwater from tube wells was initially thought to be free from pathogens in the past, but this has now been found to be uncertain. Test results showed 47% out of 14394 water samples were found to contain coliforms i.e. pathogenic contamination was found in groundwater samples taken from shallow tube well (Water Aid, 2011).

Bacterial quality control of total coliform, particularly faecal coliforms has therefore become a high priority parameter from the health risk aspect, because of widespread contamination of surface and shallow ground water. It was indicated surface water sources in many rural areas have been found to be contaminated by human feces and ground water in many urban areas, especially Kathmandu, has been contaminated by seepage from septic tanks and soak pits.

The British Geological Survey (BGS) fact sheet indicated that faecal and total coliform counts are often high in drinking water. According to BGS, some groundwater samples from deep alluvial aquifers and the karstic limestone aquifers of the Kathmandu Valley have detectable coliforms. However, these probably originate from contamination at the well head rather than contamination of the aquifer themselves (Water Aid, 2011).

The protection of sources and the operation and maintenance of water treatment facilities has thus become a critical issue if the overall health status is not to suffer as a result of microbiological contamination in both surface and ground water sources.

Statistically only 85.80% of the total populations of Nepal have access to basic water supply facilities while only 11.06% of total population have access to safe drinking water. While the plan up to 2017 is access of 95% to basic water supply facilities and 15% to safe drinking water (Thirteenth Plan, NPC).

Due to lack of safe drinking water many people are suffering day by day due to microbiologically contaminated water. Sufficient supply and required level of treatment at the point of use is the best solution to get rid of water related diseases.

With no chemicals or highly technical design variables, slow sand filtration is an ideal technology for developing country drinking water treatment applications. Consisting of water flowing downward through sand media, slow sand filtration has been used in diverse locations of the world for the past two centuries. Slow sand filtration has been proven to be successfully remove microbial contamination, although just recently have the more precise methods of removal been explored. For example, researchers have moved beyond just demonstrating that biological processes are integral to slow sand filtration pathogen removal and into identifying how these removal mechanisms actually work. An observed lack in slow sand filtration literature between 1915 and 1970 can be attributed to the developed world's focus on highly technical, automated designs that can be readily patented with profits secured and operation more easily replicated. With conventional drinking water treatment depending on disinfectants such as chlorine, new concern about the potential health risks of disinfection byproducts and pathogens resistant to these disinfectants has mounted. This concern has resulted in the recent revival of interest, study, and application of slow sand filtration in developed countries. Since 1995, at least three New England towns have built new, innovative slow sand filtration systems (Lucas, 2002). This more aesthetically pleasing treatment depends on natural physical, chemical, and biological processes for contaminant removal. With filtration rates 50-100 times slower than those of rapid sand filters, a much larger sand bed area is required for a given capacity. In addition, cleaning is accomplished by scraping or filter harrowing as opposed to the more frequent backwashing required by rapid sand filtration. With minimal material and no chemical or electrical requirements, traditional slow sand filtration technologies, used on a community scale for several centuries, have been tailored for developing country applications.

Efficiency of filters to remove coliforms is found moderate. Although the coliform removal percentage is about 94% in both the filters, the quality of water is still doubtful by public health point of view (Shrestha, 2004).

1.2 Removal Mechanism in Slow Sand Filter

Slow sand filters operate at a very low filtration rates, use very fine sand and usually function without pre-chlorination. The low filtration rate results in long detention times in the water above the filter sand and within the bed of the sand. The long detention time results in substantial biological life in the slow sand filtration process.

Slow filtration particle removal occurs mainly at the surface of the sand bed with minor removal within the bed. Rapid filtration particle removal occurs mainly within the bed over a substantial depth. Slow sand filters usually are returned to operational status by scraping and removing the top layer of sand because that is where the clogging takes place. Compared to rapid sand filtration, there is a net savings of water as large quantities of backwash water are not required. Slow sand filters are suitable for developing countries and small rural systems, where sufficient land is available. Slow sand filtration is simpler to operate than rapid filtration, as frequent backwashing is not required. Therefore, in terms of level of operation and maintenance, rapid filtration requires a technically qualified operator whereas operating a slow filter requires little technical skills. Furthermore, rapid filtration typically requires the addition of coagulant chemicals whereas slow filtration does not. A slow sand filter usually has a height ranging from 3 to 5m and a width of 4 to 15m. The Bio Sand Filter also has a higher flow rate than a typical slow sand filter (Lee, 2001).

Although slow sand filtration is such an old water treatment technology, the purification processes that make it efficient in contaminants removal are still not fully understood. It is believed that the development of the slime layer called “the schmutzdecke” is primarily responsible for this benefit. The word “schmutzdecke” came from German and means “dirty layer”. (Pachocka, 2010)

Imprecise terminology has contributed to the confusion surrounding proposed particle removal mechanisms in slow sand filters. Particle removal in slow sand filters has been attributed to the schmutzdecke, but the schmutzdecke has been defined in several different ways, including (1) a layer of particles deposited on top of the filter bed (2) biological growth on top of the filter bed (3) biologically active zone within the filter bed. Weber-Shirk and Dick has proposed using “filter cake” to denote the first two

definitions and “biologically active zone” for the third definition so as to avoid confusion (Lee, 2001).

Biological activity in the sand bed is not well understood. Scientists have a vague idea of the possible processes involved, but specific interactions are still unknown. Suggested biological removal mechanisms of harmful microorganisms are metabolic breakdown, predation, scavenging, natural death and inactivation (Lee, 2001).

Two proposed physical removal mechanisms in a slow sand filter are surface straining and inter particle attraction (or attachment). An experimental-based research to study the physical chemical mechanisms responsible for particle removal in slow sand filters was recently conducted in Cornell University. The study suggests that straining is the “dominant mechanism of particle removal in slow sand filter cakes where the pore sizes are the smallest”, while “inter-particle attraction is primarily responsible for particle removal within the slow sand filter beds” (Lee, 2001).

Slow sand filters require a long ripening period at the beginning of each filter run. This is to allow the biology in the sand layer to mature. Filter ripening is a complex process that involves both biological and physical mechanisms. As filtration progresses, biological growth consisting of algae, bacteria, and zooplankton occurs within the sand bed and gravel layer. During the ripening period, the filter does not effectively remove bacteria. Bellamy et al, 1985 concluded that a new sand bed will remove 85% of the coliform bacteria in the influent. As the sand bed matures biologically, the percent removal improves to more than 99% for coliform bacteria.

1.3 Rationale of the Study

In different literatures the removal mechanism in slow sand filter is active on topmost layer with some few centimeter of depths using fine sand only, but as per guideline value of the design of slow sand filters the depth is above (AWWA, 1991). This study was to find out the performance of slow sand filter against total coliform in coarse sand for increased depth of filter media as well as for increased HLR also. As coliform is an indicator organism, the study is to find removal of total coliform with respect to depth as per the standard range of height and media.

1.4 Objective of the Study

The main objective of the study was to know the total coliform removal efficiency in slow sand filter using coarse sand. Other specific objectives were:

- to determine the removal efficiency of turbidity and total coliform on continuous slow sand filter model with depth of filter media
- to study variation of pH with respect to media depth

1.5 Limitations of the Study

Limitations of the study are:

a) Development of biological organisms on supernatant water layer was neglected and inflow was considered as only source of contamination.
b) Variation of temperature throughout the day was not considered, only average daily temperature was taken.
c) The effect of algae growth and its effect on removal efficiency was not considered.

1.6 Organization of the Report

The report is divided into five chapters.

a) Chapter I: Introduction- Introduction includes brief background about total coliform and slow sand filtration, rationale of the study, objectives of the study and limitations of the study.
b) Chapter II: Literature Review- This chapter deals with the brief literature review relating to the area of the study.
c) Chapter III: Methodology- This chapter includes the detail about the methodology followed to perform the study.
d) Chapter IV: Results and discussion- This chapter shows the results obtained during the study period.
e) Chapter V: Conclusion and recommendation– This chapter contains conclusion of the research and further recommendation for similar researchers.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Total Coliform bacteria

2.1.1 General description

Total coliform bacteria include a wide range of aerobic and facultative anaerobic, gram negative, non-spore-forming bacilli capable of growing in the presence of relatively high concentrations of bile salts with the fermentation of lactose and production of acid or aldehyde within 24 hrs. at 35–37 °C. Escherichia coli and thermo tolerant coliforms are a subset of the total coliform group that can ferment lactose at higher temperatures. As part of lactose fermentation, total coliforms produce the enzyme b-galactosidase. Traditionally, coliform bacteria were regarded as belonging to the genera *Escherichia*, *Citrobacter*, *Klebsiella* and *Enterobacter*, but the group is more heterogeneous and includes a wider range of genera, such as *Serratia* and *Hafnia*. The total coliform group includes both faecal and environmental species (WHO, 2006).

2.1.2 Indicator value

Total coliforms include organisms that can survive and grow in water. Hence, they are not useful as an index of faecal pathogens, but they can be used as an indicator of treatment effectiveness and to assess the cleanliness and integrity of distribution systems and the potential presence of biofilms. However, there are better indicators for these purposes. As a disinfection indicator, the test for total coliforms is far slower and less reliable than direct measurement of disinfectant residual. In addition, total coliforms are far more sensitive to disinfection than are enteric viruses and protozoa. Heterotrophic plate count measurements detect a wider range of microorganisms and are generally considered a better indicator of distribution system integrity and cleanliness (WHO, 2006).

2.1.3 Source and occurrence

Total coliform bacteria (excluding *E. coli*) occur in both sewage and natural waters.

Some of these bacteria are excreted in the faeces of human and animals, but many coliforms are heterotrophic and able to multiply in water and soil environments. Total

coliforms can also survive and grow in water distribution systems, particularly in the presence of biofilms (WHO, 2006).

2.1.4 Application in practice

Total coliforms are generally measured in 100 ml samples of water. A variety of relatively simple procedures are available based on the production of acid from lactose or the production of the enzyme b-galactosidase. The procedures include membrane filtration followed by incubation of the membranes on selective media at 35–37 °C and counting of colonies after 24 hrs. Alternative methods include most probable number procedures using tubes or micro-titer plates and P/A tests. Field test kits are also available (WHO, 2006).

2.1.5 Significance in drinking water

Total coliforms should be absent immediately after disinfection, and the presence of these organisms indicates inadequate treatment. The presence of total coliforms in distribution systems and stored water supplies can reveal regrowth and possible biofilm formation or contamination through ingress of foreign material, including soil or plants (WHO, 2006).

2.2 Working of slow sand filters

In a slow sand filter water is subjected to various purifying actions as it percolates through the filter media. Impurities present in water are removed by a combination of straining, sedimentation, biochemical and biological process. Shortly after starting of filtration, a thin slimy layer called the schmutzdecke is formed on the surface of the sand bed. It consists of a great variety of biological, organisms which feed on the organic matter and convert it into simple, harmless substances. Considerable portion of inert suspended particles is mechanically strained out in this layer. Further during its passes through the sand bed the water becomes virtually free from suspended and colloidal matter, pathogenic bacteria and complex salts in solution. This results in simultaneous improvement in the physical, chemical and bacteriological quality of water (Modi, 2010).

Slow sand filters are operated up to a maximum filter head of 75 cm or equal to 65 to 85% of the thickness of the sand bed. The filter head is only 10 to 15 cm, but as the suspended matter is arrested and the thickness of schmutdecke increases, the resistance

to the flow of water increases, which results in the increase of the filter head. When the filter head reaches the maximum permissible value then the filter requires cleaning (Modi, 2010).

The slow sand filter requires cleaning after one to three months depending upon impurities present in the raw water. In each cleaning, some depth of filter sand is removed due to which the thickness of the sand bed goes on decreasing. The process of cleaning by scrapping is continued till the thickness of the sand bed reaches a minimum value of 600 mm. When this stage is reached, the top of the sand bed is provided with a fresh layer of clean new sand or the old washed sand up to its original level (Modi P.N, 2010).

For the work of Bellamy et al. (1985a) hydraulic loading rate from 0.04m/hr. to 0.4m/hr. the percentage removal of *Giardia* cysts, total coliform bacteria and turbidity all showed linear declines, generally in percentage removals with increasing hydraulic loading rate (AWWA, 1991).

The Kanchan Arsenic Filter (KAF) is an innovation that combines two proven water treatment techniques–arsenic adsorption on ferric hydroxide and microbial removal by the slow sand filtration process. The KAF was found to be technically appropriate for the water conditions generally encountered in the Terai region of Nepal. Arsenic removal averaged about 85–90%; iron removal averaged 90–95%; phosphate removal averaged 80–85%; turbidity removal averaged 80–95%; total coliform removal averaged 85–99%; pH increased by 0.35–0.40 units after filtration (Ngai *et* al., 2007).

The normal rate of filtration for a slow sand filter varies from 100 to 200 litres per hour per square meter of filter area. The efficiency of slow sand filters are as per follows:

(i) Bacterial load: The slow sand filters are highly efficient in the removal of bacterial load from water. It is expected that they remove about 98 to 99% of bacterial load from raw water and this percentage may be as high as 99.50 to 99.90 when pretreatment has been given to the raw water. However, for complete removal of bacteria, disinfection is essential.

(ii) Turbidity: The slow sand filters can remove turbidity to the extent of about 50 ppm. As such for water having higher turbidity it is necessary to give preliminary treatment to bring down its turbidity below 50 ppm.

Table 2.1 Guideline for Design of Slow Sand Filters

Description	Recommended design value
1. Design period	10 years
2. Filtration rate	
(i) Normal rate	0.10 m/hr.
(ii) Maximum overload rate	0.20 m/hr.
3. Number of filter beds	
(i) Minimum	2
(ii) Area up to 20 m^2	2
(iii) Area 20 to 249 m^2	3
(iv) Area 250 to 649 m^2	4
(v) Area 650 to 1200 m^2	5
(vi) Area 1201 to 2000 m^2	6
4. Depth of supernatant water	1 m
5. Freeboard	0.40 m
6. Thickness of filter sand layer	
(i) Initial	1 m
(ii) Final (minimum)	0.40 m
7. Sand specifications	
(i) Effective size	0.20 to 0.30 mm
(ii) Uniformity coefficient	5
8. Gravel (3-4 layers) thickness	0.30 m
9. Under drains (made of bricks or perforated pipes)	0.20 m
10. Depth of filter box	2.70 m
11. Effluent weir level above sand bed	20-30mm

(Modi, 2010)

(iii) Colour: The slow sand filters are less efficient in the removal of colour of raw water. It is estimated that they remove about 20 to 25% colour of raw

water. As such slow sand filters are not suitable for raw water having higher colour content.

(iv) Colloidal matter: The slow sand filters are not highly efficient in the removal of colloidal matter (Modi, 2010).

Table 2.2 Typical treatment performance of conventional slow sand filters

Parameters	Values
Turbidity	<1 NTU
Coliforms	1-3 log units
Enteric viruses	2-4 log units
Giardia Cysts	2-4+ log units
Cryptosporidium Oocysts	>4 log units
Dissolved Organic Carbon	<15-25%
Biodegredable Dissolved Organic Carbon	<50%
Trihalomethane Precursors	<20-30%
Zn, Cu, Cd, Pb	>95-99%
Fe, Mn	>67%
As	<47%

(Lee, 2001)

CHAPTER THREE

3.0 METHODOLOGY

Methodology includes laboratory setup, slow sand filter setup, collection of sample and analysis of sample.

3.1 Experimental Setup

Selection of laboratory and setup:

The study was concerned to find out the total coliform removal efficiency by Slow sand filter (SSF). For the microbiological and other analysis, public health laboratory of Institute of Engineering (IOE) was used initially and then due to problem of load shading (discontinuous supply of electricity) it was carried out by Wagtech Potatest Kit at the premises of the setup area.

Set up and regular run of filter:

For the study, SSF was set up at the premises of IOE, Examination control division (ECD) and it was regularly operated through the source of shallow well inside the premises of it. Major components of SSF were 2 polyethylene water tanks with capacity of 500 L and 200 L, 2 ball valves for each tank and 1 gate valve for flow control. By using a tee joint a cleanout point (influent sampling point) is attached connected with a ball valve and poly vinyl chloride tap as shown in Figure 3.1. The pipe was continued to the height of fiber glass filtration tank and assembled with a pvc floating valve so as to maintain the constant head in the tank throughout the filter run time, as listed on Table 3.1. The fiber filter tank consist of 8 sampling ports at 15cm c/c and one outlet at the bottom as shown in Figure 3.1.

3.2 Flow Regulation

The overhead water tanks were fed on regular basis to maintain the continuous flow on the filter. The flow was adjusted so that the flow was continuous throughout the run time and in the range of slow sand filter.

3.3 Collection of Sample

Setup and installation of SSF was done on the first phase of study by making fiber glass filter tank at Axis Glass Industries Sanobharayng along with installation of tank nipples for sampling ports during casting. And then the filter was transported to ECD, IOE and installed. For filter media different sand and gravel media was sieved manually using

different sieve sizes as shown on Table 3.2 and Table 3.3 at Central Material Testing Lab (CMTL), Central Campus, Pulchowk. The gradation of media was found out and the media was laid on the filter as per required depth and gradation of base and filter media. Then flow was started through media and sampling was carried out through different sampling ports as shown on Figure 3.1. After regulating the flow, sample was taken in the regular interval. Generally, sample was taken every day at around 9-10 am for the data of head loss, pH, temperature and flow while in every 3rd day for biological tests. The 1st run of filter was stopped on 54 days with maximum head loss and no yield. Then scraping of top 10cm of layer was done by using rod stirring and pumping through the pipe then similar depth of new media was used to maintain the same height of media. Then sampling of 2nd cycle was started which was continued up to 52 days of filter run and again scraping as on 1st cycle. Then 3rd cycle was started with higher hydraulic loading rate was continued up to 21 days of filter run.

Table 3-1, Description of SSF

Components	Dimension	Remarks
Overhead tank	500 L, 200 L.	HDPE Water tank
Operating ball valve	15mm each at 2 tanks	For two tanks
Flow regulating valve	15mm Brass Gate valve	For flow control mechanism
Influent pipe	15mm PPR pipe line	Connection pipe
Filter tank	0.22m*0.22m*2.75m	Glass fiber double layer tank
Ball cock for flow control at filter		Polythene ball cock
Sampling ports	8 nos. 15mm sampling port at 15 cm c/c in vertical direction	Using tank nipple, ball valve and nozzle at each port
Freeboard	10 cm at the top of filter	
Outlet	15mm ball valve, nozzle, tee and piezometer	2 ball valve

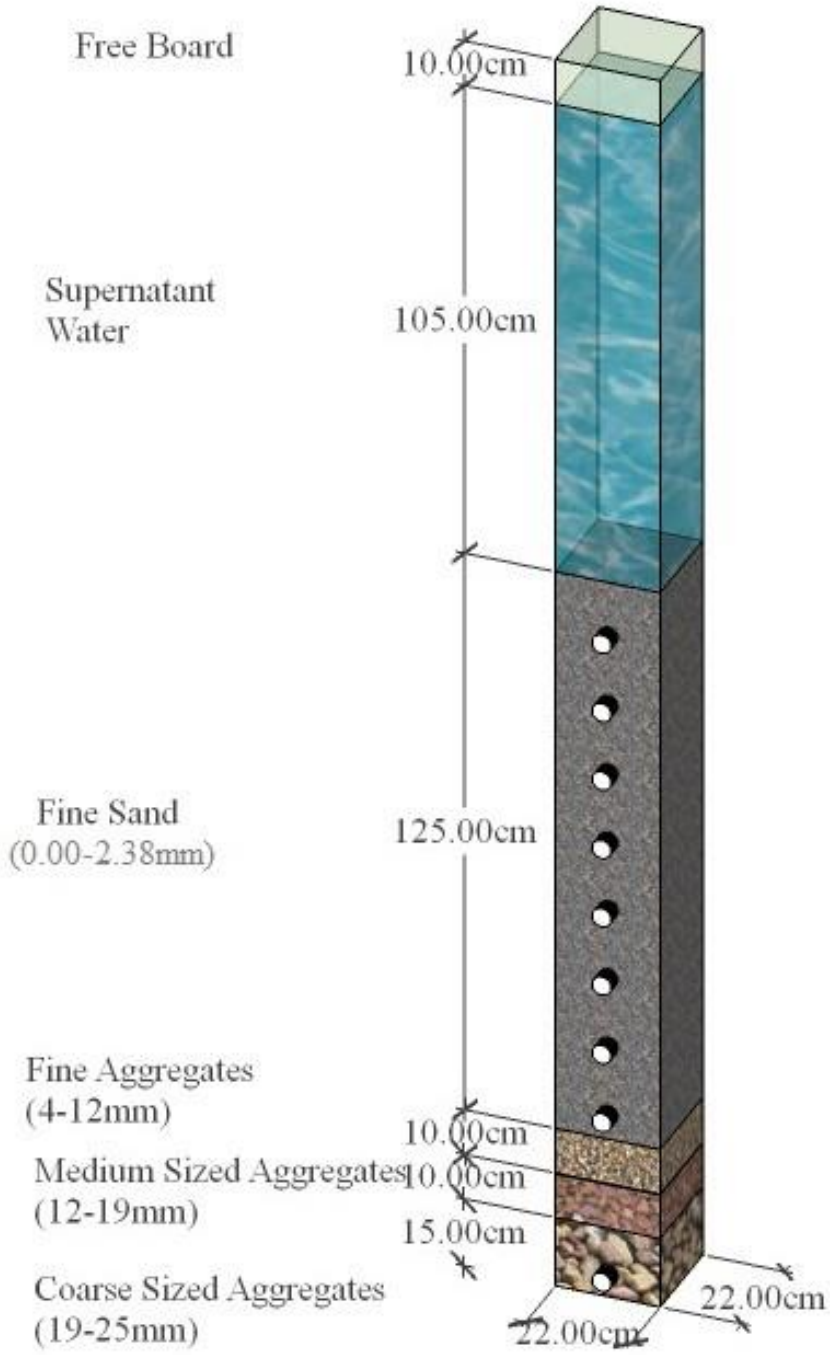


Figure 3.1: Experimental setup of slow sand filter

Barrett (1989) in experiments at the University of Colorado, observed total coliform removals of 99.99 percent using sand with d_{10} = 0.92 mm and C_u = 2.0. The sand bed was mature enhanced by nutrient rich water and a temperature of 25 ˚C. The coarse sand gave run times of two months, compared with runs of six days for sands with d_{10} = 0.21 mm under the same conditions (AWWA, 1991). In general effective size of sand (d_{10}) for the slow sand filter is 0.2 mm to 0.3 mm for the HLR upto 0.1 m/hr. to 0.2m/hr,

but sand used in this research was of effective size (d_{10}) =0.87 mm to find out the removal efficiency upto HLR of 0.6m/hr and for increase of filter run time.

Table 3.2: Gradation of base material

Sieve Size(mm)	Wt. of Sand retained in grams	% Retained	Cumulative % retained	% Passing
25.40	650	0.57	0.57	99.43
19.10	12800	11.16	11.73	88.27
12.70	19800	17.27	29.00	71.00
9.52	12800	11.16	40.17	59.83
4.76	68600	59.83	100.00	0.00
Total	114650			

Table 3.3: Gradation of filter material

Sieve Size(mm)	Wt. of Sand retained in gram	% Retained	Cumulative % retained	% Passing
4.76	0	0.00	0.00	100.00
2.38	620	4.09	4.09	95.91
0.84	13400	88.45	92.54	7.46
0.59	690	4.55	97.10	2.90
0	440	2.90	100.00	0.00
Total	15150			

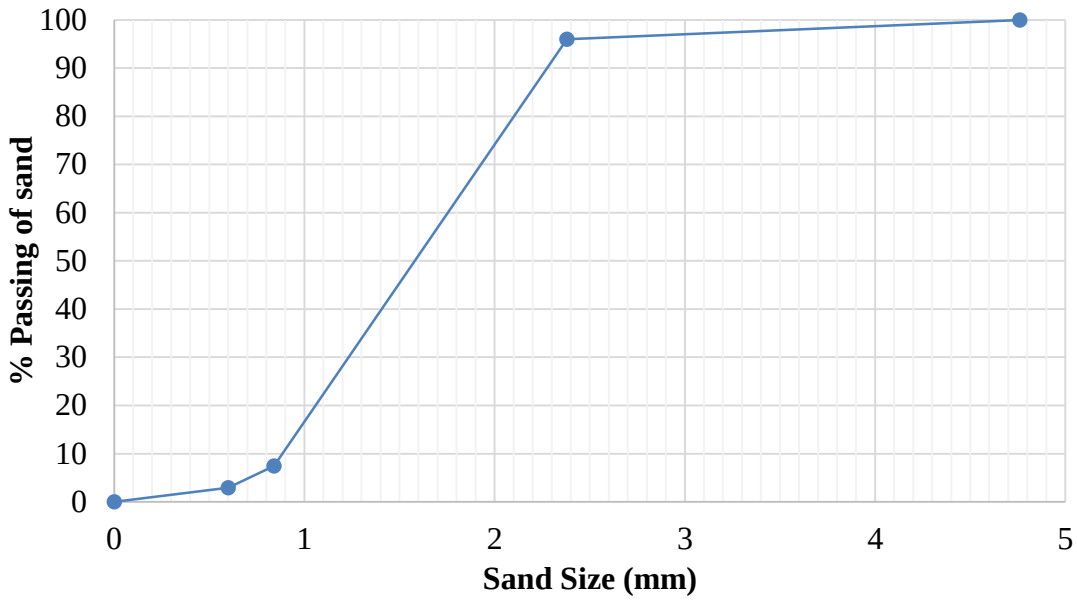


Figure 3.2: Gradation of filter material

The sand was then tested for the acid test. A known mass of washed and dried sand was soaked in conc. HCL for twenty four hours. The sand was then washed with distilled water several times and dried in oven. The weight lost in the process was calculated. For the suitability of filter media in slow sand filter, the loss should not be more than 5% (Shrestha, 2004). The weight lost in the sand was only 0.26%. The characteristics of fine sand were presented in Table 3.4.

Table 3.4: Characteristics of filter material sand

S.N.	Parameters	Units	Values
1	Effective size (D10)	mm	0.87
2	60% finer size (D60)	mm	1.75
3	Uniformity Coefficient		2.01
4	Density (Bulk)	Kg/m3	2439.02
5	Porosity	%	43.06
6	Weight loss in acid test	%	0.26

3.4 Analysis of Sample

For the biological analysis, section 9222B of Standard method for examination of water and wastewate, 20th edition (APHA, 1999) was followed initially till the first two data but due to load shading problem it couldn't be completed on lab using standard method. Then further sampling of it is being carried out using Wagtech Potatest Field Test Kit (WAG-WE 10005) brought from Department of Water Supply and Sewerage at Examination Control Division, IOE and the detail of the procedure of testing was as described on Annex A.

Turbidity from sampling ports i.e. influent, intermediate and effluent were measured after 8 days of filter operation. The samples were taken once a day. Consistency in the measurements was maintained throughout the study period. In this study turbidity was measured by LT-33 Nephelometric turbidity meter manufactured by Labtronics India. Manufacturer's instructions were followed while calibrating the instrument. For the turbidity analysis, section 2130 B of Standard method for examination of water and wastewate, 20th edition (APHA, 1999) was followed.

Table 3.5: Methods of analysis

S.N.	Parameters	Methods
1	Temperature	Thermometer
2	pH	Wagtech Digital pH meter
3	Head loss	Using measuring scale on piezometer pipe
4	Discharge	100 ml measuring cylinder
5	Total Coliform	Wagtech Potatest Kit (WAG-WE 10005)
6	Turbidity	Nephelometric Turbidity Meter

3.5 Composition of the media

The filter was composed of bottom media with different proportion which is as shown in Table 3.6.

Table 3.6, Media Composition

S. No	Description	Depth of media	Size
1	Aggregate for base material	15cm	19-25mm
2	Aggregate for base material	10cm	12-19mm
3	Aggregate for base material	10cm	4-12mm
4	Sand for filter media	125cm	0-2.38mm

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

Among various parameters, our concern was to know the total coliform removal efficiency of slow sand filter. The performance of slow sand filter was measure in terms of total coliform removal and turbidity removal with different media depth and hydraulic loading rates. Analysis was done on the basis of Wagtech Potatest Kit (WAG-WE 10005) field method for total coliform removal and Standard Method for turbidity removal.

4.1 Performance of Slow sand filter

4.1.1 Total coliform removal with respect to media depth

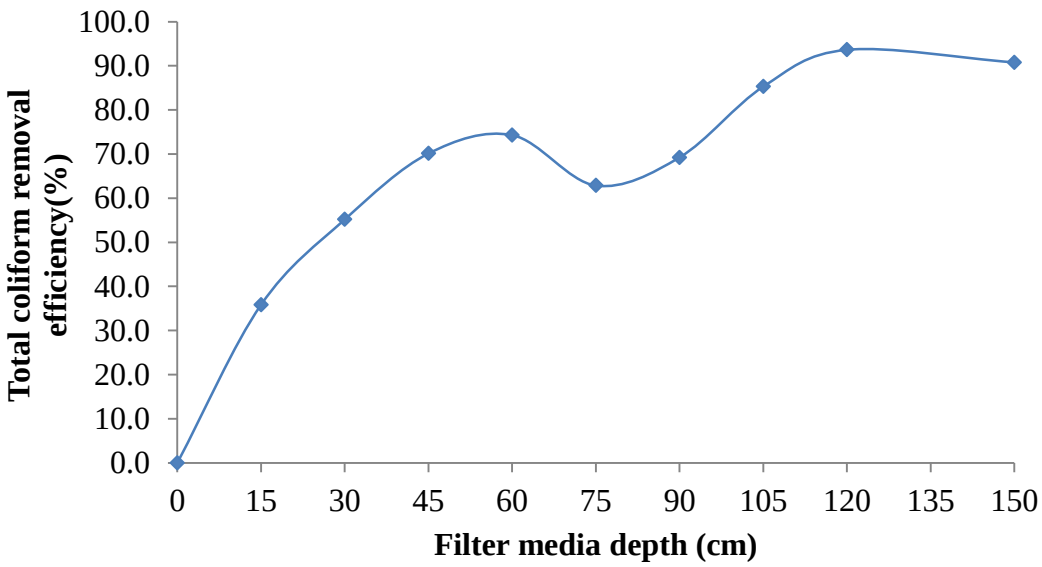


Figure 4.1: Total coliform removal efficiency on 1st cycle

During 1st cycle (24 to 54 days) run of filter the removal efficiency of total coliform was low; minimum removal efficiency 35.80% on 15cm depth of media and maximum was found to be 93.60% on outlet and removal efficiency at 75cm depth was found to be decreased because of some sampling error is presented in Figure 4.1.

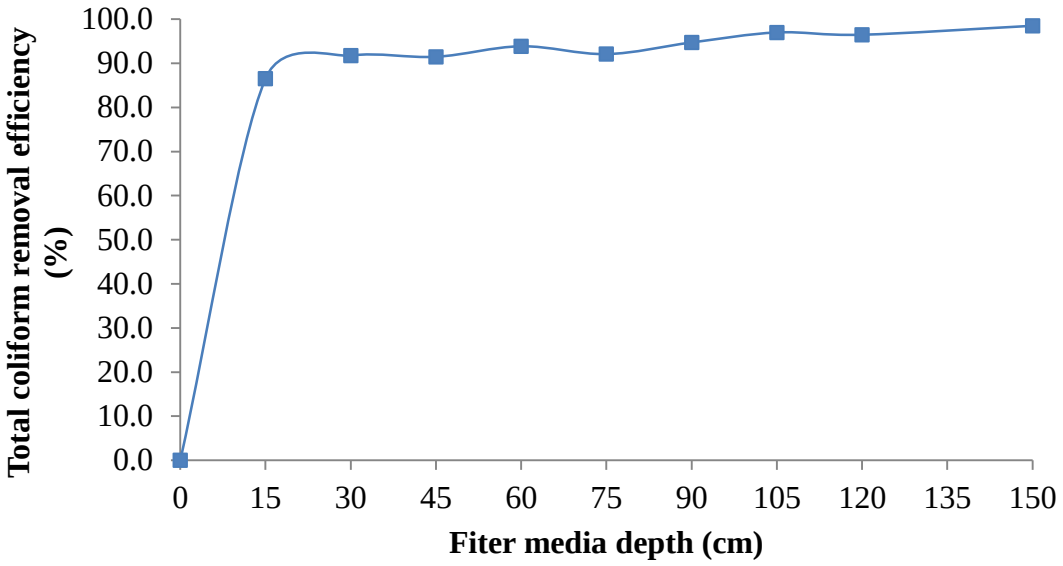


Figure 4.2: Total coliform removal efficiency on 2nd cycle

During 2nd cycle (3 to 51 days) run of filter the removal efficiency of total coliform was high; minimum removal efficiency 86.50% on 15cm depth of media and maximum was found to be 98.50% on outlet which is presented in Figure 4.2. The removal efficiency was maximum at outlet showing that there was significant removal in first 15 cm of depth then increasing gradually.

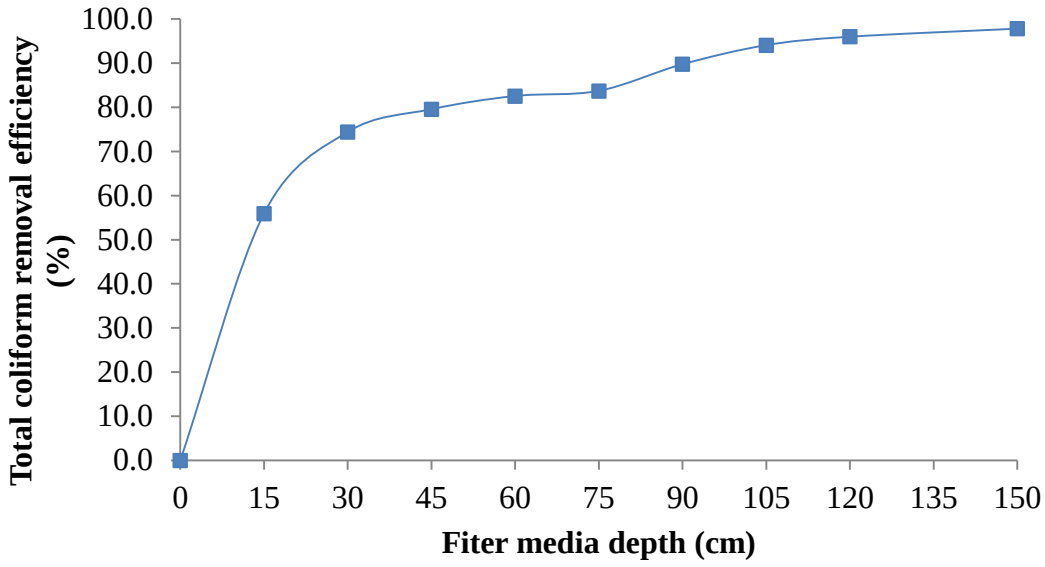


Figure 4.3: Total coliform removal efficiency on 3rd cycle

During 3rd cycle (3 to 21 days) run of filter the removal efficiency of total coliform was moderate due to higher flow rate; minimum average removal efficiency 59.90% on 15cm depth of media and maximum average removal efficiency was found to be

97.80% on outlet which is presented in Figure 4.3. The removal efficiency was maximum at outlet there was increase in some extent of biological removal with respect to increase of media depth.

4.1.2 Turbidity removal

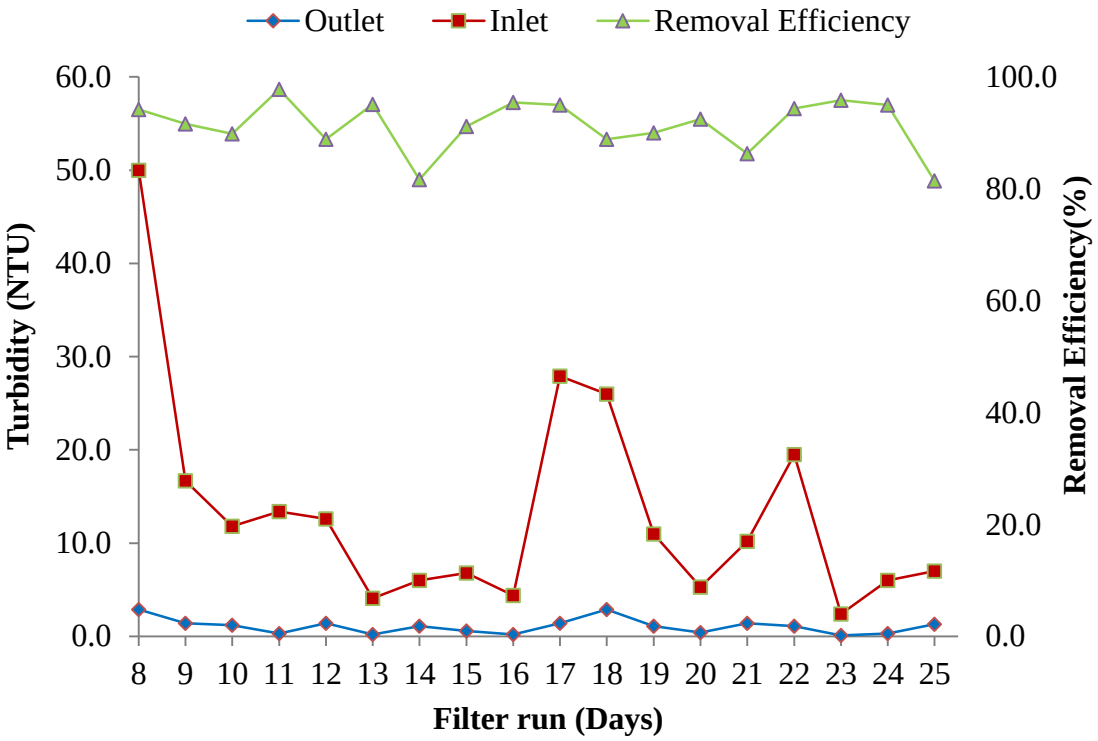


Figure 4.4: Turbidity removal efficiency on 1st cycle 1st phase

During 1st cycle 1st phage (8 to 25 days) run of filter, turbidity removal efficiency was moderate; minimum and maximum turbidity removal efficiencies were 81.70% and 97.80% respectively up to turbidity range of 50 NTU as presented in Figure 4.4. The figure showing the fluctuation on removal efficiency but the overall outlet turbidity was within the range of National drinking quality standards. Observations shows that though the turbidity varies in the effluent, the filter was able to true care of it.

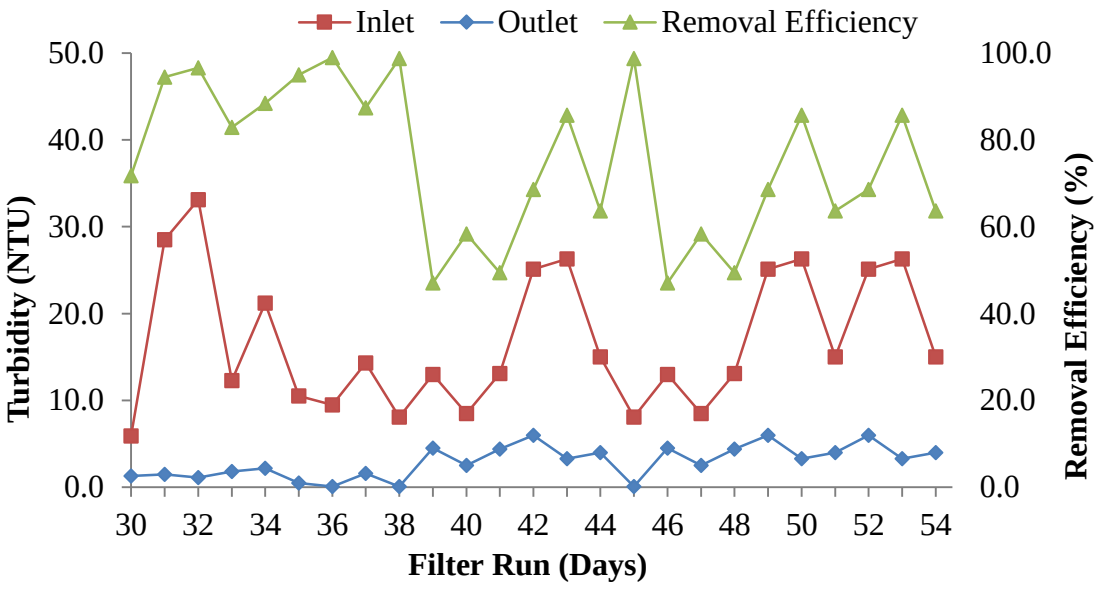


Figure 4.5: Turbidity removal efficiency on 1st cycle 2nd phase

During 1st cycle 2nd phage (30 to 54 days) run of filter, turbidity removal efficiency was low; minimum and maximum turbidity removal efficiencies were 47.10% and 99.90% respectively up to turbidity range of 50 NTU as presented in Figure 4.5. The figure showing the fluctuation on removal efficiency but the overall outlet turbidity was within the range of National drinking quality standards. Observations shows that though the turbidity varies in the influent, the filter media was able to true care of it.

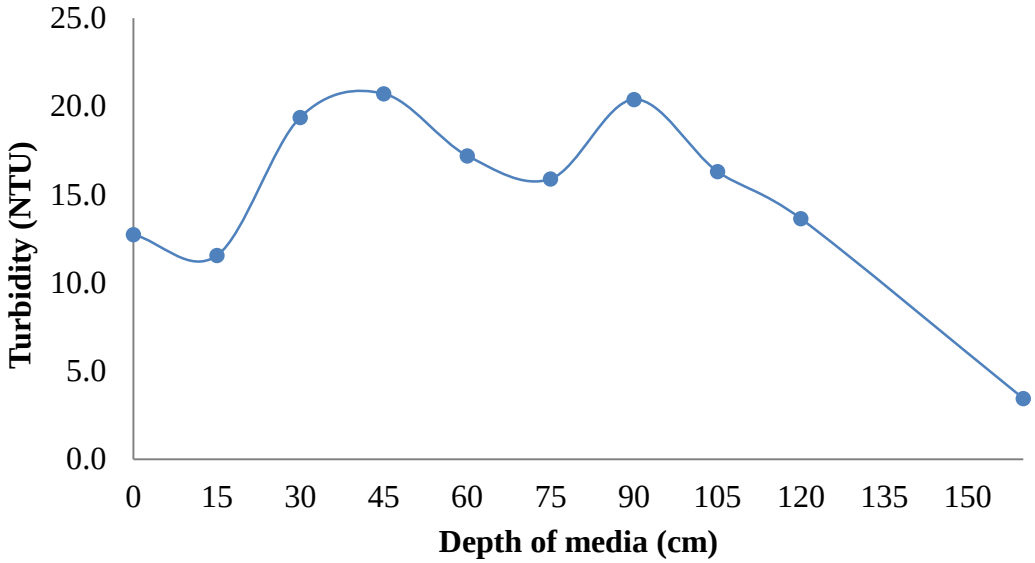


Figure 4.6: Turbidity level with respect to depth at 2nd cycle

During analysis of the turbidity data from 2nd cycle of filter run, samples were taken and analyzed from different sampling ports installed as in Figure 3.1. During 2nd cycle run (2 to 51 days) of filter run the average turbidity of the water sample was 12.70 NTU and effluent turbidity is 3.40 NTU as the removal efficiency was 73% as shown in Figure 4.6 . The value were fluctuating on intermediate depths but overall removal efficiency at the outlet was within the range of Nepal drinking water quality.

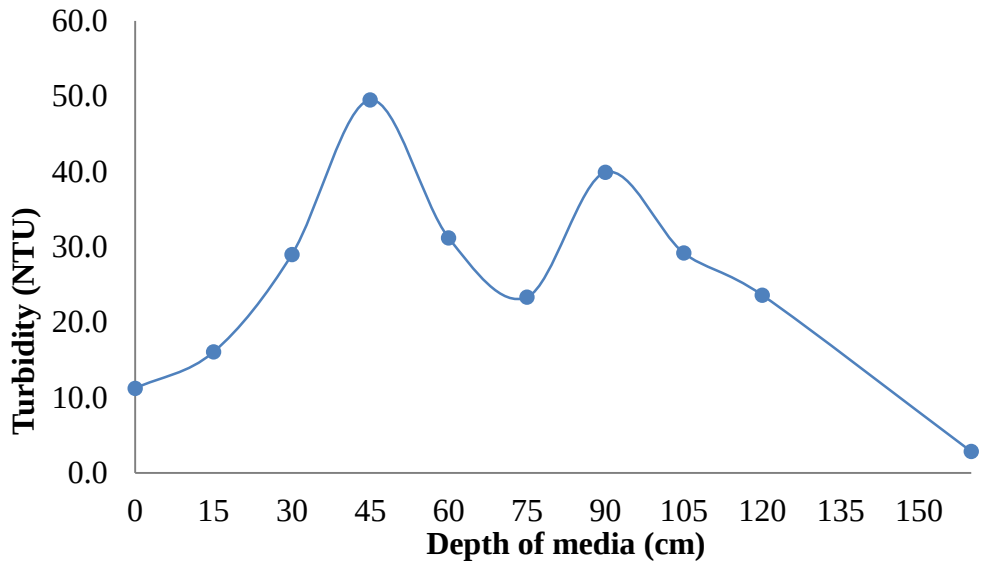


Figure 4.7: Turbidity level with respect to depth at 3rd cycle

During 3rd cycle of filter run (1 to 21 days) of filter run the average turbidity of the water sample was 11.20 NTU and effluent turbidity was 2.80 NTU as the removal efficiency was 74.70% as shown in Figure 4.7 and the value were fluctuating on intermediate depths but overall removal efficiency at the outlet was within the range of Nepal drinking water quality standards.

4.1.3 Total coliform removal with respect to hydraulic loading rate

During all three cycles all the data of discharge was recorded and the hydraulic loading rate was calculated for each data. Among all the HLR data they were categorized as the HLR< 0.10 m/hr., HLR 0.10 m/hr. – 0.20 m/hr., HLR 0.20 m/hr. – 0.30 m/hr., HLR 0.30 m/hr. – 0.40 m/hr., HLR > 0.40 m/hr. and the average removal efficiency of total coliform were 99.58%, 97.34%, 95.41%, 90.32%, 89.91% respectively as shown in Figure 4.8. The result shows that there is requirement of sufficient contact time of water molecules with schmutdeck for kill of total coliform present in the water.

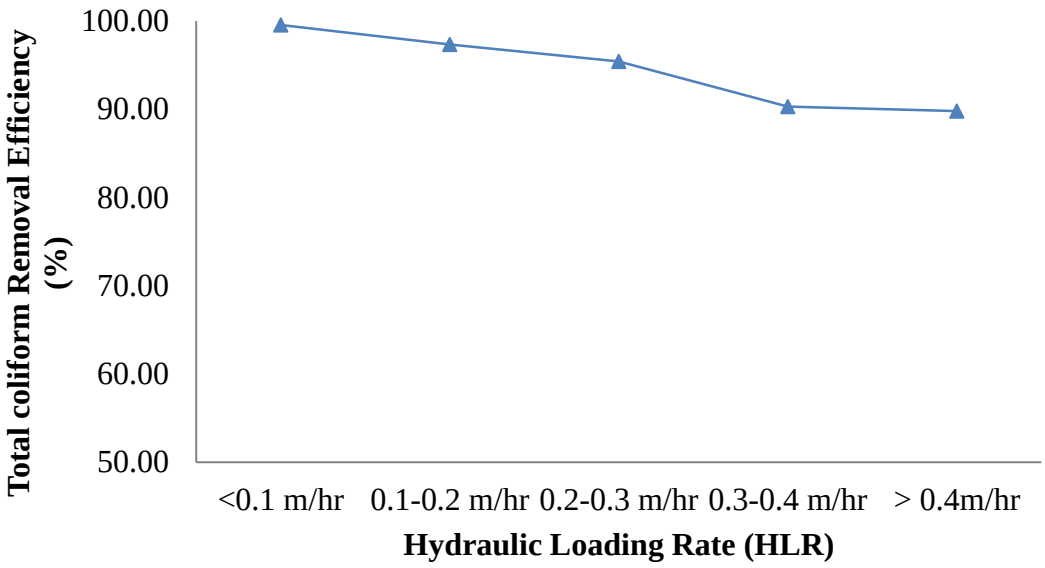


Figure 4.8: Total coliform removal efficiency with respect to HLR

4.1.4 Turbidity removal with respect to hydraulic loading rate

During all three cycles all the data of discharge was recorded and the hydraulic loading rate was calculated for each data. Among all the HLR data they were categorized as the HLR< 0.1m/hr., HLR from 0.1m/hr. – 0.2m/hr., HLR from 0.2m/hr. – 0.3m/hr., HLR from 0.3m/hr. – 0.4m/hr., HLR > 0.4m/hr. and the average removal efficiency of turbidity were 77.02%, 62.62%, 60.36%, 81.06%, 87.66% respectively as shown in Figure 4.9. The result showed that there is no significance of HLR in the case of turbidity removal and overall effluent quality of water was within range of National drinking water quality standards.

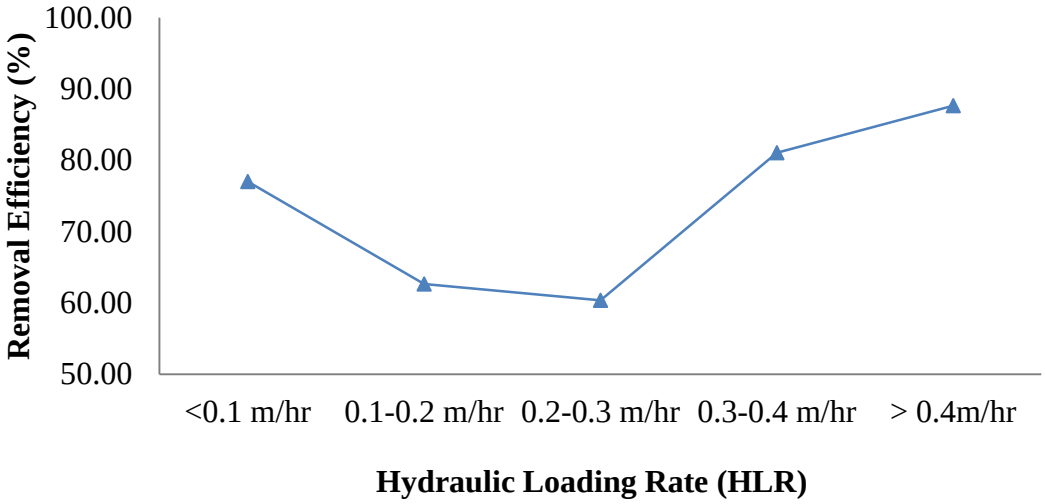


Figure 4.9: Turbidity removal efficiency with respect to HLR.

4.1.5 pH change in slow sand filter

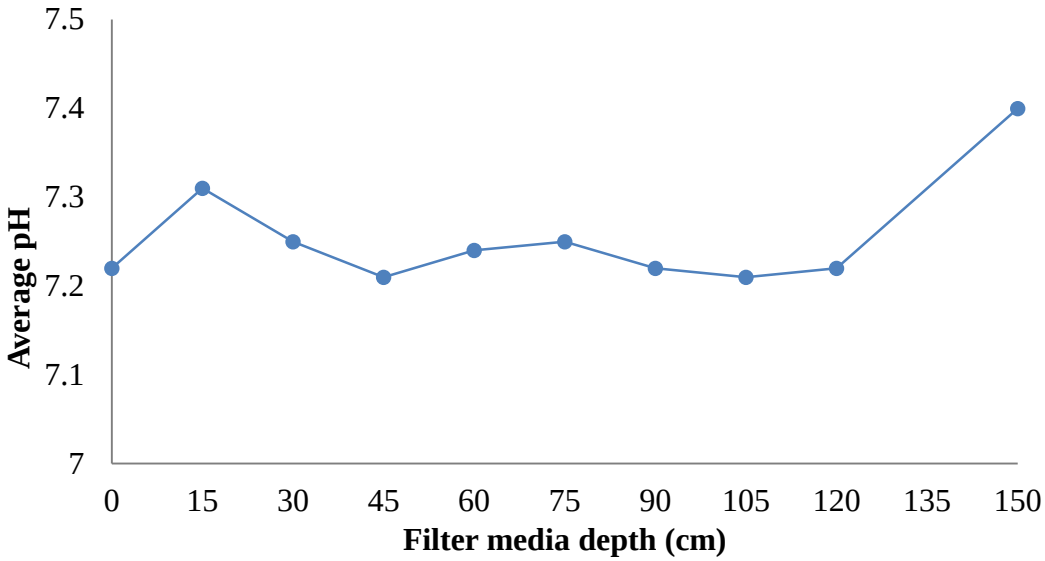


Figure 4.10: pH change in slow sand filter

The average pH fluctuation of 3rd cycle run of slow sand filter was as shown on Figure 4.10. On overall the pH was increased on outlet but was within the range of National Drinking Water Quality Standards, 2005.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Present research was aimed to find out the total coliform removal efficiency in slow sand filter. Based on the results of pilot plant of proposed set up following conclusions were made:

1. Total coliform removal efficiency of the slow sand filter was found 35.9% to 100% on an average basis of three complete cycle of filter run.
2. Total coliform removal mechanism has been found to be occur mainly at first layer of sand of few centimeters of depth but some extent of removal also occurs up to the full depth of filter media.
3. On the basis of HLR the minimum the HLR maximum will be the total coliform removal efficiency. It has been found that total coliform removal efficiency was 99.58%, 97.34%, 95.41%, 90.32%, 89.81% for HLR < 0.1m/hr., HLR 0.1m/hr. – 0.2m/hr., HLR 0.2m/hr. – 0.3m/hr., HLR 0.3m/hr. – 0.4m/hr., HLR > 0.4m/hr. respectively.
4. Up to the initial turbidity of 50 NTU slow sand filter can reduce the turbidity of water below 5 NTU which is in the range of NDWQS, 2005.
5. In filter media the pH of the effluent water has been slightly increased but it was within the range of NDWQS, 2005.
6. In some set of analysis, total coliform removal efficiency was upto 100%. Since it is not common in all experiment it is suggested for further disinfection process before using as drinking water.
7. With decreasing of hydraulic loading rate the performance of slow sand filter has been increased against the total coliform removal whereas there was no significant pattern of increase and decrease of turbidity removal with hydraulic loading rate up to 0.6m/hr.

5.2 Recommendations:

1. It is recommended to study the removal efficiency of Iron and Manganese in slow sand filter.

2. It is recommended to study the effect of algae growth in slow sand filter and its effect on pH and further contamination at outlet.
3. It is recommended to study the biological removal using sand of lower effective size and comparison of effect between coarse and fine sand.
4. It is recommended to study the combined effect of turbidity removal efficiency along with bacteriological removal efficiency as it seems number of total coliform was high where the turbidity was also high in general.

REFERENCES

1. APHA, 1999, *"Standard method for examination of water and wastewater"*, 20th edition, pp. 157, 2230
2. AWWA, 1991, *"Manual of Design for Slow Sand Filtration"*, pp. 27, 63-64.
3. Lea, Tse-Leun, 2000,"Biosand household water filter project in nepal" *M. Sc. Thesis*, University of Torronto, pp.17-27.
4. Lukas Hether A. 2002, "From design to implementation: innovative slow sand filtration for use in developing countries" *M. Sc. Thesis*, Massachusetts Institute of Technology, pp 9.
5. Modi, P.N, 2010, *"Water Supply Engineering"*, Standard Book House, pp.512-514.
6. NDWQS, 2005, *"National Drinking Water Quality Standards",* Ministry of Physical Planning and Works, pp.1.
7. Pachocka Magdalena, 2010, "Intermittant slow sand filters:improving their design for developing world application" *M. Sc. Thesis*, University of Delaware, pp.7.
8. Shrestha, Prem Krishna, 2004,"Arsenic, iron and coliforms removal efficiency of household level biosand filters", *M. Sc. Thesis*, Institute of Engineering, TU, pp.v.
9. NPC, 2071, *"Thirteenth Three year plan"* , National Planning Commission, pp.148.
10. Tommy K.K. Ngai , Roshan R. Shrestha , Bipin Dangol , Makhan Maharjan & Susan E. Murcott, 2007, "Design for sustainable development—Household drinking water filter for arsenic and pathogen treatment in Nepal", *Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering*, pp.1886.
11. Water Aid, 2011, Protocol,*"Water quality standards and testing policy"* , Water Aid in Nepal, pp.26,
12. WHO, 2006, *"Guidelines for drinking water Quality: Volume 1"*, World Health Organisation, pp.282-283.

ANNEXES

Title	Page
A. Total coliform analysis data	39
B. Turbidity analysis data	52
C. pH analysis data	65
D. Temperature analysis data	71
E. Photographs	77
F. Water quality test results	80

Name and depth of sampling ports:

Name	Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
Sampling Depth	0 cm =Inlet	15 cm	30 cm	45 cm	60 cm	75 cm	90 cm	105 cm	120 cm	150 cm = Outlet

A. Total Coliform analysis

A.1 Test Procedure of Total Coliform by using Wagtech Field test kit (WAG-WE10005)

a) Initially using sterile vessel and 10 spatula of Membrane Lauryl Sulphate Broth to 25 ml of sterile distilled water the food (inoculum) for the sapling was prepared on every days of sampling.

b) The samples from each sampling ports were collected on 160ml autoclaved sampling bottles starting from top to bottom for each days of sampling.

c) The filtration cup was sterilized by using ethanol burning on sampling cup and after burning at end stage the filtration cup was inverted on sampling cup so as to sterilize by flame and wait for 5 minutes for each no of water samples.

d) The cup portion of filtration cup was detached and with sterile forceps membrane filter of individual sterile pack was placed on the filter.

e) The detached cup portion was again joined and water sample of sampling bottle was poured on filtration cup to the upper marking of 100ml.

f) Then manual suction hand pump was used to pump the water.

g) After completion of pumping the cup was detached again assuring that no rotation and damage to the gridded filter paper.

h) The broth prepared on step a) was poured on sterile petric plate with laying of absorbent pad so as to absorb the food for the coliform organism and the paper was placed on the absorbent pad assuring no air bubbles were entrapped.

i) Step b to h was repeated on each number of samples.

j) The all the petric plates were covered by its cover and placed carrying container on normal atmospheric condition for 1 hour.

k) The petric carrying container was placed on inbuilt incubator of test kit and started the incubation with temperature 37ºC for 24 hour. After 24 hours the yellow colonies were counted by using colony counter or magnifying lens. And the data were recorded.

Table A-1: Total Coliform data on 1st cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
1st cycle								1st cycle									
17 Nov 2015	1		500.00	30.00	0.62	0.0											
18 Nov 2015	2		500.00	30.00	0.62	0.0											
19 Nov 2015	3		500.00	30.00	0.62	0.0											
20 Nov 2015	4		500.00	30.00	0.62	0.0											
21 Nov 2015	5		500.00	30.00	0.62	5.0											
22 Nov 2015	6		500.00	30.00	0.62	6.5											
23 Nov 2015	7		500.00	30.00	0.62	7.2											
24 Nov 2015	8		447.20	26.83	0.55	9.5											
25 Nov 2015	9		454.48	27.27	0.56	14.0											
26 Nov 2015	10		416.69	25.00	0.52	16.4											
27 Nov 2015	11		413.56	24.81	0.51	19.8											
28 Nov 2015	12		382.47	22.95	0.47	20.5											
29 Nov 2015	13		388.76	23.33	0.48	18.2											
Flow adjustment								Flow adjustment									
29 Nov 2015	13		274.36	16.46	0.34	5.2											
30 Nov 2015	14		279.37	16.76	0.35	9.6											
01 Dec2015	15		280.67	16.84	0.35	9.8											
02 Dec 2015	16		280.63	16.84	0.35	13.3											
03 Dec2015	17		280.17	16.81	0.35	13.3											

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
04 Dec 2015	18		278.20	16.69	0.34	13.3											
05 Dec 2015	19		273.60	16.42	0.34	11.6											
06 Dec 2015	20		275.50	16.53	0.34	14											
07 Dec 2015	21		270.54	16.23	0.34	11.6											
Flow adjustment								Flow adjustment									
08 Dec 2015	22		495.96	29.76	0.61	12.7											
09 Dec 2015	23		467.37	28.04	0.58	15.8											
10 Dec 2015	24		452.50	27.15	0.56	18.2		100	96	22	89	34	52	73	21	10	20
11 Dec 2015	25		447.27	26.84	0.55	20.2											
12 Dec 2015	26		441.75	26.51	0.55	21.3											
13 Dec 2015	27		433.56	26.01	0.54	28.1											
14 Dec 2015	28		425.66	25.54	0.53	68.3											
15 Dec 2015	29		417.75	25.07	0.52	40.2											
16 Dec 2015	30		401.17	24.07	0.50	50.5											
17 Dec 2015	31		392.72	23.56	0.49	60.5		185	145	124	19	62	64	41	30	12	10
18 Dec 2015	32		374.42	22.47	0.46	70.5	11										
19 Dec 2015	33	2pm	396.92	23.82	0.49	85.8	19										
20 Dec 2015	34	8.30pm	370.90	22.25	0.46	106	12										
21 Dec 2015	35		338.70	20.32	0.42	121	12										
22 Dec 2015	36		315.78	18.95	0.39	141.5	10										
23 Dec 2015	37		300.51	18.03	0.37	150	12										
24 Dec 2015	38	12pm	285.24	17.11	0.35	158.5	18										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
25 Dec 2015	39	1pm	254.07	15.24	0.31	172	18										
26 Dec 2015	40		241.15	14.47	0.30	199	17.6	15	13	15	14	5	105	2	0	0	1
27 Dec 2015	41		192.82	11.57	0.24	195.4	14										
28 Dec 2015	42		163.23	9.79	0.20	208.3	13										
29 Dec 2015	43	5pm	248.60	14.92	0.31	228.5	20										
Flow adjustment								Flow adjustment									
30 Dec 2015	44	4pm	276.61	16.60	0.34	240	18	14	5	3	5	3	14	9	8	1	5
31 Dec 2015	45	4pm	221.89	13.31	0.28	19	18										
01 Jan 2016	46	10am	205.50	12.33	0.25	59	11										
02 Jan 2016	47	7am	170.85	10.25	0.21	110	10	53	4	3	0	1	4	2	1	2	6
03 Jan 2016	48	8am	145.77	8.75	0.18	144.5	10										
Flow adjustment								Flow adjustment									
04 Jan 2016	49	10am	16.00	0.96	0.02	55	14										
05 Jan 2016	50	7am	27.00	1.62	0.03	48	10	4	2	0	0	3	0	1	1	1	0
06 Jan 2016	51	9am	20.23	1.21	0.03	58	14										
07 Jan 2016	52	9am	15.00	0.90	0.02	56	15										
08 Jan 2016	53	4pm	24.00	1.44	0.03	75	22										
09 Jan 2016	54	10am	29.00	1.74	0.04	145.5	14	84	27	37	9	9	30	12	6	3	0

Table A-2: Total Coliform data on 2nd cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
2nd cycle with filter ripening								2nd cycle with filter ripening									
10 Jan 2016	1	9am	165.00	9.90	0.20	2.9	11										
11 Jan 2016	2	9am	85.26	5.12	0.11	2	12										
12 Jan 2016	3	7am	82.00	4.92	0.10	6	10	500	103	84	99	67	74	54	47	53	30
13 Jan 2016	4	7am	130.00	7.80	0.16	11	10										
14 Jan 2016	5	9am	82.00	4.92	0.10	11	10										
15 Jan 2016	6	11am	83.00	4.98	0.10	6	16	38	5	11	3	2	6	5	7	6	4
16 Jan 2016	7	1pm	77.00	4.62	0.10	7	19										
Flow adjustment								Flow adjustment									
16 Jan 2016	7	1pm	135.00	8.10	0.17	9	19										
17 Jan 2016	8	5pm	118.00	7.08	0.15	22.5	17										
18 Jan 2016	9	8am	119.00	7.14	0.15	28.2	10	500	73	33	21	56	28	23	4	18	4
19 Jan 2016	10	9am	120.00	7.20	0.15	19.8	10										
20 Jan2016	11	9am	122.00	7.32	0.15	16.9	10										
21 Jan 2016	12	7.30 am	120.00	7.20	0.15	15.2	10	500	80	55	46	9	30	14	8	15	1
22 Jan 2016	13	9am	130.00	7.80	0.16	14	11										
23 Jan 2016	14	9am	134.00	8.04	0.17	12	11										
24 Jan2016	15	7am	118.00	7.08	0.15	14.3	7.5	500	128	56	43	10	37	17	13	11	4
25 Jan 2016	16	10am	122.00	7.32	0.15	11.9	17										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
26 Jan 2016	17	5pm	118.00	7.08	0.15	11.5	17										
27 Jan 2016	18	8am	104.00	6.24	0.13	14.5	9	89	19	12	10	21	26	11	6	5	1
28 Jan 2016	19	11am	93.00	5.58	0.12	13.5	10										
29 Jan 2016	20	4pm	82.00	4.92	0.10	12.5	11										
30 Jan 2016	21	9am	86.00	5.16	0.11	16	9	43	4	3	2	8	3	6	2	8	1
31 Jan 2016	22	10am	80.00	4.80	0.10	14	13										
01 Feb 2016	23	12pm	70.00	4.20	0.09	13	21										
02 Feb 2016	24	3pm	60.00	3.60	0.07	7	24	500	70	62	54	51	34	20	12	17	2
03 Feb 2016	25	10am	50.00	3.00	0.06	8	11										
04 Feb 2016	26	4pm	54.00	3.24	0.07	8	21										
Flow adjustment								Flow adjustment									
04 Feb 2016	26	5pm	252.00	15.12	0.31	13	21										
05 Feb 2016	27	7am	241.58	14.49	0.30	28	11	56	29	18	29	4	4	9	12	6	4
06 Feb 2016	28	6pm	208.00	12.48	0.26	33.5	18										
07 Feb 2016	29	5pm	240.00	14.40	0.30	16.5	21										
08 Feb 2016	30	10am	240.00	14.40	0.30	12.5	14	124	20	7	7	13	25	39	11	6	4
09 Feb 2016	31	9am	232.00	13.92	0.29	17.5	12										
10 Feb 2016	32	4pm	227.59	13.66	0.28	21.5	21										
11 Feb 2016	33	1pm	232.50	13.95	0.29	33.5	23	54	5	14	5	9	13	15	8	5	1

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
12 Feb 2016	34	4pm	231.22	13.87	0.29	22	22										
13 Feb 2016	35	5pm	260.00	15.60	0.32	31.5	22										
14 Feb 2016	36	8am	320.00	19.20	0.40	50.5	15	500	9	38	80	47	73	24	6	25	8
15 Feb 2016	37	3pm	211.62	12.70	0.26	39	22										
16 Feb 2016	38	11am	206.19	12.37	0.26	38.5	19										
17 Feb 2016	39	8am	203.40	12.20	0.25	60	14	500	43	19	12	9	16	13	8	4	3
18 Feb 2016	40	2pm	200.00	12.00	0.25	43.5	27										
19 Feb 2016	41	2pm	208.00	12.48	0.26	40.5	27										
20 Feb 2016	42	5pm	128.00	7.68	0.16	37.5	21	500	42	40	18	7	12	11	5	4	1
21 Feb 2016	43	5pm	60.00	3.60	0.07	46	25										
22 Feb 2016	44	5pm	104.67	6.28	0.13	51.5	27										
23 Feb 2016	45	7am	161.39	9.68	0.20	60	13	500	24	8	4	2	2	1	3	2	2
24 Feb 2016	46	4pm	106.00	6.36	0.13	70.5	25										
25 Feb 2016	47	8am	102.00	6.12	0.13	71.5	14										
26 Feb 2016	48	2pm	189.72	11.38	0.24	73.5	27	254	35	11	3	5	3	2	3	1	0
27 Feb 2016	49	12pm	150.00	9.00	0.19	76.5	24										
Flow adjustment								Flow adjustment									
27 Feb 2016	49	1pm	441.60	26.50	0.55	23.5	24										
28 Feb 2016	50	8am	141.00	8.46	0.17	83	14										
Flow adjustment								Flow adjustment									
28 Feb 2016	50	9am	165.00	9.90	0.20	90	14										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
29 Feb 2016	51	8am	68.00	4.08	0.08	95	14	79	17	11	11	7	4	3	3	1	1
01 Mar 2016	52	12pm	68.00	4.08	0.08	95	28										

Table A-3: Total Coliform data on 3rd cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
3rd Cycle with filter ripening								3rd Cycle with filter ripening									
01 Mar 2016	0	5pm	397.95	23.88	0.49	7	23										
02 Mar 2016	1	8am	360.67	21.64	0.45	9	17										
03 Mar 2016	2	6am	364.00	21.84	0.45	10.5	22										
04 Mar 2016	3	8am	341.00	20.46	0.42	20.5	11	500	52	24	20	8	27	6	7	8	5
05 Mar 2016	4	8am	329.41	19.76	0.41	28.5	18										
06 Mar 2016	5	8am	262.57	15.75	0.33	42.5	17										
07 Mar 2016	6	9am	432.00	25.92	0.54	25	19	81	20	18	17	18	12	9	12	6	5
08 Mar 2016	7	4pm	292.00	17.52	0.36	26.5	25										
09 Mar 2016	8	5pm	294.00	17.64	0.36	26.5	24										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
10 Mar 2016	9	4pm	276.00	16.56	0.34	29	27	500	294	82	47	86	65	58	20	8	4
11 Mar 2016	10	1pm	255.00	15.30	0.32	39	28										
12 Mar 2016	11	1pm	124.00	7.44	0.15	75	29										
Flow adjustment								Flow adjustment									
12 Mar 2016	11	2pm	419.00	25.14	0.52	87	25										
13 Mar 2016	12	8am	314.76	18.89	0.39	47	19	500	146	123	103	78	64	35	20	13	3
14 Mar 2016	13	11am	212.00	12.72	0.26	71	24										
15 Mar 2016	14	2pm	207.00	12.42	0.26	72	27										
Flow adjustment								Flow adjustment									
15 Mar 2016	14	3pm	368.00	22.08	0.46	85	23										
16 Mar 2016	15	8am	154.00	9.24	0.19	90	21	500	295	173	129	122	102	84	43	27	21
Flow adjustment								Flow adjustment									
16 Mar 2016	15	9am	164.00	9.84	0.20	95											
17 Mar 2016	16	8am	143.00	8.58	0.18	95	19										
Flow adjustment								Flow adjustment									
17 Mar 2016	16	9am	314.00	18.84	0.39	13											
18 Mar 2016	17	8am	225.88	13.55	0.28	43	19										
19 Mar 2016	18	1pm	170.85	10.25	0.21	63	29	278	226	178	164	97	114	49	35	28	11
Flow adjustment								Flow adjustment									
19 Mar 2016	18	2pm	292.00	17.52	0.36	85											
20 Mar 2016	19	8am	203.32	12.20	0.25	87	19										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Total Coliform (CFU/100ml)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
Flow adjustment								Flow adjustment									
20 Mar 2016	19	9am	250.03	15.00	0.31	95											
21 Mar 2016	20	10am	240.00	14.40	0.30	95	29										
22 Mar 2016	21	8am	242.00	14.52	0.30	95	19	46	27	17	11	10	7	5	5	6	3

Table A-4: Total Coliform data based on HLR

Date	Filter run days	HLR (m3/m2/hr)	Total Coliform (CFU/100ml)										Removal Efficiency	Average Efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
HLR<0.1m/hr.														
05 Jan 2016	50	0.03	4	2	0	0	3	0	1	1	1	0	100.00	
09 Jan 2016	54	0.04	84	27	37	9	9	30	12	6	3	0	100.00	
02 Feb 2016	24	0.07	500	70	62	54	51	34	20	12	17	2	99.60	
29 Feb 2016	51	0.08	79	17	11	11	7	4	3	3	1	1	98.73	99.58
HLR 0.1m/hr-0.2m/hr.														
12 Jan 2016	3	0.10	500	103	84	99	67	74	54	47	53	30	94.00	
15 Jan 2016	6	0.10	38	5	11	3	2	6	5	7	6	4	89.47	
18 Jan 2016	9	0.15	500	73	33	21	56	28	23	4	18	4	99.20	97.34

Date	Filter run days	HLR (m3/m2/hr)	Total Coliform (CFU/100ml)										Removal Efficiency	Average Efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
21 Jan 2016	12	0.15	500	80	55	46	9	30	14	8	15	1	99.80	
24 Jan 2016	15	0.15	500	128	56	43	10	37	17	13	11	4	99.20	
27 Jan 2016	18	0.13	89	19	12	10	21	26	11	6	5	1	98.88	
30 Jan 2016	21	0.11	43	4	3	2	8	3	6	2	8	1	97.67	
20 Feb 2016	42	0.16	500	42	40	18	7	12	11	5	4	1	99.80	
23 Feb 2016	45	0.20	500	24	8	4	2	2	1	3	2	2	99.60	
16 Mar 2016	15	0.19	500	295	173	129	122	102	84	43	27	21	95.80	
HLR 0.2m/hr-0.3m/hr.														
26 Dec 2015	40	0.30	15	13	15	14	5	105	2	0	0	1	93.33	
02 Jan 2016	47	0.21	53	4	3	0	1	4	2	1	2	6	88.68	
05 Feb 2016	27	0.30	56	29	18	29	4	4	9	12	6	4	92.86	
08 Feb 2016	30	0.30	124	20	7	7	13	25	39	11	6	4	96.77	
11 Feb 2016	33	0.29	54	5	14	5	9	13	15	8	5	1	98.15	
17 Feb 2016	39	0.25	500	43	19	12	9	16	13	8	4	3	99.40	
26 Feb 2016	48	0.24	254	35	11	3	5	3	2	3	1	0	100.00	
19 Mar 2016	18	0.21	278	226	178	164	97	114	49	35	28	11	96.04	
22 Mar 2016	21	0.30	46	27	17	11	10	7	5	5	6	3	93.48	95.41
HLR 0.3m/hr-0.4m/hr.														
30 Dec 2015	44	0.34	14	5	3	5	3	14	9	8	1	5	64.29	
14 Feb 2016	36	0.40	500	9	38	80	47	73	24	6	25	8	98.40	
10 Mar 2016	9	0.34	500	294	82	47	86	65	58	20	8	4	99.20	
13 Mar 2016	12	0.39	500	146	123	103	78	64	35	20	13	3	99.40	90.32

Date	Filter run days	HLR (m3/m2/hr)	Total Coliform (CFU/100ml)										Removal Efficiency	Average Efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
HLR >0.4m/hr.														
10 Dec 2015	24	0.56	100	96	22	89	34	52	73	21	10	20	80.00	
17 Dec 2015	31	0.49	185	145	124	19	62	64	41	30	12	10	94.59	
04 Mar 2016	3	0.42	500	52	24	20	8	27	6	7	8	15	97.00	
07 Mar 2016	6	0.54	81	20	18	17	18	12	9	12	6	10	87.65	89.81

B. Turbidity analysis data

Table B-1: Turbidity at 1st cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
1st cycle																	
17 Nov 2015	1		500.00	30.00	0.62	0.0											
18 Nov 2015	2		500.00	30.00	0.62	0.0											
19 Nov 2015	3		500.00	30.00	0.62	0.0											
20 Nov 2015	4		500.00	30.00	0.62	0.0											
21 Nov 2015	5		500.00	30.00	0.62	5.0											
22 Nov 2015	6		500.00	30.00	0.62	6.5											
23 Nov 2015	7		500.00	30.00	0.62	7.2											
24 Nov 2015	8		447.20	26.83	0.55	9.5		50.0									2.9
25 Nov 2015	9		454.48	27.27	0.56	14.0		16.7									1.4
26 Nov 2015	10		416.69	25.00	0.52	16.4		11.8									1.2
27 Nov 2015	11		413.56	24.81	0.51	19.8		13.4									0.3
28 Nov 2015	12		382.47	22.95	0.47	20.5		12.6									1.4
29 Nov 2015	13		388.76	23.33	0.48	18.2		4.1									0.2
Flow adjustment																	
29 Nov 2015	13		274.36	16.46	0.34	5.2											

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
30 Nov 2015	14		279.37	16.76	0.35	9.6		6.0									1.1
01 Dec 2015	15		280.67	16.84	0.35	9.8		6.8									0.6
02 Dec 2015	16		280.63	16.84	0.35	13.3		4.4									0.2
03 Dec 2015	17		280.17	16.81	0.35	13.3		27.9									1.4
04 Dec 2015	18		278.20	16.69	0.34	13.3		26.0									2.9
05 Dec 2015	19		273.60	16.42	0.34	11.6		11.0									1.1
06 Dec 2015	20		275.50	16.53	0.34	14		5.3									0.4
07 Dec 2015	21		270.54	16.23	0.34	11.6		10.2									1.4
Flow adjustment																	
08 Dec 2015	22		495.96	29.76	0.61	12.7		19.5									1.1
09 Dec 2015	23		467.37	28.04	0.58	15.8		2.4									0.1
10 Dec 2015	24		452.50	27.15	0.56	18.2		6.0									0.3
11 Dec 2015	25		447.27	26.84	0.55	20.2		7.0									1.3
12 Dec 2015	26		441.75	26.51	0.55	21.3											
13 Dec 2015	27		433.56	26.01	0.54	28.1											
14 Dec 2015	28		425.66	25.54	0.53	68.3											
15 Dec 2015	29		417.75	25.07	0.52	40.2											
16 Dec 2015	30		401.17	24.07	0.50	50.5		4.6									1.3
17 Dec 2015	31		392.72	23.56	0.49	60.5		27.0									1.5
18 Dec 2015	32		374.42	22.47	0.46	70.5	11	32.0									1.1
19 Dec2015	33	2pm	396.92	23.82	0.49	85.8	19	10.5									1.8

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
20 Dec 2015	34	8.30pm	370.90	22.25	0.46	106	12	19.0									2.2
21 Dec 2015	35		338.70	20.32	0.42	121	12	10.0									0.5
22 Dec 2015	36		315.78	18.95	0.39	141.5	10	9.4									0.1
23 Dec 2015	37		300.51	18.03	0.37	150	12	12.7									1.6
24 Dec 2015	38	12pm	285.24	17.11	0.35	158.5	18	8.0									0.1
25 Dec 2015	39	1pm	254.07	15.24	0.31	172	18	8.5									4.5
26 Dec 2015	40		241.15	14.47	0.30	199	17.6	6.0									2.5
27 Dec 2015	41		192.82	11.57	0.24	195.4	14	8.7									4.4
28 Dec 2015	42		163.23	9.79	0.20	208.3	13	19.1									6.0
29 Dec 2015	43	5pm	248.60	14.92	0.31	228.5	20	23.0									3.3
Flow adjustment																	
30 Dec 2015	44	4pm	276.61	16.60	0.34	240	18	11.0									4.0
31 Dec2015	45	4pm	221.89	13.31	0.28	19	18	8.0									4.5
01 Jan 2016	46	10am	205.50	12.33	0.25	59	11	8.5									4.5
02 Jan 2016	47	7am	170.85	10.25	0.21	110	10	6.0									2.5
03 Jan 2016	48	8am	145.77	8.75	0.18	144.5	10	8.7									4.4
Flow adjustment																	
04 Jan 2016	49	10am	16.00	0.96	0.02	55	14	19.1									6.0
05 Jan 2016	50	7am	27.00	1.62	0.03	48	10	23.0									3.3
06 Jan 2016	51	9am	20.23	1.21	0.03	58	14	11.0									4.0
07 Jan 2016	52	9am	15.00	0.90	0.02	56	15	19.1									6.0

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
08 Jan 2016	53	4pm	24.00	1.44	0.03	75	22	23.0									3.3
09 Jan2016	54	10am	29.00	1.74	0.04	145.5	14	11.0									4.0

Table B-2: Turbidity on 2nd cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
2nd cycle with filter ripening								2nd cycle with filter ripening									
10 Jan 2016	1	9am	165.00	9.90	0.20	2.9	11										
11 Jan 2016	2	9am	85.26	5.12	0.11	2	12	11.0	5.2	8.0	6.1	13.1	9.3	8.2	8.1	15.1	4.0
12 Jan 2016	3	7am	82.00	4.92	0.10	6	10	8.0	6.1	6.0	3.8	6.4	3.7	6.4	4.7	5.5	0.1
13 Jan 2016	4	7am	130.00	7.80	0.16	11	10	8.5	5.4	14.2	6.1	6.3	6.7	5.2	4.1	5.2	4.5
14 Jan 2016	5	9am	82.00	4.92	0.10	11	10	6.0	8.2	6.1	16.6	8.5	8.3	13.3	10.3	6.4	2.5
15 Jan 2016	6	11am	83.00	4.98	0.10	6	16	8.7	12.0	10.6	27.0	19.4	22.0	19.1	24.0	12.5	4.4
16 Jan 2016	7	1pm	77.00	4.62	0.10	7	19										
Flow adjustment								Flow adjustment									
16 Jan 2016	7	1pm	135.00	8.10	0.17	9	19	19.1	7.3	11.4	13.2	10.1	12.7	13.6	12.8	9.1	4.0
17 Jan 2016	8	5pm	118.00	7.08	0.15	22.5	17	23.0	20.6	20.0	26.0	18.4	18.9	19.4	9.5	18.2	3.3
18 Jan 2016	9	8am	119.00	7.14	0.15	28.2	10										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
19 Jan 2016	10	9am	120.00	7.20	0.15	19.8	10										
20 Jan 2016	11	9am	122.00	7.32	0.15	16.9	10										
21 Jan 2016	12	7.30 am	120.00	7.20	0.15	15.2	10										
22 Jan 2016	13	9am	130.00	7.80	0.16	14	11										
23 Jan 2016	14	9am	134.00	8.04	0.17	12	11										
24 Jan 2016	15	7am	118.00	7.08	0.15	14.3	7.5										
25 Jan 2016	16	10am	122.00	7.32	0.15	11.9	17										
26 Jan 2016	17	5pm	118.00	7.08	0.15	11.5	17										
27 Jan 2016	18	8am	104.00	6.24	0.13	14.5	9										
28 Jan 2016	19	11am	93.00	5.58	0.12	13.5	10										
29 Jan 2016	20	4pm	82.00	4.92	0.10	12.5	11										
30 Jan 2016	21	9am	86.00	5.16	0.11	16	9										
31 Jan 2016	22	10am	80.00	4.80	0.10	14	13										
01 Feb 2016	23	12pm	70.00	4.20	0.09	13	21										
02 Feb 2016	24	3pm	60.00	3.60	0.07	7	24										
03 Feb 2016	25	10am	50.00	3.00	0.06	8	11										
04 Feb 2016	26	4pm	54.00	3.24	0.07	8	21										
Flow adjustment								Flow adjustment									
04 Feb 2016	26	5pm	252.00	15.12	0.31	13	21										
05 Feb 2016	27	7am	241.58	14.49	0.30	28	11										
06 Feb 2016	28	6pm	208.00	12.48	0.26	33.5	18										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
07 Feb 2016	29	5pm	240.00	14.40	0.30	16.5	21										
08 Feb 2016	30	10am	240.00	14.40	0.30	12.5	14										
09 Feb 2016	31	9am	232.00	13.92	0.29	17.5	12										
10 Feb 2016	32	4pm	227.59	13.66	0.28	21.5	21										
11 Feb 2016	33	1pm	232.50	13.95	0.29	33.5	23										
12 Feb 2016	34	4pm	231.22	13.87	0.29	22	22										
13 Feb 2016	35	5pm	260.00	15.60	0.32	31.5	22										
14 Feb 2016	36	8am	320.00	19.20	0.40	50.5	15	21.0	19.4	30.0	31.0	27.0	21.0	33.0	24.0	12.0	5.6
15 Feb 2016	37	3pm	211.62	12.70	0.26	39	22										
16 Feb 2016	38	11am	206.19	12.37	0.26	38.5	19	12.2	12.2	66.0	49.0	31.0	28.0	44.0	38.0	20.0	5.7
17 Feb 2016	39	8am	203.40	12.20	0.25	60	14	15.2	13.5	39.0	49.0	34.0	37.0	50.0	32.0	29.0	5.0
18 Feb 2016	40	2pm	200.00	12.00	0.25	43.5	27	13.6	13.9	44.0	45.0	33.0	36.0	56.0	38.0	24	4.7
19 Feb 2016	41	2pm	208.00	12.48	0.26	40.5	27										
20 Feb 2016	42	5pm	128.00	7.68	0.16	37.5	21										
21 Feb 2016	43	5pm	60.00	3.60	0.07	46	25										
22 Feb 2016	44	5pm	104.67	6.28	0.13	51.5	27										
23 Feb 2016	45	7am	161.39	9.68	0.20	60	13										
24 Feb2016	46	4pm	106.00	6.36	0.13	70.5	25										
25 Feb 2016	47	8am	102.00	6.12	0.13	71.5	14										
26 Feb 2016	48	2pm	189.72	11.38	0.24	73.5	27										
27 Feb 2016	49	12pm	150.00	9.00	0.19	76.5	24										

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
Flow adjustment								Flow adjustment									
27 Feb 2016	49	1pm	441.60	26.50	0.55	23.5	24										
28 Feb 2016	50	8am	141.00	8.46	0.17	83	14										
Flow adjustment								Flow adjustment									
28 Feb 2016	50	9am	165.00	9.90	0.20	90	14										
29 Feb 2016	51	8am	68.00	4.08	0.08	95	14	17.4	29.0	27.0	31.0	31.0	26.0	33.0	32.0	28.0	1.6
01 Mar 2016	52	12pm	68.00	4.08	0.08	95	28	19.2	18.5	12.8	15.7	19.9	12.4	12.3	12.4	14.5	2.0

Table B-3: Turbidity on 3rd cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
3rd Cycle with filter ripening								3rd Cycle with filter ripening									
01 Mar 2016	0	5pm	397.95	23.88	0.49	7	23										
02 Mar 2016	1	8am	360.67	21.64	0.45	9	17	9.4	23.0	18.0	26.0	25.0	23.0	27.0	26.0	27.1	3.3
03 Mar 2016	2	6am	364.00	21.84	0.45	10.5	22	14.9	10.0	8.8	15.3	10.6	8.2	11.9	7.6	9.2	4.7
04 Mar 2016	3	8am	341.00	20.46	0.42	20.5	11	20.5	12.0	19.4	32.0	16.6	15.6	20.0	26.0	12.5	1.6
05 Mar 2016	4	8am	329.41	19.76	0.41	28.5	18	10.0	11.9	21.0	49.0	25.0	24.0	33.0	23.0	16.3	1.3
06 Mar 2016	5	8am	262.57	15.75	0.33	42.5	17	13.8	13.6	18.4	17.0	13.2	10.0	13.1	11.2	11.3	4.6

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
07 Mar 2016	6	9am	432.00	25.92	0.54	25	19	17.0	11.7	16.7	46.0	26.0	20.5	31.0	31.0	18.7	4.2
08 Mar 2016	7	4pm	292.00	17.52	0.36	26.5	25	17.4	15.7	34.0	41.0	37.0	14.9	34.0	20.0	11.6	3.1
09 Mar 2016	8	5pm	294.00	17.64	0.36	26.5	24	17.7	12.1	27.0	34.0	13.6	19.0	27.0	24.0	8.4	2.3
10 Mar 2016	9	4pm	276.00	16.56	0.34	29	27	14.6	13.2	47.0	61.0	24.0	38.0	55.0	25.0	19.5	2.7
11 Mar 2016	10	1pm	255.00	15.30	0.32	39	28	16.9	13.6	27.0	49.0	27.0	29.0	55.0	38.0	24.0	5.1
12 Mar 2016	11	1pm	124.00	7.44	0.15	75	29	23.0	15.6	39.0	47.0	26.0	27.0	32.0	22.0	34.0	4.3
Flow adjustment								Flow adjustment									
12 Mar 2016	11	2pm	419.00	25.14	0.52	87	25										
13 Mar 2016	12	8am	314.76	18.89	0.39	47	19	6.3	18.0	30.0	35.0	27.0	16.8	43.0	26.0	14.0	3.2
14 Mar 2016	13	11am	212.00	12.72	0.26	71	24	8.7	5.3	28	41	38	32	43	51	34	3.9
15 Mar 2016	14	2pm	207.00	12.42	0.26	72	27	4.0	4.1	48.0	69.0	56.0	14.6	58.0	46.0	27.0	1.6
Flow adjustment								Flow adjustment									
15 Mar 2016	14	3pm	368.00	22.08	0.46	85	23										
16 Mar 2016	15	8am	154.00	9.24	0.19	90	21	6.3	79	34	61	53	33	63	37	37	4.5
Flow adjustment								Flow adjustment									
16 Mar 2016	15	9am	164.00	9.84	0.20	95											
17 Mar 2016	16	8am	143.00	8.58	0.18	95	19	2.1	3.3	32	58	38	22	58	33	32	1.1
Flow adjustment								Flow adjustment									
17 Mar 2016	16	9am	314.00	18.84	0.39	13											
18 Mar 2016	17	8am	225.88	13.55	0.28	43	19	3.8	4.7	26	55	40	22.5	42	40	36	2.5
19 Mar 2016	18	1pm	170.85	10.25	0.21	63	29	5.3	4.5	4.6	62	56	35	61	47	52	1.4

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Turbidity (NTU)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
Flow adjustment								Flow adjustment									
19 Mar 2016	18	2pm	292.00	17.52	0.36	85											
20 Mar 2016	19	8am	203.32	12.20	0.25	87	19	5.8	44	26	77	30	32	27	22	30	1.4
Flow adjustment								Flow adjustment									
20 Mar 2016	19	9am	250.03	15.00	0.31	95											
21 Mar 2016	20	10am	240.00	14.40	0.30	95	29	10.5	14	72	81	50	31	57	34	23	0.5
22 Mar 2016	21	8am	242.00	14.52	0.30	95	19	8	7.7	32	83	23	22	47	23	18	2.3

Table B-4: Turbidity data based on HLR

Date	Filter run days	HLR (m3/m2/hr)	Turbidity (NTU)										Removal Efficiency	Average efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
HLR<0.1m/hr.														
04 Jan 2016	49	0.02	19.1									6.0	68.59	77.02
05 Jan 2016	50	0.03	23.0									3.3	85.65	
06 Jan 2016	51	0.03	11.0									4.0	63.64	
07 Jan 2016	52	0.02	19.1									6.0	68.59	
08 Jan 2016	53	0.03	23.0									3.3	85.65	
09 Jan 2016	54	0.04	11.0									4.0	63.64	

Date	Filter run days	HLR (m3/m2/hr)	Turbidity (NTU)										Removal Efficiency	Average efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
29 Feb 2016	51	0.08	17.4	29.0	27.0	31.0	31.0	26.0	33.0	32.0	28.0	1.6	90.80	
01 Mar 2016	52	0.08	19.2	18.5	12.8	15.7	19.9	12.4	12.3	12.4	14.5	2.0	89.58	
HLR 0.1m/hr-0.2m/hr.														
03 Jan 2016	48	0.18	8.7									4.4	49.43	62.62
11 Jan 2016	2	0.11	11.0	5.2	8.0	6.1	13.1	9.3	8.2	8.1	15.1	4.0	63.64	
12 Jan 2016	3	0.10	8.0	6.1	6.0	3.8	6.4	3.7	6.4	4.7	5.5	0.1	98.75	
13 Jan 2016	4	0.16	8.5	5.4	14.2	6.1	6.3	6.7	5.2	4.1	5.2	4.5	47.06	
14 Jan 2016	5	0.10	6.0	8.2	6.1	16.6	8.5	8.3	13.3	10.3	6.4	2.5	58.33	
15 Jan 2016	6	0.10	8.7	12.0	10.6	27.0	19.4	22.0	19.1	24.0	12.5	4.4	49.43	
16 Jan 2016	7	0.17	19.1	7.3	11.4	13.2	10.1	12.7	13.6	12.8	9.1	4.0	79.06	
17 Jan 2016	8	0.15	23.0	20.6	20.0	26.0	18.4	18.9	19.4	9.5	18.2	3.3	85.65	
12 Mar 2016	11	0.15	23.0	15.6	39.0	47.0	26.0	27.0	32.0	22.0	34.0	4.3	81.30	
16 Mar 2016	15	0.19	6.3	79	34	61	53	33	63	37	37	4.5	28.57	
17 Mar 2016	16	0.18	2.1	3.3	32	58	38	22	58	33	32	1.1	47.62	
HLR 0.2m/hr-0.3m/hr.														
26 Dec 2015	40	0.30	6.0									2.5	58.33	60.36
27 Dec 2015	41	0.24	8.7									4.4	49.43	
28 Dec 2015	42	0.20	19.1									6.0	68.59	
31 Dec 2015	45	0.28	8.0									4.5	43.75	
01 Jan 2016	46	0.25	8.5									4.5	47.06	
02 Jan 2016	47	0.21	6.0									2.5	58.33	

Date	Filter run days	HLR (m3/m2/hr)	Turbidity (NTU)										Removal Efficiency	Average efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
16 Feb 2016	38	0.26	12.2	12.2	66.0	49.0	31.0	28.0	44.0	38.0	20.0	5.7	53.28	
17 Feb 2016	39	0.25	15.2	13.5	39.0	49.0	34.0	37.0	50.0	32.0	29.0	5.0	67.11	
18 Feb 2016	40	0.25	13.6	13.9	44.0	45.0	33.0	36.0	56.0	38.0	24	4.7	65.44	
14 Mar 2016	13	0.26	8.7	5.3	28	41	38	32	43	51	34	3.9	55.17	
15 Mar 2016	14	0.26	4.0	4.1	48.0	69.0	56.0	14.6	58.0	46.0	27.0	1.6	60.00	
18 Mar 2016	17	0.28	3.8	4.7	26	55	40	22.5	42	40	36	2.5	34.21	
19 Mar 2016	18	0.21	5.3	4.5	4.6	62	56	35	61	47	52	1.4	73.58	
20 Mar 2016	19	0.25	5.8	44	26	77	30	32	27	22	30	1.4	75.86	
21 Mar 2016	20	0.30	11	14	72	81	50	31	57	34	23	0.5	95.24	
HLR 0.3m/hr-0.4m/hr.														
30 Nov 2015	14	0.35	6.0									1.1	81.67	81.06
01 Dec 2015	15	0.35	6.8									0.6	91.18	
02 Dec 2015	16	0.35	4.4									0.2	95.45	
03 Dec 2015	17	0.35	27.9									1.4	94.98	
04 Dec 2015	18	0.34	26.0									2.9	88.85	
05 Dec 2015	19	0.34	11.0									1.1	90.00	
06 Dec 2015	20	0.34	5.3									0.4	92.45	
07 Dec 2015	21	0.34	10.2									1.4	86.27	
22 Dec 2015	36	0.39	9.4									0.1	98.94	
23 Dec 2015	37	0.37	12.7									1.6	87.40	
24 Dec 2015	38	0.35	8.0									0.1	98.75	

Date	Filter run days	HLR (m3/m2/hr)	Turbidity (NTU)										Removal Efficiency	Average efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
25 Dec 2015	39	0.31	8.5									4.5	47.06	
29 Dec 2015	43	0.31	23.0									3.3	85.65	
30 Dec 2015	44	0.34	11.0									4.0	63.64	
14 Feb 2016	36	0.40	21.0	19.4	30.0	31.0	27.0	21.0	33.0	24.0	12.0	5.6	73.33	
06 Mar 2016	5	0.33	13.8	13.6	18.4	17.0	13.2	10.0	13.1	11.2	11.3	4.6	66.67	
08 Mar 2016	7	0.36	17.4	15.7	34.0	41.0	37.0	14.9	34.0	20.0	11.6	3.1	82.18	
09 Mar 2016	8	0.36	17.7	12.1	27.0	34.0	13.6	19.0	27.0	24.0	8.4	2.3	87.01	
10 Mar 2016	9	0.34	14.6	13.2	47.0	61.0	24.0	38.0	55.0	25.0	19.5	2.7	81.51	
11 Mar 2016	10	0.32	16.9	13.6	27.0	49.0	27.0	29.0	55.0	38.0	24.0	5.1	69.82	
13 Mar 2016	12	0.39	6.3	18.0	30.0	35.0	27.0	16.8	43.0	26.0	14.0	3.2	49.21	
22 Mar 2016	21	0.30	8	7.7	32	83	23	22	47	23	18	2.3	71.25	
HLR > 0.4m/hr.														
24 Nov 2015	8	0.55	50.0									2.9	94.20	87.66
25 Nov 2015	9	0.56	16.7									1.4	91.62	
26 Nov 2015	10	0.52	11.8									1.2	89.83	
27 Nov 2015	11	0.51	13.4									0.3	97.76	
28 Nov 2015	12	0.47	12.6									1.4	88.89	
29 Nov 2015	13	0.48	4.1									0.2	95.12	
08 Dec 2015	22	0.61	19.5									1.1	94.36	
09 Dec 2015	23	0.58	2.4									0.1	95.83	
10 Dec 2015	24	0.56	6.0									0.3	95.00	

Date	Filter run days	HLR (m3/m2/hr)	Turbidity (NTU)										Removal Efficiency	Average efficiency
			Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout		
11 Dec 2015	25	0.55	7.0									1.3	81.43	
16 Dec 2015	30	0.50	4.6									1.3	71.74	
17 Dec 2015	31	0.49	27.0									1.5	94.44	
18 Dec 2015	32	0.46	32.0									1.1	96.56	
19 Dec 2015	33	0.49	10.5									1.8	82.86	
20 Dec 2015	34	0.46	19.0									2.2	88.42	
21 Dec 2015	35	0.42	10.0									0.5	95.00	
02 Mar 2016	1	0.45	9.4	23.0	18.0	26.0	25.0	23.0	27.0	26.0	27.1	3.3	64.89	
03 Mar 2016	2	0.45	14.9	10.0	8.8	15.3	10.6	8.2	11.9	7.6	9.2	4.7	68.46	
04 Mar 2016	3	0.42	20.5	12.0	19.4	32.0	16.6	15.6	20.0	26.0	12.5	1.6	92.20	
05 Mar 2016	4	0.41	10.0	11.9	21.0	49.0	25.0	24.0	33.0	23.0	16.3	1.3	87.00	
07 Mar 2016	6	0.54	17.0	11.7	16.7	46.0	26.0	20.5	31.0	31.0	18.7	4.2	75.29	

C. pH analysis data

Table C-1: pH on 2nd cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
2nd cycle with filter ripening								2nd cycle with filter ripening									
10 Jan 2016	1	9am	165.00	9.90	0.20	2.9	11	7.09	7.10	7.01	6.98	6.96	7.00	6.96	6.97	7.01	7.14
11 Jan 2016	2	9am	85.26	5.12	0.11	2	12	6.99	7.19	7.02	7.04	7.02	7.03	7.04	7.04	7.01	7.10
12 Jan 2016	3	7am	82.00	4.92	0.10	6	10	7.30	7.30	7.17	7.17	7.15	7.11	7.13	7.13	7.13	7.22
13 Jan 2016	4	7am	130.00	7.80	0.16	11	10	7.45	7.49	7.47	7.46	7.44	7.42	7.37	7.40	7.38	7.40
14 Jan 2016	5	9am	82.00	4.92	0.10	11	10	7.23	7.29	7.21	7.17	7.17	7.15	7.17	7.16	7.21	7.31
15 Jan 2016	6	11am	83.00	4.98	0.10	6	16	7.29	7.20	7.19	7.15	7.10	7.12	7.09	7.09	7.12	7.26
16 Jan 2016	7	1pm	77.00	4.62	0.10	7	19	7.18	7.42	7.26	7.27	7.26	7.26	7.20	7.17	7.23	7.35
Flow adjustment								Flow adjustment									
16 Jan 2016	7	1pm	135.00	8.10	0.17	9	19	7.18	7.42	7.26	7.27	7.26	7.26	7.20	7.17	7.23	7.35
17 Jan 2016	8	5pm	118.00	7.08	0.15	22.5	17	7.25	7.29	7.23	7.24	7.23	7.22	7.24	7.24	7.21	7.22
18 Jan 2016	9	8am	119.00	7.14	0.15	28.2	10	7.18	7.36	7.17	7.18	7.18	7.17	7.18	7.11	7.14	7.23
19 Jan 2016	10	9am	120.00	7.20	0.15	19.8	10	7.26	7.18	7.17	7.14	7.13	7.12	7.19	7.20	7.11	7.11
20 Jan 2016	11	9am	122.00	7.32	0.15	16.9	10	7.25	7.17	7.14	7.12	7.10	7.11	7.10	7.09	7.11	7.19
21 Jan 2016	12	7.30 am	120.00	7.20	0.15	15.2	10	7.12	7.10	7.12	7.16	7.10	7.11	7.10	7.08	7.08	7.18
22 Jan 2016	13	9am	130.00	7.80	0.16	14	11	7.24	7.32	7.27	7.23	7.18	7.15	7.15	7.18	7.19	7.21

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
23 Jan 2016	14	9am	134.00	8.04	0.17	12	11	7.11	7.21	7.16	7.12	7.12	7.12	7.10	7.12	7.15	7.27
24 Jan 2016	15	7am	118.00	7.08	0.15	14.3	7.5	7.34	7.35	7.33	7.25	7.28	7.22	7.23	7.19	7.20	7.30
25 Jan 2016	16	10am	122.00	7.32	0.15	11.9	17	7.20	7.16	7.14	7.08	7.07	7.07	7.05	7.07	7.12	7.29
26 Jan 2016	17	5pm	118.00	7.08	0.15	11.5	17	7.14	7.36	7.27	7.13	7.21	7.15	7.09	7.15	7.22	7.37
27 Jan 2016	18	8am	104.00	6.24	0.13	14.5	9	7.15	7.13	7.10	7.09	7.04	7.07	7.03	7.05	7.10	7.24
28 Jan 2016	19	11am	93.00	5.58	0.12	13.5	10	7.10	7.19	7.14	7.13	7.09	7.07	7.06	7.07	7.11	7.37
29 Jan 2016	20	4pm	82.00	4.92	0.10	12.5	11	7.04	7.24	7.18	7.16	7.13	7.07	7.08	7.09	7.10	7.40
30 Jan 2016	21	9am	86.00	5.16	0.11	16	9	7.10	7.09	7.06	7.03	7.04	7.08	7.06	7.09	7.12	7.49
31 Jan 2016	22	10am	80.00	4.80	0.10	14	13	6.96	7.02	7.00	6.98	6.97	6.95	6.96	6.99	7.00	7.31
01 Feb 2016	23	12pm	70.00	4.20	0.09	13	21	7.16	7.13	7.06	7.04	7.00	6.98	7.01	6.99	7.02	7.10
02 Feb 2016	24	3pm	60.00	3.60	0.07	7	24	7.18	7.25	7.25	7.13	7.13	7.10	7.11	7.10	7.12	7.52
03 Feb 2016	25	10am	50.00	3.00	0.06	8	11	7.15	7.31	7.27	7.22	7.19	7.17	7.18	7.19	7.20	7.57
04 Feb 2016	26	4pm	54.00	3.24	0.07	8	21	7.25	7.37	7.32	7.27	7.22	7.13	7.12	7.17	7.20	7.55
Flow adjustment								Flow adjustment									
04 Feb 2016	26	5pm	252.00	15.12	0.31	13	21	7.25	7.37	7.32	7.27	7.22	7.13	7.12	7.17	7.20	7.55
05 Feb 2016	27	7am	241.58	14.49	0.30	28	11	7.31	7.35	7.37	7.25	7.25	7.20	7.19	7.21	7.18	7.42
06 Feb 2016	28	6pm	208.00	12.48	0.26	33.5	18	7.33	7.46	7.27	7.30	7.35	7.31	7.28	7.30	7.37	7.39
07 Feb 2016	29	5pm	240.00	14.40	0.30	16.5	21	7.12	7.29	7.25	7.23	7.20	7.25	7.38	7.28	7.27	7.24
08 Feb 2016	30	10am	240.00	14.40	0.30	12.5	14	7.27	7.26	7.22	7.22	7.20	7.18	7.14	7.19	7.20	7.26
09 Feb 2016	31	9am	232.00	13.92	0.29	17.5	12	7.23	7.25	7.26	7.20	7.20	7.19	7.18	7.19	7.16	7.32
10 Feb 2016	32	4pm	227.59	13.66	0.28	21.5	21	7.17	7.25	7.17	7.14	7.16	7.12	7.07	7.07	7.12	7.28

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
11 Feb 2016	33	1pm	232.50	13.95	0.29	33.5	23	7.03	7.18	7.13	7.15	7.15	7.11	7.10	7.09	7.14	7.20
12 Feb 2016	34	4pm	231.22	13.87	0.29	22	22	7.01	7.20	7.18	7.18	7.19	7.20	7.20	7.23	7.26	7.41
13 Feb 2016	35	5pm	260.00	15.60	0.32	31.5	22	6.99	7.23	7.19	7.20	7.19	7.21	7.18	7.21	7.23	7.24
14 Feb 2016	36	8am	320.00	19.20	0.40	50.5	15	7.09	7.21	7.17	7.12	7.16	7.14	7.13	7.16	7.11	7.12
15 Feb 2016	37	3pm	211.62	12.70	0.26	39	22	7.15	7.28	7.25	7.23	7.25	7.24	7.20	7.24	7.23	7.49
16 Feb 2016	38	11am	206.19	12.37	0.26	38.5	19	7.18	7.27	7.18	7.20	7.17	7.19	7.19	7.17	7.21	7.32
17 Feb 2016	39	8am	203.40	12.20	0.25	60	14	7.28	7.34	7.30	7.28	7.26	7.27	7.25	7.25	7.22	7.35
18 Feb 2016	40	2pm	200.00	12.00	0.25	43.5	27	7.42	7.55	7.37	7.31	7.34	7.30	7.23	7.25	7.33	7.52
19 Feb 2016	41	2pm	208.00	12.48	0.26	40.5	27	7.14	7.43	7.44	7.49	7.45	7.37	7.42	7.43	7.54	7.57
20 Feb 2016	42	5pm	128.00	7.68	0.16	37.5	21	7.21	7.27	7.25	7.26	7.31	7.28	7.30	7.26	7.31	7.37
21 Feb 2016	43	5pm	60.00	3.60	0.07	46	25	7.17	7.28	7.23	7.29	7.27	7.26	7.30	7.32	7.36	7.43
22 Feb 2016	44	5pm	104.67	6.28	0.13	51.5	27	7.30	7.45	7.24	7.21	7.27	7.20	7.19	7.19	7.24	7.49
23 Feb 2016	45	7am	161.39	9.68	0.20	60	13	7.11	7.47	7.41	7.42	7.40	7.40	7.37	7.36	7.50	7.57
24 Feb 2016	46	4pm	106.00	6.36	0.13	70.5	25	7.25	7.31	7.17	7.24	7.25	7.17	7.23	7.27	7.50	7.56
25 Feb 2016	47	8am	102.00	6.12	0.13	71.5	14	7.22	7.40	7.25	7.22	7.22	7.23	7.19	7.21	7.22	7.52
26 Feb 2016	48	2pm	189.72	11.38	0.24	73.5	27	7.21	7.34	7.24	7.20	7.22	7.24	7.16	7.21	7.21	7.43
27 Feb 2016	49	12pm	150.00	9.00	0.19	76.5	24	7.24	7.31	7.25	7.17	7.20	7.18	7.17	7.19	7.20	7.44
Flow adjustment								Flow adjustment									
27 Feb 2016	49	1pm	441.60	26.50	0.55	23.5	24	7.24	7.31	7.25	7.17	7.20	7.18	7.17	7.19	7.20	7.44
28 Feb 2016	50	8am	141.00	8.46	0.17	83	14	7.22	7.26	7.21	7.17	7.20	7.12	7.13	7.16	7.17	7.29
Flow adjustment								Flow adjustment									

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
28 Feb 2016	50	9am	165.00	9.90	0.20	90	14	7.22	7.26	7.21	7.17	7.20	7.12	7.13	7.16	7.17	7.29
29 Feb 2016	51	8am	68.00	4.08	0.08	95	14	7.17	7.40	7.24	7.24	7.22	7.20	7.18	7.19	7.20	7.50
01 Mar 2016	52	12pm	68.00	4.08	0.08	95	28	7.27	7.40	7.32	7.25	7.25	7.19	7.23	7.23	7.25	7.53

Table: C-2 pH on 3rd cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
3rd Cycle with filter ripening								3rd Cycle with filter ripening									
01 Mar 2016	0	5pm	397.95	23.88	0.49	7	23	7.27	7.40	7.32	7.25	7.25	7.19	7.23	7.23	7.25	7.53
02 Mar 2016	1	8am	360.67	21.64	0.45	9	17	7.11	7.16	7.14	7.11	7.11	7.11	7.12	7.07	7.04	7.16
03 Mar 2016	2	6am	364.00	21.84	0.45	10.5	22	7.30	7.43	7.36	7.34	7.42	7.42	7.36	7.37	7.40	7.56
04 Mar 2016	3	8am	341.00	20.46	0.42	20.5	11	7.30	7.34	7.29	7.26	7.27	7.26	7.25	7.23	7.21	7.34
05 Mar 2016	4	8am	329.41	19.76	0.41	28.5	18	7.31	7.33	7.34	7.23	7.28	7.27	7.27	7.23	7.27	7.37
06 Mar 2016	5	8am	262.57	15.75	0.33	42.5	17	7.27	7.26	7.25	7.25	7.24	7.26	7.24	7.26	7.28	7.35
07 Mar 2016	6	9am	432.00	25.92	0.54	25	19	7.28	7.35	7.33	7.30	7.29	7.31	7.29	7.28	7.27	7.43
08 Mar 2016	7	4pm	292.00	17.52	0.36	26.5	25	7.18	7.27	7.22	7.18	7.18	7.22	7.20	7.20	7.25	7.29
09 Mar 2016	8	5pm	294.00	17.64	0.36	26.5	24	7.21	7.34	7.27	7.24	7.32	7.28	7.26	7.29	7.28	7.35
10 Mar 2016	9	4pm	276.00	16.56	0.34	29	27	7.20	7.32	7.22	7.20	7.27	7.26	7.19	7.24	7.27	7.36

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
11 Mar 2016	10	1pm	255.00	15.30	0.32	39	28	7.15	7.32	7.24	7.15	7.24	7.22	7.18	7.18	7.20	7.41
12 Mar 2016	11	1pm	124.00	7.44	0.15	75	29	7.27	7.34	7.30	7.28	7.30	7.30	7.26	7.24	7.23	7.56
Flow adjustment								Flow adjustment									
12 Mar 2016	11	2pm	419.00	25.14	0.52	87	25										
13 Mar 2016	12	8am	314.76	18.89	0.39	47	19	7.30	7.32	7.29	7.27	7.28	7.29	7.28	7.287.	7.27	7.40
14 Mar 2016	13	11am	212.00	12.72	0.26	71	24	7.35	7.38	7.34	7.28	7.30	7.34	7.31	7.33	7.33	7.42
15 Mar 2016	14	2pm	207.00	12.42	0.26	72	27	7.36	7.46	7.38	7.33	7.34	7.38	7.33	7.32	7.33	7.51
Flow adjustment								Flow adjustment									
15 Mar 2016	14	3pm	368.00	22.08	0.46	85	23										
16 Mar 2016	15	8am	154.00	9.24	0.19	90	21	7.22	7.24	7.19	7.17	7.18	7.20	7.18	7.15	7.15	7.46
Flow adjustment								Flow adjustment									
16 Mar 2016	15	9am	164.00	9.84	0.20	95											
17 Mar 2016	16	8am	143.00	8.58	0.18	95	19	7.21	7.40	7.31	7.26	7.28	7.31	7.26	7.25	7.23	7.44
Flow adjustment								Flow adjustment									
17 Mar 2016	16	9am	314.00	18.84	0.39	13											
18 Mar 2016	17	8am	225.88	13.55	0.28	43	19	7.21	7.27	7.23	7.20	7.21	7.23	7.18	7.19	7.20	7.35
19 Mar 2016	18	1pm	170.85	10.25	0.21	63	29	7.06	7.22	7.09	7.07	7.10	7.14	7.08	7.08	7.05	7.44
Flow adjustment								Flow adjustment									
19 Mar 2016	18	2pm	292.00	17.52	0.36	85											
20 Mar 2016	19	8am	203.32	12.20	0.25	87	19	7.10	7.16	7.09	7.02	7.07	7.08	7.07	7.06	7.03	7.32
Flow adjustment								Flow adjustment									

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	pH									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
20 Mar 2016	19	9am	250.03	15.00	0.31	95											
21 Mar 2016	20	10am	240.00	14.40	0.30	95	29	7.05	7.22	7.05	6.99	7.03	7.06	6.99	6.99	7.00	7.31
22 Mar 2016	21	8am	242.00	14.52	0.30	95	19	7.17	7.37	7.24	7.16	7.28	7.32	7.26	7.25	7.28	7.5

D. Temperature analysis data

Table D-1: Temperature on 2nd Cycle

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
2nd cycle with filter ripening								2nd cycle with filter ripening									
10 Jan 2016	1	9am	165.00	9.90	0.20	2.9	11	14.70	14.2	14.8	14.8	14.8	14.6	15.3	15.7	14.9	14.1
11 Jan 2016	2	9am	85.26	5.12	0.11	2	12	13.60	12.8	13.3	13.7	13.7	13.7	13.8	13.4	13.1	13.7
12 Jan 2016	3	7am	82.00	4.92	0.10	6	10	9.60	9.3	9.2	9.1	9.0	9.0	9.1	9.3	9.3	9.2
13 Jan 2016	4	7am	130.00	7.80	0.16	11	10	11.10	9.9	9.6	9.3	9.3	9.3	9.3	9.2	9.2	9.4
14 Jan 2016	5	9am	82.00	4.92	0.10	11	10	12.10	11.2	11.0	10.8	11.0	11.0	11.0	11.1	10.8	11.2
15 Jan 2016	6	11am	83.00	4.98	0.10	6	16	18.00	17.6	17.7	17.9	17.7	18.2	17.7	18.2	18.6	18.8
16 Jan 2016	7	1pm	77.00	4.62	0.10	7	19	20.20	19.9	19.2	18.1	17.7	17.4	17.3	17.2	17.3	17.1
Flow adjustment								Flow adjustment									
16 Jan 2016	7	1pm	135.00	8.10	0.17	9	19	20.2	19.9	19.2	18.1	17.7	17.4	17.3	17.2	17.3	17.1
17 Jan 2016	8	5pm	118.00	7.08	0.15	22.5	17	14.8	15.7	16.1	16.1	16.2	16.1	15.9	15.8	15.7	15.2
18 Jan 2016	9	8am	119.00	7.14	0.15	28.2	10	8.6	8.7	8.3	8.1	8.1	8.0	7.9	9.8	7.7	7.5
19 Jan 2016	10	9am	120.00	7.20	0.15	19.8	10	11.7	10.2	9.9	9.6	9.6	9.4	9.2	9.7	9.2	9.8
20 Jan 2016	11	9am	122.00	7.32	0.15	16.9	10	12.2	11.5	11.4	11.3	11.2	11.1	10.9	10.8	10.8	10.6

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
21 Jan 2016	12	7.30 am	120.00	7.20	0.15	15.2	10	10.3	9.7	9.6	9.6	94.0	9.4	9.4	9.4	9.4	9.4
22 Jan 2016	13	9am	130.00	7.80	0.16	14	11	11.6	11.2	11.2	11.2	11.4	11.4	11.5	11.5	11.4	12.8
23 Jan 2016	14	9am	134.00	8.04	0.17	12	11	11.9	11.4	11.4	11.2	11.1	11.2	11.4	10.9	10.8	10.8
24 Jan 2016	15	7am	118.00	7.08	0.15	14.3	7.5	7.1	6.6	6.7	6.6	6.7	6.8	7.0	7.2	7.3	7.1
25 Jan 2016	16	10am	122.00	7.32	0.15	11.9	17	15.3	14.3	14.8	14.7	14.6	14.6	14.4	14.2	14.0	13.7
26 Jan 2016	17	5pm	118.00	7.08	0.15	11.5	17	13.9	14.8	14.9	14.7	14.6	14.3	14.1	14.1	13.9	13.8
27 Jan 2016	18	8am	104.00	6.24	0.13	14.5	9	9.9	10.7	9.1	8.7	8.7	8.8	8.7	9.0	9.6	10.6
28 Jan 2016	19	11am	93.00	5.58	0.12	13.5	10	12.3	13.4	12.8	12.5	12.5	12.5	12.4	12.5	12.6	12.5
29 Jan 2016	20	4pm	82.00	4.92	0.10	12.5	11	14.6	16.1	16.4	16.3	16.3	16.2	16.1	15.9	15.6	14.3
30 Jan 2016	21	9am	86.00	5.16	0.11	16	9	12.9	12.6	12.8	12.4	12.4	12.4	12.6	12.4	12.6	13.3
31 Jan 2016	22	10am	80.00	4.80	0.10	14	13	14.7	12.6	12.7	12.6	12.4	12.4	12.3	12.2	12.1	13.2
01 Feb 2016	23	12pm	70.00	4.20	0.09	13	21	17.3	16.4	16.6	15.7	15.8	16.8	15.9	15.8	15.7	15.3
02 Feb 2016	24	3pm	60.00	3.60	0.07	7	24	19.1	18.1	18.8	18.6	18.1	17.8	17.9	19.7	17.5	17.3
03 Feb 2016	25	10am	50.00	3.00	0.06	8	11	15.3	13.6	13.6	13.3	13.1	12.9	12.8	12.7	12.7	14.2
04 Feb 2016	26	4pm	54.00	3.24	0.07	8	21	17.7	17.5	17.9	17.7	17.9	17.9	17.7	17.5	16.7	17.2
Flow adjustment								Flow adjustment									
04 Feb 2016	26	5pm	252.00	15.12	0.31	13	21	17.7	17.5	17.9	17.7	17.9	17.9	17.7	17.5	16.7	17.2
05 Feb 2016	27	7am	241.58	14.49	0.30	28	11	21.4	22.4	23.2	26.6	25.9	27.1	27.1	27.8	27.3	27.6
06 Feb 2016	28	6pm	208.00	12.48	0.26	33.5	18	15.5	15.9	16.3	16.7	16.8	17.8	17.2	17.2	17.1	17.1
07 Feb 2016	29	5pm	240.00	14.40	0.30	16.5	21	17.6	18.4	19.2	19.6	19.8	20.0	19.8	19.9	19.6	19.2
08 Feb 2016	30	10am	240.00	14.40	0.30	12.5	14	13.7	13.2	13.2	13.2	13.2	13.1	13.0	13.0	12.9	12.9

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
09 Feb 2016	31	9am	232.00	13.92	0.29	17.5	12	13.3	12.6	12.5	12.3	12.2	12.0	12.1	12.0	12.2	12.5
10 Feb 2016	32	4pm	227.59	13.66	0.28	21.5	21	17.7	18.7	19.4	19.8	20.1	20.0	20.2	20.2	20.0	19.0
11 Feb 2016	33	1pm	232.50	13.95	0.29	33.5	23	20.1	23.3	20.1	19.9	19.9	19.3	19.4	19.3	19.1	18.8
12 Feb 2016	34	4pm	231.22	13.87	0.29	22	22	18.7	20.1	20.7	21.1	21.0	20.9	20.8	20.6	20.4	18.0
13 Feb 2016	35	5pm	260.00	15.60	0.32	31.5	22	18.7	19.9	20.5	20.6	20.7	20.5	20.2	20.2	19.9	20.0
14 Feb 2016	36	8am	320.00	19.20	0.40	50.5	15	14.3	14.1	14.3	14.2	14.5	14.3	14.5	14.4	14.8	15.5
15 Feb 2016	37	3pm	211.62	12.70	0.26	39	22	20.3	21.3	22.1	22.6	22.5	22.4	22.3	22.1	21.4	19.8
16 Feb 2016	38	11am	206.19	12.37	0.26	38.5	19	19.2	19.2	18.9	18.8	18.3	18.2	18.0	17.6	17.6	18.8
17 Feb 2016	39	8am	203.40	12.20	0.25	60	14	14.4	14.1	14.1	13.8	13.6	13.4	13.4	13.6	13.6	14.5
18 Feb 2016	40	2pm	200.00	12.00	0.25	43.5	27	21.8	22.9	24.2	24.1	24.0	23.8	23.3	23.6	22.8	22.1
19 Feb 2016	41	2pm	208.00	12.48	0.26	40.5	27	23.8	24.4	25.3	25.1	24.9	24.8	24.8	24.5	24.4	24.2
20 Feb 2016	42	5pm	128.00	7.68	0.16	37.5	21	19.8	20.4	20.4	20.3	20.0	19.9	20.1	20.0	20.0	19.9
21 Feb 2016	43	5pm	60.00	3.60	0.07	46	25	19.8	21.9	22.2	22.3	21.7	22.3	21.8	21.6	20.6	22.6
22 Feb 2016	44	5pm	104.67	6.28	0.13	51.5	27	22.7	22.2	20.6	22.1	23.2	23.6	23.8	23.9	23.6	23.3
23 Feb 2016	45	7am	161.39	9.68	0.20	60	13	14.8	13.4	13.1	13.0	13.1	13.2	13.2	13.4	13.5	13.9
24 Feb 2016	46	4pm	106.00	6.36	0.13	70.5	25	18.7	17.8	17.9	17.9	17.9	17.8	18.8	18.9	19.1	18.8
25 Feb 2016	47	8am	102.00	6.12	0.13	71.5	14	15.3	14.5	14.4	14.2	13.9	14.0	13.9	13.9	14.0	14.7
26 Feb 2016	48	2pm	189.72	11.38	0.24	73.5	27	21.9	21.6	21.4	21.2	21.2	21.2	21.2	21.1	20.9	20.2
27 Feb 2016	49	12pm	150.00	9.00	0.19	76.5	24	21.6	21.0	20.9	20.5	20.4	20.5	20.7	20.7	20.4	20.0
Flow adjustment								Flow adjustment									
27 Feb 2016	49	1pm	441.60	26.50	0.55	23.5	24	21.6	21.0	20.9	20.5	20.4	20.5	20.7	20.7	20.4	20.0

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
28 Feb 2016	50	8am	141.00	8.46	0.17	83	14	15.3	15.2	15.3	15.3	15.2	15.1	15.1	15.1	15.7	14.7
Flow adjustment								Flow adjustment									
28 Feb 2016	50	9am	165.00	9.90	0.20	90	14	15.30	15.20	15.30	15.30	15.20	15.10	15.10	15.10	15.70	14.70
29 Feb 2016	51	8am	68.00	4.08	0.08	95	14	16.80	17.30	16.70	16.40	16.10	15.80	15.90	16.00	15.80	16.90
01 Mar 2016	52	12pm	68.00	4.08	0.08	95	28	22.30	22.90	23.10	23.20	23.50	23.80	23.80	23.80	23.70	21.10

Table D-2: Temperature on 3rd cycle

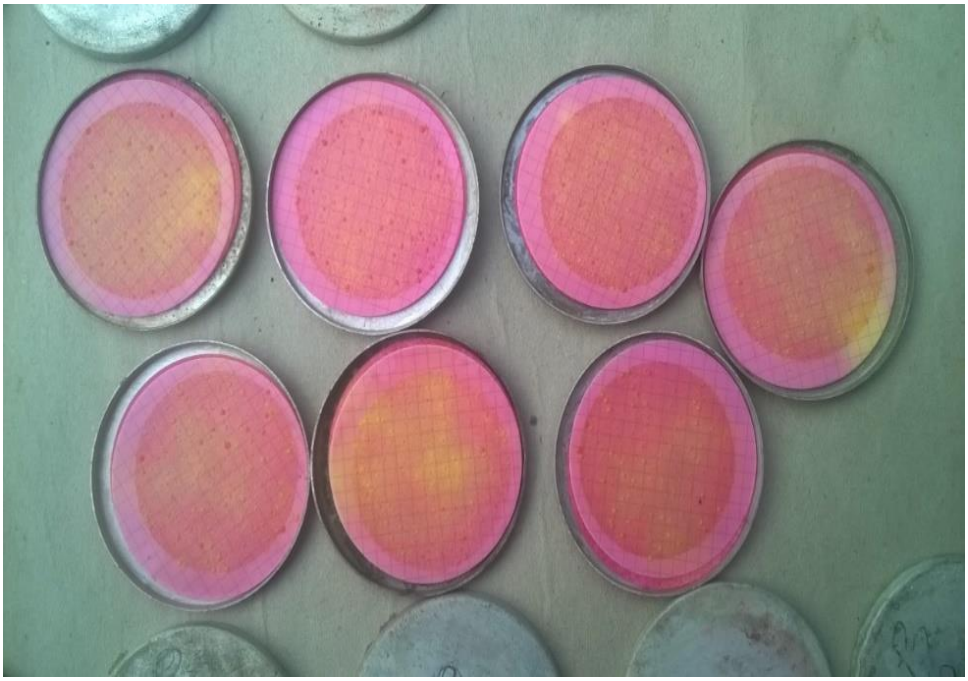
Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
3rd Cycle with filter ripening								3rd Cycle with filter ripening									
01 Mar 2016	0	5pm	397.95	23.88	0.49	7	23	22.3	22.9	23.1	23.2	23.5	23.8	23.8	23.8	23.7	21.1
02 Mar 2016	1	8am	360.67	21.64	0.45	9	17	19.1	16.4	16.2	16.1	15.9	15.8	16.6	15.9	16.1	16.3
03 Mar 2016	2	6am	364.00	21.84	0.45	10.5	22	19.9	20.0	20.2	20.4	20.4	20.4	20.6	20.7	20.7	20.3
04 Mar 2016	3	8am	341.00	20.46	0.42	20.5	11	16.4	15.2	15.4	15.3	15.2	15.4	15.3	15.2	15.3	15.5
05 Mar 2016	4	8am	329.41	19.76	0.41	28.5	18	17.9	17.4	17.3	17.4	17.3	17.3	17.2	17.1	17.1	17.1
06 Mar 2016	5	8am	262.57	15.75	0.33	42.5	17	16.4	15.1	15.0	15.2	14.8	14.8	14.7	14.7	14.6	15.4
07 Mar 2016	6	9am	432.00	25.92	0.54	25	19	17.3	19.2	19.4	19.6	20.2	20.9	20.0	20.2	20.8	19.9

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
08 Mar 2016	7	4pm	292.00	17.52	0.36	26.5	25	23.6	25.7	25.8	25.6	25.1	25.5	25.0	24.8	24.7	24.8
09 Mar 2016	8	5pm	294.00	17.64	0.36	26.5	24	22.3	24.7	24.3	24.2	24.2	23.9	23.9	23.7	23.8	24.5
10 Mar 2016	9	4pm	276.00	16.56	0.34	29	27	24.4	26.7	26.8	26.5	26.2	26.3	26.3	25.9	26.0	25.9
11 Mar 2016	10	1pm	255.00	15.30	0.32	39	28	24.4	26.9	27.7	27.6	27.5	27.4	27.1	26.9	26.9	25.6
12 Mar 2016	11	1pm	124.00	7.44	0.15	75	29	24.1	25.6	25.2	26.3	26.3	26.2	26.2	26.2	25.8	25.6
Flow adjustment								Flow adjustment									
12 Mar 2016	11	2pm	419.00	25.14	0.52	87	25										
13 Mar 2016	12	8am	314.76	18.89	0.39	47	19	20.3	20.0	20.1	19.9	19.7	19.7	19.5	19.4	19.4	19.6
14 Mar 2016	13	11am	212.00	12.72	0.26	71	24	22.9	21.9	21.9	21.8	21.8	21.8	21.7	21.6	21.3	21.7
15 Mar 2016	14	2pm	207.00	12.42	0.26	72	27	21.9	24.4	24.8	24.6	24.7	24.7	24.3	23.9	23.8	23.0
Flow adjustment								Flow adjustment									
15 Mar 2016	14	3pm	368.00	22.08	0.46	85	23										
16 Mar 2016	15	8am	154.00	9.24	0.19	90	21	20.5	19.2	20.4	19.6	19.1	18.9	18.8	18.7	18.8	18.5
Flow adjustment								Flow adjustment									
16 Mar 2016	15	9am	164.00	9.84	0.20	95											
17 Mar 2016	16	8am	143.00	8.58	0.18	95	19	20.9	20.4	20.0	19.5	19.1	18.8	18.7	18.4	18.4	17.7
Flow adjustment								Flow adjustment									
17 Mar 2016	16	9am	314.00	18.84	0.39	13											
18 Mar 2016	17	8am	225.88	13.55	0.28	43	19	19.3	17.8	17.9	17.9	17.8	17.7	17.4	17.5	17.4	18.0
19 Mar 2016	18	1pm	170.85	10.25	0.21	63	29	24.8	26.4	26.7	26.6	26.4	26.2	26.3	26.4	26.4	25.3
Flow adjustment								Flow adjustment									

Date	Filter run days	Time	Q (ml/min)	Q (ltr/hr)	HLR (m3/m2/hr)	H_f (cm)	Supernatant Water temp (˚C)	Temperature (˚C)									
								Pin	P1	P2	P3	P4	P5	P6	P7	P8	Pout
19 Mar 2016	18	2pm	292.00	17.52	0.36	85											
20 Mar 2016	19	8am	203.32	12.20	0.25	87	19	20.4	19.2	19.4	19.9	19.7	19.3	19.2	19.0	19.2	19.7
Flow adjustment								Flow adjustment									
20 Mar 2016	19	9am	250.03	15.00	0.31	95											
21 Mar 2016	20	10am	240.00	14.40	0.30	95	29	29.6	28.6	27.8	27.6	27.2	27.2	26.8	26.7	26.8	26.8
22 Mar 2016	21	8am	242.00	14.52	0.30	95	19	15.7	16.1	17.2	17.2	17.5	17.2	16.1	16.8	16.7	15.3

E. Photographs

E-1. Acid loss test in Public Health Lab



E-2. Development of total coliform colonies during testing

E.3 Filter setup installed at ECD, IOE

E.4 Fabrication at factory

E.5 Wagtech Field Test Kit

E.6 Wagtech Field Test Kit

E. Water parameter test report

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Ministry of Water Supply and Sanitation
Department of Water Supply and Sewerage

Central Water Quality Testing Laboratory
Panipokhari, Kathmandu

WATER QUALITY TEST REPORT

Name of Client:- Arjun Adhikari (**069-MSE-901**)
Sampled By:- Client
Source of Sample:- Well (ECD)

Date of Collection:- 2072/11/13
Date of Analysis:- 2072/11/13
Date of Completion:- 2072/11/20

Location : Pulchowk, Lalitpur
GPS:-

S.No.	Category	Parameters	Observed Values	NDWQS, 2062 BS	Methods Used
1	Physical	Turbidity (NTU)	10.9	5 (10)	2130 B, APHA, 21st EDITION
2		Temp. ^{0}c	17	-	2550 B, APHA, 21st EDITION
3		pH	6.8	6.5 - 8.5 *	4500-H$^+$ B, APHA, 21st EDITION
4		Electrical Conductivity (µs/cm)	845	1500	2510 B, APHA, 21st EDITION
5	Chemical	Iron (mg/L)	0.6	0.3 (3)	3111 B. APHA, 21st EDITION
6		Manganese (mg/L)	0.4	0.2	3111 B. APHA, 21st EDITION
7		Arsenic (mg/L)	<0.01	0.05	3114 C, APHA, 21st EDITION
8		Ammonia (mg/L)	<0.2	1.5	4500-NH3 C.,APHA, 17th EDITION
9		Nitrate (mg/L)	17.1	50	4500-No3-B.,APHA, 21st EDITION
10		Fluoride (mg/L)	0.3	0.5-1.5*	4500-D.APHA.21st EDITION
11		Total Hardness (mg/L as $CaCO_3$)	196	500	2340 C, APHA, 21st EDITION
12		Calcium Hardness (mg/L)	68.9	200	3500-Ca B. APHA, 21st EDITION
13		Residual Chlorine (mg/L)	-	0.1-0.2*	COLORIMETRY
14	Microbiological	Faecal coliform *E.coli*(CFU/100 ml)	0	0	9222 D., APHA.21st EDITION
15		Total Coliform (CFU/100ml)	10	0 in 95% samples	9222 B., APHA,21st EDITION

APHA: American Public Health Association, Standard Methods for Examination of Water & Waste Water
** These values show lower and upper limits.*
( ) Values in parentheses refer the acceptable values only when alternative is not available.

Note: - The entire test was conducted as per the National Drinking Water Quality Standard Guide Line, 2062BS

Analyzed By:

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Ministry of Water Supply and Sanitation
Department of Water Supply and Sewerage

Central Water Quality Testing Laboratory
Panipokhari, Kathmandu

WATER QUALITY TEST REPORT

Name of Client:- Arjun Adhikari (069-MSE-901)
Sampled By:- Client
Source of Sample:- SSF outlet, ECD

Date of Collection:- 2072/11/13
Date of Analysis:- 2072/11/13
Date of Completion:- 2072/11/20

Location : Pulchowk, Lalitpur
GPS:-

S.No.	Category	Parameters	Observed Values	NDWQS, 2062 BS	Methods Used
1	Physical	Turbidity (NTU)	0.5	5 (10)	2130 B, APHA, 21st EDITION
2		Temp. ^{0}c	17	-	2550 B, APHA, 21st EDITION
3		pH	7.2	6.5 - 8.5 *	4500-H$^+$ B, APHA, 21st EDITION
4		Electrical Conductivity (µs/cm)	854	1500	2510 B, APHA, 21st EDITION
5	Chemical	Iron (mg/L)	<0.2	0.3 (3)	3111 B. APHA, 21st EDITION
6		Manganese (mg/L)	<0.2	0.2	3111 B. APHA, 21st EDITION
7		Arsenic (mg/L)	—	0.05	3114 C, APHA, 21st EDITION
8		Ammonia (mg/L)	<0.2	1.5	4500-NH3 C..APHA, 17th EDITION
9		Nitrate (mg/L)	19.2	50	4500-No3-B..APHA, 21st EDITION
10		Fluoride (mg/L)	0.3	0.5-1.5*	4500-D.APHA,21st EDITION
11		Total Hardness (mg/L as $CaCO_3$)	202	500	2340 C, APHA, 21st EDITION
12		Calcium Hardness (mg/L)	73.4	200	3500-Ca B. APHA, 21st EDITION
13		Residual Chlorine (mg/L)		0.1-0.2*	COLORIMETRY
14	Microbiological	Faecal coliform *E.coli*(CFU/100 ml)	0	0	9222 D., APHA.21st EDITION
15		Total Coliform (CFU/100ml)	3	0 in 95% samples	9222 B., APHA.21st EDITION

APHA: *American Public Health Association, Standard Methods for Examination of Water & Waste Water*
** These values show lower and upper limits.*
( ) Values in parentheses refer the acceptable values only when alternative is not available.

Note: - The entire test was conducted as per the National Drinking Water Quality Standard Guide Line, 2062BS

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