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"Design of Water Treatment Plan in Birgunj"

Course: Environmental Engineering (CLE1006)

A PROJECT REPORT

Submitted in partial fulfillment for the award of the degree of

Bachelor of Technology

In

CIVIL ENGINEERING

By

Deepak Dulal - 18BCL0267

Ujjwal Rauniyar - 20BCL0130

Ambikesh Kumar Sah - 20BCL0144

Krrishtina Shrestha - 20BCL0134

Bikalpa Gautam - 20BCL0135

Anil Khadka - 20BCL0138

DECLARATION BY THE CANDIDATE

We hereby declare that the project report entitled “Design of Water Treatment Plan in Birgunj” submitted by us to Vellore Institute of Technology University, Vellore in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Civil Engineering is a record of bonafide project work carried out by us under the guidance of Prof. Dr. Parimala Renganayaki S. We further declare that the work reported in this project has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Signature of the Candidates

Mode: Online Mode
Web: Microsoft Teams
Date: 27-November-2021

Deepak Dulal - 18BCL0267
Ujjwal Rauniyar - 20BCL0130
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School of Civil and Chemical Engineering

CERTIFICATE

This is to certify that the project report entitled “Design of Water Treatment Plant in Birgunj(Nepal)” submitted by Deepak Dulal - 18BCL0267, Ujjwal Rauniyar - 20BCL0130, Ambikesh Kumar Sah - 20BCL0144, Krrishtina Shrestha - 20BCL0134, Bikalpa Gautam - 20BCL0135, and Anil Khadka - 20BCL0138, to Vellore Institute of Technology University, Vellore, in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Civil Engineering is a record of bona fide work carried out by them under my guidance. The project fulfills the requirements as per the regulations of this Institute and in my opinion meets the necessary standards for submission. The contents of this report have not been submitted and will not be submitted either in part or in full, for the award of any other degree or diploma and the same is certified.

Prof. Dr. Parimala Renganayaki S

Project Guide

Dr. Saravana Kumar M P

HOD-SCE

ACKNOWLEDGEMENT

We find immense pleasure in expressing our profound gratitude and thanks to our guide Prof. Dr. Parimala Renganayaki S for her invaluable guidance, constant encouragement and keen interest in the progress and completion of this work. She has always been most willing to spend his valuable time for discussion. The discussions were always enjoyable as well as her comments have been extremely valuable. We learned a lot from the discussion. She has associated with us as a friend, philosopher and advisor. We would like to thank our HODs and Dean for providing all the infrastructure facilities to carry out our project successfully.

Deepak Dulal - 18BCL0267

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Content

1st Review

2nd Review

3rd Review

Population Forecasting

S. No.	Year	Population
1.	1971	12,999
2.	1981	43,642
3.	1991	68,764
4.	2001	112,484
5.	2011	135,904

Table: - *Previous census data of Birgunj as per Final Report Urbanization of Birgunj Metropolitan City*

Observing the above data appropriate forecasting method would be Logistic Curve method.

Justification

Birgunj is a well-established city. The population growth rate is increasing at the normal rate with conditions of birth, death, and migration. Also, the population of the city is not much affected by any epidemics such as the COVID pandemic neither it's affected by disasters. Therefore, the logistics curve method is appropriate for population forecasting.

CALCULATION

Design Period = 3 decades, P2041 =?

P0 = 12,999 t0 = 0
P1 = 68,764 t1 = 20
P2 = 135,904 t2 = 40 (Population of last census)
Ps (Saturated Population) = (2*P0*P1*P2 – P1^2*(P0 + P2))/(P0*P2 – P1^2)

= (2*12999*68764*135904 – 68764^2*(12999 + 135904))/(12999*135904 – 68764^2)

=1,55,688

For calculating the expected population in next 30 years:

m = (Ps – P0)/P0 = (155688-12999)/12999 = 10.977

n =(2*3)/t1 * log10 ((P0(Ps-P1))/P1(Ps-P0))

= (2*3)/20 * log10 ((12999*(155688-68764))/68764*(155688-12999))

= -0.2816

Now,

Calculating population for a design period of 30 years,

t = 2041 – 1971 = 70 years

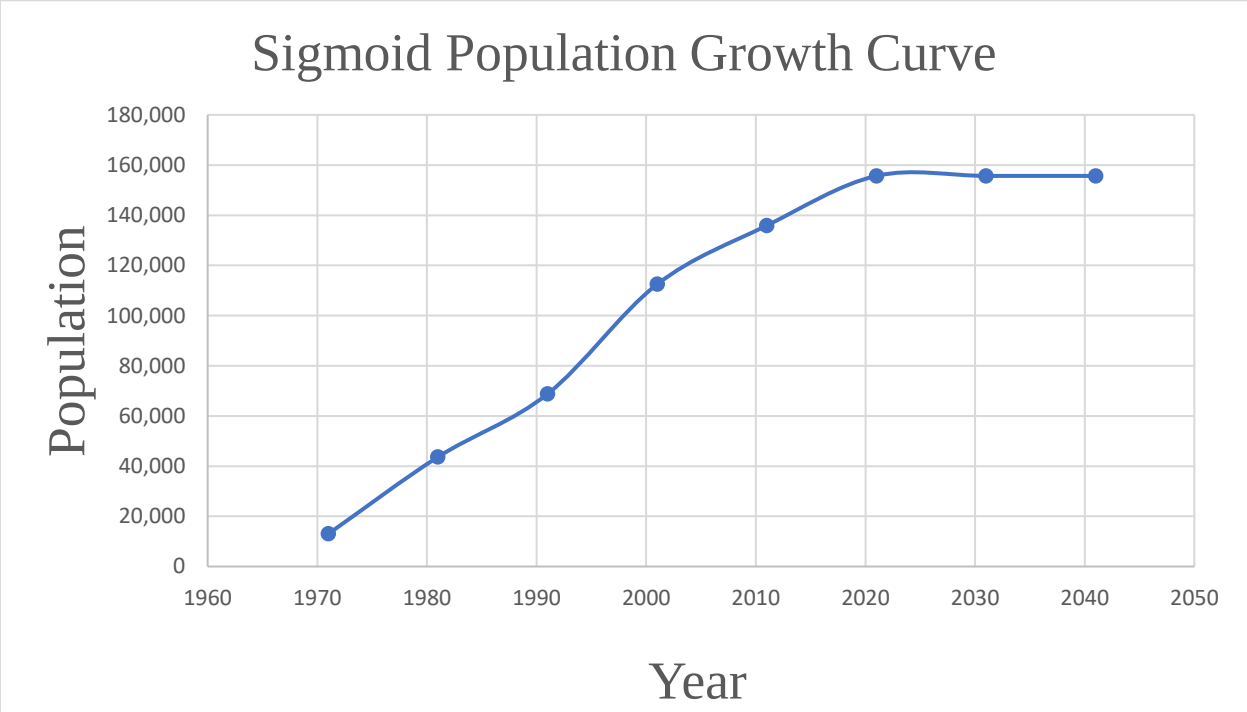
P2041 = Ps / (1 + m*loge ^ -1(n*t))

= 155688 / (1 + 10.977*loge ^ -1(-0.2816*70))

= 155687.9953

= 1,55,688

Therefore, the future population of Birgunj in year 2041 is forecasted to be 1,55,688 according to given data using logistic curve method.



Quantification of Water Supply

Water demand = 135 lpcd (For urban population)

Average daily demand = 135 * (population in 2041)

= 135 * 155688

= 21,017,880 liters

We know,

Maximum daily demand(Q) = 1.8* Average daily demand

= 1.8*21017880 liters

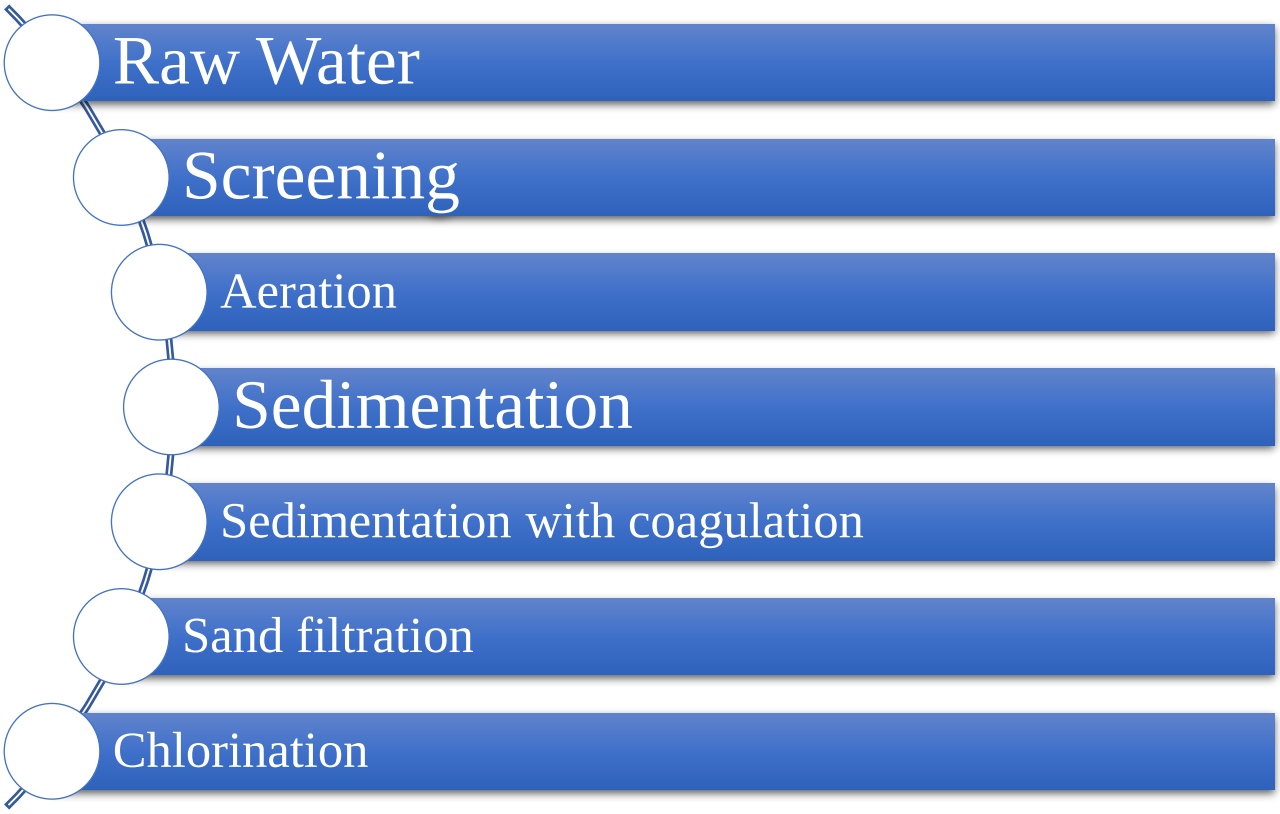
= 37,832,184 liters

The maximum daily demand for Birgunj metropolitan city is 37,832,184 liters.

Characteristics Of Water in Sirsiya River

- Presence of clothes, logs, plastics, etc.
- Presence of organic wastes
- Foul smell, dissolved gases like Carbon dioxide, hydrogen sulphide
- Traces of volatile compounds of petroleum
- Presence of gravel, sand, dirt
- Muddy in colour
- Presence of pathogens like bacteria, microbes
- Presence of colloidal and suspended particles

Layout of Treatment Plant



Design of Sedimentation Tank

Reference from S.K Garg (Water supply engineering)

Specifications

Detention Time = 4 hours to 8 hours
Depth of sedimentation tank = 3m to 6m

Assumptions

Detention time = 6 hours
Horizontal Velocity of Sedimentation Tank= 0.005 m/s
Depth of sedimentation tank = 5 m

From the above data, (population forecasting), the maximum daily demand for the forecasted population in the year 2041 was calculated.

Maximum Daily demand = 37832.184 m^3/day = (37832.184 / 24) m3 / hour = 1576.341 m3 / hour

Calculating the volume of the sedimentation tank (required according to the forecasted population)

T = V/Q
V = T * Q
V = (6 * 1576.341) m^3
Volume of the sedimentation tank = 9458 m^3

We know that, detention time = Length of sedimentation tank(L) / Velocity(v)
6*60*60 = L / 0.005
L = 0.005 * 21600
L = 108 m

Now,
V = L * B * H
9458 = 108 * B * 5
B = 9458 / (108 * 5)
B =17.515 m

Thus, the dimensions of the sedimentation tank should be **108 m * 18 m * 5 m.**

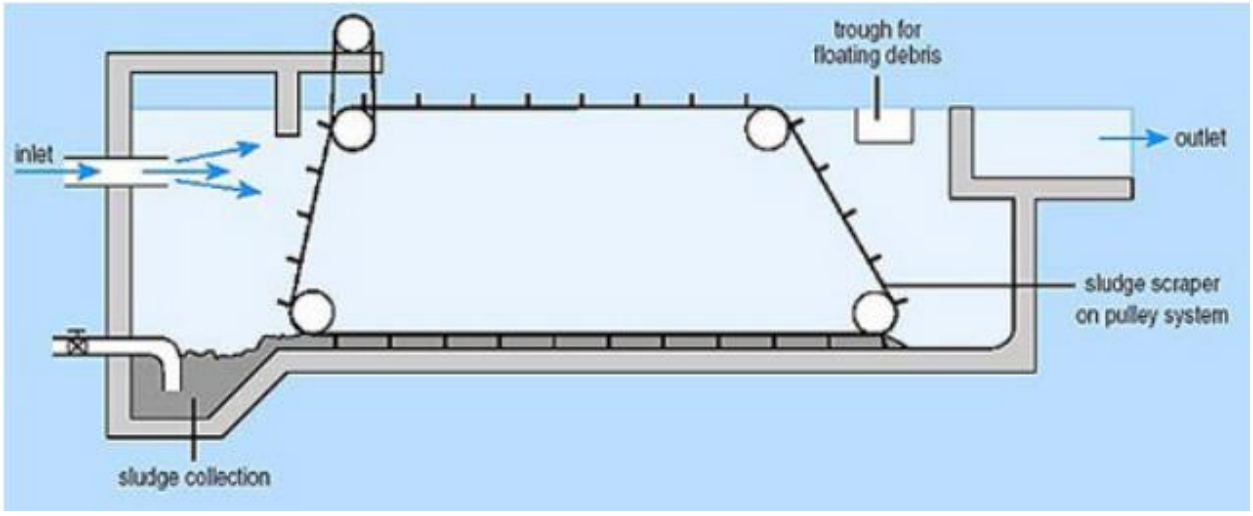


Fig.: *Cross section of a Rectangular Sedimentation Tank*

Source: Portable Water treatment:4.4 Sedimentation - OpenLearn - Open University - T210_1

Design of Sand Filter

The sand filter is used to remove suspended matter, floating particles, and sinkable particles. The permeable bed of fine sand or gravel directs the flow of water vertically.

We have a Maximum Daily Demand of **37,832,184 Liters**.

Let us take Slow Sand Filter.

Specifications of Chosen Sand Filter

Filtration rate: 0.1 – 0.2 m/hour

Head Space: 0.5 m

Sand Depth: 0.9 m

System underdrain + Gravel depth: 0.5m

Supernatent water: 1 m

Source: Recommended level(UK experience)

Let us assume the following:

Filtration Rate = 0.20m/hr

Out of 5, one **is Kept as Standby(4 for 20)**

L= 2B

Height of the Tank = 2.9 m

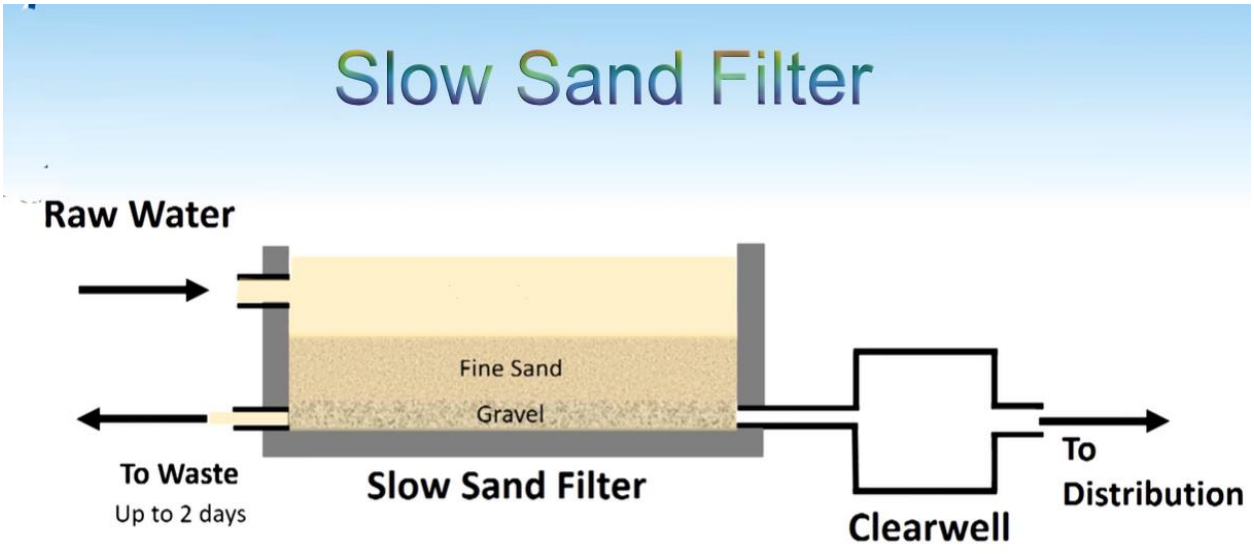


Fig.: *Slow Sand Filter*

Maximum Daily Demand = 37,832,184 Liters/Day **=** 37832.184 m3/Day **nearly equal to 37,833 m3/Day**

Here,

Q is big and numerous Sand filter is required for such volume of Water. Let us take 20 **Tanks** in total.

Now,

Rate of Filtration (v) = 0.20m/hour = 0.20 * 24 = 4.8 m/day

We Know,

Total surface area requirement to filter (A) = Maximum daily demand/ Rate of filtration

A = 37833/4.8 = 7881.875 m2

As Assumed,

Four is kept as stand by for 20 tanks. So,

Surface Area of each unit = 7881.875/16 = **492.62 m2**

Also, L=2B (ASSUMED)

So,

A = L * B = 2B*B = 2B^2,

Or, 492.62 = 2B^2,

Or B^2 = 246.31

So,

B = 15.69 m

So, L = 2*B = 2*15.69= **31.38 m**

Hence, Required Dimensions of single unit is **32m * 16m * 2.9m**.

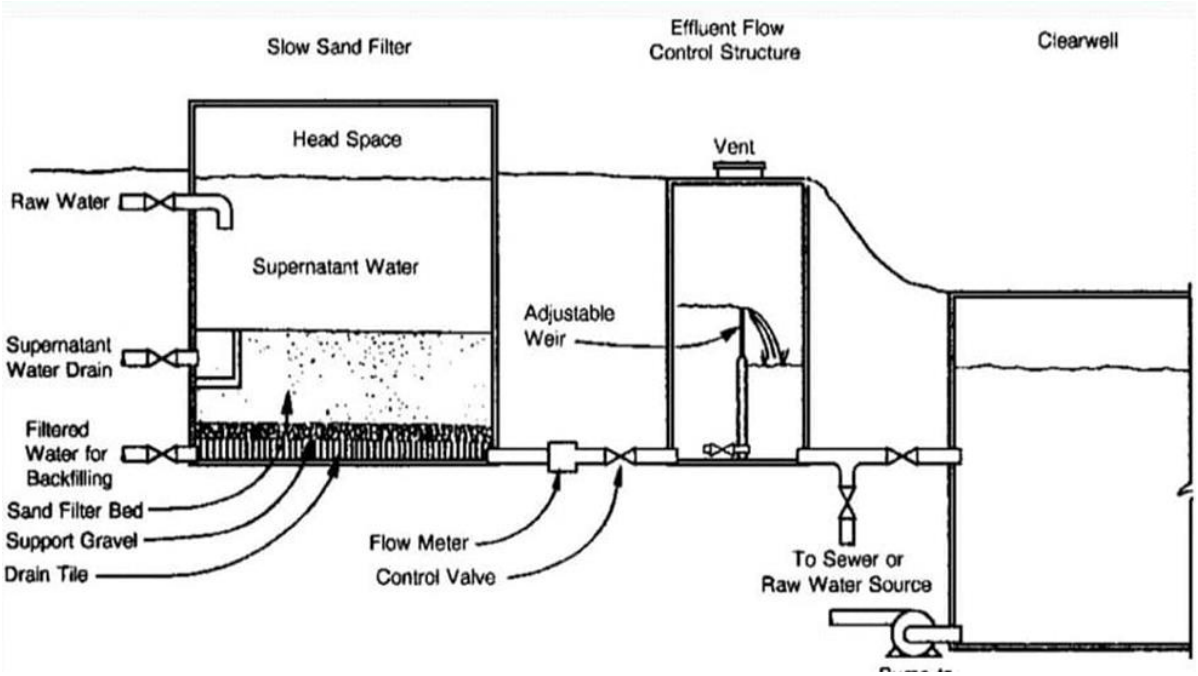


Fig.: *Cross section of a Filtration Tank*

Source: [Slow Sand Filter - Wikipedia]

Major Water Quality issue in Sirsiya River

Discharge of untreated water from Tanneries Industries

Major contributor:

- Narayani Leather And Manufacturing
- Everest Leather Industries

Contaminant:

- Chromium Salt

Health Effects due to this contaminant:

~ Blindness

~ Coughing and/or shortness of breath

~ Destructive to the skin, eyes, teeth, and lungs

~ Inhalation of concentrated vapor can be extremely irritating to the upper respiratory tract

Reference Paper

Citation:

Shah, B. P., & Pant, B. R. (2012). Water quality assessment of sirsiya river. Nepal Journal of Science and Technology, 13(2), 141-146.

Link:

Water Quality Assessment of Sirsiya River | Nepal Journal of Science and Technology (nepjol.info)

Contents for the Review work of Research Paper

- Abstract
- Introduction
- Methodology: - Study area
  - Sampling
  - Physio-chemical analysis
- Results and Discussion
- Conclusion
- Acknowledgments
- References

Abstract

- The physic-chemical parameters(temperature, PH, TSS, TDS, ammonia, phenol, cyanide, sulfide, oil and grease, chloride, DO, COD and BOD) were taken to assess the water quality of Sirsiya river.
- All the parameters except oil and grease were found within the generic standard.

- The physio-chemical characteristic of the river water was changing as a result of the discharge of untreated effluents from different industries.

Introduction

- Due to the pollution by the effluents from the Industries and other sources, people are compelled to use wastewater for their daily use like irrigation and drinking purpose which pose human health hazards.
- To control these pollutants, cost effective methods like wastewater stabilization ponds can be used.
- Study and observations was done to estimate the water quality of Sirsiya river due to the industrial effluents.

Methodology

Study area:

- Located at approximate latitude of 27°18’ N and longitude 84°E at about 130 m above mean sea level.
- Birgunj and surrounding area of Parsa district that have direct connection with Sirsiya river.

Sampling:

- Water samples were collected from upstream, midstream and downstream from the point where effluent is discharged into Sirsiya river.
- Bottles were rinsed three times with river water and then the samples were collected.

- Dipped each sample bottle at approximately 10-20 cm below the water surface, projecting the mouth of the container against the flow direction.
- Transported within 24 hr to the Water Engineering and Training Center (WETC) at Kathmandu for analysis.

Physicochemical analysis

- Analyzed for total suspended solids, total dissolved solids, ammonia, phenol, cyanide, sulfide, oil and grease, chloride, dissolved oxygen, chemical oxygen demand and biological oxygen demand using standard methods for analysis of water and wastewater (APHA 2008)
- Temperature and pH were measured onsite using a multiparameter ion specific meter
- TSS was estimated using gravimetric method
- Chemical parameters estimated for the determination of ammonia, phenol and cyanide were measured by UV spectrophotometer
- Sulfide was determined iodometrically.

Results and Discussion

- Total three samples were collected from upstream, midstream, and downstream to the effluent discharged point at Sirsiya river in order to estimate the pollution level before and after the mixing of effluent in the Sirsiya river.
- The result of this work shows that physical parameters estimated for PH, temperature, TSS, TDS were measured within the generic standard.

The parameters determining the chemical quality of water such as chromium, cyanide, chloride, sulphate etc were examined with consequent effects.

Table 1. Physical quality of water

Parameters	Generic Standard	Sampling Sites		
		Upstream	Midstream	Downstream
PH	5.5-9.0	6.6	6.8	6.9
Temperature(°C)	40.0	18.6	22.4	17.6
TSS(mg/l)	30-200	<1.0	28.0	54.0
TDS(mg/l)	NA	218.0	348.0	488.0

NA - Not available

Table 2. Chemical quality of water

Parameters	Generic Standard	Sampling Sites		
		Upstream	Midstream	Downstream
Ammonia	50.0	2.84	0.68	6.6
Phenol (mg/l)	1.0	<0.01	0.05	0.64
Cyanide (mg/l)	0.2	<0.05	0.06	0.08
Sulfide(mg/l)	2.0	0.4	1.6	1.6
Oil & grease (mg/l)	10.0	<1.0	19.0	16.0
Chloride (mg/l)	600.0	25.7	25.7	50.5
Chromium(mg/l)	0.1	<0.01	0.04	0.02
DO(mg/l)	NA	3.8	2.9	0.0
BOD(mg/l)	30-100	1.2	30.8	32.0

NA- Not available

- The study revealed that the continuous discharge of effluent negatively impacts the receiving water bodies and also affects aquatic lives.
- Carrying out the present study it was found that except for oil and grease all the parameters were within the generic standard.
- BOD increases from upstream to downstream due to increase in organic load
- However, from the study, it is concluded that due to the dilution of water by tributaries of the Sirsiya river we observed a lower concentration of pollutants.
- The physical appearance itself is proof of heavy contamination of river water and therefore the effluent could pose significant health and environmental risk to rural communities.

Acknowledgments

Sincere gratitude to Mr. Surendra Parajuli, Officer at Water Engineering and Training Center Pvt. Ltd for his support in field and laboratory works. The financial support provided by the Himalayan Alliance for Climate Change (HIMCCA) to conduct this study is highly acknowledged.

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Individual Contribution

Team-mates	Review-1	Review-2	Review-3
Deepak Dulal	Introductory part	Design of Sand Filter	Report preparation
Ujjwal Rauniyar	Location and Data collection	Characteristics of water, contribution slide and editing.	Results and Discussion
Ambikesh Kumar Sah	Graph and merging slides	Layout of Treatment plant and major contamination	Introduction and References
Krrishtina Shrestha	Justification for appropriate method	Design of Sand Filter	Results and Discussion
Bikalpa Gautam	Population Forecasting Calculation	Design of Sedimentation Tank	Abstract and Introduction
Anil Khadka	Quantification of Water Supply	Design of Sedimentation Tank	Methodology