SETTLING COLUMN ANALYSIS OF SURFACE WATER SOURCE-CHHAUSHA RIVER

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

Dr. Rishi Rana

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234

HIMACHAL PRADESH, INDIA

MAY- 2019

DECLARATION

We hereby declare that the project report entitled "**SETTLING COLUMN ANALYSIS OF SURFACE WATER SOURCE-CHHAUSHA RIVER**" submitted for partial fulfillment of the requirement for the award of degree of Bachelor of Technology in CIVIL ENGINEERING at **JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT** is authentic record of our work carried out under the supervision of **Dr. Rishi Rana**. This work has not been submitted elsewhere for award of any other Degree/Diploma. We are fully responsible for the content of our project.

Akal Singh Gurung Abhishek Ahluwalia

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"SETTLING COLUMN ANALYSIS OF SURFACE WATER SOURCE- CHHAUSHA RIVER"** in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Akal Singh Gurung (Enrolment no. 151113) and Abhishek Ahluwalia(Enrolment no. 151606)** during a period from July 2018 to May 2019 under the supervision of **Dr. Rishi Rana**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: 06/05/2019

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ABSTRACT

Surface water sources such as rivers, streams and lakes contain suspended solids which are settable and colloidal in nature. The presence of the suspended solids, increase in the level of turbidity along with presence of few coloring reagents makes the water malicious. These suspended solids make water unacceptable for drinking and industrial use. Therefore, for healthy and pure drinking water, separation of solid particles is required through method of gravity settlement. In the present study, the phenomenon of gravity settling for discrete particles in dilute suspensions i.e. Type-I and Type-II settling are analyzed. Water sample was collected from different locations of River Chhausha in Podhna village, Domehar near Jaypee University of Information Technology. Water samples are subjected to Type-I and Type-II settling using Settling Columns. Iso-removal lines for Type-II settling and plot between mass fractions remaining vs. settling velocity for Type-I are drawn, which helps us about knowing the settling characteristics of water sample collected from different location of the surface water source.

Based on the results and data collected through the experiments and literatures from different studies, the design for rectangular tank is carried out. In our university lab, we have only Cylindrical settling column for the analysis. Hence, for future purpose of studies, rectangular sedimentation tank will be much useful because they are least likely to short circuit and easy to construct and use. In circular tanks due to many dead ends, stagnation of water occurs in pipes due to which the designing of the rectangular sedimentation tank for clarification of water is needed. Our designed work is much more accurate in obtaining results and have low maintenance cost. It is economically feasible because determination of pressure and discharges in rectangular sedimentation tank is easier due to less number of valves.

The design of rectangular tank is governed by Stoke’s law with the laminar flow velocity. The climate change is all around the world. The environment is degrading and being polluted every day. The levels of turbidity, total solids(TS), dissolved solids(DS) and suspended solids(SS) are increasing in water sources. Therefore, to clarify quality of water for day to day use, it is necessary for us to study its nature and rectify the causes of pollution. Our study provides the knowledge on quality of water near JUIT. This enhances level of interest in other individual to protect environment and it’s useful to society and world at large.

Keywords: Suspended Solids, Settling, Iso-removal, Stoke's Law, Sedimentation, Clarification, Total Suspended Solids.

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LIST OF ACRONYMS AND ABBREVATION

AWT	Advanced Waste Water Treatment
ASCE	American Society of Civil Engineering
CS	Cohesive Sediments
CST	Circular Sedimentation Tank
DS	Dissolved Solids
HSC	Hindered Settling Column
JUIT	Jaypee University of Information and Technology
LF	Laminar Flow
OD	Optimal Design
SCT	Settling Column Test
SS	Suspended Solids
STP	Sewage Treatment Plant
TS	Total Solids
TSS	Total Suspended Solids
VSB	Vortex Settling Basin

CHAPTER 1
INTRODUCTION

1.1 GENERAL

Water is critical in any life [1,4,10]. Water covers around 71 per cent of the surface of the earth. Oceans and seas covers 96.5 percent of earth, 1.7 percent are groundwater, 1.7 percent is icy masses and the ice tops of Antarctica and Greenland, a little part of expansive body of waters, and 0.001 percent noticeable all around as vapour, mists, and precipitations [4, 12]. Just 2.5 percent of this water is freshwater and percent of that water is in ice tops and ice sheets and groundwater [11, 51]. Freshwater from surface sources like waterways have strong suspended solids that creates water undesirable and grant impurity and shading to water [12, 36]. Sedimentations are widely utilized procedure for the removal of inorganic settling solids from water [1, 9,22]. The settling tank speaks to around one-fourth of the absolute capital expense for treatment plant [7]. Since most solids have a specific gravity more than 1, gravity settling is utilized to remove suspended particles [9,33,49]. At the point when specific gravity is under 1, floatation is regularly utilized. Settlement for the most part relies upon molecule size, shape and thickness. Different kinds of sedimentation exist, in view of attributes and fixations. Discrete or Type-I settling: particles whose size, shape, and specific gravity don't change after some time [7]. Flocculating or Type-II settling particles that change size, shape and maybe specific gravity after some time [5]. The rate at which discrete particles will settle in a liquid of steady temperature is given by the Stoke’s condition for laminar stream equation 1.1

$$vt = g(\rho p - \rho w)d2/18 \qquad \text{... (Equation1.1)}$$

where:

g = acceleration due to gravity (m/sec^2)

ρ_p= density of particle (kg/m^3)

ρ_w= density of water (kg/m^3)

d = diameter of particle (mm)

μ = coefficient of viscosity (m^2/sec)

Anyway in Type-I settling, direct use of above condition isn't regularly applied in water treatment on the grounds that the extent of particles must be known and the remedy factor to represent takeoff from spherecity must be resolved. In Type-II settling, Stoke's equation can't be utilized on the grounds that flocculating particles are persistently changing in size, shape and specific gravity on account of agglomeration of flocculants molecule. A roundabout strategy for deciding settling qualities of a suspension is designed in the study [15].

1.2 STUDY AREA

The samples were collected from the river called Chhausha along the Gamberpul-Waknaghat road which lies in Podhna, Solan (30.993638N, 77.038854E) shown in figure 1.1. We have taken these three points on River Chhausha because in these locations we have found the most of the turbid water.

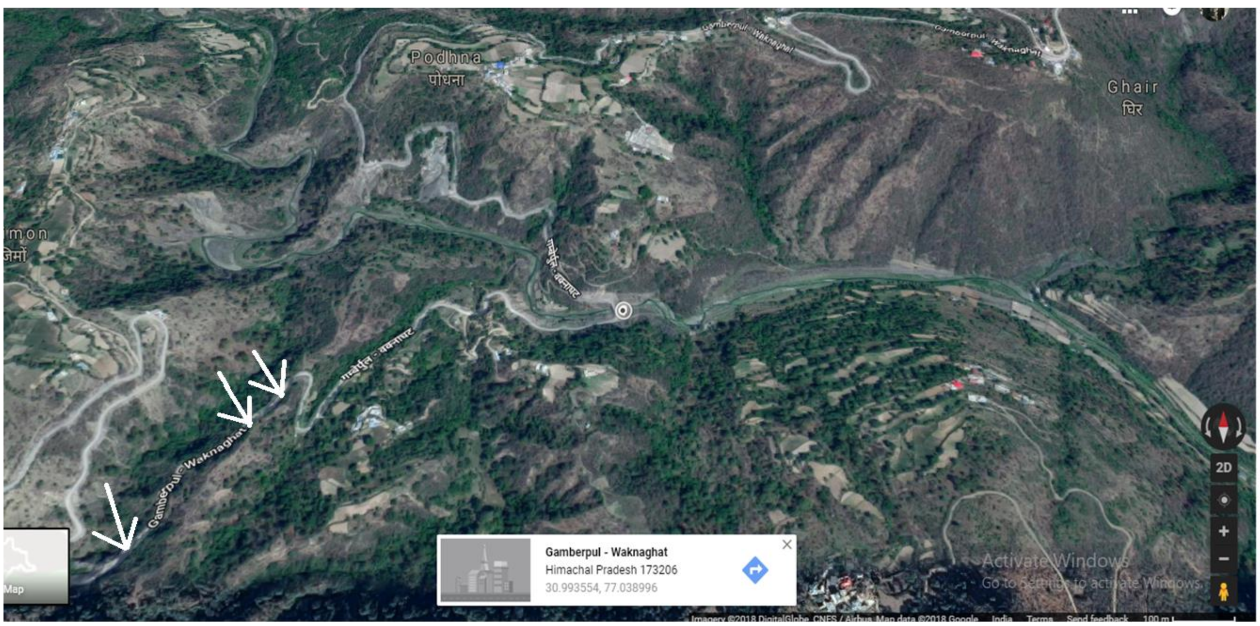

Fig 1.1 Map of Chhausha river.
Source: Google Maps

1.3 OBJECTIVES OF THE STUDY

The objectives of the study are as follows:

- To study the characteristics of suspended solids in surface water body near JUIT during different seasons.

- To analyze the water quality of river Chhausha near JUIT using settling columns of Type-I and Type-II
- Proposed Design of Rectangular sedimentation tank for clarification of water

1.4 NEED OF STUDY

A purification process is the initial step for any surface water and wastewater. Purification includes sedimentation of particles and successive steps of coagulation-flocculation with growth of floc and collision of particles to sink at the base of experimental model to treat reasonable water from rivers and streams. Water purification is removal of total solids, suspended solids and dissolved particles to make water pure and consumable. In-organic solids from raw water is normally removed by method of sedimentation.

Sedimentation is phenomenon of gravity in which suspended particles in water settle down at the bottom of sedimentation tank under its impact. In our study, we discuss two types of sedimentations viz Type-I settling for Discrete and Type-II settling for Flocculating particles. The settling rate of discrete particles in a liquid of consistent temperature is given by the Stoke's equation for laminar flow but it is not applicable for Type-II settling because the dimensions and shape of flocculating particles changes when depth and time of sedimentation tank is altered.

The River Chhausha serves many populations in drinking and domestic purpose. However the quality of river water has not been assessed yet, therefore, it is necessary for us to determine the level of turbidity, presence of suspended solids and settling characteristics of the water. We can provide information to people about the nature of water and help them to clean the water through process like sedimentation.

CHAPTER 2
REVIEW OF LITERATURE

2.1 GENERAL

The Type-I and Type-II settling columns are designed and constructed on the basis of stokes law and settling characteristics for different sources of river are analyzed. The Type-I settling column is provided with single port and Type-II settling column with multiple ports [10].

The study [11] showed that the colloidal particles are more complex to be separated from water because they do not have settling weights and having lack of settlement by gravity and involved the transportation of fine sediments in water which describes the outcome of type-II settling. The study showed that due to the flocculation of the dilute particles in the suspension formation of sludge was observed in a case similar to water treatment in sea. The filters used for pre-treatment were very rapid single-stage dual media units. This process of membranes seawater pretreatment is an alternative to conventional granular media filtration [12].

To determine the water quality of estuary and coastal area, settling velocity of strong silt are determined allowing floc to break up and settle in three dimensional model. Then the floc is treated applying the Stoke's equation [13]. This study determines the characteristics of alluvial river system. The deformation of river bed is corrected by studying the nature of particles that are present in the river system by understanding the settling velocities of particles in a designed model [14].

A method for type 2 settling data analysis was modified for spreadsheet calculations. The data obtained are comparable to results that were obtained from traditional manual method. It allows rapid and objective analysis of experimental data [15, 16].

Performance of a uniform scale settling column was evaluated for various particle systems and settling velocity of different particles are compared to calculate the removal efficiency of model. The study concludes that uniform scale settling column analysis is better than traditional model [17]. The settling behavior and removal efficiencies of particles were studied using rectangular sedimentation settling tank. The result showed that it is easier to control flow of water in rectangular tank compared to circular sedimentation tank [18]. To find out the causes of soil erosion in cohesive sediment bed, settling column analysis was performed. The ideas on size of particles and their settling characteristics helped combat the problem [19].

A study for inverse calculation used algorithm and forward model to provide inverse calculation to design optimal parameters for rectangular sedimentation tank. This model has the ability to search direct optimum design and also gives good results compared to other traditional models [20]. A different study on numerical model for Type-I circular sedimentation tanks was modeled to provide knowledge in a circular tank operation. The flow and movement of particles was considered steady and non-uniform particle size distribution of water sample was taken into account. The results were compared with other model and it was found that the results from their model gave more accurate information on overall removal efficiency and particle size distribution [21].

Settling data for complete removal of turbidity from water sample was developed. Main equation based on model was linear regression analysis equation. The model directly removes turbidity from column by collecting percentage turbidity removal data obtained from each depth and time without drawing any graphs of iso-removal lines. The results obtained was closer to that obtained from graphical methods [22]. The study in design of rectangular sedimentation tank was carried out. The construction of this apparatus was economical and easily controls flow of water. Removal efficiency of particles is higher and fraction of particles remained were accurately found. The dimensions and volume of this rectangular sedimentation tank was assumed based on Stoke’s law [23].

The study developed two equations with regards to settling time and depth to analyze accuracy of the removal efficiency for the settling tanks. When depth of sedimentation tank and settling rate of time is increased, the overall removal efficiency of particles also increases [24]. The study investigates cohesive sediments of flocculation which relate the studies with water systems. They have designed settling column to measure and calculate Type-II settling under specific temperature [25]. The lab testing and site testing was performed for three lakes and thus results obtained were compared and analyzed. The geotechnical characteristics of particles sediments in the wetlands were found with the data obtained. The data showed the characteristics of area around the lakes [26]. For the feasible and quick interpretation of data and results, the advanced and economical apparatus to calculate suspended solids settling velocities in urban drainage was made [27].

Settling column analysis performed from seven AWT and two conventional wastewater treatment. The results were illustrated and compared to find out the difference in removal efficiency of sedimentation tank [28]. Settling column for Discrete particle or Type-I settling was designed to measure results in non-cohesive silt and sand size from 2 to 2000 micro-meters (μm). The particles with greater size showed quick settling at the base of tank while the particles with small size took time longer time to settle [29]. Soft mixtures of mud and sand was set in lab to interpret the settling and consolidation characteristics. It provides idea on nature of sediments and time required by mixture of sediments to settle in the sedimentation tank [30].

If the sediment is uniformly distributing in the initial stage the effective velocities can be measured from a single concentration time series of mixture [31]. The characteristics of settlement of particles are being studied with the special technique called high speed imaging technique which determines shape, size and other characteristics of particles [32]. The type –II settling analysis was made with the help of two mathematical equations where removal efficiency was obtained from settling column test. The overall removal based on the equation was more accurate and efficient [33].

In the study fall velocity of 174 angular shaped particles made out of various characteristics were analyzed in calm water state in a cylindrical settling column. According to the study, the different particles took different time to settle [34]. The study concluded that the fly ash based geo polymer dredged mud slurry extracted from port of Townsville Queensland Australia showed the characteristics of Type-II settling behavior. Geo polymer altered the structures of dredged mud and its shrinkage cracks [35].

In a rectangular sedimentation tank the study of water flow and suspended solids was conducted with a 3D computational fluid dynamics method. The result showed the mud surface settled gradually and reached dynamic equilibrium in the tank [36]. In the rectangular sedimentation secondary tank, the different sludge floc distribution was experimented with different chamber. The study can be used to design systems to collect loose sludge solids. It also describes the behavior of the bottom current surface flow along with concentration distribution and simulation of density waterfall phenomenon in a secondary rectangular tank [37].

The study of removal efficiency and scour velocity of particles is performed. The removal efficiency equation is based on particle size distribution and equation of scour velocity was based on Rouse equation which is carried on primary settling tank [38]. The study of hydrodynamics of a rectangular sedimentation basin under turbulent condition in a steady, two dimensional numerical model was conducted. The quality of water is compared with the study made from Stoke's laminar condition [39].

Numerical results from a computer model compares the buoyant flow within sewage treatment plant settling basin with the results of several new experiments. The comparison enables the alternative treatment of sewage [40]. The prediction of the dye concentration field was related to flow filed prediction. The study imparts knowledge on removal of sediments, minimization of pollution and sewer line corrosion [41]. An integral model describes sedimentation from a turbulent, buoyant jet injected at an angle into a stationary uniform ambient fluid [42].

To overcome difficulty of effective removal of suspended particles from settling columns and sedimentation tank. The new concept of method of Bottom Grid Structure was introduced for greater efficiency. This type of structure provides greater stability to sample [43]. The Reynolds number, fall velocity, shape factor and drag coefficient of sand grains of Oahu Hawaii was analyzed in sedimentation tank. The study concluded that particle's shape plays stronger role in settling characteristics of molecule [44].

In a prototyped rectangular basin of biological treatment plants the flow and density of particles are observed. The study on flow gives idea on designing the best alternate sedimentation tank. The density of particles is highly related to the sedimentation of suspended particles [45]. The study explained the in-situ test carried out to estimate the settling velocity of suspended fine grained sediments. The result obtained was time consuming and was best alternative for determining the settling characteristics of surface water [46].

An optical backscatter sensor and a laser in situ scattering and transmissometer measures the settling velocity when the current was less than 1.5 m/s to improve previously published approaches [47]. The natural sediments of grain sizes between 0.063 and 1 mm is presented in to calculate the settling velocity. Calculations of settling velocity of greater particles was much easier than that of smaller sized particles [48].

The study was carried out in a rectangular sedimentation tank to determine the dimensions of circular sedimentation tank. The Vortex Settling Basin (VSB) shows that the circular settling must have diameter equal to five times the bed width of inlet canal. The paper basically presents the design of VSB [49]. The batch settling process with four parameter provides best results for both zone and compression settling [50]. To remove the sediments from irrigation and hydropower channel, the settling basins are used. The width of approach channel was widened and floor was lowered to reduce mean velocity [51].

In the study the characteristics of rectangular settling tank was studied under various flow levels with the help of statistical analysis of thirteen configurations. The mean kinetic energy and turbulence kinetic energy gives the energy balance [52]. In the settling columns of type-II settling, the distribution of flocculent particles was discussed with the empirical formula. The empirical formula easily calculates the mass fraction remaining and removal efficiency compared to Stoke's equation [53].

In a secondary sedimentation tank of Europe's largest sewage treatment plant(STP), the computational fluid dynamics model is used in its design. The number of tanks and their dimensions are based on empirical design procedure [54]. The study conducted to obtain the settling velocity of sediment particles that are dispersed in water. The relationship between Drag coefficient and Reynolds Number gives the settling velocity of dispersed particles. The result was then compared with results that are obtained from other traditional methods [55].

CHAPTER 3
MATERIAL AND METHODOLOGY

3.1 GENERAL

For laboratory studies, total suspended solids(TSS) analysis, turbidity, Type-I and Type-II settling was carried to decide the settling characteristics of river Chhausha. The water sample is poured in the coloumn. The readings were taken at the different time intervals.

3.2 SETTLING COLUMN

The apparatus is cylindrical in shape with height 2m and diameter 0.1016m (4 inch), Type-I settling column has only one sampling port 0.2m from the bottom of column and Type-II settling column has six sampling ports as shown in figure 3.1.

FIG 3.1 Settling Column

3.3 SURFACE WATER SAMPLE COLLECTION

The samples of 20 liters were collected monthly for laboratory testing from different locations of river Chhausha which is situated at Podhna village in Solan district, Himachal Pradesh.

3.4 LABORATORY STUDY

To determine the settling characteristics of water sample, turbidity of water is found in nephelometer. Jar test is conducted to estimate the optimal dosage of coagulant to clarify the water. Type-I and Type-II settling, total suspended solid test and filtration to decide settling qualities of water sample. Quantity of water sample gathered is 20 liters each for Type-I and Type-II settling column. For the accurate result and settlement of particle the water sample is mixed properly.

3.4.1 SETTLING

Water has discrete and flocculating molecule. Type-I contains discrete particles which is called primary sedimentation. Type-II settling exhibits flocculation and furthermore known as secondary sedimentation.

In Type-I settling, molecules settle autonomously without adjustment in size of molecule. Along these lines, settling velocity for discrete molecule stays constant. In Type-II settling, flocculent molecule forms flocs and get greater in size. In this manner, the settling speed of flocculent molecule increments with depth. Computations was finished by filtering samples through whatman filter paper and weighing the suspended solids after oven drying the filter paper at 100 to 103ºC.

3.4.2 DISCRETE PARTICLE SETTLING, TYPE-I

In Type-I settling, particles present in water sample settle separately without interacting with other nearby particle. In this type of settling, specific gravity of particles does not change with time thus settling velocity of particle remains constant. Fig. 3.4 shows the Type-I settling performed in laboratory with settling column for Type-I.

THEORY

Water sample is mixed thoroughly to obtain uniform distribution and it is poured in settling column for the test shown in fig.2.1.

Molecules which are at the surface of settling column has an average settling velocity of:

$$V_o = \frac{\text{distance traveled}}{\text{time of travel}} = \frac{Zo}{to} \quad \text{...(Equation 3.1)}$$

Molecules found at distance Zp has settling velocity less than the surface molecule V_0, but reaches at the bottom of the sedimentation tank at the same time with settling velocity of

$$v_p = z_p/t_p \quad \text{...(Equation3.2)}$$

where,

z_p=Distance travelled

t_p=time travelled

Hence, both the molecules have equal time of travel, i.e. $t_0 = z_o/v_o = z_p/v_p$ and $v_p/v_o= z_p/z_o = h/H$. Therefore, on the basis of (3.2), generalized statement can be produced.

All molecules consisting a diameter equal to or greater than d_o, will have settling velocity greater than v_o, and will take time t_o to arrive at or pass the ports. Molecules having diameter $d_p< d_0$ will have a settling velocity $v_p<v_o$, and time taken arrive at or pass the sampling port is t_o, but its position must be at or below z_p. If the suspension is quiescently mixed and molecules are distributed uniformly then the fraction of molecules with size d_p with settling velocity v_p will arrive at or pass the sampling port in time $t_{o,}$ which is given by $z_p/z_o = v_p/v_o$. Thus, the removal efficiency of any size molecules from suspension is the ratio of the settling velocity of that particle to the settling velocity v_o defined as z_o/t_o.

PROCEDURE

For Type-I settling, in lab starting focus co of totally blended suspension at time zero is dictated by suspended strong test. Time interim for taking out example from Type-I settling section is chosen as 15 minutes. Measure C1 at time t1 equivalent to 15 minutes. All particles involving C1 have a settling speed not exactly $zo/t1$, where $v1 = zo/t1$. In this way, the mass division of particles evacuated with v1< zo/t1 is given by x = c1/co. Procedure is rehashed multiple times as length of test is chosen as 30 minutes, with xi continually being.

These qualities are then plotted on a diagram to acquire Fig.4.1, where the division of particles staying for any settling velocity can be resolved.

For any detainment time to, a general percent expulsion (X) can be gotten, for example all particles having a settling speed more prominent that $vo = zo/to$, will be expelled 100%. Thus, 1 – xo particles are totally evacuated so as to. The rest of the particles have a $vi < vo$, will be expelled by proportion vi/vo.

In the event that the condition relating v and x are known, at that point the zone can be found through combination utilizing Equation1.1 or Equation 1.2 where X is the complete mass part expelled by sedimentation.

$$X = 1 - X + \int_0^{x0} \left(\frac{vi}{vo}\right) dx \quad \text{… (Equation 3.3)}$$

$$X = 1 - x + \sum \quad (\Delta vx. vi) \div vo \quad \text{… (Equation 3.4)}$$

Where,

X=Total mass fraction removed by sedimentation.

V_o=Initial velocity.

V_x=final velocity.

3.4.3 FLOCCULANT SETTLING, TYPE-II

In Type-II settling, settling of flocculent particles in suspensions happens, molecule settle and mixes with different particles, the sizes of particles and their settling speed increases. The investigation of settling ability of a flocculating suspension is like examination for discrete molecule suspension. The main contrast is that multiple ports are given at a few heights for settling column Type-II.

PROCEDURE

Samples are taken out of different ports and used for analysis of suspended solid concentration. These results are then used to calculate mass fractions removed at each depth and time.

$$xij = (1 - Cij/Co) * 100 \quad \text{.... (Equation 3.5)}$$

where,

C_o=Initial concentration.

x_{ij} = the mass fraction removed at the i^{th} depth at the j^{th} time interval.

These results obtained are graphed and isoremoval lines are plotted. The slope at any point on any isoremoval line is the instantaneous velocity of the fraction of particle represented by that line. Overall removal efficiency is calculated from (equation 3.6)

$$R = ro + \sum \quad (\Delta r \times Zi) \div 1.8 \quad \text{... (Equation 3.6)}$$

3.4.4 Jar Test

Theory

Coagulation and flocculation are principal units in water and wastewater treatment. The point of container test is to evacuate suspended materials, turbidity and color. Coagulation destabilizes the suspended particles, colloidal materials and macromolecules by expansion of synthetic substances. Most usually utilized coagulant are aluminum sulfate(Alum), sodium aluminate, chlorinated copperas, iron salts and ferric sulfate. Flocculation is process in which colloidal particles leave suspension as flocs. The particles in the flocculation do not dissolve in water rather they stick together to form a larger bulk and settle at the bottom of water. Flocculation is altered by duration of mix, speed of mixing, time taken to mix and time given for settlement.

Procedure:

To perform the jar test. Determine the turbidity of water sample. Pour 1000ml of water sample in 6 beakers each. Then add different dosage of preferred alum dosage in water sample. Dilution of 10mg of alum in 1000ml of water gives 1% alum solution. At the speed of 100 rpm for 1 minute distributes the coagulant entirely in each jar. Set the speed to 40rpm and allow the sample to mix for a period of 10 minutes. After 10 minutes of the mixing period, turn the switch off and let the flocs settle for 20 minutes. After 20 minutes or more, carefully determine the turbidity in each of the samples using the turbidity meter.

3.4.5 Sedimentation Tank Design.

Working principle

The main principle involved in the sedimentation tank is to reduce the flow velocity of water which allows the major amount of suspended particles to settle down which is known as settling velocity. The amount of suspended particles collected at bottom of tank is based on different factors like shape and size of tank, size of particle, temperature of water, flow velocity, detention period etc. The settling velocity of particle is calculated by Stoke's Law which is mentioned in (1.1).

The major problem faced during the study conducted was controlling the flow in cylindrical tank. The water flowing through confined settling column leaked through ports which lead to delay and inaccuracy in the results obtained. Operational loss of water caused decrease in the volume of water. The space was less for experimental purpose.

Therefore, to overcome all of above stated drawbacks, we designed rectangular sedimentation tank which has better efficiency. The rectangular tanks are cheap as compared to circular tanks, Rectangular tanks have the simplest design, low maintenance, least likely to short circuit and removal of sludge is simpler in rectangular tanks. The construction cost of rectangular tank is much more lesser than circular tank. We can easily control the flow in rectangular tanks.

Parameters for design of sedimentation tank

The following parameters for design of rectangular sedimentation tank are based on study [23]

- **Over flow velocity (V_O)**

The ratio of volume of water over surface area is called over flow velocity. Over flow velocity must be less than settling velocity to prevent particles escape without settling.

$$V_o = \text{Discharge/Surface area}$$

$$= Q/(BL)$$

Where,

V_o=Over flow velocity

Q=Discharge

BL=Surface area

- **Flow through velocity(V)**

The flow through velocity is the ratio of discharge (volume) over area. Limited V to be provide is 0.005m/s.

$$V = \text{Discharge/Area}$$

$$= Q/(BH)$$

Where,

V=Flow through velocity.

Q=Discharge

BH=Area

- **Detention Period(T)**

Travel time of water from inlet to outlet is called detention period. Detention time for rectangular tank is usually from 30 minutes to about 3 hours.

$$\text{Detention time} = \text{Volume of tank/Discharge}$$

$$= (V/Q)$$

Where,

V=volume of tank

Q=Discharge

- **Sedimentation tank dimensions**

The length, width and depth of tank are computed from the volume of tank and flood speed. We figure the zone of tank,

$$Area = Volume\ of\ water/Over\ flow\ velocity$$

In the wake of getting the zone we accept length and depth dependent on passable points of confinement as expressed underneath.

The length of sedimentation tank to be given is at least multiple times the width of sedimentation tank. The depth of tank to be given is 3 to 4.5 meters [23].

- **Efficiency**

Efficiency is maximum when the maximum amount of suspended particles in the raw water are separated. Efficiency depends upon settling velocity and overflow velocity.

$$Efficiency\ of\ sedimentation\ tank = \left(\frac{Vs}{Vo}\right)$$

Where,

V_s=settling velocity

V_o=Overflow velocity

- **Rectangular Sedimentation Tank Design for River Chhausha**

  Let us consider population of 20000 [56]. Rate of water supply is 150 litre/no/day. Detention period is 2 hours. And 80% of water supply as sewage flow [56].

Now, Average Discharge is calculated as:

$$Q = 150 * 20000 * 80\%$$

=2400000 litre/day

=2400 m^3/day

$$Capacity\ of\ Tank = (2400 * 2)/24$$

$Length * Breadth * depth$ = 200m^3

Volume of tank is 200m^3.

Let us assume depth as 3m and Length 3b

Volume of tank = $3b * b * 3$

$$200 = 9b2$$

$$b = 4.7m$$

$$Length = 3 * 4.7$$
$$= 14.15m$$

Provide 4m for inlet and outlet then,

$$Length = 14.15 + 4 = 18.15m$$

Let's provide 1m for sludge and 0.5m as freeboard,

$$Total\ Depth = (3 + 1 + 0.5) = 4.5m$$

After designing the tank for the study. An AutoCAD pictorial figure 3.2 is designed.

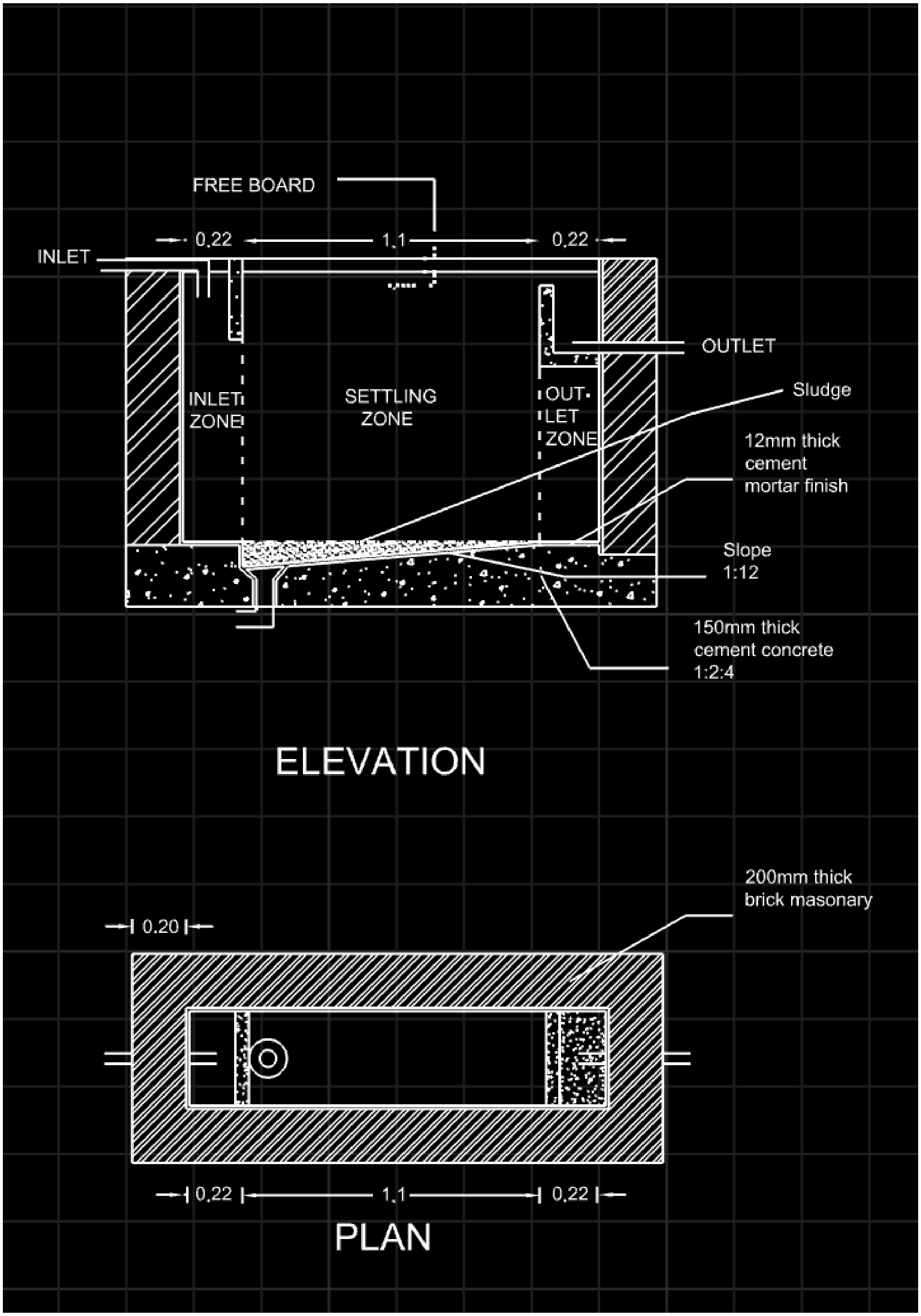

Fig 3.2 Design of a rectangular sedimentation tank

CHAPTER 4
RESULTS AND DISCUSSION

4.1 DISCRETE SETTLING, TYPE-I

In Type-I settling sedimentation of discrete molecule present in water suspension happens by gravitational force when suspension is permitted to settle calmly.

4.1.1 RESULTS AND DISCUSSION

Results of Type-I Settling are shown below:

a) **In August**

Table 4.1 Mass fraction remaining and corresponding settling rate for River Chhausha in August

.

Time Interval (Minutes)	Concentration (mg/l)	Mass Fraction Remaining	Velocity
0	321	1	-
30	262.5	0.90	6
60	205	0.63	3
90	176.5	0.54	2
130	130	0.40	1.3
150	110	0.34	1.2
180	90	0.28	1

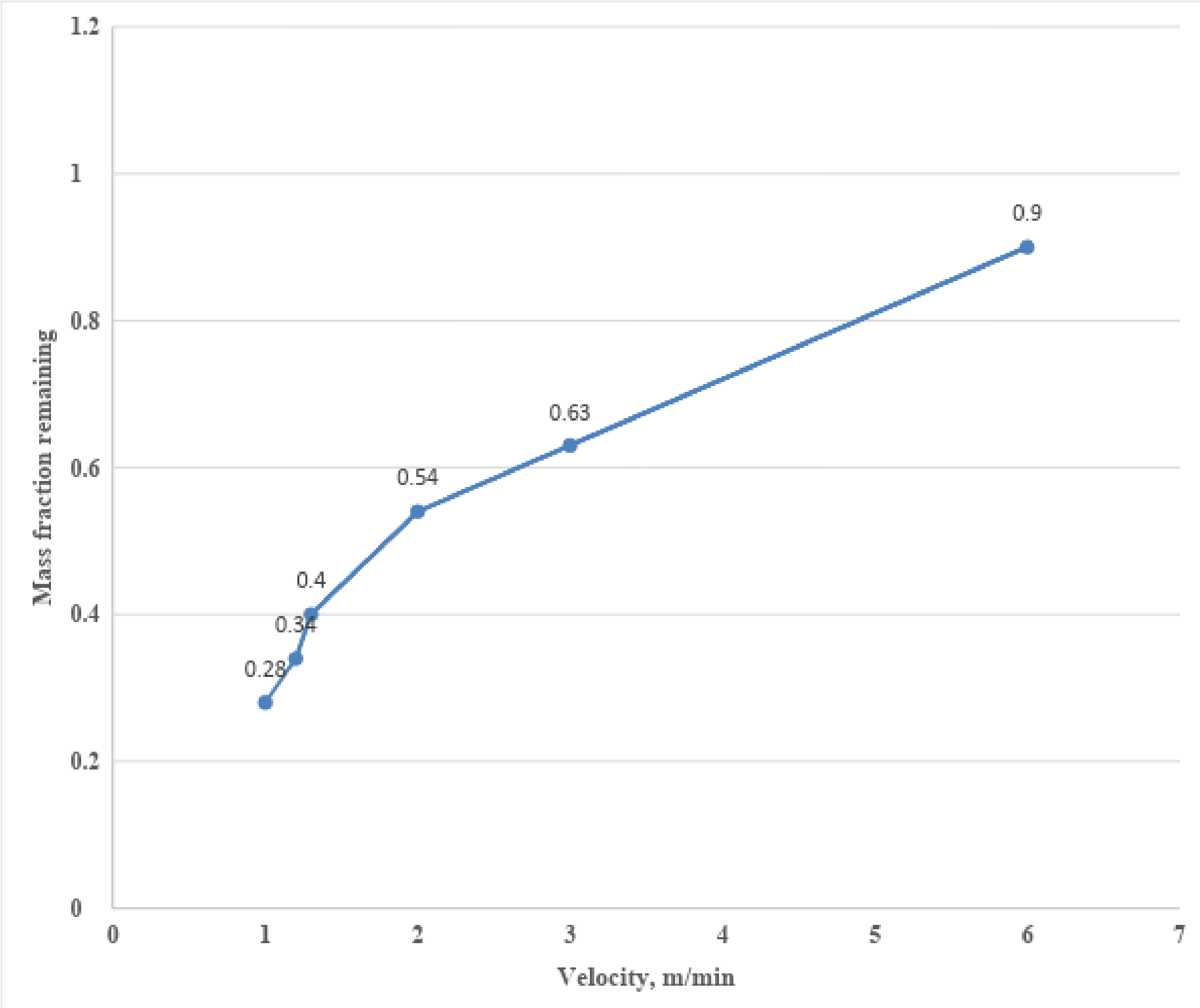

Fig 4.1 Mass fraction remaining and corresponding settling rate for location for River Chhausha in August.

From fig.4.1 Overall efficiency at settling velocity (v_o) = 2 and x_o = 0.54

The value $of\ \Sigma\ (\Delta x\ .vi)\ =\ 0.628$, Table A.1, Annexure A

$$X = 1 - xo + \Sigma\ (\Delta x\ .vi)/vo$$

= (1-0.54) + 0.628/2

= 77.4 %

The results for month of august were shown in figure 4.1 having the removal efficiency of 77.4% for river Chhausha which showed that during the time interval of 30 minutes the settling of discrete particles is efficient.

b) In September

Table 4.2 Mass fraction remaining and corresponding settling rate for River Chhausha in September.

Time interval (min)	Concentration (mg/l)	Mass Fraction Remaining	Velocity
0	93.2	1	-
15	82	0.87	9
30	71	0.76	4.5
45	63	0.67	3
60	50	0.53	2
75	41.8	0.44	1.8

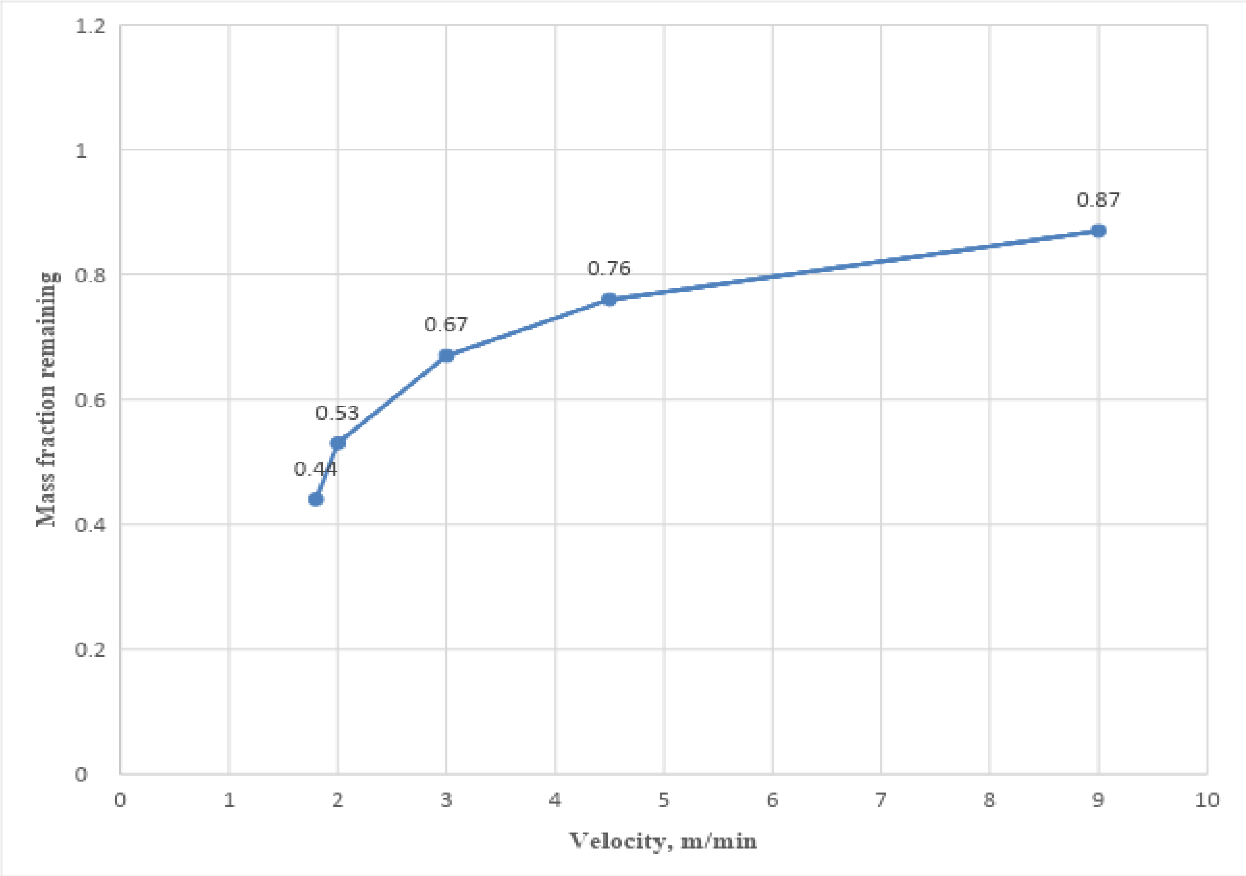

Fig 4.2 Mass fraction remaining and corresponding settling rate for river Chhausha in September-2019.

From Fig. 4.2, Overall efficiency (X) at settling velocity (v_o) = 3 and x_o = 0.67

The value of $\Sigma\ (\Delta x\ .\, vo)\ =$ 0.89, Table A.2, Annexure B

$$X = 1 - xo + \Sigma\ (\Delta x\ .\, vi)/vo$$

= 0.32 + 0.89/3

= 61.66 %

The figure 4.2 showed the removal efficiency of the river during month of September 2019. The removal efficiency of river was observed to be 61.66% for time interval of 15 minutes. This showed that the efficiency decreased for lower time interval than month of August having time interval of 30 minutes.

c) In October

Table 4.3 Mass fraction remaining and corresponding settling rate for River Chhausha in October-2019

Time Interval (minutes)	Concentration (mg/l)	Mass fraction remaining	Velocity
0	85	1	-
15	67	0.78	12
30	53	0.62	6
45	49	0.52	4
60	17	0.2	3
75	10	0.11	2.4
90	7	0.08	2

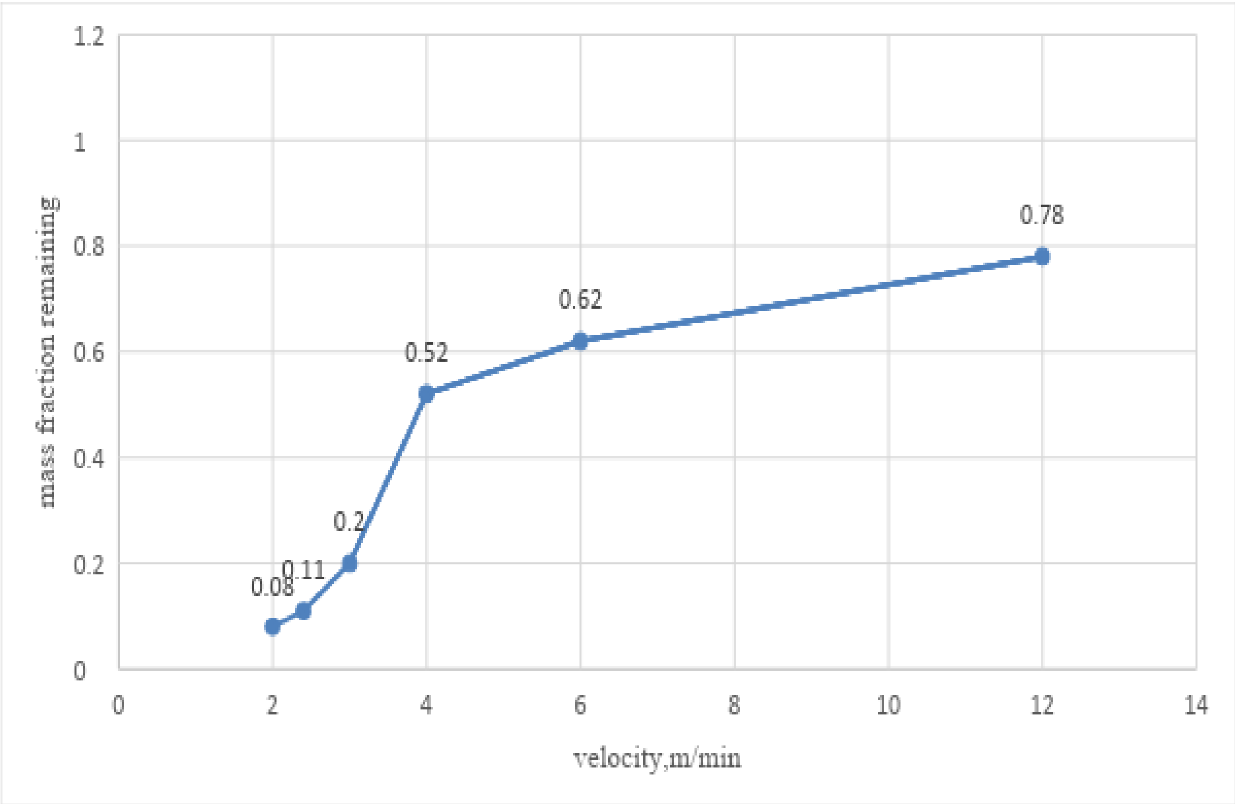

Fig4.3 Mass fraction remaining and corresponding settling rate for River Chhausha in October-2018.

From Fig. 4.3, Overall efficiency (X) at settling velocity (v_o) = 4 and x_o= 0.52

The value of $\Sigma\ (\Delta x\ .vi)\ =\ 0.4$, Table A.3, Annexure A

$$X = 1 - xo + \Sigma\ (\Delta x\ .vi)/vo$$

$$= 0.48 + 1.668/4 = 89.97\ \%$$

The removal efficiency of river was obtained to be 89.97% for time interval of 15 minutes which is slightly higher than the one obtained in the month of September. This change in the removal efficiency is owed to the increased levels of turbidity in the month of September than october. The similar results were observed in the literature [31, 32,34,36].

d) In February

Table 4.4 Mass fraction remaining and corresponding settling rate for River Chhausha in February-2019.

Time Interval (Minutes)	Total Suspended solid (mg/l)	Turbidity (NTU)	Mass fraction Remaining	Velocity
0	82	23	1	-
15	78	21	0.951	13.3
30	73.3	19	0.893	6.6
45	69	17	0.841	4.4
60	63	14	0.768	3.3
75	56	12	0.682	2.6
90	49	9	0.597	2.2

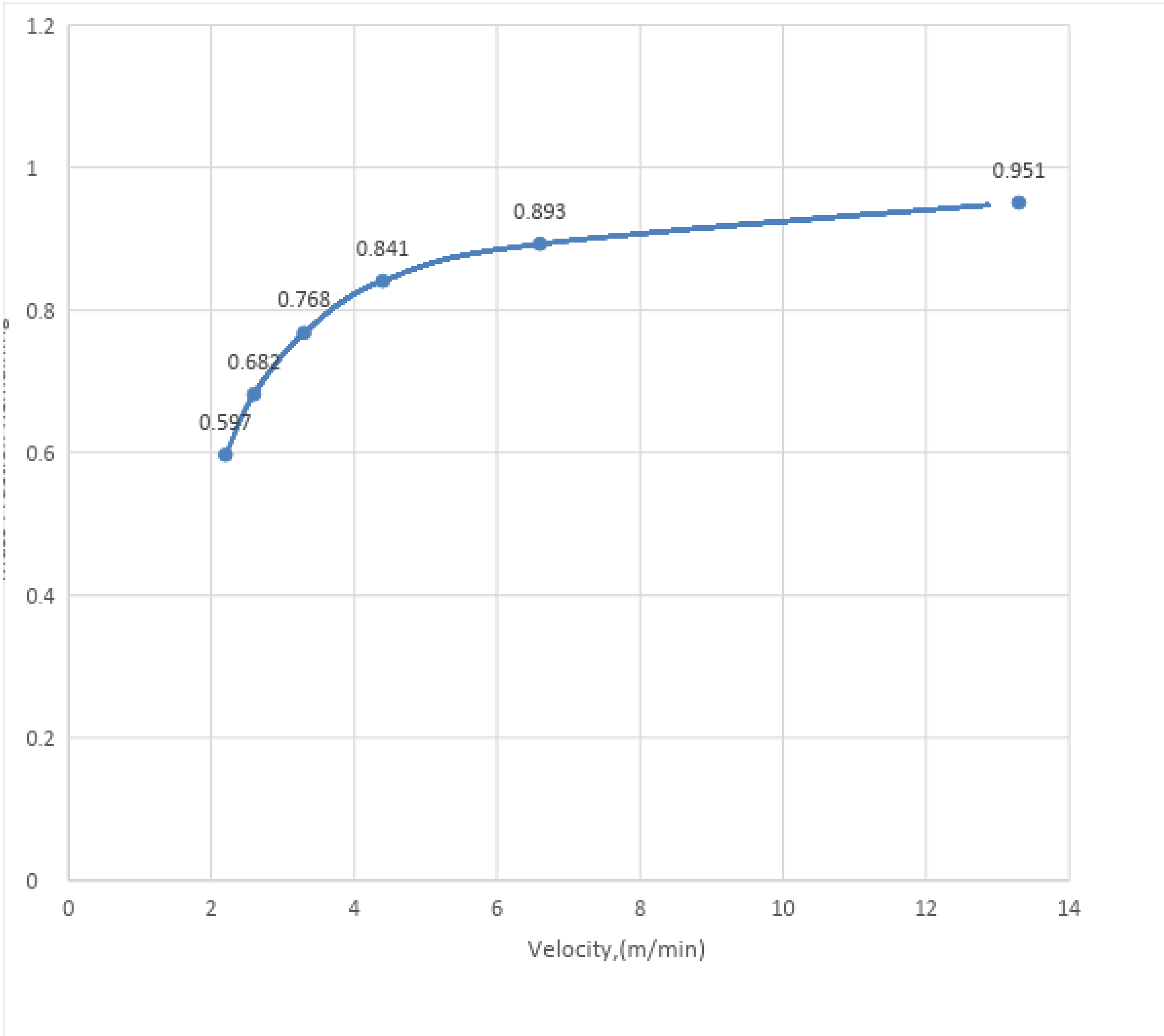

Fig 4.4. Mass fraction remaining and corresponding settling rate for River Chhausha in February.

From fig.4, Overall efficiency at settling velocity, v_o=2.2 and x_o=0.59

The value of $\Sigma\ (\Delta x\ .\ vi)\ =\ 0.5689$

$$X = 1 - xo + \Sigma(\Delta x\ .\ vi)/vo$$

$$= 0.41 + 0.5689/2.2$$

$$= 69.45\%$$

e) In March

Table 4.5 Mass fraction remaining and corresponding settling rate for location for River Chhausha in March-2019.

Time Interval (Minutes)	Total Suspended solid (mg/l)	Turbidity (NTU)	Mass Fraction Remaining	Velocity
0	89	24	1	-
15	82	21	0.921	12
30	78	18	0.876	6
45	71	14	0.797	4
60	65	11	0.730	3
75	60	9	0.674	2.4
90	55	7	0.617	2

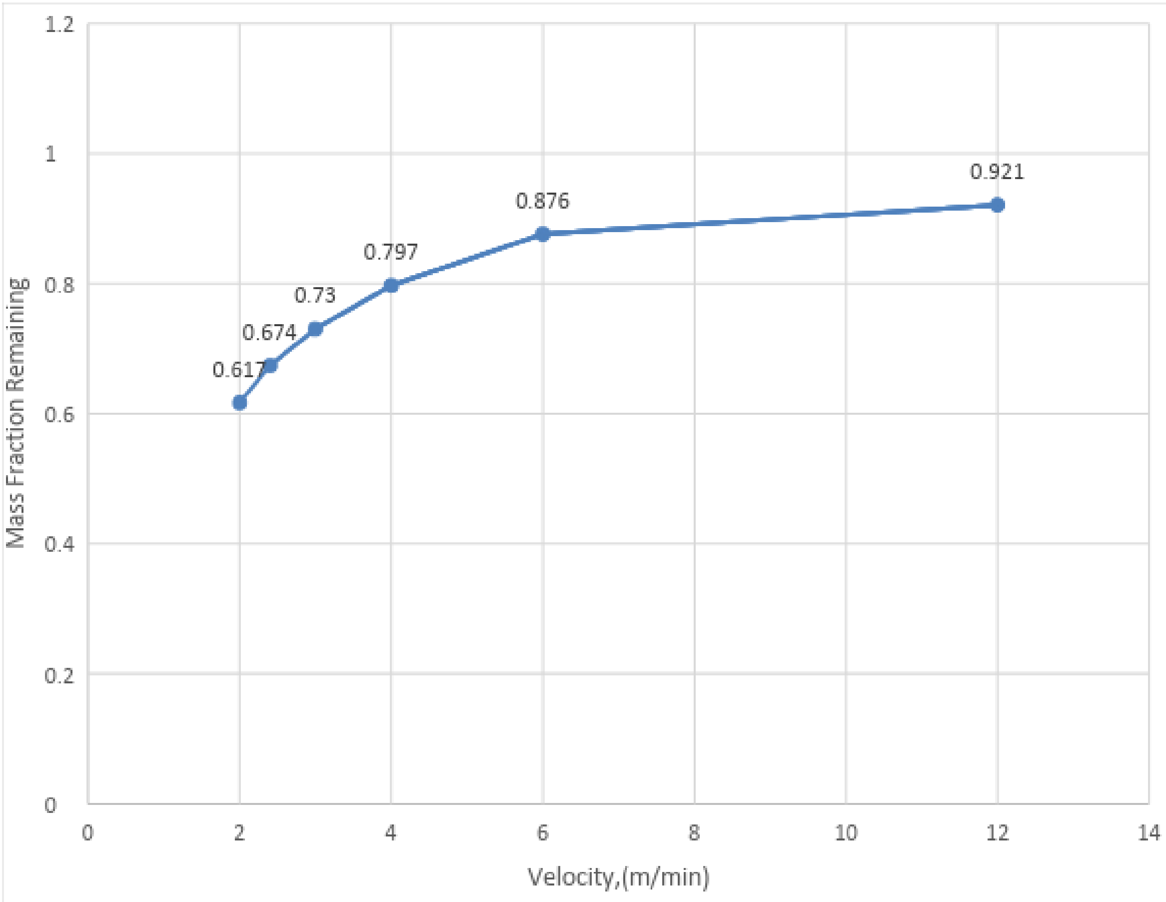

Fig 4.5: Mass fraction remaining and corresponding settling rate for River Chhausha in March-2019.

From fig.6, Overall efficiency at settling velocity, $v_o = 2$ and $x_o = 0.61$

$$\Sigma(\Delta x \,.\, vi) \;=\; 0.1676$$

$$X = 1 - xo + \Sigma(\Delta x \,.\, vi)/vo$$

= 0.39 + 0.5421/2

= 66.10 %

The level of turbidity of water during the winter seasons is lower [22,23]. Thus the removal efficiency for months of February and March is obtained to be 69.45% and 66.10% for time interval of 15 minutes.

Thus the above results for different months showed that with increase in the time interval, the efficiency is increased because the particles will get enough time to settle [4,6,10]. The time interval for setting was selected based upon the turbidity of water.

4.2 FLOCCULANT SETTLING, TYPE-II

4.2.1 RESULTS AND DISCUSSION

Type-II settling results are given below:

Calculation of removal rate of particle is given in Table B.1, Annexure B.

a) In November

Table 4.6 Removal rate of particles in water at each Height and Time for river Chhausha in November-2018

.

Height(m)	**Sampling Time**					
	5	**10**	**15**	**20**	**25**	**30**
0.3	0.3	41.7	64.91	-	-	-
0.6	0.6	37.74	50.19	73.91	82.26	-
0.9	0.9	26.98	45.28	66.04	75.66	82.45
1.2	1.2	17.92	39.81	60.75	72.08	77.36
1.5	1.5	16.79	34.53	50.38	66.23	73.96
1.8	1.8	11.7	29.62	44.15	63.02	70

Removal efficiency at time 15 min,

$$R = ro + \Sigma\ (\Delta r\ x\ Zi)\ /1.8$$

Where,

r_o is .32 as 32% iso-removal line meets at 15 minutes in x-axis.

The value of $\Sigma\ (\ \Delta r\ x\ Zi) \ = \ 0.506$, Annexure B

=.32+Σ0.5061.8

= 60.11 %

The slope of isoremoval line as shown in fig.4.6 at any point gives the instantaneous velocity of fraction of particles represented by that line. Slope of isoremoval line become steeper at greater depth, shows that velocity becomes greater at greater depth. This is because of the increase in the particle size due to flocculation in the raw water suspension which causes continued collision and aggregation with other particles. For assumed detention time of 15 minutes removal efficiency is 60.11%

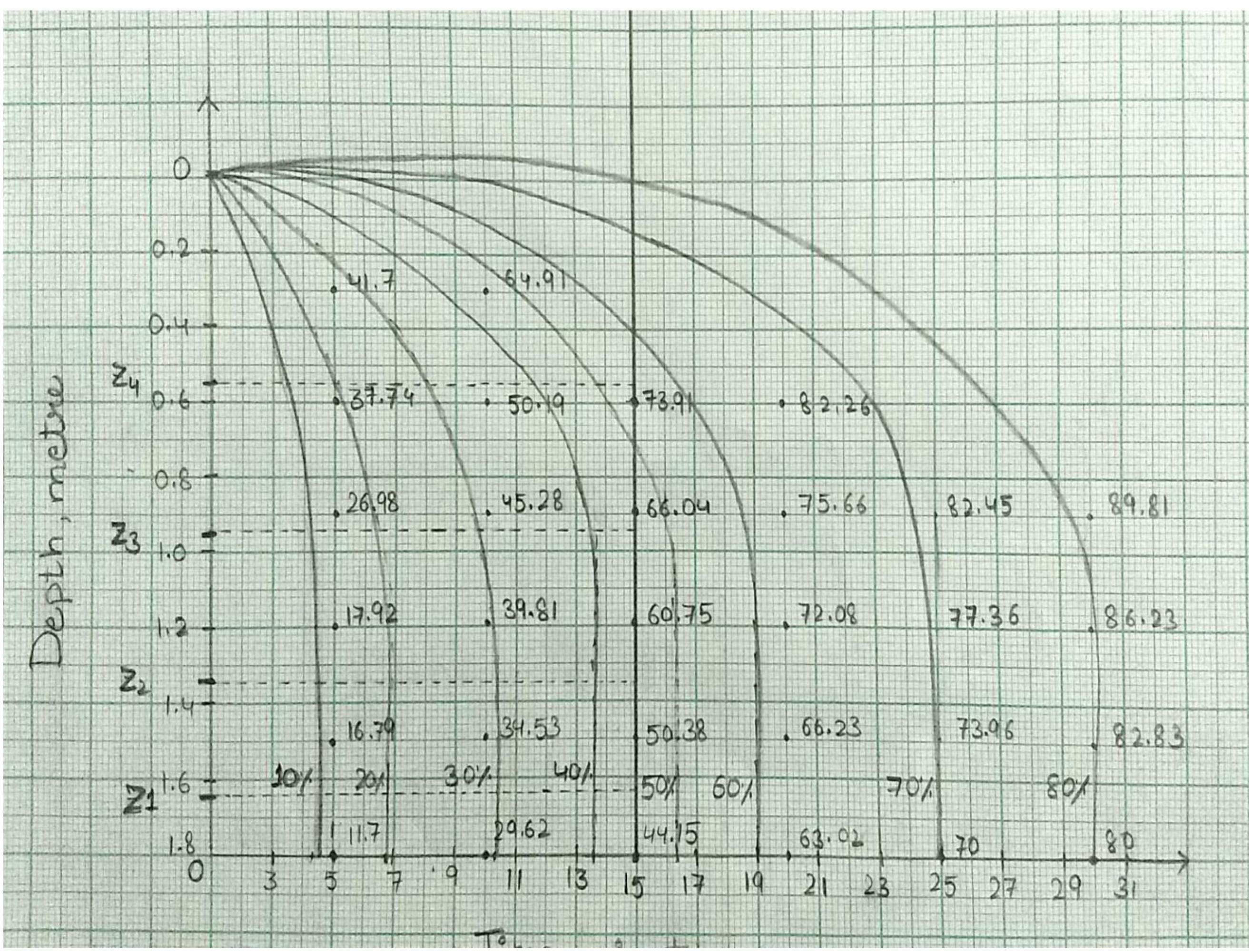

Fig 4.6 Isoremoval lines from settling analysis for river Chhausha in November-2018.

b) In April

Calculation of removal rate of particle is calculated in table B.2, Annexure B

Table 4.7 Rate of removal of particles at each Height and Time for river Chhausha in April-2019

Height(m)	**Sampling Time**				
	15	**30**	**45**	**60**	**90**
0.3	63.81	70.89	76	87.92	98.88
0.6	52.91	62.79	69.08	73.60	88.26
0.9	35.01	53.82	60.02	67.31	80.66
1.2	26	43.92	54.15	60.75	73.08
1.5	18.92	36.08	44.18	53.38	65.23
1.8	13.92	30	38.81	47.15	60.02

Removal efficiency at time 45 min, from graph 4.7

$$R = ro + \Sigma(\Delta r\ x\ Zi)/1.8$$

where, r_o is .42 as 42%, iso-removal line meets at 45 minutes in x-axis.

The value of $\Sigma(\ \Delta r\ x\ Zi)\ =\ 0.612$, Annexure B

=.42+Σ0.612/1.8

= 76.11 %

When time interval was increased for same sample of water from the same source, the removal efficiency also increased. Therefore, it indicates that clarification of water is best with more settling period.

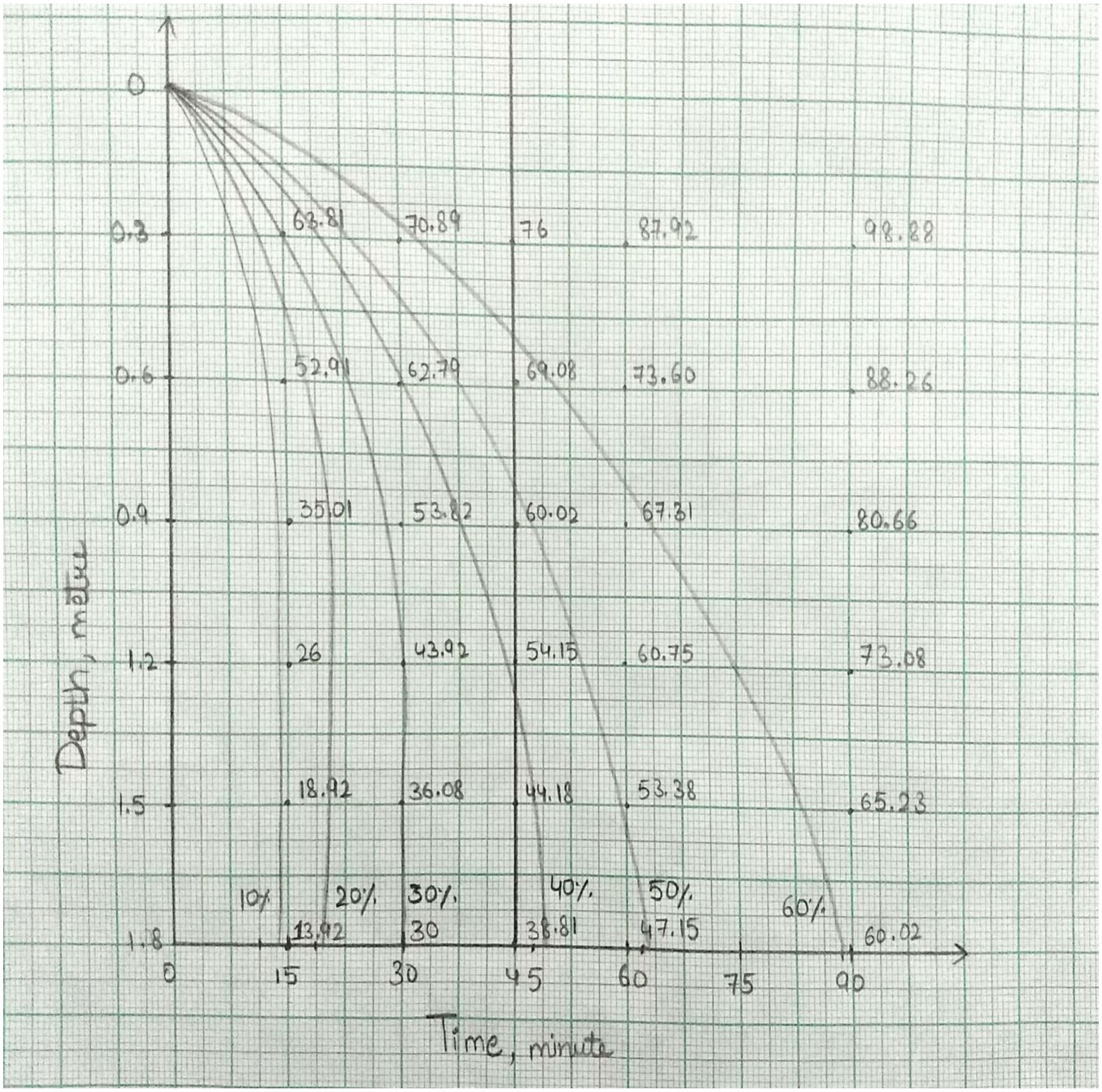

Fig.4.7 Isoremoval lines from settling column analysis for River Chhausha

4.3 Jar Test

4.3.1 Results and Discussions

The optimum dosage of alum for river chhausha is given below in the table.

Table 4.8 Turbidity and dosage of Alum

Sample Details/Jar number	Dosage of alum solution (ml)	Dosage of Coagulant (mg/l)	Residual Turbidity (NTU)
1	2	20	24
2	4	40	18
3	6	60	9
4	8	80	17
5	10	100	21
6	12	120	25

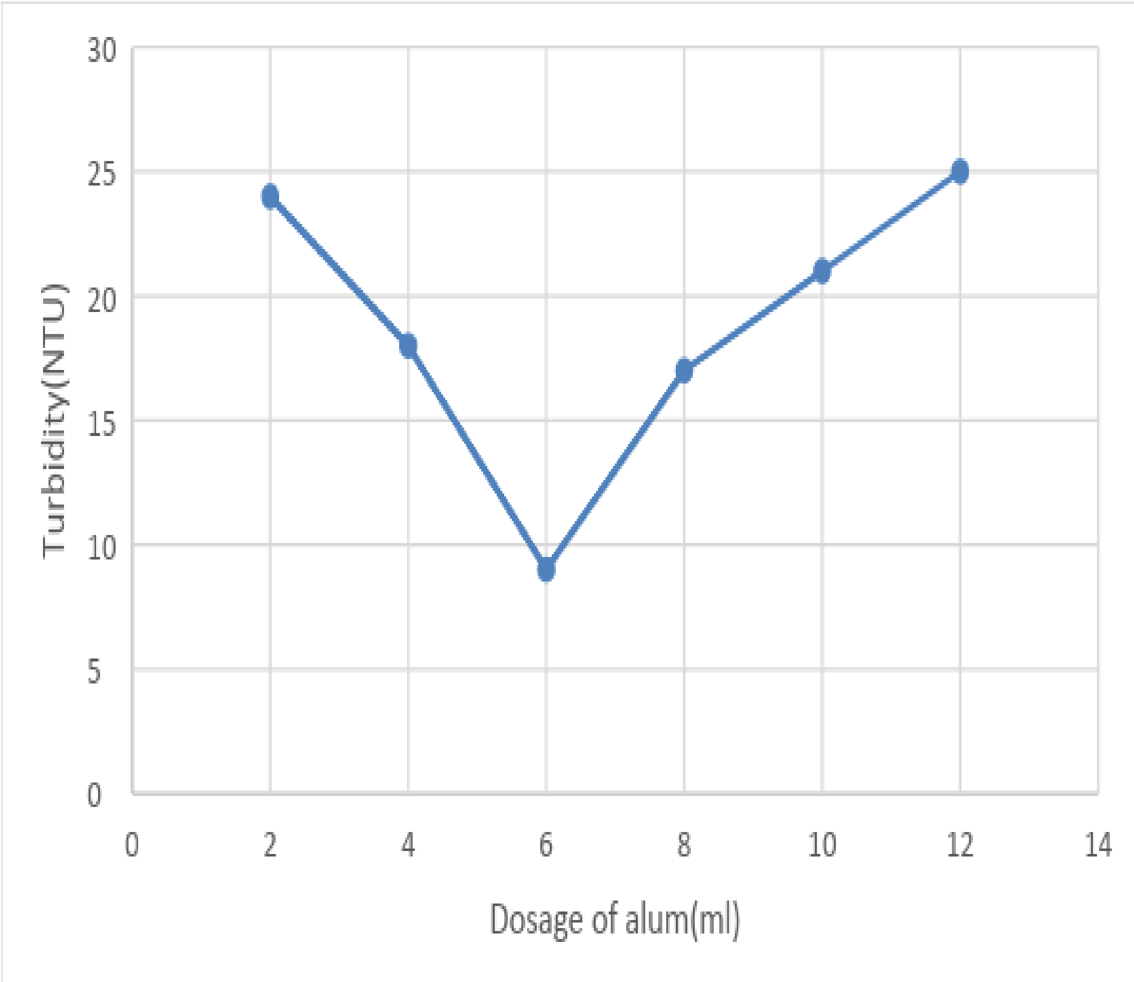

Fig 4.8 Turbidity and dosage of Alum for collected sample of water.

The optimum alum dosage from graph for river Chhausha for clarification is 6ml/l. After addition of alum, turbidity increased due to presence of residual alum.

CHAPTER 5
CONCLUSION

Type-I and Type-II settling Experiment did for analysis of settling characteristics of particles present in water test. The Experiment was done from water test of river chhausha. Type-I settling gives the plot between settling Velocity and mass fraction remaining. The plot presumes that settling speed of molecule is in charge of the proficiency of framework. Type-II settling gives the plot between depth of settling column versus time.

From chart we can reason that depth of framework is foremost parameter i.e. higher the depth, higher the floc arrangement. The experiment is accomplished for 120 minutes detention time which gave an expanded exactness of results.

The cheapest and feasible way of clarification of water is done using the optimal dosage alum present in the university laboratory. The jar test clarifies the surface water and provides information on coagulation, flocculation and clarification. Understanding these process will help engineers on account of designing of particular sedimentation tank to remove overall impurities present in the surface water so that it is pure and safe for domestic uses and drinking.

Throughout our studies and experiment, the analyzed results were obtained from cylindrical settling column. The handling of settling column was difficult. There were times where our work was delayed due to instrumental errors and leakage in apparatus. For the accuracy of data, we had to do multiple experiments on the same sample. For the benefit of future, we designed rectangular sedimentation which is expected to provide more accurate results. The handling of tank will be easier and will need less maintenance. The progress will be very rapid and will serve as an alternative apparatus for sedimentation studies. This will even boost the information obtained because they can compare the result from both the test and confirm firmly.

Our studies throw light on clarification of water and its importance. It encourages engineers to develop various methods of designing of other sedimentation tanks. Therefore, to marvel on pure water in present as well as hand over same to future generation, we need to understand the importance of clarification of surface water. The particles are liable to flocculation; such settling tanks can't be structured based on surface flood rate alone yet should mull over water driven living arrangement time detention period too. Be that as it may, rate of flocculation quickly decreases as detention period is expanded past specific qualities.

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ANEXAURE A

Table A.1: Showing calculation of mass fraction remaining for type-1 analysis for August.

Sample No	Time, min	Weight of filter paper before filtration(g)	Weight of filter paper after filtration (g)	Weight of suspended solid (mg/l)	Percent mass fraction remaining (%)	velocity, m/min X 10^2
1	30	1.831	1.916	321	100	6
2	60	1.818	1.885	262.5	90	3
3	90	1.812	1.865	205	63	2
4	120	1.812	1.865	176.5	54	1.3
5	150	1.797	1.846	130	40	1.2
6	180	1.835	1.818	110	34	1

Table A.2: Showing calculation for determination of $\Sigma\ \Delta x\ .vt$

Δx	Vt	Δx .vt
0.1	0.4	0.04
0.1	0.7	0.07
0.1	1.1	0.11
0.1	0.15	0.15
0.1	1.8	0.18
0.02	0.038	0.038
0.02	0.04	0.04

Table A.3: Showing calculation of mass fraction remaining for type-1 analysis for september:

Sample No	Time, min	Weight of filter paper before filtration (g)	Weight of filter paper after filtration (g)	Weight of suspended solid (mg/l)	Percent mass fraction remaining (%)	velocity, m/min X 10^2
0	0	1.830	1.913	93.2	1	
1	15	1.814	1.883	82	87	9
2	30	1.813	1.864	71	76	4.5
3	45	1.815	1.868	63	67	3
4	60	1.797	1.846	50	53	2
5	75	1.1816	1.1920	28	44	1.8

Table A.4: Showing calculation for determination of $\Sigma\ \Delta x. vt$

Δx	Vt	Δx .vt
0.1	0.4	0.04
0.1	0.8	0.08
0.1	1.2	0.12
0.1	1.6	0.16
0.1	1.9	0.19
0.1	2.5	0.25
0.07	3	0.21

Table A.5: Showing calculation of mass fraction remaining for type-1 analysis for October:

Sample No	Time, min	Weight of filter paper before filtration(g)	Weight of filter paper after filtration (g)	Weight of suspended solid (mg/l)	Percent mass fraction remaining (%)	velocity, m/min X 10^2
0	0	1.830	1.913	85	1	
1	15	1.814	1.983	67	0.78	12
2	30	1.813	1.964	53	0.62	6
3	45	1.815	1.968	49	0.52	4
4	60	1.897	1.946	17	0.2	3
5	75	1.842	1.947	10	0.11	2.4

Table A.6: Showing calculation for determination of $\Sigma\, \Delta x. vt$

Δx	V_t	$\Delta x .v_t$
0.1	0.4	0.04
0.1	0.8	0.08
0.1	1.2	0.12
0.1	1.6	0.16
0.1	1.9	0.19
0.1	2.5	0.25
0.07	3	0.24

Table A.7: Showing calculations for determination $\Sigma\ \Delta x . vt$

Δx	V_t	Δx .V_t
0.4	0.05	0.02
0.4	0.09	0.036
0.2	0.26	0.058
0.2	0.55	0.11
0.2	0.88	0.176
0.08	0.95	0.076
0.08	0.95	0.076

Table A.8 Showing the calculations for determining $\Sigma\ \Delta x.vt$

Δx	v_t	$\Delta x.v_t$
0.06	1.23	0.0738
0.06	1.72	0.1032
0.1	0.89	0.089
0.1	0.66	0.066

ANNEXURE B

Table B.1: Showing calculation of Removal efficiency for Type-II analysis

Sample No.	Turbidity (NTU)	Initial wt. of filter paper before filtration (g)	Final wt. of filter paper after filtration (g)	Wt. of suspended solid (mg/100ml)	Wt. of suspended solid (mg/l)	Removal efficiency (%)
A1	22	1.8036	1.8247	21.1	105.5	50.35
A2	11	1.8645	1.8796	15.1	75.5	64.47
B1	20	1.8401	1.8653	25.2	126	40.71
B2	15	1.8488	1.8707	21.9	109.5	48.47
B3	14	1.1801	1.8968	16.7	83.5	60.71
B4	8	1.1829	1.9021	12.1	60.5	71.53
C1	22	1.1762	1.8023	26.1	130.5	38.59
C2	18	1.1832	1.1872	24	120	43.53
C3	16	1.1703	1.1898	19.5	97.5	54.12
C4	9	1.1787	1.1872	13.3	66.5	68.71
C5	6	1.1732	1.1842	11	55	74.12
C6	6	1.1875	1.1984	6.5	32.5	84.71
D1	23	1.1864	1.1975	31.1	155.5	26.82
D2	16	1.1807	1.1975	26.8	134	36.94
D3	14	1.1713	1.1818	20.5	102.5	51.76
D4	8	1.1727	1.1873	14.6	73	65.65
D5	7	1.1735	1.1963	12.8	64	69.88
D6	4	1.1712	1.1838	8.6	43	79.76
E1	29	1.1854	1.1912	35.8	179	15.76
E2	13	1.1801	1.1918	31.7	158.5	25.41
E3	10	1.1792	1.1856	26.4	132	37.88
E4	9	1.1823	1.1978	19.8	99	53.41
E5	6	1.1847	1.1981	14.4	72	66.12
E6	4	1.1765	1.1869	10.4	52	75.53
F1	31	1.6689	1.8071	38.2	191	10.12
F2	15	1.1893	1.1935	34.2	171	19.53
F3	11	1.1711	1.1849	27.8	139	34.59
F4	9	1.1738	1.1852	21.4	107	49.65
F5	7	1.1817	1.1938	16.8	84	60.47
F6	5	1.1769	1.1827	13.7	68.5	67.76

Table B.2: Showing calculation of removal efficiency for Type-II analysis

Sample No.	Turbidity(NTU)	Initial wt. of filter paper before filtration (g)	Final wt. of filter paper after filtration (g)	Wt. of suspended solid (mg/200ml)	Wt. of suspended solid (mg/l)	Removal efficiency (%)
A1	28	1.211	1.289	78	39.0	41.70
A2	40	1.233	1.2845	51.5	257.5	64.91
B1	30	1.318	1.351	33	165	37.74
B2	11	1.384	1.4954	111.4	55.7	50.19
B3	5	1.298	1.3333	35.4	176.5	73.91
B4	4	1.261	1.3129	51.9	259.5	82.26
C1	32	1.222	1.3658	143.8	71.9	26.98
C2	44	1.544	1.5655	21.5	107.5	45.28
C3	11	1.656	1.6897	33	165	66.04
C4	8	1.325	1.3567	31	155	75.66
C5	12	1.214	1.2564	42	210	82.45
C6	37	1.258	1.2968	38	190	89.81
D1	25	1.254	1.398	144	72.0	17.92
D2	14	1.997	2.331	334	167.0	39.81
D3	20	1.458	1.654	196	98.0	60.75
D4	6	1.455	1.548	93	46.5	72.08
D5	4	1.3014	1.568	266.6	133.3	77.36
D6	40	1.235	1.2956	60.6	30.3	86.23
E1	17	1.879	2.336	457	228.5	16.79
E2	45	3.311	4.112	80.1	400.5	34.53
E3	17	0.369	1.258	889	44.45	50.38
E4	23	1.144	1.3258	181	90.5	66.23
E5	17	1.365	1.666	301	150.5	73.96
E6	11	1.802	2.002	200	100	82.83
F1	8	1.894	1.965	71	355	11.70
F2	5	0.654	1.361	707	353.5	29.62
F3	6	1.325	1.652	327	163.5	44.15
F4	11	1.987	3.256	126.9	63.45	63.02
F5	5	1.104	1.423	319	159.5	70.00
F6	7	0.985	1.222	237	118.5	80.00