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Use of Tube Settler for the Removal of Inorganic Suspended Particles Present in Water.

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Abstract—the inorganic suspended particles removal efficiency of tube settler was evaluated by measuring the turbidity and suspended particles concentration at various turbidity ranges and flow rates. The tube settler performs maximum up to 73.37% turbidity removal at overflow rate of 0.42 m/hr (10.18 m3/m2-d) for the turbidity range of 100-125 NTU. If 60% efficiency is accepted for practical design, overflow rates of 10.18, 17.82 and 30.04 m3/m2/d can be treated for raw water turbidity up to 100-125, 75-100 and 50-75 NTU respectively. From the experiment, it was found that to remove the particles size above 11.6 µm, the SOR should maintain 0.42m/h. similarly to remove particles size above 15.4 µm, 20 µm, 22.5 µm and 25.5 µm the SOR should be 0.74m/hr,1.25 m/h, 1.59 m/h & 2.02m/h respectively. The particles removal concentration from tube settler of different turbidity ranges with respective SOR was found to be 68.81%, 59.15%, 55.64%, 51.82% and 43.39% at SOR of 0.42m/h, 0.74m/h, 1.25m/h, 1.59m/h and 2.02m/h respectively. The turbid water of turbidity 125-150 NTU at overflow rate of 1.25 m/hr gives the best performance (63% turbidity removal efficiency and 6 min retention time) and 55.64% suspended particles removal at overflow rate of 1.25m/hr

Keywords— Turbidity, Surface overflow, Settling velocity, Tube settler, Retention time, Efficiency, Suspended particles, Sedimentation tank

I. INTRODUCTION

Water is the most essential commodity for the continuation of life. Water is also required for various types of industrial & commercial purposes. Safe drinking water supply and sanitation services is fundamental to improving public health. The investments in water supply and sanitation can yield net economic benefit, as the reductions in adverse health effects and health-care cost outweigh the cost of undertaking the interventions (WHO, 2011).

Turbidity and suspended particles removal is a major challenge in community water supply schemes where streams or rivers are the sources of supply. The ever-increasing deforestation, construction activities in many catchments has increased the landslide and soil erosions problem tremendously, thereby resulting highly turbid stream and river (Sharma, 2016). The availability of O&M fund is extremely poor condition in Nepal i.e. only 4.5% (NMIP, 2014).

The major contaminants in river sources are organics & inorganic suspended materials .The in-organic materials like fine sand, clay, silt are major contributors for water to be turbid in river sources. Turbidity is one of the main characteristics of water sources in rainy seasons. Excessive turbidity in drinking water is aesthetically unappealing, and may also represent a health concern. Turbidity can provide food and shelter for pathogens by reducing their exposure to attack by disinfectants (WHO, 2011). In rainy seasons as well as construction activities near to periphery of water source leads to excessive concentration of organic & inorganic particles. Concentration of inorganic & organic particles are the cause of turbid water in water source. The most of inorganic particles are settle by gravity but small fine particles of size less than 1 mm are in suspension which could leads to turbidity in the water source.

Hazen (1904) suggested the idea of shallow-depth settling, Camp (1946) explored it, and Hansen and Culp (1967) demonstrated its practical application. Sedimentation- tanks incorporating small sized tubes of various shapes with detention times of 15 minutes or less settlers can achieve settling efficiencies comparable or better than those normally obtained in conventional rectangular settling tanks generally having detention times of two hours or more. (Khatri, 2001).

Two basic shallow depth & high rate settling systems are available with (5-degree & 45 degree to 60 degree) to the horizontal). Tube-settlers are compact and can provide the benefits of significant cost savings in construction and land costs. They can also be used for upgrading an existing overloaded conventional sedimentation tank and still provide comparable or better settling efficiencies normally obtained in conventional settling tanks.

II. MATERIALS AND METHODOLOGY

Firstly, water samples are taken from the different river and determine the size of particles in suspension from the flowing water to check the practical feasibility of the research work. The sample result provide ideas about more than 70% particles have size less than 1mm and have density less than water are in suspension during flowing on river. The sieve analysis is carried out for the preparation of in-organic particles of equivalent size to that of suspended particles. The influent water is then prepared by mixing ground water with fine solids inorganic particles. The study was then started with preparation of influent water by mixing ground water with fine solids inorganic particles at various flow rate and run the model of design tube Settler constructed at pulchowk campus.

III. Experimental Setup

The experiment setup model of tube settler constructed at IOE Pulchowk campus is used for the study. The experimental set up consisted two numbers of storage tanks of 5000-liter capacity and constant head maintaining tank of 500 liter capacity and a designed tube settler tank. Tube settler was connected with constant head tank by 50 mm diameter pipes under the gravity flow to maintain the head. Inlet, outlet, flow control point were installed with gate valves of 50mm diameter. The tube pipes were supported on the bottom of the tank by an acrylic sheet of 5mm thickness with openings of size equal to the projected areas of the pipes. Tube settler tank was designed to remove the suspended particles of size greater than 20 microns. Tube settler tank was 0.85 m long and 0.87 m wide with effective depth of 1.1 m. Tube settler consisted 144 numbers of 95 cm long with 50 mm internal diameter UPVC pipes at an inclination of 60 degree to horizontal as main settling devices. It has a relative length of 13.35. Total sectional area of the tubes was 0.28 m^2.

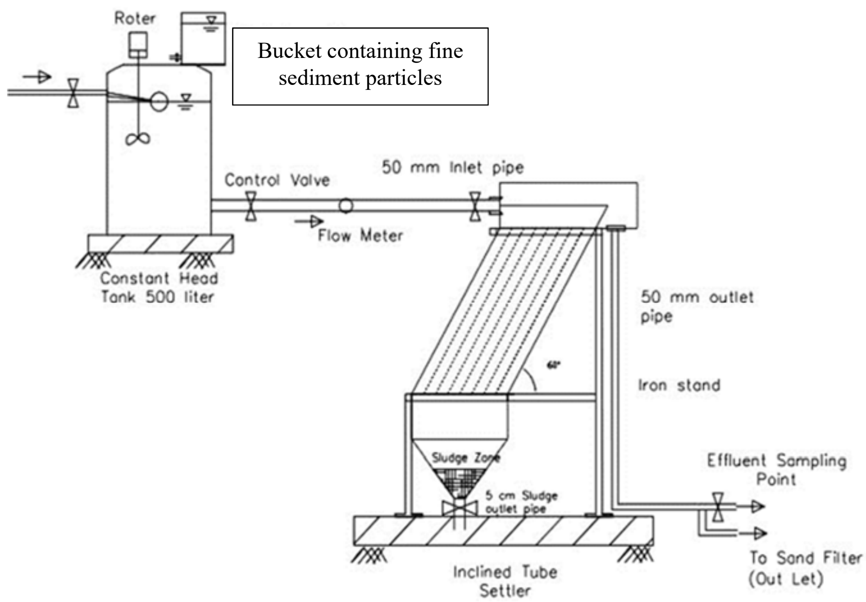

Figure 1 Schematic Diagram of tube settler model

IV. TURBIDITY AND SUSPENDED PARTICLES ANALYSIS

The turbidity was measured at constant head tank, Inlet and outlet of tube settler for flow rate 5lit/m, 10lit/m 20 lit/m, 25lit/m and 30 lit/m at different turbidities ranges from 20-250 NTU.The turbidity removal efficiency is calculated based on measured influent & effluent turbidity. Suspended particles removal efficiency is then calculated based on turbidity removal efficiency through tube settler.

Sediment sample of 100ml capacity bottle is used for water sample collection from constant head tank, inlet and outlet of tube settler. All the samples are filtered in filter paper & weight of the water sample with sediment is measured before filtration. Filtered samples are then dried & dry weight of the filter paper with sediment is determined. The suspended sediment concentration (PPM) is calculated according to the amount of water collected.

V. Turbidity Removal Profile through Tube settler

The turbidity removal capacity of the tube settler is observed by measuring influent and effluent turbidity at discharges 5, 10, 20, 25 and 30 lit/min and SOR: 0.42, 0.74, 1.25, 1.59 and 2.02 m/hr at different turbidity ranges from 20 to 250 NTU.The removal capacity decreases with the increase of overflow rate. The influent water of turbidity ranges up to 125, 100, 75 & 50 NTU are only allowed to treat in the designed tube settler system at over flow rate of 0.42, 0.74, 1.25 and 1.59 m/hr respectively. However, at designed SOR of 1.59 m/hr, tube settler can only treat the turbid water of turbidity ranges of 50-75 NTU.

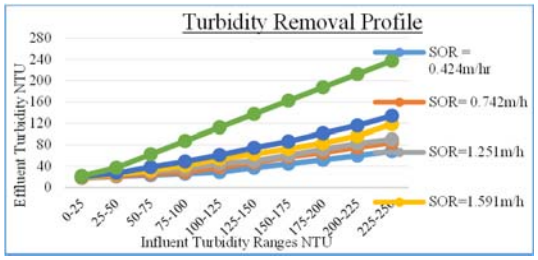

Figure 2 Effluent turbidity Vs Influent Turbidity Ranges

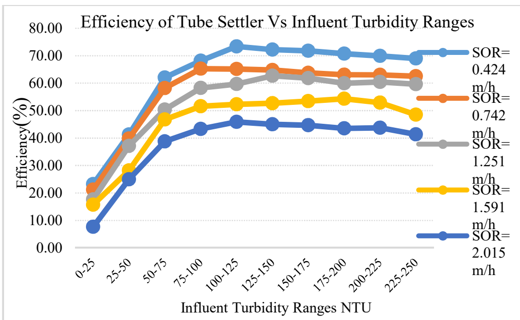

Figure 3 Efficiency of tube settler Vs Influent Turbidity

The turbidity removal efficiency increases continuously, when reach at maximum level then become consistent and decreases slowly. Maximum efficiency reaches about 73.37% at overflow rate 0.42m/hr (i.e. Flow discharge at 5 lit/min) in the influent raw water of 100-125 NTU range.

VI. Effect of Turbidity on Efficiency

The effluent turbidity increases with increase of raw water turbidity for all overflow rates.

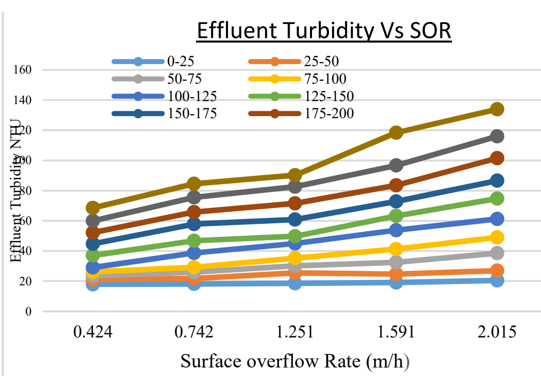

Figure 3 Effluent turbidity Vs SOR

VII. Suspended Particles Concentration Analysis

The particles removal concentration from tube settler of different turbidity ranges with respective SOR was found to be 68.81%, 59.15%, 55.64%, 51.82% and 43.39% at SOR of 0.42m/h, 0.74m/h, 1.25m/h, 1.59m/h and 2.02m/h respectively.

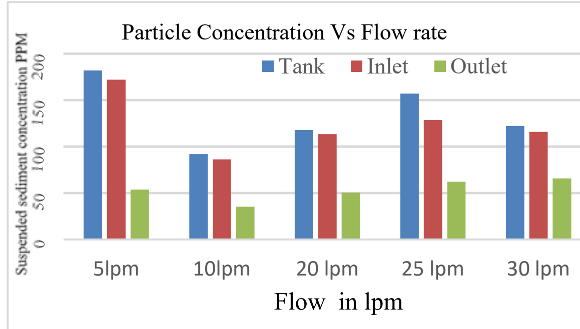

Table 1: showing SS and efficiency removal with respective SOR.

SOR(m/hr)	0.424	0.742	1.251	1.591	2.015
Target particle Removed(µm)	11.6	15.4	20	22.5	25.5
Total % of SS Particles removed(Theoretical)	70.72	63	60.95	53.23	46
Total % of SS Particles Removed(Practical)	68.81	59.15	55.64	51.82	43.39
Average Turbidity Removal Efficiency (%)					
75-100	68.13	65.25	58.26	51.54	43.30
100-125	73.37	65.14	59.68	52.27	45.88
125-150	72.19	64.78	62.69	52.68	45.00
175-200	70.72	63.08	59.95	54.32	43.54

VIII. CONCLUSION

Study shows that the turbidity removal capacity decreases with the increase of overflow rate. The maximum turbidity removal efficiency in tube settler is obtained as 73.37%, 65.25%, 62.29%, 54.32% & 45.88 % at SOR of 0.42m/h, 0.74m/h,1.25m/h & 2.02m/h respectively. If 60% efficiency is accepted for practical design, overflow rates of 10.18, 17.82 and 30.04 m3/m2/d for water turbidity up to 100-125, 75-100 and 50-75 NTU can be used respectively. The particles removal concentration from tube settler of different turbidity ranges with respective SOR was found to be 68.81%, 59.15%, 55.64%, 51.82% and 43.39% at SOR of 0.42m/h, 0.74m/h, 1.25m/h, 1.59m/h and 2.02m/h respectively.

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