WASTE WATER TREATMENT USING GRAVEL-GEO TEXTILE FILTER

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Submitted By

AADARSH KUMAR SINGH

Examination Roll No– **M6WRP22017**

Registration No - **150289 of 2019-2022**

Under Guidance of:

Prof. Dr. PANKAJ KUMAR ROY

Director & Professor

School Of Water Resources Engineering, Jadavpur University

School Of Water Resources Engineering

M.E. (Water Resources and Hydraulic Engineering)

Course affiliated to

Faculty of Engineering & Technology

Jadavpur University

Kolkata – 700032, West Bengal, India

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M.E. (Water Resources and Hydraulic Engineering) Course affiliated to

Faculty of Engineering and Technology

Jadavpur University

Kolkata – 700032, India

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This is to certify that the thesis entitled **"WASTE WATER TREATMENT USING GRAVEL-GEO TEXTILE FILTER"** is a bonafide work carried out by **AADARSH KUMAR SINGH** (Examination Roll No: **M6WRP22017**), a student of School of Water Resources Engineering, Jadavpur University, under my supervision and guidance for partial fulfilment of the requirement for the Post Graduate Degree of Master of Engineering in Water Resources And Hydraulic Engineering (6^{th} semester) during the academic session 2021-2022 from Jadavpur University**.**

DIRECTOR
Prof. (Dr.) Pankaj Kumar Roy
School of Water Resources Engineering
Jadavpur University
Kolkata – 700032

THESIS ADVISOR
Prof. (Dr.) Pankaj Kumar Roy
School of Water Resources Engineering
Jadavpur University
Kolkata – 700032

DEAN
Faculty of Interdisciplinary Studies,
Law & Management
Jadavpur University
Kolkata – 700032

M.E. (Water Resources and Hydraulic Engineering) Course affiliated to

Faculty of Engineering and Technology

Jadavpur University

Kolkata – 700032, India

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The Final Report is hereby approved as a creditable study of an Engineering subject titled **"WASTE WATER TREATMENT USING GRAVEL-GEO TEXTILE FILTER"** carried out and presented in a manner of excellence to warrant its acceptance as a perquisite for the degree of 'Master of Engineering' for which it has been submitted. It is understood that by this approval the undersigned does not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the Final Report only as a perquisite for the Project Work.

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DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Engineering in Water Resources & Hydraulic engineering (6TH SEM) degree in the Faculty of Interdisciplinary studies, Jadavpur University during academic session 2021-2022.

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Name: AADARSH KUMAR SINGH

Examination Roll No: M6WRP22017

Thesis Title: "Waste water treatment using Gravel Geo textile filter"

Date: **22.08.2022**

Place: S.W.R.E, Jadavpur University

AADARSH KUMAR SINGH

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Date: 22.08.2022

Place: JADAVPUR UNIVERSITY

AADARSH KUMAR SINGH

Examination Roll No**: M6WRP22017**

ABSTRACT

A Comparative study was carried out to assess the effectiveness of geotextile in gravel-geotextile filter in removing Total Suspended solid (TSS) and Biochemical Oxygen demand (BOD_5) from municipal waste water and comparison was made with gravel-only filter & Gravel-PET filter with respect to TSS and BOD_5 removal. The experiment was conducted by setting up three test filter columns at Concrete Pathology Lab, Metro car Depot Joka Kolkata and TSS & BOD_5 values were obtained after testing inlet and outlet samples at School of Water Resources Engineering Laboratory, Jadavpur university, Kolkata. The waste water was collected from the municipal sewer nearby Metro car Depot Joka. The TSS removal efficiency of Gravel-geotextile filter was the highest with TSS removal up to 81.65 % of inlet value compared to other two filter test columns which managed to remove TSS up to 65 % and 69.75 % respectively. The BOD_5 removal efficiency of Gravel-geotextile filter was also the highest with BOD_5 removal up to 64 % of inlet value compared to other two test filter columns which managed to remove BOD_5 up to 57.6 % and 49 % respectively. The Gravel-geotextile filter can be used for water treatment in small communities discharging low to medium strength sewage.

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INTRODUCTION

1.1 General Background:

Water is one of the most important resources available on Earth. As we try to find life on other planets, the first thing we always look to find is water. It is quite accurate to say that water is the back bone of human civilization. Waste water is a contaminated form of Water which is generated after it has gone through different uses or processes. Depending upon the process or use of water, degree of pollution of water also varies greatly. It also dictates how and what type of treatment is to be given in order to make it safe for disposal or further use in any particular environment.

In our daily life we use water for many purposes such as in the kitchen, Toilet, Washrooms, for cleaning floors, drinking etc. Apart from this many industries and commercials establishments use water such as paper pulp industries, leather industry, cement industry, Hospitals, Schools etc. Water coming out of our household or community or an industrial source is contaminated with organic & inorganic materials, gaseous substances, and pathogenic organisms. Waste water so generated needs treatment to avoid harmful effect on human and its environment.

Waste water treatment and its safe disposal have become one of the most challenging works in recent time owing to rapid population growth, relative increase in standard of living worldwide, climate change, scarcity of fresh water & cost associated with the use of conventional technologies. Technological advancement is very much necessary to keep balance with challenges of present situation of waste water management. It is also important to note that financial feasibility of a project using a definite technology has impacted the implementation of such project greatly over time. It leads to the point where we are not only required to find a better solution for waste water treatment but also to assess its applicability in terms of financial feasibility of the project.

The world would face a 40% global water deficit by 2030 under a business-as-usual scenario (2030 Water Resources Group, 2009). We are of practice to use fresh water for purposes such as gardening, agriculture, fountains, cleaning of public places etc. The use of fresh water for activities which do not require stringent standards of quality of water should be discouraged at community level by local authorities. We need to look at solutions where we can find easy and effective method to treat wastewater and regenerate it at a certain standard so that it can be used for different purposes as mentioned above. It is also important to understand that the local authorities, govt needs to put a lot of effort to set standards categorically for use of water for a certain purpose and quality standard required for that particular purpose. In this way not only the management of water coming out of a particular source would be easy but also its application can be made more efficient in terms of distribution. Technologies can be developed accordingly as per the need to treat water to a certain standard. It is important to develop technologies which enables us to use the maximum quantity of treated water in a planned and efficient manner to keep balance with ground water extraction and recharge.

India is home to a population of more than 1.21 billion people of which 68.9 % and 31.1 % reside in rural and urban areas respectively (Census India, 2011). Over the years, there has been a continuous migration of people from rural and semi-urban areas to cities and towns. The proportion of population residing in urban areas has increased from 27.8% in 2001 to 31.2 % in 2011 (CPHEEO, 2013). Due to increase in population of cities waste water generation is also increasing by the day and management of waste water right from the source point till its final disposal needs to be done in a strategic and planned manner.

It is often seen in Indian condition that management of waste water which includes its transportation from the source, treatment and final disposal of effluent at specified standard badly managed specially in smaller towns, suburban areas, congested parts of the cities and villages. We often see waste water flowing over road side drains, which is not only aesthetically unpleasant but also creates several health hazards. Most of households, smaller industries, and local bodies discharge their waste water in a nearby water body. This is mostly the practice in smaller towns, sub urban areas and villages. Due to lack of sewer networks in these areas, waste water overflows practically all over its route and creates a several health problems. It is quite common to spot stagnant water at several places in Indian towns and villages producing foul smells due to lack of sewer networks. The other problem of an inefficient water management, involves waste water treatment units being too far from the source or even not at all present. Waste water treatment units or Sewage treatment plans are sparsely located in cities& towns and waste water is expected to flow through a network of connected sewers to a particular unit for further treatment. As mentioned before many areas of towns, villages, suburban areas are not connected by a proper network of sewers; the only option left to treat waste water is by diluting it in a nearby water body. The water body polluted with waste water is often used for other purposes such as bathing, cleaning clothes etc which is not only unhygienic but also creates several health problems at community level in humans as well as animals using it for drinking water. It is very important to develop technologies which can be implemented at smaller community levels specially in these areas where there is a lack of sewer networks and waste water cannot be transported to treatment units. The mere reliance on treatment by dilution should be discouraged at community level and research should be carried out to find solution which is not only effective but also financially feasible. We Often see in Indian condition, conventional technologies and methods are followed for waste water treatment. Use of Conventional technologies is usually done to treat Municipal waste water as it contains fewer toxic substances as compared to industrial effluents. Also, the technology involved is quite simple and easy to maintain but it takes a lot of space, cost and time to build it. It is very common in our country that Organization and public bodies responsible for waste water management do not give much emphasis on technological advancement or innovation in waste water treatment methods. The common thought is to bring waste water to a particular treatment unit by building a better network of sewers. As the population increase in India is quite exponential, cities and towns especially older towns are getting densely populated. It will be very difficult to handle such large volumes of waste water at treatment Units in future. Technological advancement is needed in waste water treatment methods. It is very important for public bodies, organisations to understand the gravitas of the current situation and encourage such research and development in this field.

Traditional wastewater treatment systems require a significant investment in real estate and equipment, neither of which are mobile or reusable. The concept of using a filtration unit instead of settling tanks was developed to avoid the risk and expense of local hauling and dumping and to provide an indigenous mobile treatment capability.

Waste water treatment involves removal of Suspended solids and BOD5 to bring it to specified standards for safe disposal. Suspended solids can be seen with eyes which include the larger floating particles and consist of sand, grit, clay, fecal solids, paper, and pieces of wood, particles of food and garbage, and similar materials. They may organic or inorganic in nature. Suspended solids are approximately 70% organic solids and 30% inorganic solids, the latter composed mainly of clay, sand. and grit (Kotha, 2001).

The suspended solids in wastewater are usually removed by gravity-separation methods such as the sedimentation units. It requires large areas to construct and higher cost is associated with it. Removal efficiencies for the removal of SS range from 40 to 60% for the sedimentation units (Kotha, 2001). The settled sewage in sedimentation units require further treatment. Also, the operation and maintenance are difficult. This takes to the point where there is a need to develop a new technique to remove SS concentration as well as BOD_5 reduction.

Traditional wastewater treatment systems require a significant investment in real estate and equipment, neither of which are mobile or reusable. The concept of using a filtration unit instead of settling tanks was developed to avoid the risk and expense of local hauling and dumping and to provide an indigenous mobile treatment capability. Developing cheap and easy-to-operate wastewater treatment methods are crucial in order to surpass the low economies issues and maintain the sanitation.

In this research paper, Gravel-Geo textile filtration technique is explored by providing single layers of Geo textile at the intermediate levels of Gravel layer. Geo textile has a membrane structure which allows water to flow through it but arrests other particle from flowing through it depending on its structure.

Over the past years, global plastic production has increased thanks to demand from the growing population. The plastic water bottle may be useful and cheap but has environmental consequences. From production to disposal, plastic water bottles affect climate change, humans, and wildlife. In Modern days of today, waste plastic has become one of the most challenging problems as it is not a bio degradable material. Plastic waste especially plastic bottles are used extensively in food industries, households, factories etc. The safe disposal of such waste bottles is poorly managed especially in smaller towns and villages. Many industries have started to develop new technologies to reuse waste plastic. In this paper, Waste PET bottles are used as a replacement of gravel layer to filter waste water. It is expected that the smaller pieces of bottles can develop biomass on their surface. Gravel filters are commonly used in water and Waste water treatment extensively in many types of filters such as Trickling filter, slow sand filters etc. A gravel only filter is also constructed in this research to find out its removal efficiency with respect to various water quality parameters and compare it with the other two test column filters constructed using Geo textile and PET bottle with gravel. Detailed discussion about materials used, methodology adopted etc. is done in subsequent chapters.

CHAPTER 2

Literature Review

2.0 Overview: Waste water treatment technology needs to be developed for varying range of conditions to suit socio-economic Environment. Many Researchers have successfully conducted experiments in this fields to develop new technologies to improve treatment efficiencies. The technologies so developed need to keep the financial aspect in consideration for it becomes a deciding factor in many sectors. The literature review is done to understand the concepts, findings, results, discoveries, methods, inventions etc in similar work or factors related to the research work. The research work involves use of Filtration technique, gravel media, geotextile material, PET bottles. It was attempted to review as many literatures as possible to get a good idea of the processes and material. Few of them are mentioned in subsequent sections.

2.1 Filtration and Filter media Characteristics: Filtration is a unit operation to separate suspended particles from a liquid phase by passing the liquid through a porous medium. When the liquid is forced through such a porous medium, the suspended particles are retained on the medium's surface or within the medium itself. The liquid that passes through is referred to as the filtrate. A porous medium is defined as a solid containing many holes and tortuous passages. A porous medium is characterized by the manner in which openings are embedded, the extent of their interconnection, and their location, size and shape. The fraction of the medium that contains voids is defined as porosity. When a liquid passes through a porous medium, the fraction of the medium that contributes to the flow is termed as effective-porosity.

There are two types of filtrations: "cake " and "filter-medium" filtration. The cake-filtration is also termed as surface filtration because solid particles generate a cake on the surface of the filter medium. In filter-medium filtration, solid particles get entrapped within the pore structure of the filter medium. The cake and filter medium influence each other. During filtration, the volumetric rate through a filter medium is directly proportional to the existing pressure gradient across the filter medium and inversely proportional to the flow resistance imposed by the formation of filter cake and filter medium. The pressure gradient is the driving force for the liquid to flow through the medium. The driving force increases proportionally, irrespective of how the pressure gradient is developed. But in most cases, the rate of filtration increases slower than the rate at which the pressure gradient increases. Pores size and shape normally depends on the manufacturing method used for the construction of the filter medium. Pore characteristics also depend on the properties of fibres. The separation process occurring within the pore passages influences the pore characteristics, as this decreases pore size, and increases flow resistance across the filter medium (Cheremisinoff, 1998).

In practice, cake filtration is preferred over the filter-medium filtration. In cake filtration, once the cake attains a certain thickness, the cake is removed from the filter medium by using mechanical devices or by reversing the flow of filtrate. The structure of the cake formed and its resistance to liquid flow depends on the properties of the solid particles, the liquid phase suspension, and the conditions of filtration. Cake structure is characterized by hydrodynamic factors such as cake porosity, mean particle size, particle size distribution, and other such factors. The cake structure is also influenced by some physicochemical factors such as the rate of coagulation of solid particles; presence of impurities clogging the pores, presence of solvate shells on the solid particles, etc. The influence of physicochemical factors is a surface phenomenon and exists at the solid-liquid boundary (Cheremisinoff, 1998).

2.2 Biological Treatment of waste water: Biological wastewater treatment method, also known as the conventional method, is a common and widely used method of treatment. It takes into account biodegradation bleaching by taking aid of several micro-organisms, fungi, bacteria, yeasts, and algae. The microorganisms utilize the organic substances to live and reproduce. This is a cheap and easy process that goes through a combination of aerobic and anaerobic process. The surface of the media develops a biofilm which acts as small tube with aerobic condition on surface and anaerobic condition deep down the surface of the film. The microorganisms present in the unit degrades the food and bio degradable materials and hence the water gets purified. It is important for a bio degradation process that proper Food/mass ratio is maintained. Food/Mass (F/M) ratio indicates Contents of organic substances present to the microorganisms existing in the system at a certain time. The conditions in which a certain type of bacteria actively participates in biological treatment process can be classified based on the presence of Oxygen during the process. The aerobic bacteria decompose organic matter in the presence of oxygen. The anaerobic bacteria decompose organic matter and facultative bacteria can work in both these

environments. The aerobic unit final produce or effluents are quite stable with no foul smell coming out of the effluent. The anaerobic bacteria work in an oxygen free environment and produces foul smells during the process of degradation. Both these processes find its application in different types of waste water treatment application.

The process of biological degradation is also classified based on how the media is kept in the waste water treatment unit. In a suspended-growth system, such as activated sludge processes (also aerated lagoons and aerobic digestion), the waste flows around and through the free-floating microorganisms, gathering into biological flocs that settle out of the wastewater. The settled flocs retain the microorganisms, meaning they can be recycled for further treatment. Attached-growth systems use a medium to retain and grow microorganisms. Trickling filters and rotating biological contactors (RBCs) are two common types. The trickling filter (AKA trickling biofilter, biofilter, biological filter, etc.) consists of a fixed bed of gravel, peat moss, ceramic, plastic, or textile media — to name just a few — over which sewage passes and creates a biofilm that becomes thick and falls off (called "sloughing"). RBCs consist of a series of circular disks rotating through the wastewater flow, partially submerged. These disks, usually plastic, are the media on which the biofilm develops and eventually sloughs off.

In this paper Geo textile is used at intermediate level of gravel layers to assess its effectiveness in removing TSS and BOD_5. PET waste bottles are used to find its effectiveness as a replacement of gravel media particles in developing biofilm on the surface.

2.3 Geo Textile: Geotextiles are permeable textile material that is used mainly for civil engineering purposes. Geo textile mainly finds its application in Geo-technical engineering field as a separation membrane between layers of different materials. It is also used as reinforcing material in ground soil improvement and subgrade stability. Geo textile has good permeability characteristic so it doesn't let the pore pressure build up and quickly dissipates it. They are also used for bank Protection of Railway embankment, retaining walls. Geo textile can also be used a filtration unit as it has good permeability characteristic. Its excellent performance in terms of strength, permeability and durability under adverse conditions makes it a very popular material in a wide range of applications.

Geotextile is a synthetic fabric made of different polymer compounds. The four most important groups of raw materials used in the manufacture of geotextiles are polyamides, polyethylene terephthalate (polyester), polyethylene and polypropylene. II these materials are polymer compounds or synthetic materials derived from the processing of crude oil and natural gas. Yet, they each impart unique properties to the geotextile in terms of specific gravity, melting point, chemical resistance, and such other properties.

2.3.1 Classification Based on the manufacturing procedures:

Geotextiles can be classified as-

1. Woven
2. Knitted
3. Heat-bonded non-woven
4. Needle-punched non-woven

2.3.1.1 Woven Geo textile: These fabrics are made in looms. Their rectilinear construction varies upon the type of component fibre and weave's structure. The main advantage of woven geotextiles in terms of reinforcement is that they can absorb the stress with minimal mechanical elongation. It means that they exhibit excellent stiffness properties.

2.3.1.2 Knitted Geotextile: The knitted geotextiles are mainly warp-knitted textiles made from warp-knitting machines. It can produce fine filter, medium meshes, and large diameter soil reinforcement fabric. Their main advantage is that they can provide high strength at a low cost. These are mainly used for soil reinforcement and embankment support.

2.3.1.3 Heat-bonded non-woven: These fabrics are produced by Lying continuous fine filaments into a moving belt randomly and passing them between heated roller systems. They form a thin sheet of textiles.

2.3.1.4 Needle-punched non-woven: Needle-Punched Non-Woven is produced by passing blended webs of continuous or staple filaments through banks of several reciprocating barbed needles. When the needles create entanglements among the filaments, they acquire their coherence and strength. These geotextiles are felt-like in appearance and will be very thick in heavier weights. This thickness enables needle-punched geotextiles to transmit fluid within their planes. Needle punched non-woven geotextiles have porosities greater than 90%. This high porosity reduces the potential for clogging and makes these fabrics ideal for subsurface drainage and erosion control applications. Heat bonded non-woven use heat and pressure to bond the fibres into a geotextile. Because these fabrics are bonded using heated rolls. they are very thin and stiff. Heat bonding does increase the geotextile's tensile properties. These geotextiles have been used in road stabilization applications (Veldhuijzen, 1986).

2.3.2 Properties of Geo Textile: Geotextiles can be distinguished based on mechanical properties (such as thickness, unit weight, tensile strength, tear strength, and UV resistance) and hydraulic properties (such as apparent opening size, permeability/permittivity, and flow rate). For filtration application of geo textile only hydraulic properties are of importance.

a. Apparent Opening Size (AOS): AOS is defined as the number, or opening size, of the U.S. standard sieve having openings closest in size to the largest openings in a geotextile.

b. Permittivity: Permittivity is a measure of the flow in the normal direction through a geotextile. It can be expressed as L/m2/sec (vertical flow). (permittivity) or cm/sec (coefficient of permeability, k).

c. Unit weight: Unit weight is referred to as the mass per unit area of a geotextile. Thickness is the dimension perpendicular to the fabric under a specific pressure and is expressed in length units. The use of geotextiles as filter media requires the prior determination of specific filter criteria, a permeability criterion and a retention criterion. The former uses the particle size and latter uses the filtration opening size, as characteristic geotextile parameters.

d. The filtration opening size: The filtration opening size corresponds to the size of the largest particle capable of percolating through the geotextile. It can be determined by experimental and theoretical approaches and the most frequently used experimental method is the sieve analysis.

e. Porosity: Porosity is a measure of the size of voids existing between the solid parts of a porous medium. In geotextiles, which is a fibrous material, these voids or pores form a continuous medium of extremely complex geometry.

f. Geotextile permeability: Geotextile permeability is normally expressed in terms of volume flow rate through the geotextile i.e., volume of water passing/unit area/unit time/unit water head. This volume permeability determines the number of pores per unit area in the geotextile. If two geotextiles have the same indicative pore size, then the one with the higher volume permeability will have the greater number of pores per unit area. For good filtration, it is a requirement that for a given indicative pore size, the optimal geotextile should have as high permeability as possible. As the number of pores per unit area is quite critical to the filtration performance of the geotextile, it is essential to be able to determine the critical geotextile permeability to ensure best filtration performance. Hence the geotextile properties that determine its filter performance are its pore size and its water permeability (Lawson, 1982).

As mentioned before few papers are presented here depicting the use of geo textile material in filtration application. Use of waste PET bottles as a support medium for biofilm development is also presented in one of the papers given below.

Yaman et al. (2006): This paper presents a feasibility study to remove biodegradable materials from water pollution sources with Geo-textiles. In this pilot plant study, Geo-textile filters were used as biofilm attachment media in Wastewater treatment. The geo-textiles filtered suspended solids and hosted growth of microorganisms to decompose carbonaceous and nitrogenous compounds. The authors used the primary treatment effluent as the test liquid. The study used 10.16 cm (4inch) diameter packed columns containing alternating layers of gravel, sand and geotextile filters. The parametric variables included the number of geo-textile filter layers, the hydraulic loading rate (HLR) and pattern, and provision for passive re-aeration. The authors used geo textile with varying features during initial screening based on Composite permeability test before and after wastewater application to the geotextile filter column and Treatment efficiency (TSS, BOD5 and NH3 removal) of the geotextile filter column. **In all measures, the needle punched Geo Textiles showed best results**. They found that the needle punched Geo- Textile rapidly formed and retained biomass without dramatic change in permeability and were thus selected for use in parametric study. The primary effluent used in the study is classified as "dilute" or "weak" raw wastewater. The test variables in the study were rate of supply of suspended and dissolved organics (HLR x TSS vs HLR x BOD5), Continuity of flow (continuous vs. cyclic) and Aeration (saturated vs. unsaturated). Overall, this study combined geosynthetic and sanitary engineering, investigating the feasibility of using pervious, polymeric geotextiles to treat wastewater by physical and biological filtration. It was inspired by previous work at Drexel University; the investigation of biofilm clogging of geotextile filters used in landfill leachate collection systems, (Koerner,1993). Most applications envisioned included discharge of treated effluent to groundwater discharge. The concept appeared to be particularly applicable to dispersed "non-point" sources of potential water pollution such as onsite wastewater treatment systems (rural and suburban), and stormwater (urban). The criteria for success were established in both treatment and economic/engineering practicality terms. The former included reaching at least secondary standards in treatment, removing suspended solids and carbonaceous oxygen demand, and, hopefully, substantial reduction in nitrogenous content as well. First, it was found that only porous nonwoven geotextiles fully carried out all of the four processes cited above. The study was successful in satisfying the treatment criteria for a complex combined (sanitary and runoff) wastewater that had first undergone primary treatment. TSS and BOD5 were reduced over 90 % to less than 5mg/l, ammonia was reduced over 90 % to 2.0 mg/l and the effluent nitrate (NO3-) was at or below 10 mg/l. The economic and engineering feasibility centred on the "footprint" required treating a given discharge, i.e., the sustainable hydraulic loading rate. The sustainability is expressed primarily in terms of permeability. It was found that the two key parameters in this regard were the organic loading rate, roughly proportional to the HLR, and opportunity to maintain aerobic conditions. HLR of 9 gallon/day.ft2 (365 L/m2.day) for the dilute wastewaters were found to be feasible; presumably, a slightly lower HLR would be required for wastewaters that were stronger in BOD5 terms. It was found, however, that a TSS over 75 mg/l would be questionable. By operating two filter layers embedded in granular spacing layers, and applying the influent at least twice daily in a dose and drain mode, the rate of organic loading and the oxygen supply required to mineralize it were balanced, producing minimal reduction in Permeability. The results of this study show that geotextile biofilters can be applied to septic effluents and weather-generated non-point pollution sources.

Revathi and Sadashiva (2016): This paper presents a study to investigate the filtration performance of non-woven geotextile. A laboratory column setup was assembled to test the efficiency of geotextile in filtrating domestic wastewater. The wastewater was filtered using four (150GSM, 200GSM, 300GSM and 500GSM) non-woven geotextile along with Sand, granular activated carbon (GAC) and Gravel in four different filter bed arrangement. The domestic wastewater used in this study was collected from Sri Jayachamarajendra College of Engineering (SJCE)campus. The type of sampling adopted was grab sampling. Samples were stored in refrigerator. Raw influent i.e., wastewater which has passed only through the screens was collected and analysed in the laboratory. The four different types of geotextiles were initially checked for the better filtration efficiency by passing the raw wastewater through it and the one with greater removal efficiency (500GSM) was selected to place in the filter bed. The treated effluent was checked for various parameters such as pH, COD, BOD and TDS. And by comparing the removal efficiency of these parameters the best filter bed arrangement was selected. The study was carried out in a column of 49cm length hand an internal diameter of

7cm. 3mm perforated support was provided at 2cm, 16cm and 37cm respectively, so that the water trickles down with uniform distribution. The four non-woven geotextiles (150GSM, 200GSM,300GSM, 500GSM) used in the study were examined to check the better removal efficiency in terms of COD and TDS. These non-woven geotextiles were arranged vertically (16 layers) and the raw domestic wastewater was passed through it. The filtered wastewater was then analysed for parameters such as COD and TDS. The removal efficiency in terms of COD and TDS showed maximum removal for 500GSM non-woven geotextile. The average percentage removal in terms of COD and TDS for 500GSM material was found to be 93.7% and 88% respectively. Also, it was noted that the performance of the material decreased with the increase in pore size. Out of the collected non-woven geotextile 500GSM had lowest pore size. As specific weight of material increases system performance gets increased. This because of the reason that as pore size increases area exposed for filtration. This project investigated the judicious use of nonwoven geotextiles as one or more layers placed in domestic wastewater treatment. Best system configuration would include both an upper and a lower geotextile membrane for optimal and higher efficiencies of treatment, while potential simultaneous reductions in volumes of granular material could also be achieved. Geotextiles showed capability to extend lifetime of intermittent sand filters by inhibiting the accumulation of material in the surface of it. Use of geotextiles has been found very effective solution in the treatment of wastewater. Geotextiles provide more strength, flexibility, durability and controlled degradation compared to sand filters. As geotextiles consist of synthetic fibres, bio degradation and subsequent short lifetime is not problem. Geotextile filters improve the reliability and performance of traditional graded soil filters and are easier to construct. The low thickness of geotextile, as compared to their natural soil counterparts, is an advantage insofar as light weight on the subgrade, less airspace used. The ease of geotextiles installation is significant in comparison to thick soil layers (sands, gravels, or clays).

Spychała and Nguyen (2019): This paper presents the study to evaluate the usefulness of novel non-woven textile filter technology for greywater treatment. Experimental sets were located in the laboratory of Department of Hydraulic and Sanitary Engineering (Poznan´ University of Life Sciences, Piatkowska Str. 94 A, Poznan). ´ The Study was conducted at a temperature close to room temperature, however some differentiation was observed (17'c to 27'c). Samples treated as greywater inflowing into filters were taken from reactors and outflowing-collected in beakers as dropping form filters (through the outflow flow pipes). Two sets of filters were used in tests. The first test (Set-I) consisted of two filters: four-layers filter (filter-I) (3.6 mm thick, polyfelt TS20 with a thickness of 0.9 mm each) and eight-layer filter (filter 2) (with a thickness of 7.2 mm). The dimensions of filters inside set-I were: 6.0x20.0x40.0 cm (height). The reactor containing filters of set I was made of a PE panels, and its internal dimensions were: 17.0x28.0x40.0 cm. The filters of Set-I were made of geo textile wrapped around a plastic framework. The second set (Set II) consisted of five filters made of four-layer filtering material-polyfelt TS 20 (with a thickness of 3.6 mm). The reactor containing filters of set II was made of a PVC tube of 16.0 cm diameter and 40.0 cm long with five filters. The external diameter of a single filter was 2.36 cm and its height 35 cm. non-woven geotextiles (polyfelt TS 20) layers were glued on a galvanized steel grid with dimensions of a single mesh 12x12 mm. The reactors were fed with greywater by a pump controlled by a programmable time controller, six times a day every 4 hr. The start-up period longevities were 12 weeks for set I and 22 weeks for set II. Th average filter hydraulic capacities (flow rates) of both filter sets for operational period (after the end of start-up period) were nearly equal: 1 ± 0.1 cm/d for filter 1 and 1.4 cm/d for filter 2 of set 1 and 1.0 ± 0.1 -1.4±0.2 cm/d for filters of set-II. Efficiencies of removal of dissolved organic substances expressed as CODcr were 68.7 ±5.6 % for filter I and 68.9 ± 4.0 % for filter 2 of set I. Efficiencies of removal of CODcr by filters of set II were from 58.8 ±3.6 % to 71.6 ± 6.4% and were related to their hydraulic capacity. In general, they found that - lower the hydraulic capacity, higher the removal efficiency. Efficiencies of removal of dissolved organic substances expressed as BOD5 were 79.8 ± 6.2 % for filter I and 79.4 ± 3.5 % for filter 2 of set I. Efficiencies of removal of BOD5 by filters of set II were from 56.7 ± 4.7 % to 66.7 ± 0.0 %. Efficiencies of removal of total phosphorous were 61.2 ±3.3 % in filter I and 60.2 ± 2.8 % for filter 2 of set I. Efficiencies of removal of total phosphorous by filters of set II were from 52.9 ± 7.0 % to 73.3 ± 1.6%. Efficiencies of removal of TSS were 67.0 ±11.4 % for filter I and 79.8 ± 6.1 % for filter 2 of set I. Efficiencies of removal of TSS by filters of set II were from 83.2 ±7.1 % to 88.4 ± 7.5 %. The efficiencies of COD cr (59–72%) and BOD5 (57–80%) removal from greywater by nonwoven textile filters were comparable to the efficiency of nonwoven textile filters treating septic tank effluent. The effectiveness of the removal of total phosphorus on non-woven filters (53–73%) was much lower than the efficiency of the removal of organic compounds. The removal of phosphorus compounds, mainly in the form of phosphates, proceeded with very variable efficiency. The relatively high efficiency of mechanical treatment of greywater on nonwoven textile filters was obtained by reducing the effective pore size of the filtration layer due to high biomass concentration and accumulation of suspended solids. Aerobic decomposition of dissolved organic compounds at relatively high efficiency was possible due to the sufficient concentration of dissolved oxygen greywater flowing in the immediate vicinity of the biomass fixed on the nonwoven fabric and due to the low flow rate with a high efficiency of oxygen diffusion from the atmospheric air. During the studies, it was observed that filters were covered by a filter cake of low cohesion, susceptible to dropping away due to the vertically oriented filtration layer. Due to this, these filters are less susceptible to clogging (they can operate without rinsing for at least one to two years) and the possible rinsing can be carried out in a simple way—by washing the filter surface with a water jet. It was found that the filters worked, at least in the air-side layer, in aerobic conditions, which was indirectly confirmed by periodic removal of total and ammonium nitrogen. The basic processes occurring during greywater treatment on non-woven filters were: the removal of organic contaminants, determined as BOD5, COD_{Cr}, and total phosphorus. However, the removal of the latter ones proved to be unstable. A relatively high efficiency of biological treatment of dissolved organic substances (COD_{Cr}: 58.8–71.6%; BOD5: 56.7–79.8%) in greywater on both nonwoven textile filter sets was obtained thanks to the relatively low flow rate (filtration velocity), effective diffusion of atmospheric air into the greywater. The relatively high efficiency of mechanical treatment of greywater on both nonwoven textile filter sets (67.0–88.4%) was obtained by reducing the effective pore size of the filtration layer due to high biomass concentration and accumulation of suspended solids. No statistically significant difference (95% difference interval) between set I (fed during start-up period with septic tank effluent) and set II (fed during start-up period with greywater) was stated. No statistically significant difference (95% difference interval) between four-layer material filter and eight-layer material filter of set I was stated. The filters worked, at least in the air-side layer, in aerobic conditions, which was indirectly confirmed by the fact that the observed colour of the filter cake on the filter surface was always grey or brown-grey, while the biomass smell was earthy. The investigated filters seem to be very useful and attractive technology for greywater reuse e.g., with the objective of its usage for irrigation or toilets flushing thanks to relatively high treatment efficiency, greywater aeration (air-side surface of filter layer has a contact with atmospheric air at very thin film of treated greywater, what is flowing down on this surface), simple construction, easy maintenance, and very low energy consumption.

<u>Kane et al. (2000):</u> The paper investigates the feasibility of developing a deployable geotextile-based wastewater filtration unit. More specifically, the intent was to find out if it is feasible to develop a filtration unit capable of achieving treatment results equivalent to primary settling tanks in a conventional wastewater plant. All of the geotextiles considered in this study shared two key characteristics; they were non-woven, and they are composed entirely of polypropylene (disregarding possible trace impurities). During the studies data of previous research was collected, one such CRREL study strongly indicated that **geotextiles could act as cost-effective and highly efficient wastewater filters. Specifically, experiments indicated that geotextiles were effective at reducing total suspended solids (TSS) by about 60% and BOD by about 40%, given raw wastewater with initial TSS and BOD of 137mg/1 and 276mg/1, respectively.** They found that needle-punched geotextile fabrics (the Mirafi and Amoco products) are capable of filtering in the range of 2,0001/m^2 of wastewater. The fabrics were excellent at TSS removal and adequate for the reduction of **BOD.** They concluded that Geotextiles are highly effective wastewater filters that will perform well as a primary treatment method and in removal of solids from secondary treatment methods. Also, they found Little or no advantage is likely to be gained in terms of TSS removal by adding geotextile filters in combination with primary settlement or flocculation. No significant TSS effluent changes were noted after allowing settling, despite large changes in influent TSS levels. In other words, the particles most likely to be captured by filtration had already been removed by settling. Filtration of a biological secondary treatment process is likely to generate a TSS reduction because of larger particles in the effluent that could be attributed to sloughing of microbial growth. The clogging of geotextile filters was probably driven by the presence of particles within a fairly narrow size range. Larger particles will tend to sit atop the filter, rather than embed within it, and slow down flow. Smaller particles will pass through the filter without clogging it. **An examination of the TSS and BOD data showed that the geotextile filters were highly suitable for the removal of TSS, rarely removing less than 50% of the solids load**. In many cases, the removal efficiency was much higher than 50%, particularly at low head levels. However, head level was not a strong driver of TSS removal efficiency. In the case of BOD removal, the fabrics were somewhat less effective, removing about 50% of the BOD, depending on fabric type. However, since a secondary treatment system is a near certainty, high BOD is not of as much concern as high TSS would be. In summary, the fabrics were excellent at TSS removal and adequate for BOD reduction.

Espinoza et al. (2019): This paper investigates the application of discarded plastics LDPE, PET and HDPE as biofilm support in aerobic biological reactors, as these materials are the most common plastic wastes found in the south of Ecuador. Furthermore, to apply the LDPE, it was thermally modified to increase the density and enhance the surface roughness. According to this, this research is looking for study of the optimum operational parameters to treat domestic wastewater using these wastes. The application of three kinds of solid plastic wastes as support materials in aerobic fixed bed biofilm reactors to treat domestic wastewater were assessed. The plastic wastes evaluated were: low density polyethylene (LDPE), polyethylene terephthalate (PET) and high-density polyethylene (HDPE). Three reactors of 12 L were assembled and operated for 182 days divided into three phases of 90 days each, where the volumetric organic loading was varied between 1.6 to 3.5 kg COD m-3 dia^{-1}. Real domestic wastewater from Machala-Ecuador was used, this was collected from a gutter which conduce the urban wastewater to the sea. To obtain better surface conditions, low density polyethylene material was thermally modified (m-LDPE). Scanning electron microscopy was used to observe the plastic surface before and after the biomass adhesion. The biomass growth was measured as the total amount of SSV on the materials, moreover the material surfaces were observed by SEM. The material m-LDPE can accumulate around 2 g of SSV m^{-2}, meanwhile PET and HDPE retain on the surface 1.02 and 0.25 g m^{-2} respectively. It is to say that m-LDPE showed around twice adhesion than PET, and eight times more than HDPE. The biomass formed in this same support media after 30 days from the initial inoculation. Chemical oxygen demand and attached volatile suspended solids were monitored to know the organic matter removal and the biomass formation over the materials respectively. COD removals over 80% was achieved for m-LDPE and PET, meanwhile HDPE shows lower COD efficiencies. The best cell adhesion was achieved to the m-LDPE, mainly due to the high roughness acquired during the thermal modification applied. The three-support media evaluated PET, HDPE and m-LDPE contributed for the development and growth of biofilm. However, the technical feasibility is limited at the use of PET and m-LDPE. The materials m-LDPE and PET evaluated in the reactors, achieved high removal of organic matter, and better biofilm adhesion in the support material compared with

HDPE, which could be concluded that these polymers are effective for use as carrier materials at the operational conditions applied (1.6 to 3.5 kg COD m-3 d^{-1}). The reactors with HDPE plastic waste, obtained the lowest organic matter removal, due to its smooth surface, where the biomass did not stay fixed and therefore tends to detach, and increase the amount of sludge, gradually decreasing the efficiency of the bioreactor. Thus, HDPE plastic was not advised as a support in this kind of system.

Chapter 3

Objectives: It is often seen, Specially in Indian condition, waste water treatment is not usually done and waste water is discharged in nearby water body.The main objective of the research work is to study the effect of Geo textile Membrane in waste water treatment.This research assesses the effectiveness of Geo textile material in removing BOD5 and TSS from waste water when used at intermediate layers of Gravel of different gradation. The research also involves Using waste PET bottle in place of the top most layer of gravel (PET bottle being of the same gradation as top most layer of gravel) and assess the effect of such replacement on the values of BOD5 and TSS removal with gravel layers under it in the same gradation. Finally, to compare this result in terms of BOD5 and TSS removal with a unit, consisting of only gravels layers in different gradation (but same as in the above two cases).

Chapter 4

4.1 Overview: In this experiment 3 No's of constant flow filter column apparatus are constructed to evaluate the effectiveness of materials used respectively in all three columns in removing BOD5 and TSS. The 1st constant flow filter column apparatus is constructed with a gravel filter column with 4 layers of single geo textile membranes at intermediate layers of graded gravel to perform the filtration experiments. The 2ndconstant flow filter column (without geo textiles) apparatus is constructed with PET bottle, as a replacement of the top most layer of Gravel in the filter column. The 3rd constant flow filter column apparatus is constructed with 4 layers of gravel in different gradation (but same as in the above cases) to conduct filtration experiment and compare the result with 1st and 2nd filter column results. The waste water is taken from a sewer nearby Metro car Depot, Joka. The Experimental set up was done in Concrete Pathology Lab, Metro Car Depot Joka. The ambient temp during the experiment remained at 28±5'c. The Lab tests for BOD5 and TSS were conducted in School of water Resources Engineering Laboratory at Jadavpur University.

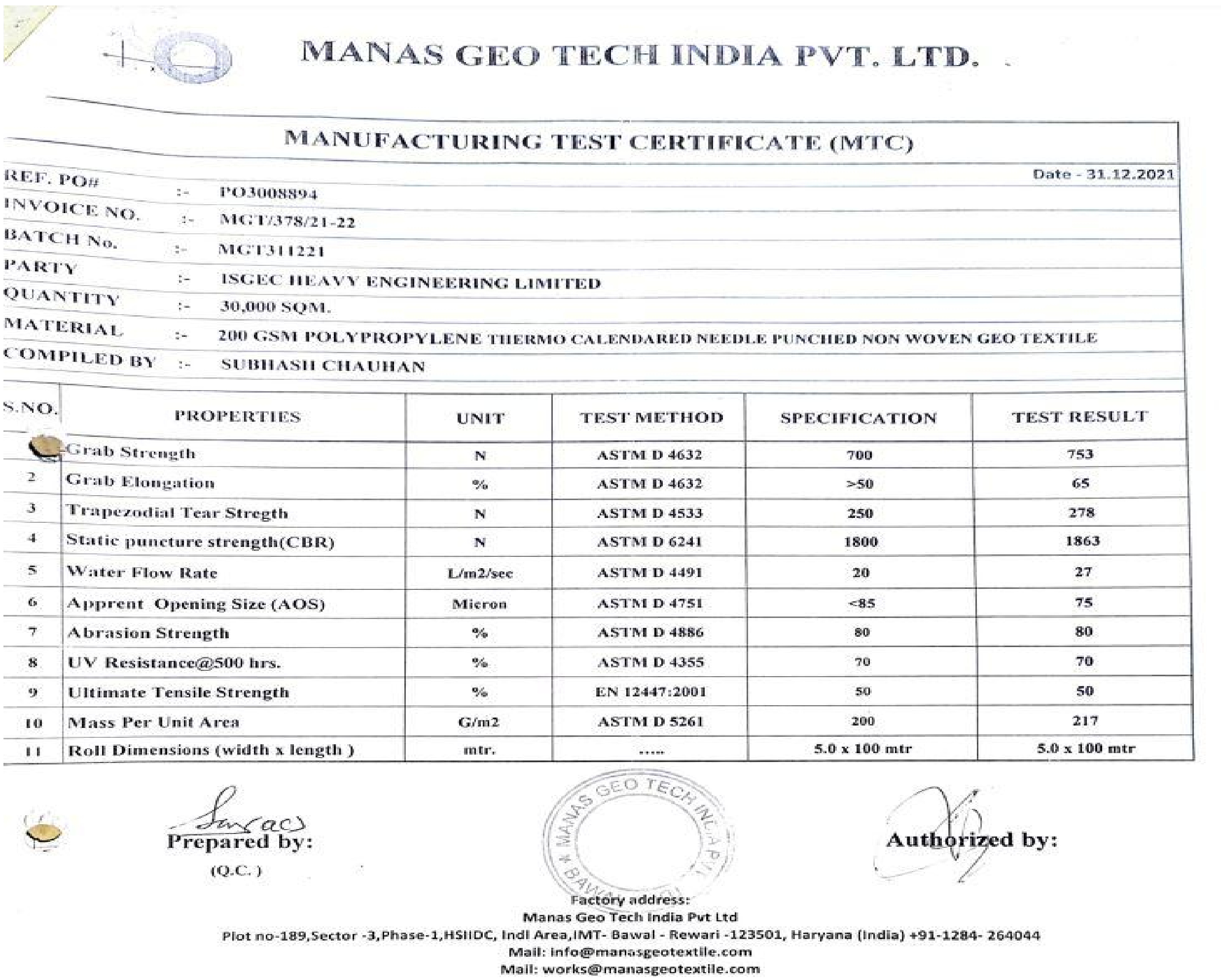
4.2 Materials: The materials used in the study were selected after the literature review and guidance by the respected advisor to conduct the filtration experiment.

4.2.1 Geo -Textile Non-woven needle punched Geo textile was used in the experiment. The geo textile material is made up of Polypropylene. The Material was obtained from Manas Geo Tech India Pvt Limited. The hydraulic and mechanical properties of the Geo textile used in this study is presented in the given table as under:

SI No.	PROPERTIES	UNIT	TEST METHOD	SPECIFICATION	TEST RESULT
1	Grab Strength	N	ASTM D 4632	700	753
2	Grab Elongation	%	ASTM D 4632	>50	65
3	Trapezoidal Tear Strength	N	ASTM D 4533	250	278
4	Static Puncture Strength	N	ASTM D 6241	1800	1863

	(CBR)				
5	Water flow rate	L/m2/ sec	ASTM D 4491	20	27
6	Apparent opening size (AOS)	Micro n	ASTM D 4751	<85	75
7	Abrasion Strength	%	ASTM D 4886	80	80
8	UV Resistance @ 500 hrs	%	ASTM D 4355	70	70
9	Ultimate Tensile Strength	%	EN 12447: 2001	50	50
10	Mass per unit area	G/m2	ASTM D 5261	200	217
11	Roll dimension (Width x length)	Mtr.	………	5.0 x 100 mtr	5.0x 100 mtr

Table 1: Hydraulic and Mechanical Properties of Non-woven Needle Punched Geo Textile



MANAS GEO TECH INDIA PVT. LTD.

MANUFACTURING TEST CERTIFICATE (MTC)

Date - 31.12.2021

REF. PO# :- PO3008894
INVOICE NO. :- MGT/378/21-22
BATCH No. :- MGT311221
PARTY :- ISGEC HEAVY ENGINEERING LIMITED
QUANTITY :- 30,000 SQM.
MATERIAL :- 200 GSM POLYPROPYLENE THERMO CALENDARED NEEDLE PUNCHED NON WOVEN GEO TEXTILE
COMPILED BY :- SUBHASH CHAUHAN

S.NO.	PROPERTIES	UNIT	TEST METHOD	SPECIFICATION	TEST RESULT
1	Grab Strength	N	ASTM D 4632	700	753
2	Grab Elongation	%	ASTM D 4632	>50	65
3	Trapezodial Tear Stregth	N	ASTM D 4533	250	278
4	Static puncture strength(CBR)	N	ASTM D 6241	1800	1863
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6	Apprent Opening Size (AOS)	Micron	ASTM D 4751	<85	75
7	Abrasion Strength	%	ASTM D 4886	80	80
8	UV Resistance@500 hrs.	%	ASTM D 4355	70	70
9	Ultimate Tensile Strength	%	EN 12447:2001	50	50
10	Mass Per Unit Area	G/m2	ASTM D 5261	200	217
11	Roll Dimensions (width x length)	mtr.	.....	5.0 x 100 mtr	5.0 x 100 mtr

Prepared by:
(Q.C.)

Authorized by:

Factory address:
Manas Geo Tech India Pvt Ltd
Plot no-189,Sector -3,Phase-1,HSIIDC, Indl Area,IMT- Bawal - Rewari -123501, Haryana (India) +91-1284- 264044
Mail: info@manasgeotextile.com
Mail: works@manasgeotextile.com

Figure 1: Material Testing certificate of 200 GSM Non-woven Needle Punched Geo Textile

Figure 2: Sample of 200 GSM Non-Woven Needle punched Geo textile

The geo textile material is cut into pieces of 100 mm diameter each in circular shape as shown in fig 3 below:

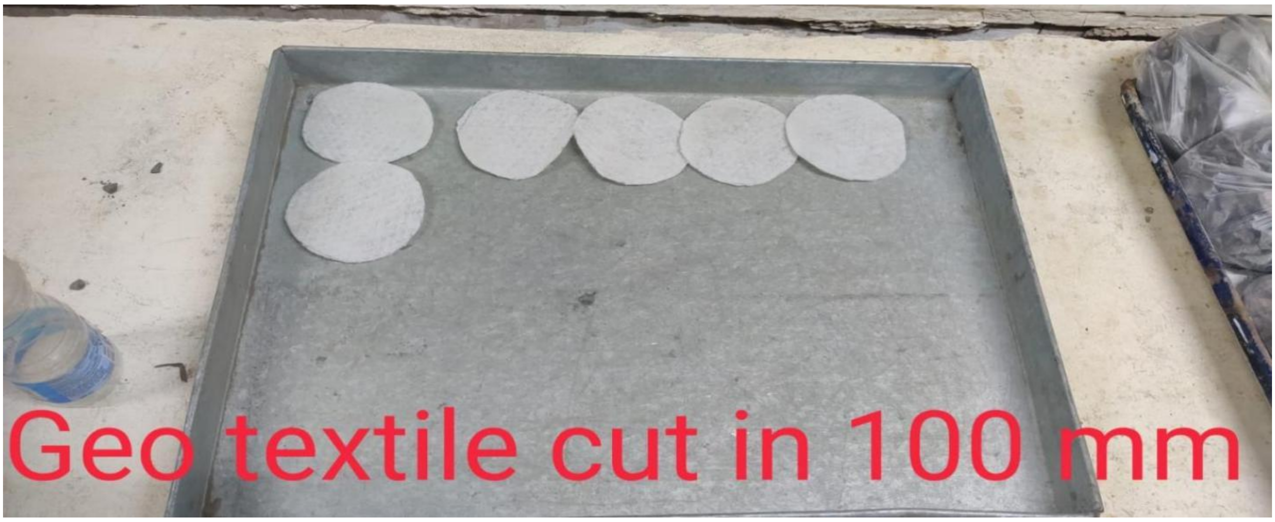

Figure 3: 200 GSM Non-Woven Needle punched Geo Textile cut in circular shape

4.2.2 Gravel: Test columns for all three sets were constructed by gravel in different gradation in 4 layers. The gravel was obtained from Pakur, West Bengal India and the gradation was done at the Concrete Pathology Lab, Metro car Depot Joka, Kolkata India. Before the gradation was done, deleterious materials were removed from the surface of gravel and kept for 24 hrs in an air-drying environment. The IS sieves used for gradation of materials were of size 25 mm, 20 mm, 16 mm, 10 mm and 4.75 mm. The sieves were arranged in a decreasing order of their size with a pan at the bottom as shown in the figure below:

Figure 4: Sieves arranged in decreasing order of their size

Figure 5: Graded gravel

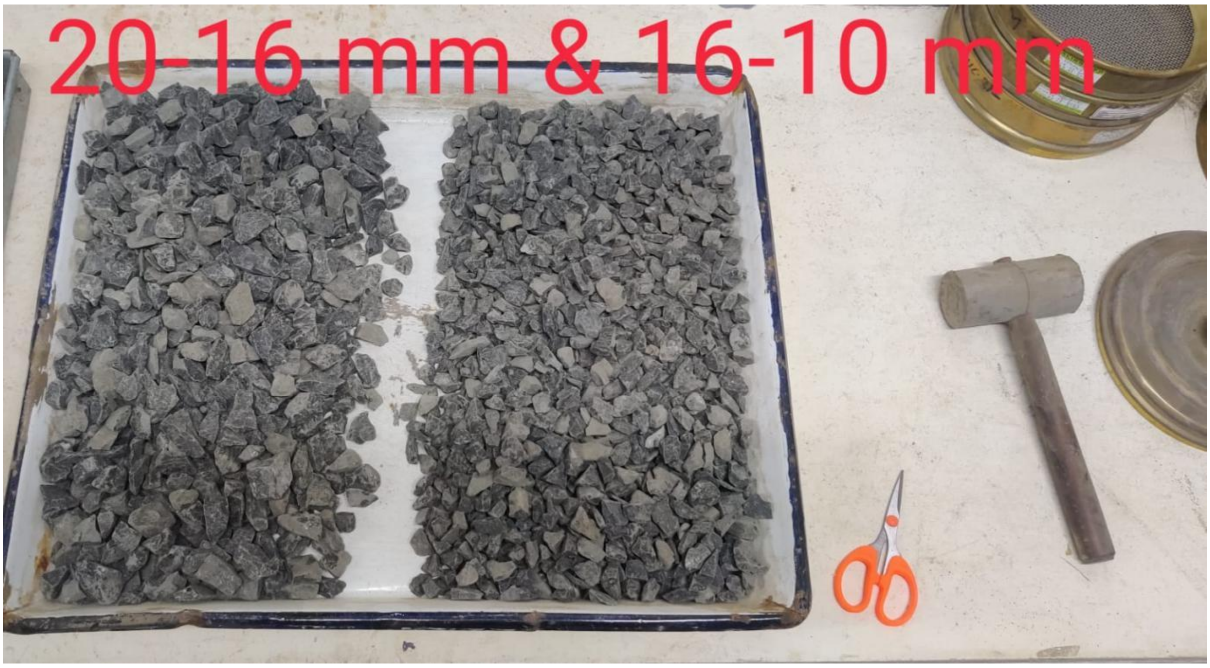

Figure 6: Graded gravel (20-16 mm and 16-10 mm)

Figure 7: Gravel kept after gradation for 3 test columns (20-16 mm and 16-10 mm)

4.2.3 Waste PET drinking water bottle: Waste PET drinking water bottles were collected from the kitchen of Metro car Depot Joka Site office and cleaned & dried to reomove any deleterious substance sticking to their surface.

Figure 8: Sample waste PET bottle

The waste PET bottles were cut into small piece and gradation was done so that their size remains between 10-4.75 mm which is the same as the size range for the top most gravel layer as shown in figure below:

Figure 9: Gradation of waste PET bottle in the size range 10-4.75 mm

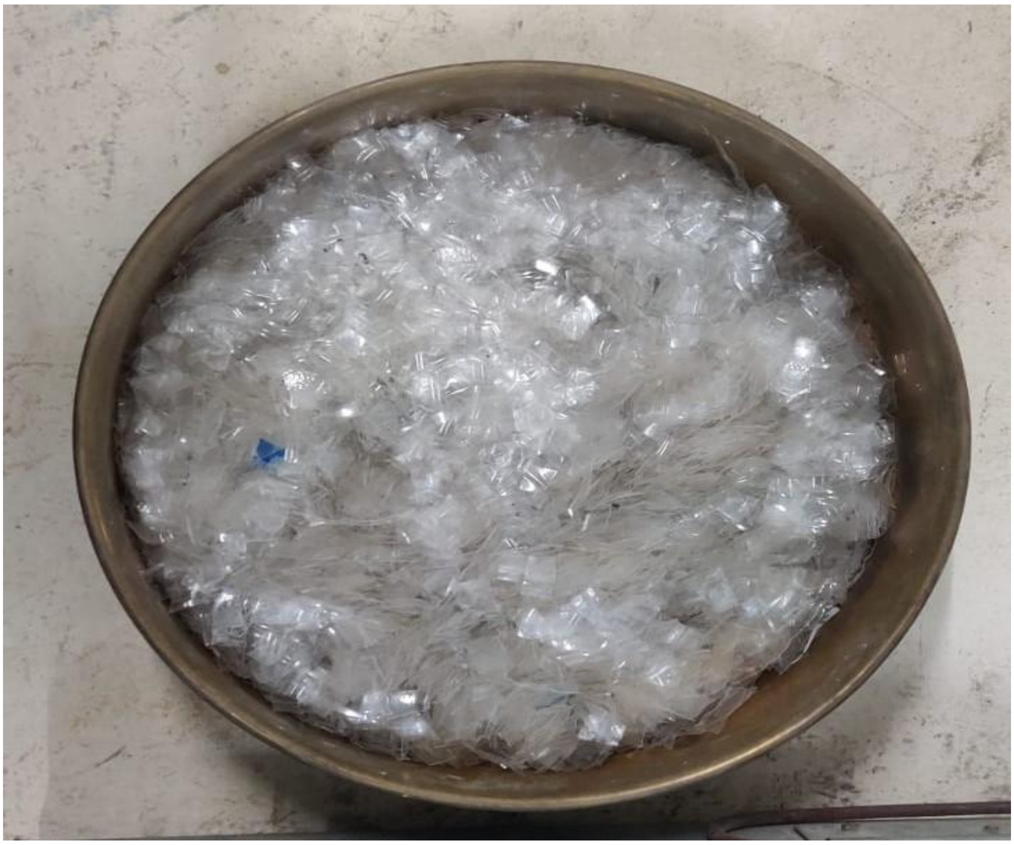

Figure 10: Graded waste PET bottle in the size range 10-4.75 mm

4.2.4 Waste water: Raw Waste water is collected as a grab sample from a sewer nearby Metro car Depot, Joka Kolkata. The sewer is connected to the sub urban/village areas of hanspukuria Mauza and mostly contains waste water coming out of households. It can be classified as medium to low strength sewage as shown below in fig No. 11.

Figure 11: Waste water being collected from Sewer at Metro car Depot, Joka Kolkata

4.3 Methodology: The waste water used in the experiment is loosely termed as a domestic waste water containing organic and inorganic substances. The hydraulic loading rate is defined as:

Hydraulic loading rate (HLR) = $\frac{\textit{Discharge from waste water Reservoir tank}}{\textit{surface area of filter}}$ **m3/m2/day**

Normally for a Standard rate trickling filter hydraulic loading rate is taken between 1-4 m3/m2/day. Assuming a hydraulic rate of 4 m3/m2/day and flow rate of 0.04 m3/day (i.e., 40 L/day) we calculate the area of filter column as:

Surface area of Filter column (A)= $\frac{0.04\ m3/day}{4\ m3/m2/day}$

A= 0.01 m^2

Also, A= $\pi/4 \times D^2$ where D is the diameter of filter column.

D= 0.112 m = 112 mm

We will take the value of **D as 100 mm** and calculate the HLR so applied.

Area of the filter= $\pi/4\text{x } 0.1^2\ m^2$

A= 0.007854 m^2

Hence HLR= $\frac{0.04\ m3/day}{0.007854\ m2}$

HLR= 5.09 m3/m2/day

The height of the filter is kept 0.4 m or 400 mm consisting of 100 mm layers of graded gravel.

Volume of the filter column (V)= Axl m3 where A and l are the area and length of column respectively.

V= 0.007854 x 0.4 m3= 0.003142 m3

Organic loading rate on filter is calculated as:

Organic loading rate (OLR) =$\frac{Discharge\ from\ waste\ water\ Reservoir\ tank\ x\ BOD5}{Voulme\ of\ the\ filter}$ **kg/m3/day**

Assuming a BOD5 of 140 mg/l:

OLR= $\frac{0.04\ m3/day\ x\ \ 140\ mg/l}{0.003142\ m3}$

OLR= 1.78 Kg/m3/day

Hydraulic Retention time (HRT)= $\frac{Volume\ of\ the\ filter}{Discharge\ from\ waste\ water\ Reservoir\ tank}$ **hr**

HRT= $\frac{0.003142\ m3}{0.04\ m3/day}$**= 0.07855 days**

HRT= =1.88 hr

The length of pipe accommodating the filter column is taken two times the actual height taken for design i.e 800 mm and hence 400 mm portion will remain without any filter material. Another 100 mm length is added to accommodate pipe connecting reservoir tank to the filter column.

Summarizing the design data:

Diameter of Filter Column pipe= 100 mm

Length of filter column pipe= 900 mm (400 mm (gravel filter column) + 400 mm (empty)+100 mm)

Flow Rate= 0.04 m3/day

Hydraulic loading rate = 5.09 m3/m2/day

Organic loading rate= 1.78 Kg/m3/day

Hydraulic Retention time= 1.88 hr

4.4 Apparatus: PVC pipes are generally used in households, offices, hospitals etc for water distribution in size ranging from 15 to 150 mm. They are corrosion resistant, easy to clean and are readily available in the market. The Filter column experiment is conducted using 3 100 mm dia PVC pipes as shown in fig 12. PVC pipes were selected for the experiment and they were cut in proper sizes to accommodate gravel filter media. The length was marked at 100 mm, 200 mm, 300 mm, 400 mm, 800mm and 900 mm spacing over the pipe as shown in figure 14 below. Small openings in the pipes were made to insert pipe to connect it with waste water reservoir tank.

Figure 12: 100 mm dia PVC test columns

Figure 13: marking on 100 mm dia PVC test columns

A waste water reservoir tank of capacity 160 L was selected to store waste water as shown in Fig 14. Small openings were made at 100 mm above the bottom of tank to fit valves. The waste water flow rate was controlled using a control valve fitted in the waste water reservoir tank as stated above.

Figure 14: Waste Water Reservoir tank fitted with control valve

To collect water coming out of filter column and support filter column base, three Buckets each having capacity of 20 l each, were selected as shown below in Fig 15. Smallperforations are made on the top of the bucket such that the filtered water enters through it but filter material is restricted.

Figure 15: Containers to collect treated Waste Water

The apparatus used in the experiment was set up in Concrete Pathology Lab, Metro car Depot Joka as shown in Fig 15 below.

Figure 16: Experimental Set up

4.5 Experimental Setup: The 1st test column was constructed by starting with a layer of geo textile just at the bottom of filter column followed by 100 mm gravel in size range of 25-20 mm. Again, a layer of geo textile is provided followed by 100 mm of gravel in size range 20-16 mm. The 3rd layer of Geo textile is laid with 100 mm of gravel in size range of 16-10 mm over it. The 4th layer of geo textile is followed by 100 mm of gravel in size range 10-4.75 mm. Finally at the top a layer of geotextile is provided. In the 2nd test column Gravel is provided in the same gradation as stated above of each 100 mm height except the top most layer which is replaced by PET bottle in size range 10-4.75 mm. The 3rd test column is constructed with 4 layers of gravel in the same gradation as stated above each 100 mm thick. Little tamping is done to partially compact the layers so that intermixing is avoided. A sketch showing the arrangement of different layers of gravel, Geo textile and PET is shown below in fig 16for all three-filter column.

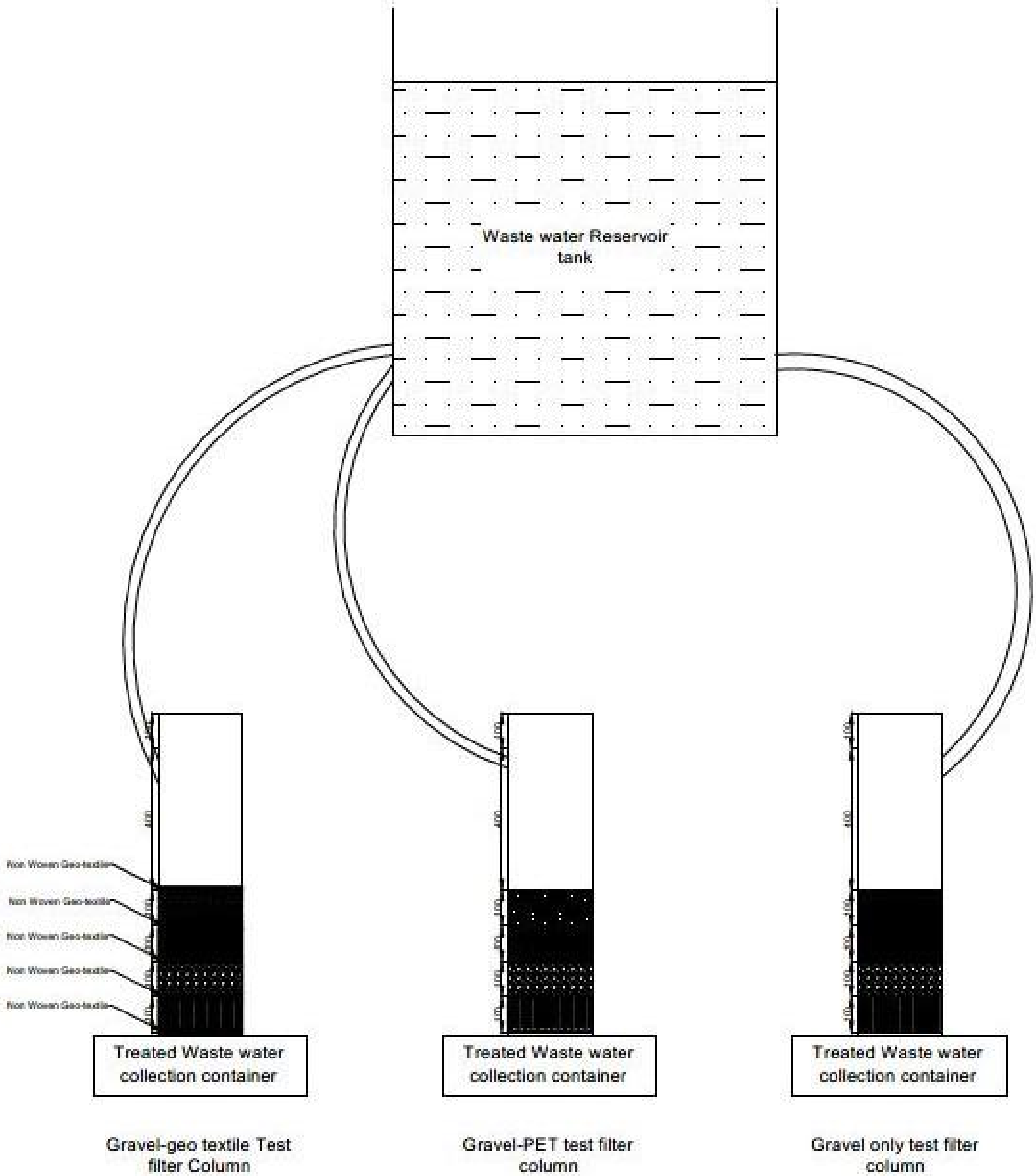

Figure 17: Experimental Set up sketch with Gravel, geo textile and PET arrangement

Chapter 5

Results and Discussions:

Initially the filter was run for a week and waste water was applied at 0.04 m3/day with unit in operation for 12 hours every day but no sample was collected. In the second week, waste water is applied to the filter at the same rate as stated above. The flow rate is controlled through the valve fitted in Waste water reservoir tank to keep HLR at a constant value throughout the filter run. Inlet sample is collected from the waste water reservoir tank just after filling the tank with source waste water. The outlets samples were collected after a period of 2 hrs and while collecting the samples it was made sure that any material settled in the bottom is well stirred before it was stored in treated water collecting bottle. Both the inlet and outlet samples were taken to School of water Resources Engineering laboratory, Jadavpur University to test for BOD5 and TSS value.

The inlet waste water sample and outlet treated waste water sample was tested for BOD5 and TSS and following results were obtained:

Test column	Test column composition	BOD_5 (mg/l)	TSS (mg/l)
	Raw sewage Inlet sample	150 mg/l	320 mg/l
1st	5 layers geotextile+ 4 layers of 100 mm thick gravel	54 mg/l	58.7 mg/l
2nd	1 layer PET Bottle+ 3 layers of 100 mm thick gravel	76.5 mg/l	112 mg/l
3rd	4 layers of 100 mm thick gravel	63.5 mg/l	96.8 mg/l

Table No. 2 Results of BOD5 and TSS testing

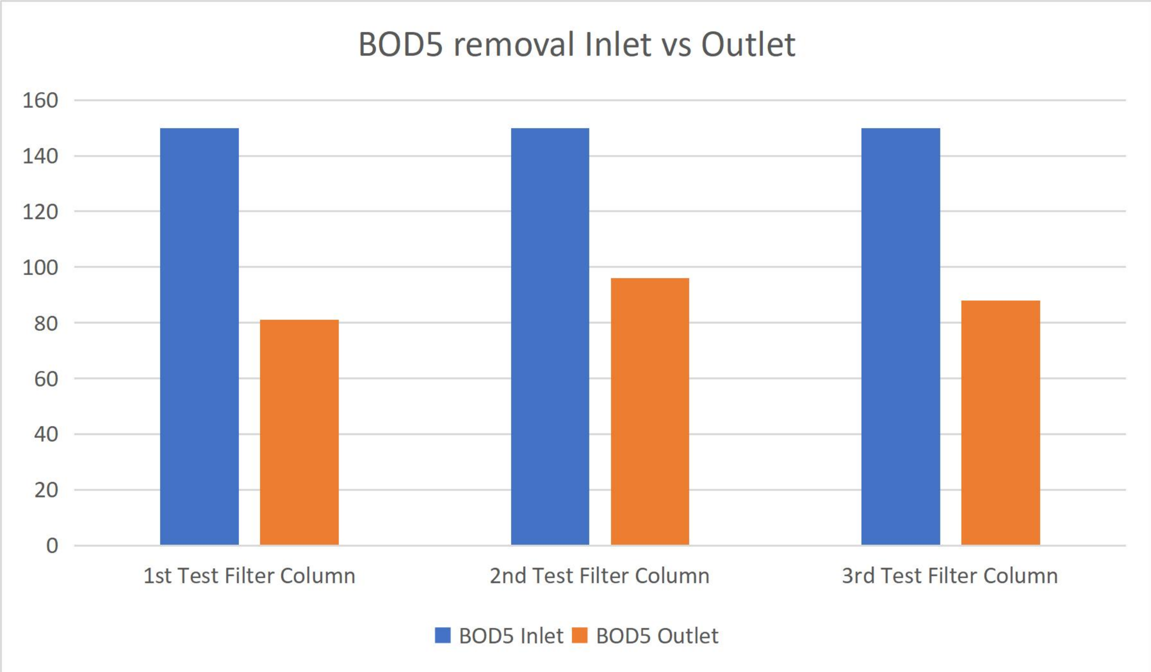

Figure 18 BOD5 test result comparison

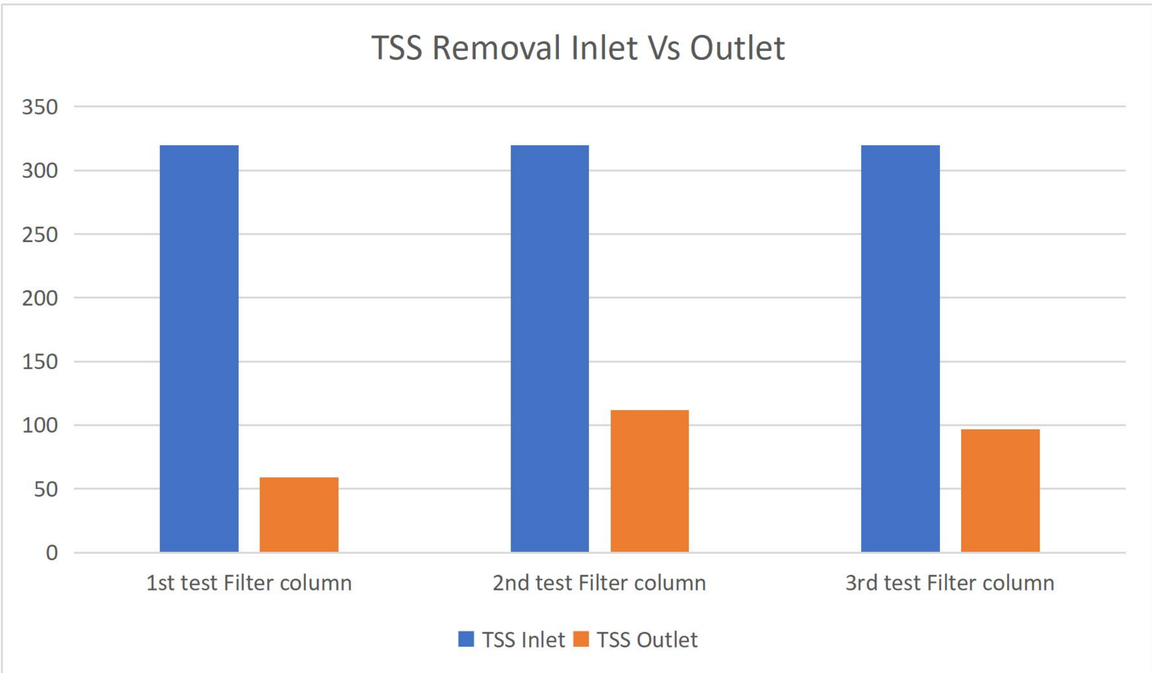

Figure 19 TSS test result comparison

It can be observed from the above result that reduction in BOD5 in Gravel filter column with geo textile layer at intermediate layers of Gravel layer has resulted in highest percentage removal in $BOD_{5\ value}$ with 64 % removal efficiency as compared to the 2^{nd} and 3^{rd} test filter columns which managed to remove BOD_5 by 49 % and 57.6 % respectively. TSS removal with Geo textile-gravel (1^{st} test filter column) filter column was highest with removal efficiency of 81.65 % as compared to PET-Gravel (2^{nd} test filter column) filter column and Gravel filter column (3^{rd} test filter column) with TSS removal efficiencies of 65 % and 69.75 % respectively. The test setup with PET Bottle at the top as a replacement of gravel layers resulted in least removal of BOD5 and TSS which can be attributed to the fact that biomass generation at the surface of such particles did not occur as can be seen after examining the smaller pieces of PET bottle post the experiment. In both cases the filter with geotextile at the intermediate levels of gravel layers performed better compared to the other two filter columns.

Chapter 6

Conclusion: Three test filter columns 1st with geo textile-gravel, 2nd with PET-gravel and 3rd with gravel layers were set up at the concrete pathology lab, Metro car Depot Joka Kolkata and samples tested at School of Water Resources Engineering laboratory, Jadavpur University, Kolkata. The following conclusions are presented based on the results of this research:

These investigations revealed that the geotextile- gravel filter was capable of achieving suspended solids removal efficiency 81.65 % and BOD_5removal efficiency 64 %. It is evident from the result that TSS removal is very significant and BOD_5 removal is also satisfactory.

The other two setups revealed that when PET bottle was used in place of gravel it did not give satisfactory result compared to Gravel only filter which performed better than PET-Gravel filter removing 8.6 % BOD_5 and 4.75 % TSS in excess of PET-gravel filter.

Overall, the performance of geo-textile-gravel filter was better as compared to PET-gravel and Gravel-only filter.

Based on the conclusion following recommendations are presented:

a) The geo textile gravel filter is suitable for treating low flow wastes and medium strength wastes, having suspended solids concentration in the range of 100 to 300 mg/L and BOD_5in the range of 80-100 mg/l.

b) The geo-textile gravel filter can be used for waste water treatment in sub urban areas, less populated towns. The smaller industries generating waste water can use such a filter before allowing waste water to flow into inland water body.

Chapter 7

Recommendation for further research:

a) Additional layers of geo textile can be used at intermediate levels of gravel layers to find out its efficiency in terms of TSS and BOD_5 removal and arrive at optimum number of layers of geotextile to be used for a given inlet condition.

b) Geo textile can be used without any other material as filter layer to assess clogging problems and TSS & BOD_5 removal efficiencies.

c) Waste PET bottles can be used in smaller gradation at intermediate levels of filter to assess its effect on TSS and BOD_5 removal.

d) Industrial effluents with less SS concentration can be used at inlet to assess the toxic substance removal efficiency with only-geo textile filter.

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