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# Development and Testing of Low Cost Sand Filter for the Treatment of Industrial and Domestic Wastewater

Taj Ali Khan, Kalsoom Rehman, Khurram Sheraz
Department of Agricultural Engineering
University of Engineering & Technology,
Peshawar, Pakistan

***Abstract:-* The research work is based on finding the efficiency of biosand filter for the treatment of industrial waste water, domestic waste water and irrigation canal water at different sites in Peshawar. Two plastic drums of 200 liters capacity were used as casing of the filters. Sand analysis was done to choose amongst the local sand available in the area as a filter media. Strainer was made from one inch pipe and surrounded by crush materials of 10 cm thick layer to control chocking. A half inch pipe was used as a spout for delivering clean water. Spout was kept 5 cm above the sand bed as to make a water layer upon the sand media. A diffuser was made from plastic tub to diffuse the falling energy of water into the drum. The samples were again tested after the filtration and results were compared with pre-filtration results. Fecal and total coliform bacteria removal efficiency of the filter was found 100%, whereas turbidity was reduced about 88%. Similarly, aesthetic of the water was highly improved when compared with clean water. Chloride and nitrate levels have also shown reduction of about 4% and 23% respectively.**

## 1. INTRODUCTION

In Pakistan, particularly in the province of Khyber Pakhtunkhwa, no proper facilities are available for treating domestic and industrial wastes. Hence, the discharges are neglected into various water bodies resulting surface/groundwater pollution and risking biodiversity and reducing agriculture production. The Kabul river showed that surface water resources are highly susceptible to pollution as the whole widen in the surrounding is deeply contaminated with sewerage and abandoned application of chemicals.

The quality of untreated effluent used in agriculture has a great influence on the soil-plant or aquaculture system. Pathogenic microorganisms, trace organics and heavy elements have produced a number of dangerous diseases in humans especially in the crops that are eaten uncooked.

Peshawar is the capital city of Khyber Pakhtunkhwa, Pakistan. Its geographical coordinates are 34° 0' 28" North, 71° 34' 24" East. The study was conducted at different water samples collected from Hayatabad industrial estate, Pabbi irrigation canal and main sewerage drain Cantonment of Peshawar. The Peshawar environment has gone through extreme variation due to an ever increasing population, unexpected growth and a poor dogmatic framework. Air and noise pollution are major issues in some parts of the city, and the water quality, once considered to be extremely good, is also fast failing. In addition, the city has lost 1100 ha of agriculture land during the two decades (1965–85). This in the addition to 160 ha of unoccupied land that has been also eaten up by spending urban functions. In the same phase, the land under parks and green areas has reduced from 66–30 ha [6].

The industrial estate consists of about 50 industries of a range of brands such as dying chemicals, pharmaceutical, textile, matches, ghee, food, drinks, rubber, marble, wood, steel and others. The discharge of all industries is falling through small open drains into main drain known as Malakandher Nala and finally into the Kabul River.

Shahi Kattha is a major open/covered drain that passes through different union councils/areas of Town-1, Peshawar with regards to catchment area served. It was designed to get across both the sewerage and rain/storm water from the heavily occupied parts of the old city. Chemicals from homes and offices, automobiles, industrial discharges, erosion from construction sites are the main sources of contamination of the existing drainage. Repeated application of this water for irrigation can build up the concentration of HMs to a level which is toxic for plants and humans (Kakar et al., 2006)[6]

## 2. LITERATURE REVIEW

Slow sand filters have been in use for the past 200 years, even before they were known to purify water. John Gibb in Scotland made the first known sand filter in 1804. Filtration for domestic supply began in 1829, when James Simpson constructed filters for London. However, it was not until 1855 when John Snow proved disease could be transmitted by contaminated water, that filtration was exposed to get rid of the agents of disease. Following on from this, in 1876 Robert Koch developed the Germ Theory of Disease, proving that microorganisms cause sickness, and by 1886, Koch's bacteriological techniques were used to demonstrate that slow sand filters removed bacteria.

Black et al. (1991) wrote a manual of design for Slow Sand Filtration provides state-of-the-art information on the possibility of using this technology and on design, construction and operations particularly suitable for small communities. They give full detail of the requirement of a range of components of the SSF. They were of the view bulk of natural activity is happening in the top 20 cm of the sand filter [1].

Palmbach and Zoltan (2004) done a study by testing a range of types of filters used by the communities and he evaluate its efficiency and cost efficiency. He accomplished that although slow sand filtration skill has been extensively used in Europe while the early 1800s, but it's with the new issuance of the facade water management rule by U.S. Environmental protection Agency and new filter condition s for all surface water systems to make sure elimination of Giardia cysts, there is improved attention in slow sand tools due to easy and low cost [1].

Ferdusai and Bolkland (2000) evaluated the present situation of slow sand filters and Pond filters in the country. He suggested improvement in the design of the filters. He felt that in present situation the filters fail to bring the Fecal Coli number below the standard level. The proposed design improvement for pre-treatment unit, the depth of the sand bed, and inlet and outlet structures' improve the water quality and increase the filter run time [4].

Lahlou (2000) describe the filtration process of SSF and also discussed the advantages and limitation of it. He stressed the biological activities to control the bacteria. Since the purification mechanism in slow sand filter is essentially a biological process, its efficiency depends upon a balanced biological community in the Schmutzdeck. Therefore, filters should operate a constant rate. When operation is stopped, the microorganisms causing bacteriological degradation of trapped impurities lose their effectiveness. Intermittent operation disturbs the continuity needed for efficient biological activity. He give idea that some slow sand filters, geotextile material is placed in layers over the surface. In this cleaning method the operator can removed a layer of filter cloth periodically so that upper sand require less frequent replacement [4].

Tech brief (1996), in his newsletter, different types of filtration process ere compared. Filtration is the process of removing suspended solids from the water by passing the water trough a permeable fabric or porous bed of materials. Diatomaceous earth filtration, direct filtration, packaged filtration, membrane filtration and cartridge filtration. He gives some points in selecting proper filtration media [5]. Following this initial selection, the basic concerns for the various alternatives should be identified and evaluated, including:

- Turbidity removal performance,
- Giardia removal performance
- Color removal performance,
- Cleaning cycle frequency,
- Necessary chemicals? Chemical dosages,
- Applicable regulatory standards,
- Required operational skills
- Necessary sludge management.

Zane (2005) gives idea about backwashing of a sand filter. Back washing a drinking water system filter means reversing and increasing the water's flow to flush out accumulated debris and particles. Back washing is not only important to the life of a filter; it is fundamental to the quality of water coming out of the filter. Sooner or later, all filters need to be back washed or replaced. He urged on backwashing and gives full procedure for doing so [2].

Chemicals in water include manganese, pesticides, arsenic, nitrate, nitrite, sulphates, fluoride, chloride, conductivity, iron, heavy metals and dissolved oxygen. In general, chemical contaminants which are at low concentrations are difficult to remove from water. Chemical precipitation, reverse osmosis and other methods become inefficient when contaminants are present in very traces concentrations. The process of adsorption is one of the few different methods available for such situations. A number of adsorbent materials have been studied for their good capacity to remove heavy metals, which include activated carbon, ion exchange resins, activated alumina, and crushed coals. Some of these materials, such as ion exchange resins are totally effective but very expensive while others, such as coal and straw, are not very expensive but ineffective. Activated carbon is very effective mean in removing heavy metals, but can readily soluble under extreme pH conditions.

In 2010 in Peru, a 2-month study proven the ability of the biosand filter to remove three metals; iron, cadmium, and chromium. Raw water of three different concentrations of these metals was prepared. The first had these metals at the maximum allowable limits set by the Peru government (Cr = 50 µg/L; Cd = 3 µg/L; Fe = 300 µg/L). The second challenge water had 10 times the regulatory limits. The third challenge water had 100 times the regulatory limits. The average removal percentages for these metals are discussed below. All filtered water samples satisfied the Peruvian regulatory limits for drinking water. While the results appear good, this study lasted only 2 months [3].

## 3. PARAMETERS

The real composition of wastewater may fluctuate from society to society, all civic wastewater composed of the following wide-ranging group of components:

1. Organic matter
2. Nutrients (Nitrogen, Phosphorus, Potassium)
3. Inorganic matter (dissolved minerals)
4. Toxic chemicals
5. Pathogens

Thus, the waste water is very dangerous if it is used without treatment. The potential impacts of wastewater used in agriculture can be covered under following points:

1. Public health
2. Land crops
3. Soil capitals
4. Groundwater reservoirs
5. Possessions values
6. Environmental impacts
7. Community

***Physical Quality Parameters***

The physical parameters of water quality are those attributes measurable in their natural state. Measuring these attributes is helpful when analyzing water and wastewater to ensure quality control for environmental health. Common parameters measured for water quality are:

i. pH
ii. Conductivity
iii. Temperature
iv. Turbidity

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***pH (0 - 14)***

The pH of a solution is given by the expression: pH = -log10 [H+], where [H+] is the hydrogen ion concentration. At pH less than 7, water is acidic, while at pH greater than 7, water is alkaline. A direct relationship between the pH of drinking water and human health effects is difficult, if not impossible to establish since pH is very closely associated with other aspects of water quality. The taste of water, its corrosivity and the solubility and speciation of metal ions are all influenced by pH. At low pH, water may taste sour, while at high pH water tastes bitter or soapy. To minimize corrosion, it is recommended that optimum pH levels are maintained. If the pH value does not meet the required limits shown above, intervention is required to rectify the situation (e.g. optimize stabilization).

***Electrical Conductivity (umhos/cm)***

Electrical Conductivity (EC) is the measure of the ease with which water conducts electricity and gives an indication of the total dissolved salt (TDS) content of the water. Health effects related to EC occur only at levels above about 370 mS/m. Adverse effects may include disturbance of salt and water balance in infants, heart patients, individuals with high blood pressure, and renal disease. The EC measurement (in mS/m) can also be used to estimate the TDS (in mg/L). If the EC exceeds the required limits, intervention is required to rectify the situation (e.g. ensure source protection, ensure treatment plant can effectively reduce EC/TDS, optimize operation at the treatment plant).

***Temperature***

The temperature of wastewater and water can affect water's ability to hold oxygen. The ability is necessary for photosynthesis of plants and metabolic rates of marine life. Weather, shade, discharge and storm water inflow can affect water temperature.

***Turbidity (NTU)***

Turbidity refers to the amount of suspended particles in water. Although water found in watersheds is naturally turbid, measuring turbidity can indicate erosion. It can also indicate excessive nutrient loading from fertilizers, algae growth and storm water runoff.

*Chemical Quality Parameters*

***Suspended Solids (mg/l)***

Suspended solids can direct to the progress of slush deposits and anaerobic situation when untouched wastewater is discharged to the marine upbringing. If the hovering solids concentration surpasses the mandatory limits, interference is required to repair the situation (e.g. ensure source security, optimize operation at the cure plant).

***Chemical Oxygen Demand (mg/l)***

Biodegradable organics are primarily self-possessed of proteins, carbohydrates and fats, and are normally calculated in provisos of Chemical Oxygen Demand (COD). If discharged raw to the environment, their biological stabilization can demand oxygen and ultimately produce infected conditions. If the COD exceeds the required limits, intrusion is necessary to fix the situation (e.g. optimize operation at the treatment plant).

*Biochemical oxygen demand (mg/l)*

Biochemical oxygen demand is a measure of the quantity of oxygen used by microbes (e.g., aerobic bacteria) in the oxidation of organic stuff. Normal sources of organic matter embrace plant rot and leaf fall. However, plant growth and decay may be inexplicably accelerated when nutrients and sunlight are overly abundant due to human influence. Municipal carries pet wastes from streets and sidewalks; nutrients from home turf fertilizers; leaves, grass trimmings, and paper from inhabited areas, which increase oxygen demand. Oxygen inspired in the decomposition process robs other water organisms of the oxygen they require to live. Organisms that are more forbearing of lesser dissolved oxygen levels may substitute a range of natural water systems include bacteria, which require oxygen (aerobic) to endure. Most of them nourish on deceased algae and other deceased organisms and are part of the disintegration cycle. Algae and other producers in the water receive inert nutrients and use them in the progression of edifice up their organic tissues.

***Nitrates and Nitrites (mg/l)***

High absorption of nitrates/nitrites in drinking-water are usually linked with methemoglobinaemia in newborn ("blue-baby syndrome"). In wastewater treatment plant, ammonia is usually oxidized to nitrites and after then to nitrates. If the nitrate/nitrite absorption becomes more than necessary limits, intrusion is required to correct the circumstances (e.g. make sure source protection, make certain that the treatment plant can successfully eliminate nitrate/nitrite, optimize process at the treatment plant).

***Phosphates/Phosphorous (mg/l)***

Eutrophication is the natural happening that results due to the gradual enhancement of a water body with nutrients (e.g. phosphates). However, accelerate eutrophication resulting from unnatural excessive discharge of nutrients to water systems is undesirable. If the phosphate/phosphorous absorption exceed the required limits, involvement is required to preparation the condition (e.g. ensures source safety, make certain that the dealing plant can successfully treat phosphates, and optimize procedure at the conduct plant).

***Sodium Adsorption Ratio***

The sodium adsorption ratio is used to envisage probable permeation problems. If the permeation is to a great extent condensed it may be impractical to supply the crop or scenery plants with adequate water for forceful growth.

***Total alkalinity (mg/l)***

Alkalinity is a find out of the aptitude of water to reduce the effect acids. Alkaline compound in the water such as bicarbonates (baking soda is one type), carbonates, and hydroxides remove $H^+$ ions and minor the sourness of the water (which means enlarged pH). They usually do this by combine with the $H^+$ ions to make new compounds. Without

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these acids neutralize capability, any acid added to a brook would cause an instantaneous modify in the pH. Calculate alkalinity is imperative in formative a stream ability to counteract bitter corruption from rainfall or wastewater. It's one of the greatest procedures of the sympathy of the tributary to acid input. Alkalinity in streams is predisposed by rocks and soils, salts, convinced plant actions, and definite industrial wastewater discharge.

Entire alkalinity is deliberate by measure the quantity of acid (e.g., sulfuric acid) required to carry the sample to a pH of 4.2.next to this pH every part of the alkaline compound in the sample is "exhausted." The result is report as milligrams apiece liter of calcium carbonate (mg/L $CaCO_3$).

***Heavy metals (mg/l)***

The word heavy metal refers to any metallic element that has a moderately high density and is deadly or venomous at low absorption. Examples of heavy metals comprise mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr) and lead (Pb).

Heavy metals are hazardous because they are likely to bioaccumulate**.** Bioaccumulation means a raise in the amount of a chemical in a biological organism above time, compared to the chemical's amount in the location. Compounds mount up in living things any time they are receive and stored sooner than they are broken down (metabolized) or excreted.

Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater.

*Biological Quality Parameter*

**Fecal Coliform/ 100ml**

Fecal coliform microorganisms are found in water wherever the water is impure with faecal waste of human or animal origin. Fecal coliforms are chiefly used to indicate the presence of bacterial pathogens such as Salmonella spp., Shigella spp., Vibrio cholerae, Campylobacter jejuni, Campylobacter coli and pathogenic E. coli. These organisms can be send out through the fecal/oral way by impure or poorly treated water and may source diseases such as gastroenteritis, dysentery, cholera and typhoid fever. The risks of being infected associate with the level of infectivity of the water and the amount of infected water frenzied. Higher amount of fecal coliforms in water will show a higher peril of constricting waterborne disease, even if small amounts of water are used. Also to note down is that for any treated wastewater discharges, 0% collapse with regards to particular limits for faecal coliforms is essential. Any bacteriological breakdown with regards to fecal coliforms can therefore be painstaking as a direct suggestion of threat to health. If the faecal coliform reckon surpasses the necessary limits, intrusion is required to correct the situation (e.g. optimize disinfection).

## 5. METHODOLOGY

***Sample Collection***

Samples were collected mainly at two stages. First, samples were collected before the operation of sand filters. Secondly, samples were collected after the operation.

***Preparation for Samples Collection***

Before collecting samples from the site, some preparation were made i.e. a cooler was used to keep the bacteriological samples in a favorable environment, Solution tape was used to keep the lids of bottle tight, so that it may not leak during transportation. Bottles were washed and sterilized as follow:

For Physio-chemical test plastic bottles used for drinking water were used. Bottles were washed well and then were allowed to dry before sample collection.

For Biological test glass bottles with glass lid were used. They were washed well with bleaching powder and the dried.

***Samples before Sand Filter Development***

Sample were collected and tested before operation of the filter mainly to get general information about the quality of wastewater. Three sites were selected for taking data; Hayatabad industrial estate, Cantonment main sewerage drain, and Regi irrigation canal.

For Physio-chemical Analysis, empty and washed bottles of mineral water were used. Samples were collected from the ponds. The bottles were filled up to the top, so that oxygen from the air may not enter and mixed with the water, as it causes error in the test.

After sterilization was completed, samples for bacteriological testing were taken from the pond by filling water up to half in the bottles and lids were kept tight for easy transportation to the laboratory. A solution tap was wrapped around the lid of the bottle, so that the collected water may not splash out of the bottles during transportation. Collected samples were placed in a cooler to provide favorable environment. The samples were then tested at laboratory.

***Samples after Sand Filter Development***

Samples were tested after the operation of filter, as to see the performance of filter and its suitability for waste water filtration in the area.

Hayatabad industrial estate and cantonment main drain, sites were selected for samples collection. Same procedure was adopted for Physio-chemical and Bacteriological tests as in above paragraph. Water samples for Physio-chemical analysis were collected from drain in the same way as mentioned earlier. Whereas water samples for Bacteriological analysis were collected from installed filters after passing through sand media. Sterilized bottles for Bacteriological test and Plastic bottles for Physio-chemical test were used to collect samples from the sput of the filters.

***Sand Analysis***

Two samples of River sand were collected from the sites where the sand was dumped for construction purposes and was from the sites where the sand was dumped in depots

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for selling purposes. Samples were collected in plastic shoppers and by the process of sieve analysis uniformity co-efficient for each sample were find out.

***Sand Filter Development and construction***

The design, construction and operation are discussed separately. No doubt construction of a sand filter is important to be considered, but proper design is key to the success of filter, proper size of perforations in the strainer, placing of gravel around the strainer and sand column placing, contribute much toward the better performance and long life of a filter.

*Design and Construction*

***i) Storage tank***

A plastic drum of 200 liters capacity and having 90 cm height and 45 cm diameter was used as storage tank. It was marked divided in three parts naturally from outer side. Its two parts were used as strainer and filter media and one for holding water layer and diffuser tub above the filter bed.

***ii) Strainer***

A strainer is the combination of perforated iron (GI) pipe and a collector pipe having one inch in (2.5 cm) diameter. Two laterals from each side were used with collector. One end of the collector was closed while the other was extended outside the drum. The outer extended end of the collector was threaded, to install elbows and an outlet discharge pipe for clean drinking water. A thin cloth sheet was wrapped around the perforated pipe so that sand particles may not enter into the delivery pipe.

***iii) Diffuser Tub***

A plastic tub used for washing clothes etc in the houses was used to diffuse the impact of pouring water in the sand filter, so that it might not disturb the media or bio layer used for bacteriological control in the filter. Holes were made in the bottom of tub and the tub was placed on the top of the drum just above the sand filter media. It works is three fold i.e. it can also be used as cover of the drum by preventing foreign material to be fallen into the filter. For higher turbidity in water a thin cloth can be placed in the tub by fitting it with the rim of tub through sewing elasting with the cloth like shelwar. It will hold all the bigger size materials like sand and silt particles and straw etc. so it works s a pre cleaner unit for the filtration process. The tub is fitted in such a way i.e. it is placed simply upon the drum, like in village some people used silver glass for drinking water and as well as put it into the earthen water container as a cover.So the tub was placed upon the drum and was kept at least 3 inches above the maintained water layer.

***iv) Flow Outlet***

It is an outlet to deliver clean drinking water out of the filter to the container or it is a sput for delivering safe drinking water to the consumers. It is made of a steel pipe of half inch in diameter. It was connected at the outer extended end of the collector of the strainer through threads. Its height is kept 60 cm against the filter's media height of 55 cm. with this a 5 cm of water layer will maintain above the sand media. This water layer does many jobs.

- It reduces the impact of pouring water into the filter.
- It protects the bio layer which is necessary for bacteriological contaminants control.
- It keeps the void of the sand media fill and so increase the filtration performance.
- It slows down the delivery of water from the sand filter so maintain safe discharge.

The height of the delivery or outlet pipe can be kept and according to the available drum height and sand media. But remember it should be kept few cm above the sand media.

***3.8.2 Construction of Sand Filter***

Construction means placing of gravel, sand materials, fitting of diffuser tub and making of water layers above the sand media, and ultimately running of filter on the site.

***i) Washing Filtration of Media***

Gravels and sand used in the drum for filtration were washed and sand analyses were also done. Sand was passes through an ordinary screen used for flours screening in the houses, so that straws or any foreign materials may be separated from the sand to be washed.

***ii) Location for Drum***

The plastic drum was placed under the shade in safe place. It should be kept out of the reach of the sun light so that biological mechanism remains active.

***iii) Filter bed***

It is composed of two components i.e. Gravels or crush materials and sand materials. It is the most important component of the filter as all performance depends on the proper placement of this part.

***a) Gravels/Crush bed***

A gravel/crush drainage system was provided at bottom of the plastic drum. It was used to prevent movement of the sand into the filter outlet. A gravel/Crush drainage system consists of two layers. First layer was of coarser gravel material generally used in 10/12 cm thick floors of the building. It was placed around and upon the strainer in a way that it hardly covers it. Roughly it was between 5 to 7 cm thick layer. Another layer of fine gravel was placed over the coarse gravel. Its total thickness reached to 10 cm. fine aggregate means gravel or crush used for chips floors in building or finer than that so that the sand layer above.

***b) Sand bed***

This is the most important component of the filter. Performance of the filter depends on this party if it was installed properly. Sand size, grading, thickness of the layer and surface area, all contributes to the performance of filter. Paniala sand of having

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effective size (ES) of 0.10 mm and UC of 2.7 was used in the filter. After placing a layer of thin cloth sheet on the gravel/crush, some water was added before placing sand. Sand was places for 14-20 inches (35-50 cm) above the gravel layer.

***iv) Diffuser***

A tub with thin cloth inside was put into the top of the plastic drum. Some force was applied on the tub so that the rim of tub may come in fit into the top edge of the plastic drum. However the most important is that the bottom of the tub was kept few cm above the water layer or above the spout.

***v) Water Layer***

Water was poured into the filter passing through the diffuser plate/tub until the media may get saturated and a layer of water 3 to 6 cm above the sand was established. The purpose of water layer above the sand media is three folds. First it helps the water to pass through the sand media due its hydraulic load. Secondly it keeps the sand media wet and not allowed to be dried, so that the biological activities remain active. Third it dissipates the falling energy of water from the diffuse and so keep the sand media undisturbed.

***vi) Bio layer***

Water was applied for few days until a bio layer was established on the sand media within the water layer. This bio layer is the most important part of the filter. It acts as a fine filter an actually 'eats up' some of the disease-causing microbes in the water. Water was poured into the filter every day. This practice was continued two to three weeks for the *schmutzdecke* to develop fully.

***Discharge Determination***

Discharge measurement means to measure the flow of water out of the filter's spout or delivery tube. It was measured by using volumetric method i.e. a bottle of known volume was used. One and a half liter bottle of a mineral water was made empty. As the water was pured at top of the PDHHSF, the water started coming out of the delivery tube. Initial time was noted (Ti) as filling of the bottle was started. The bottle was filled and the final time (Tf) recorded at the end as well. This practice was made at least for three times and the average Ti and Tf were calculated. From this net time was calculated. So discharge was determined as follow.

Q = Volume of the Bottle/Time required to fill the bottle

Q = Volume/T

T = Tf- Ti

Where

Ti = initial timing seconds at the start of the bottle filling in seconds.

Tf = Final timing seconds at the end when bottle was filled.

Q = Discharge of filter

RESULT AND DISCUSSION

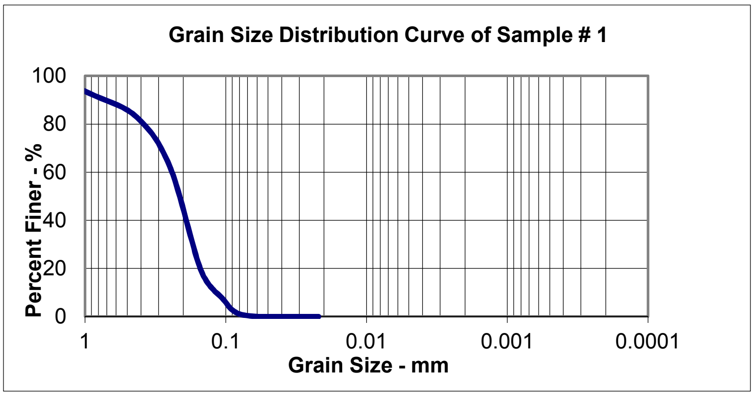
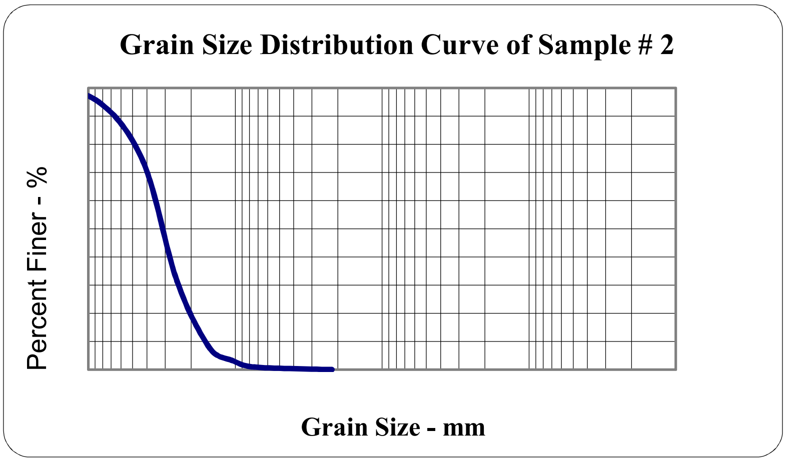



Figure 1: Grain size distribution curve of Sample 1



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***Data collected from industrial waste water sample***

Effluents samples were collected at the discharge point of selected industrial units of Hayatabad Industrial Estate; Peshawar The main drain where effluents of all industries are fallen was also sampled. The samples were collected in clean plastic containers of 1.5 L volume in such a way that no bubbles were formed in the containers.

Effluents and underground drinking water of the surrounding area were analyzed for various important characteristics such as temperature), pH, electrical conductivity, total soluble solids, total dissolved solids, biological oxygen demand and heavy metals concentration.

***Data collected from domestic waste water from cantonment main drain***

The waste water from cantonment main drain was collected for test the waste water first was allowed to settle down then the water is used to be filter by biosand filter. The water sample was taken before and after the filtration for test to PCSIR Peshawar. The test results are given in the Tables below:

Table 1: P values for different parameters between filter 1 and filter 2

| Parameters | No. of samples | Filter 1 | Filter 2 | P(value) |
|---|---|---|---|---|
| Electrical conductivity | 2 | 710 | 782 | 0.389 |
| | | 810 | 980 | |
| Total suspended solids | 2 | 10 | 5 | 0.3333 |
| | | 25 | 10 | |
| Total dissolved solids | 2 | 640 | 630 | 0.944 |
| | | 865 | 850 | |
| BOD5 | 2 | 228 | 630 | 0.944 |
| | | 865 | 850 | |
| pH | 2 | 7.1 | 7 | 0.612 |
| | | 8 | 7.49 | |

Table 2: comparison between industrial waste water samples before and after treatment with river sand filter with effective size of 0.14

| Water quality Parameters | Units | Before Filtration | After Filtration |
|---|---|---|---|
| pH | (0 -14) | 7.56 | 7.10 |
| Electrical conductivity | (umhos/cm) | 640 | 710 |
| Total suspended solids | (mg/l) | 380 reduction in settling tank up to 50 | 10 |
| Total dissolved solids | (mg/l) | 640 | 630 |
| BOD5 | (mg/l) | 415 | 228 |
| Lead | (mg/l) | 0.70 | 0.65 |
| Chromium | (mg/l) | 0.06 | 0.06 |
| Iron | (mg/l) | 0.42 | 0.30 |
| Zinc | (mg/l) | 0.01 | 0.01 |
| Copper | (mg/l) | 0.36 | 0.30 |
| Manganese | (mg/l) | 0.16 | 0.15 |

Table 3: comparison of results of domestic waste water samples before and after treatment of filter with effective size of 0.18mm

| Water quality parameters | Units | Before filtration | After Filtration |
|---|---|---|---|
| pH | (0 -14) | 8.38 | 7.49 |
| Electrical conductivity | (umhos/cm) | 740 | 980 |
| Total suspended solids | (mg/l) | 500 | 10 |
| Total dissolved solids | (mg/l) | 900 | 850 |
| Total hardness | (mg/l) | 390 | 350 |
| Total alkalinity | (mg/l) | 150 | 140 |
| Chloride | (mg/l) | 38 | 30 |
| Sulphate | (mg/l) | 146 | 140 |
| Turbidity | NTU | 60 | 5 |
| $BOD^5$ | (mg/l) | 350 | 150 |
| Total coliform | Count/liter | 350 | 0 |

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## CONCLUSIONS

After the conduction of research for MSC agricultural engineering thesis completion, the following conclusions were made:

1. The sand from the stone quarry is recommended to use as filter media as compared to other sand as it fall nearer to international standard size of sand with ES of 1.8 and uniformity co-efficient of 1.94.
2. Plastic drums of having capacity about 100 liters of 100 cm height are best to use as a casing of filter, because it is easily available in the market and is of low cost as well. It is also easy to handle during transportation, installation and in cleaning processes.
3. Plastic drum household sand filter is efficient in respect of turbidity reductions for about 88% and in removal of E.Coli bacteria for 96% to 100%.
4. For sand height of sand column should be from 30cm to 45cm, otherwise it will chock quickly due to small size of sand.
5. Discharge of water from the spout of filter was from 1.20 liter/min to 0.50 liter/min. average discharge was recorded as 0.80 liter/min which was found satisfactory to achieve good performance of the filter.
6. Gravel materials used around the strainer pipe in filter should be preferred if available in the area as compared to the crush materials. A very little change was observed in chemical's parameters of water quality after filtration process due the use of crush materials which were still found within the limits and are satisfactory.

## RECOMMENDATIONS

The following are some of the recommendations on which further study can be conducted in Peshawar area in respect of plastic drum household sand filter for the treatment of domestic, industrial and irrigation canal water:

1. To see the performance of filter with respects to the improvement of water quality for drinking purposes at different turbidity level.
2. To see the performance of the filter at different discharge level from the spout. Discharge of the filter can be varied either by increasing or decreasing the depth of sand columns, hydraulic head above the media and by varying the sizes of the sands
3. To see the performance of the filter on more small sizes drums in diameter specially, available in the local market, as it will be easy to handle and also will be of low cost. Study can also be conducted to see different casing materials effect particularly with respect to cost and local adoptability e.g. precast concrete, charcoal drum, and local clay mutca etc.
4. To check the performance of filter by using alternative filter media like crushed stone, rice husks etc.

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