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Role of different filter media in water purification and water treatment

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Title:

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Abstract

In this research have been introduced to the subject of water purification through the types of water treatment Plants. Then we focused on the work of the filters, the types, how do they work, the different designs of the filters and the advantages and disadvantages of each type. Emphasis was placed on the type of materials (media) used in the Filters, Together with the standard specifications, tables and curves of head losses during filtrations and backwashing for each media type. Then displayed models of the designs of filters in water treatment Plants in some Kurdistan cities.

Keywords: Water; Treatment; Sand; Filtration; purification; Filter media; Anthracite; Garnet; Gravel; Rapid sand filter; Slow sand filter.

A water treatment plant is a facility where water is treated to make it acceptable for the designated end-user. Various processes involved in this exercise, such facilities include sedimentation, filtration, chlorination, disinfection, clotting and so on. Water purification equipments used a stat in these plants are water filters, ozone generator, oil water separators, screening equipments, sludge treatment equipment and many more.

Treatment of water is through for different purposes and there are water treatment plants serving different applications. Here is a brief discussion:-

Wastewater Treatment

The most common application of a water treatment plant is to treat the waste water collected from homes, industries and many other sources. In order to make the waste water reusable, it is treated to remove physical, radioactive, chemic and biologic pollutants. Sewage treatment and sludge treatment are the two most popular sub-types of wastewater purification plants.

A decentralized wastewater plant is another common facility in this category. The water treated a stat in this facility is reused for landscape irrigation and toilet flush supply.

Surface Water Treatment

A surface water treatment process is used to make surface water fit for municipal applications. Suspended impurities, colloidal matter and organic components are remote through processes like sedimentation, aeration, screening, disinfection and sand filtration.

Containerized Water Treatment Plant

To make pollutant-free water available in remote areas, the containerized treatment plant for water is considered as a suitable option. A single unit arrangement is used in this family of treatment equipments. Such plants can also be installed near military and excavation camps. Environmental emergencies too ca be met with the help of such facilities.

Ozone Based Water Plant

These plants use ozone for water purification and useful to treat pool water or water present in the cooling towers. Ozone is an excellent disinfectant for variety of microorganisms, including Cryptosporidium and protozoan parasites. The main advantage of this type of plant is that it doesn't require adding any chemic to the water.

Seawater Treatment Plant

Seawater is treated to remove dissolved minerals and salts a stat in a saltwater treatment plant. Desalination, membrane separation, vacuum freezing and many such processes are employed a stat in these plants. Saudi Arabia and the USA are the two countries with most number of seawater desalinization plants.

Package Wastewater Plant

Treating wastewater using the process of aeration is done at a package wastewater treatment facility. These plants are available in unlike sizes and are used for applications in small and medium urban areas, remote mining areas, construction sites, amateur sites, educational sites and a stat in various other sites.

Bottled Water Treatment

The popularity of bottled drinking water is increasing with passing time. The water is collected a stat in the source, treated and jammed in bottles that are supplied to the market. A bottled water plant is installed near the source to make water treating easy and economical.

Mobile Water Treatment

This is another popular facility designed by water treatment plant manufacturers. Reverse osmosis and mobile wastewater treatment are the methods used to treat water a stat in these facilities. This plant is installed over a big trailer and moved to unlike sites.

Water is becoming a scarce commodity and use of treatment plants is one solution to save it from depleting.

Filtration

Filtration is commonly the mechanical or physical operation which is used for the separation of solids from fluids by **interposing a medium** through which only the fluid can pass. Oversize solids in the fluid are retained, but the separation is not complete; solids will be contaminated with some fluid and filtrate will contain fine particles (depending on the pore size and filter thickness). Filtration is also used to describe some biological processes, especially in water treatment and sewage treatment in which undesirable constituents are removed by adsorption into a biological film grown on or in the filter medium.

Achieving flow through the filter

Fluids flow through a filter due to a difference in pressure — fluid flows from the high pressure side to the low pressure side of the filter, leaving some material behind. The simplest method to achieve this is by gravity. In the laboratory, pressure in the form of compressed air on the feed side (or vacuum on the filtrate side) may be applied to make the filtration process faster, though this may lead to clogging or the passage of fine particles. Alternatively, the liquid may flow through the filter by the force exerted by a pump, a method commonly used in industry when a reduced filtration time is important. In this case, the filter need not be mounted vertically.

Filter Design

One design brings the water in the top of a container through a "header" which distributes the water evenly. The filter "media" start with fine sand on the top and then graduating coarser sand in a number of layers followed by gravel on the bottom, in gradually larger sizes. The top sand physically removes particles from the water. The job of the subsequent layers is to support the finer layer above and provide efficient drainage.

Media Filtration for Sewage and Wastewater

Media filters are also used for cleaning the effluent from septic tanks and primary settlement tanks. The materials commonly used are sand, peat and natural stone fiber.

Drinking Water Filtration Systems

Municipal drinking water systems often use a **rapid sand filter** and/or a **slow sand filter** for purification.

Rapid sand filter

The rapid sand filter or rapid gravity filter is a type of filter used in water purification and is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system. Rapid sand filters were first used in the United States in 1896 and were widely used in large municipal water systems by the 1920s, because they require smaller land areas compared to slow sand filters.

Types of Rapid Sand Filter

There are a number of different types of Rapid sand filters depending upon bed depth (e.g., shallow, conventional and deep bed) and the type of filtering medium used (mono-, dual-, and multimedia).

A further classification can be made based on the driving force as gravity or pressure filters. Typically sand is used as the filtering material in single medium filters. Dual-medium filters usually consist of a layer of anthracite over a layer of sand. Multimedia filters typically consist of a layer of anthracite over a layer of sand over a layer of garnet.

The principal filtration methods now used with reference to the rate of flow through gravity filters may be classified as

1- Constant-rate of filtration with fixed head,

2- Constant -rate filtration with variable head, and

3- Variable- declining-rate filtration.

1- Constant-rate Filtration with fixed head

In constant-rate filtration with fixed head, the flow through the filter is maintained at a constant rate. They are either in-fluent controlled or effluent controlled. Pumps or weirs are used for in-fluent control where as an effluent modulating valve that can be operated manually or mechanically is used for effluent control.

2- Constant-rate Filtration with variable head

In constant-rate variable filtration head, the flow through the filter is maintained at a constant rate. Pumps or weirs are used for in-fluent control. When the head or effluent turbidity reaches a preset value, the filter is back-washed.

3- Declining-rate filtration with fixed or variable head

In declining-rate filtration, the rate of flow through the filter is allowed to decline as the rate of head loss builds up with time. Declining-rate filtration systems are either in-fluent controlled or effluent controlled.

In the effluent controlled type of filters, the filter effluent lines are connected to a common header. A fixed orifice is built into the effluent piping for each filter so that no filter after washing will take an undue share of the flow. The filtered water header pressure may be regulated by a throttle valve which discharges to filtered water reservoir. Costly rate controllers are replaced with fixed orifices and therefore, would make the units economical particularly in large water works involving batteries of filters. For equal duration of filter runs the total output per day from a declining rate filter is higher than that in the conventional filters. In group of filters operating at an average rate of 10 m3/m2/hr, the fixed orifice will be so designed that a recently cleaned filter will begin operation at 15 m3/ m2/hr while the filter next in line for cleaning will have slowed down to about 5 m3/m2/hr. Usually the depths of filter boxes for declining rate filters are more than those for the conventional ones. These would permit longer filter runs and consequent reduced wash water requirements.

The filter beds are operated by scheduled cleaning in such a way that each of beds will be in different stage of filter cycle producing the required average flow. When the rate of flow is reduced to the minimum design rate, the filter is removed from service and back-washed. In an inlet-controlled filter, the rate of flow is controlled proportional to the rate of filtration with float control arrangement to the inlet valve. Inlet control reduces the amount of work which has to be done on the filter to just clean it.

Design and operation

Rapid sand filters use relatively coarse sand and other granular media to remove particles and impurities that have been trapped in a flock through the use of flocculation chemicals--typically salts of aluminum or iron. Water and flocks flows through the filter medium under gravity or under pumped pressure and the flocculated material are trapped in the sand matrix.

Mixing, flocculation and sedimentation processes are typical treatment stages that precede filtration. Chemical additives, such as coagulants, are often used in conjunction with the filtration system.

Types: Gravity type, e.g. Paterson's filter, and Pressure type, e.g. Candy's filter.

A disinfection system (typically using chlorine or ozone) is commonly used following filtration. Rapid sand filtration has very little effect on taste and smell and dissolved impurities of drinking water, unless activated carbon is included in the filter medium.

Advantages and Disadvantages

Rapid sand filters are typically designed as part of multi-stage treatment systems used by large municipalities. These systems are complex and expensive to operate and maintain, and therefore less suitable for small communities and developing nations.

Advantages:-

- Much higher flow rate than a slow sand filter; about 6 to 8 cubic meter of water per square meter per hour.

- Requires relatively small land area

- Less sensitive to changes in raw water quality, e.g. turbidity

- Requires less quantity of sand

Disadvantages:-

- Requires greater maintenance than a slow sand filter. For this reason, it is not usually classed as an "appropriate technology," as the term is applied in less-developed countries.

- Generally ineffective against taste and odor problems.

- Produces large volumes of sludge for disposal.

- Requires ongoing investment in costly flocculation reagents.

- Treatment of raw water with chemicals is essential.

- Skilled supervision is essential.

- Cost of maintenance is higher.

- It cannot remove bacteria.

Slow sand filter

Slow sand filters are used in water purification for treating raw water to produce a potable product. They are typically 1 to 2 meters deep, can be rectangular or cylindrical in cross section and are used primarily to treat surface water. The length and breadth of the tanks are determined by the flow rate desired by the filters, which typically have a loading rate of 0.1 to 0.2 meters per hour (or cubic meters per square meter per hour). Although they are often the preferred technology in many developing countries, they are also used to treat water in some of the most developed countries such as the UK where they are used to treat water supplied to London. Slow sand filters now are also being tested for pathogen control of nutrient solutions in hydroponic systems.

Features

Slow sand filters have a number of unique qualities:

1- Unlike other filtration methods, slow sand filters use biological processes to clean the water, and are non-pressurized systems. Slow sand filters do not require chemicals or electricity to operate.

2- Cleaning is traditionally by use of a mechanical scraper, which is usually driven into the filter bed once it has been dried out. However, some slow sand filter operators use a method called "wet harrowing", where the sand is scraped while still under water, and the water used for cleaning is drained to waste;

3- For municipal systems there usually is a certain degree of redundancy, it is desirable for the maximum required throughput of water to be achievable with one or more beds out of service;

4- Slow sand filters require relatively low turbidity levels to operate efficiently. In summer conditions and in conditions when the raw water is turbid, blinding of the filters occurs more quickly and pre-treatment is recommended.

5- Unlike other water filtration technologies that produce water on demand, slow sand filters produce water at a slow, constant flow rate and are usually used in conjunction with a storage tank for peak usage. This slow rate is necessary for healthy development of the biological processes in the filter.

While many municipal water treatment works will have 12 or more beds in use at any one time, smaller communities or households may only have one or two filter beds.

In the base of each bed is a series of herringbone drains that are covered with a layer of pebbles which in turn is covered with coarse gravel. Further layers of sand are placed on top followed by a thick layer of fine sand. The whole depth of filter material may be more than 1 meter in depth, the majority of which will be fine sand material. On top of the sand bed sits a supernatant layer of raw, unfiltered water.

How it works

Slow sand filters work through the formation of a gelatinous layer (or biofilm) called the hypogeal layer or dirt cover in the top few millimeters of the fine sand layer. The dirt top is formed in the first 10–20 days of operation and consists of bacteria, fungi, protozoa, rotifer and a range of aquatic insect larvae. As dirt top ages, more algae tend to develop and larger aquatic organisms may be present including some bryozoan, snails and Annelid worms. The dirt top is the layer that provides the effective purification in potable water treatment, the underlying sand providing the support medium for this biological treatment layer. As water passes through the dirt top, particles of foreign matter are trapped in the mucilaginous matrix and dissolved organic material is adsorbed and metabolized by the bacteria, fungi and protozoa. The water produced from a well-managed slow sand filter can be of exceptionally good quality with 90-99% bacterial reduction.

Slow sand filters slowly lose their performance as the dirt top grows and thereby reduces the rate of flow through the filter. Eventually it is necessary to refurbish the filter. Two methods are commonly used to do this. In the first, the top few millimeters of fine sand is scraped off to expose a new layer of clean sand. Water is then decanted back into the filter and re-circulated for a few hours to allow new dirt top to develop. The filter is then filled to full depth and brought back into service. The second method, sometimes called wet harrowing, involves lowering the water level to just above the dirt top, stirring the sand and thereby suspending any solids held in that layer and then running the water to waste. The filter is then filled to full depth and brought back into service. Wet harrowing can allow the filter to be brought back into service more quickly.

Advantages:-

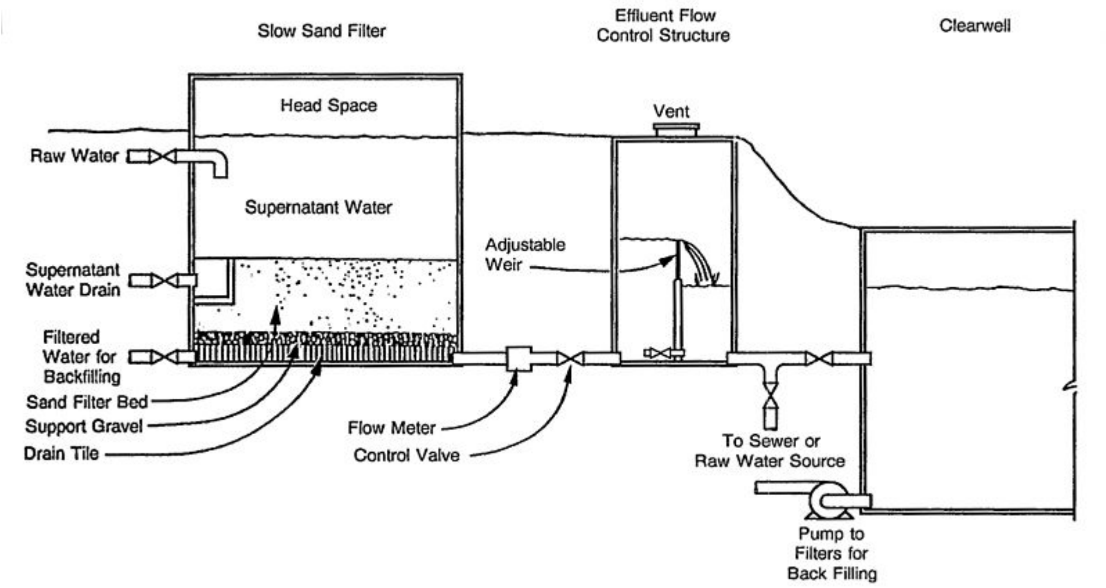
- As they require little or no mechanical power, chemicals or replaceable parts, and they require minimal operator training and only periodic maintenance, they are often an appropriate technology for poor and isolated areas.

- Slow sand filters, due to their simple design, may be created DIY (Do it yourself). DIY-slow sand filters have been used in Afghanistan and other countries to aid the poor.

- Slow sand filters are recognized by the World Health Organization, Oxfam, United Nations and the United States Environmental Protection Agency as being superior technology for the treatment of surface water sources. According to the World Health Organization, "Under suitable circumstances, slow sand filtration may be not only the cheapest and simplest but also the most efficient method of water treatment."

Disadvantages:-

- Due to the low filtration rate, slow sand filters require extensive land area for a large municipal system. Many municipal in the world initially used slow sand filters, but as cities have grown, they subsequently installed rapid sand filters, due to increased demand for drinking water.



Continuous Up flow Sand Filter

Configuration and Principle

1) Filtration process

Raw water ascends the filtration bed (3) via the raw water influent pipe (1) and raw water distributor (2). During this process, suspended solids are removed and the filtered water (4) collects at the filtrate through (5) and flows out as treated effluent.

2) Cleaning process

The filter media which have caught suspended solids are sucked from the bottom of the air lift pipe (6) and cleaned while ascending together with air and water. The filter media is separated from the cleaning wastewater at the separation section (7), then further cleaned with the filtered water flowing opposite while it falls down through the special cleaner (8), and is uniformly scattered on the surface of sand layer by the sand distributor (9).

Features

- Stable clean filtered water

The continuous up flow sand filter is operated on the continuous cleaning principle, producing stable and good-quality filtered water under constant pressure loss.

- Capabilities to filter high contaminated wastewater

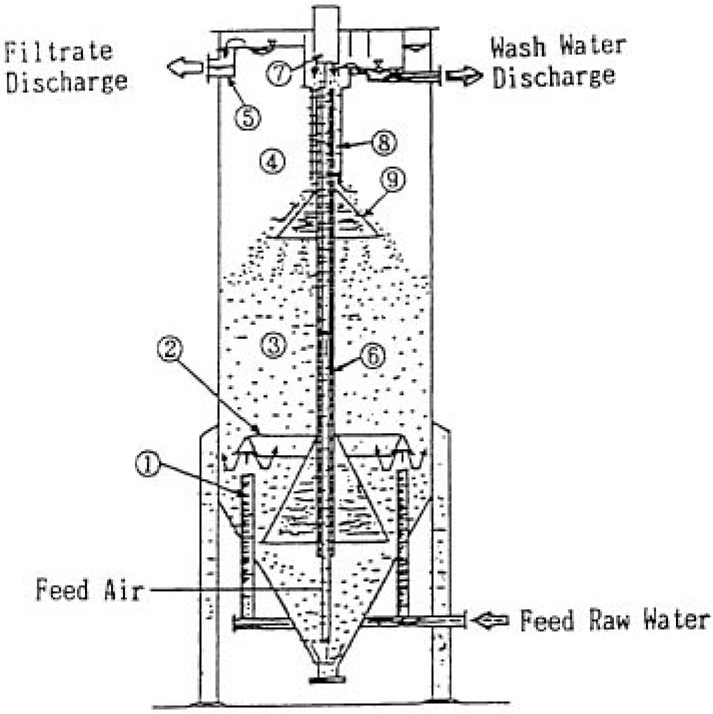
The continuous cleaning process sends suspended solids retained in the filter bed to the cleaning process in a short time. Thus filtration of high contaminated wastewater is enabled.

- Compact facilities

Because no cleaning equipment is required, a less floor space is needed and economic and compact facilities result.

- Easy maintenance control

Because of its simple structure with less supplementary equipment, maintenance is easy and operating costs are low.



Filter Media

Most major water treatment plants in the world use filter media in the process of producing drinking water. This research describes and provides data on the main types of media commonly used, anthracite, Sand, garnet and support gravel. For each type of media the standard grades are listed and the hydraulic curves given. A page is provided where the specification of filter media is explained. The advantages of multimedia filtration are discussed as is the correct way of media installation.

Type	UK Grade	Size	Effective Size	Uniformity Coefficient	SG	Bulk Density
		mm	mm		t/m3	kg/m3
Anthracite	1	0.60 - 1.18	0.65 - 0.75	<1.50	1.40	720
	1s	0.80 - 1.40	0.85 - 0.95	<1.45	1.40	720
		0.80 - 1.60	0.85 - 1.00	<1.50	1.40	720
	2	1.18 - 2.50	1.30 - 1.45	<1.50	1.40	740
	2s	1.40 - 2.50	1.50 - 1.65	<1.40	1.40	740
	2b	1.70 - 2.50	1.75 - 1.85	<1.30	1.40	740
		2.00 - 4.00	2.00 - 2.30	<1.50	1.40	750
		2.50 - 5.00	2.50 - 2.75	<1.50	1.40	750
		3.50 - 7.00			1.40	750
		4.00 - 8.00			1.40	750
Sand	16/30	0.50 - 1.00	0.54 - 0.71	<1.40	2.65	1560
	14/25	0.60 - 1.20	0.63 - 0.85	<1.40	2.65	1560
	10/18	0.85 - 1.70		<1.40	2.65	1560
	8/16	1.00 - 2.00		<1.40	2.65	1560
	6/14	1.20 - 2.80		<1.50	2.65	1560
	6/10	1.70 - 2.80		<1.35	2.65	1560
	5/8	2.00 - 3.35		<1.35	2.65	1560
Gravel	6 mm	3 - 8			2.65	1600
	10 mm	6 - 12			2.65	1600
	14 mm	10 - 20			2.65	1600
	20 mm	15 - 30			2.65	1600
	40 mm	30 - 50			2.65	1600
Garnet		0.30 - 0.60			4.10	2380
		1.40 - 2.36			3.98	2250
Manganese dioxide	18/44	0.35 - 0.85			3.75	2000
	16/30	0.50 - 1.00			3.75	20

1- Anthracite filter media

Standards: European: EN12909 American: AWWA B100

Specifications: Filter media specifications

Curves: Backwash & Expansion curves

ES	Effective Size	mm
HS	Hydraulic Size	mm
UC	Uniformity Coefficient	
SG	Specific Gravity	tone/m3
BD	Bulk Density	kg/m3

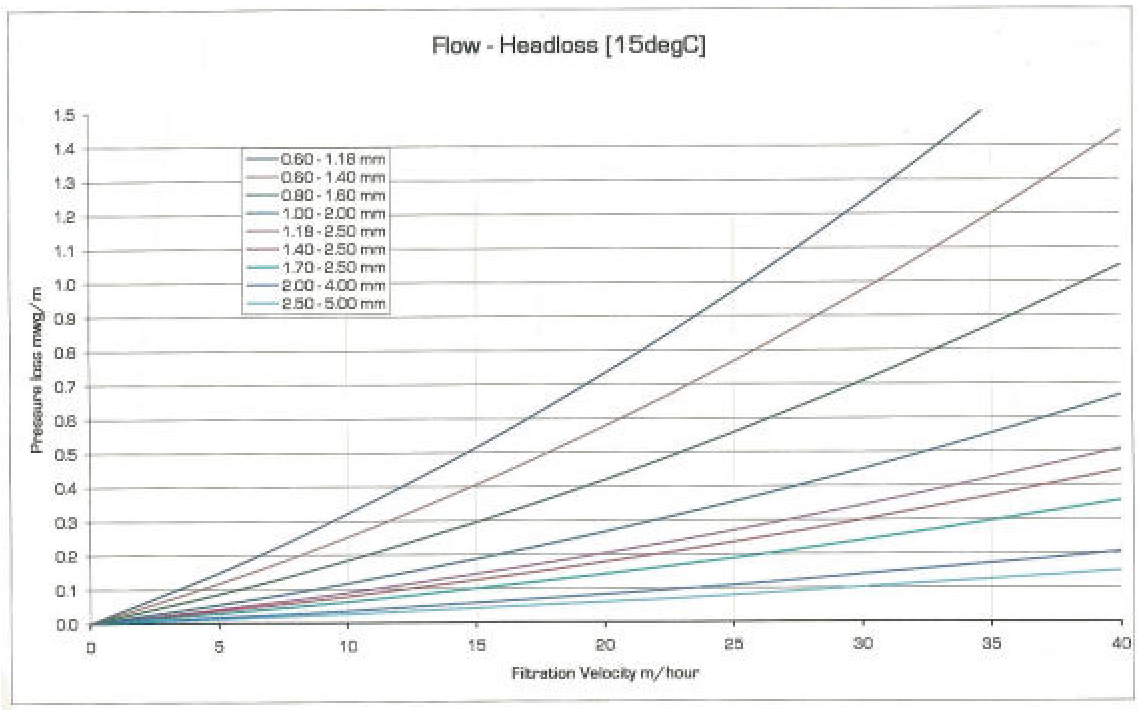
Grades Size	Size	ES	HS	UC	SG	BD
1	0.60 - 1.18	0.65 - 0.75	0.80 - 0.90	<1.50	1.40	720
1s	0.60 - 1.40	0.65 - 0.85	0.90 - 1.05	<1.45	1.40	720
.	0.80 - 1.60	0.85 - 1.00	1.05 - 1.20	<1.50	1.40	720
.	1.00 - 2.00	1.05 - 1.20	1.40 - 1.55	<1.50	1.40	730
2	1.18 - 2.50	1.30 - 1.45	1.65 - 1.85	<1.50	1.40	740
2s	1.40 - 2.50	1.50 - 1.65	1.75 - 1.95	<1.40	1.40	740
2b	1.70 - 2.50	1.75 - 1.85	2.00 - 2.20	<1.30	1.40	740
.	2.00 - 4.00	2.00 - 2.30	2.80 - 3.00	<1.50	1.40	750
3	2.50 - 5.00	2.50 - 2.75	3.20 - 3.50	<1.50	1.40	750
.	3.50 - 7.00	.	.	.	1.40	750
.	4.00 - 8.00	.	.	.	1.40	750

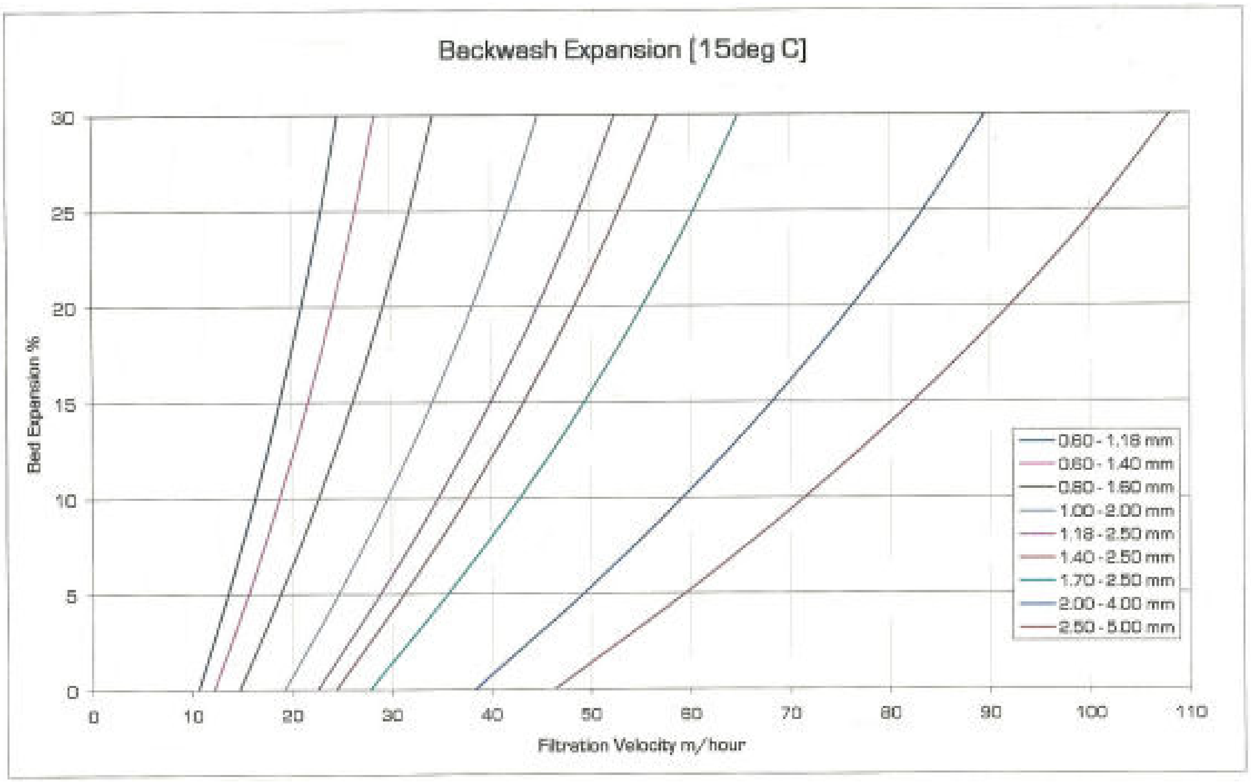
Characteristics of Anthracite	
Carbon Content	90 - 90%
Ash Content	4.0 - 7.0%
Volatile Matter	4.0 - 8.0%
Sulfur	<1.00%
Hardness	c 3 Moh
Grinding Index	60 -80 Hardgrove
Compression Index	>150 bar
Attrition Loss	below 2% in 100 hours backwashing
Acid Solubility	below 2% [24hours in 10% HCl]
Alkali Solubility	below 2% [24 hours in 10% NaOH]

Anthracite curves:

These curves give a good indication of the flow characteristics of anthracite filter media.

However, allowable production tolerances may result in variations to these curves.





Hydraulic size:

The hydraulic size of a filter media can be calculated directly from the sieve analysis. The result gives an averaged area size and is used in the Carman and Kozeny equations to calculate media flow and backwash expansion. The calculation of hydraulic size is best illustrated by an example:-

Material		Anthracite Filter Media
Grade		2 [1.18 - 2.50mm]
Sample		100 grams
Sieve [mm]	Retained %	Retained/Sieve
2.50	3.1	1.24
2.00	20.4	10.20
1.70	29.6	17.47
1.40	30.1	21.50
1.18	13.8	11.69
Tray [0.80]	3.0	3.75
Totals	100	65.85
Divide by 100		0.66
Reciprocal		1.52
Add 10%		1.67
Hydraulic Size		**1.67 mm**

2- Sand filter media

Standards: **European: EN12904** **American: AWWA B100**

Specification: **Filter Media Specifications**

Curves: **Backwash & Expansion curves**

MSDS: **Health & Safety data sheet**

ES	Effective Size	mm
UC	Uniformity Coefficient	
SG	Specific Gravity	tone/m3
BD	Bulk Density	kg/m3

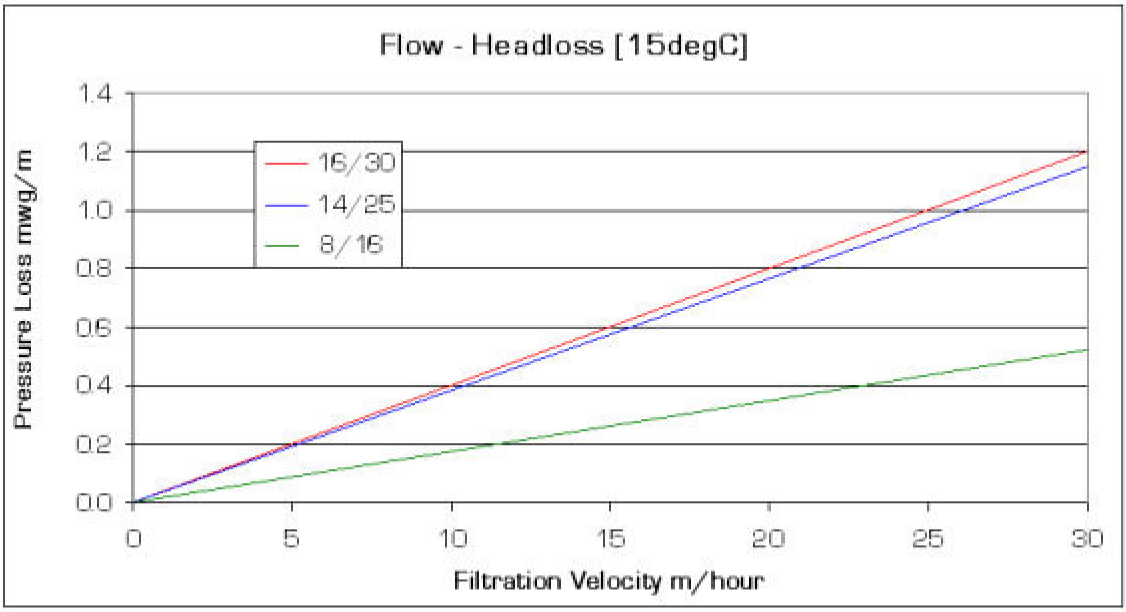
Grades	Size	ES	UC	SG	BD
16/30	0.50 - 1.10	0.54 - 0.71	<1.40	2.65	1560
14/25	0.60 - 1.20	0.63 - 0.85	<1.40	2.65	1560
10/18	0.85 - 1.70	.	<1.40	2.65	1560
8/16	1.00 - 2.00	1.05 - 1.27	<1.40	2.65	1560
6/14	1.20 - 2.80	.	<1.60	2.65	1560
6/10	1.70 - 2.80	.	<1.40	2.65	1560
5/8	2.00 - 3.35	2.00 - 2.70	<1.40	2.65	1560

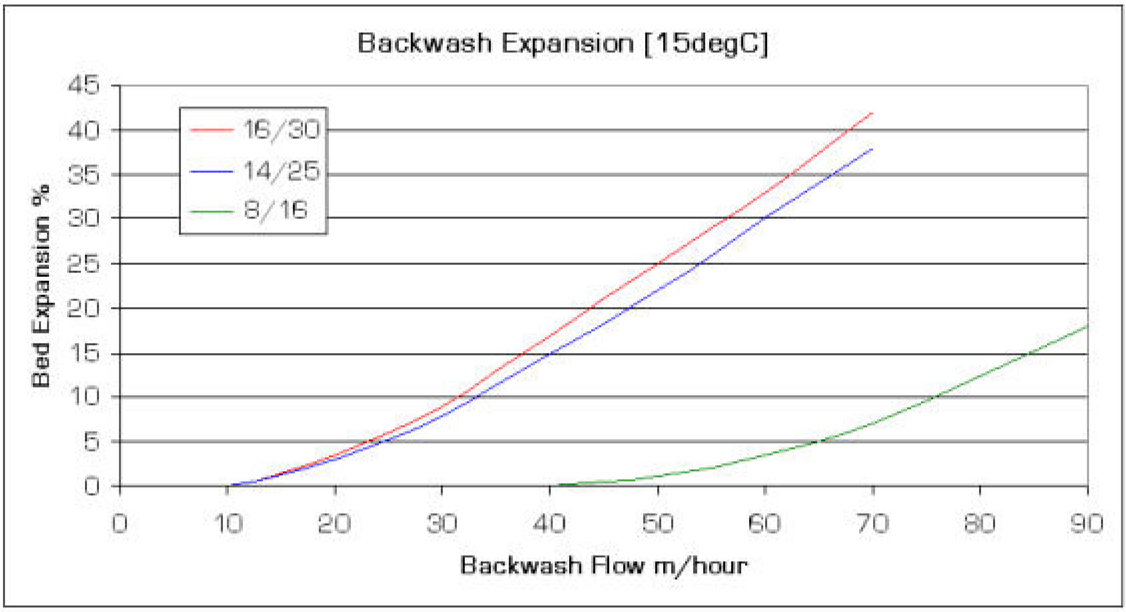
Characteristics of Sand	
Color	Brown
SiO2	96.5%
Fe2O3	2.40%
Al2O3	0.35%
K2O	0.01%
Turbidity	<100
Hardness	6 - 7 Moh
Attrition Loss	below 1% in 100 hours backwashing

Sand curves

These curves give a good indication of the flow characteristics of sand filter media.

However, allowable production tolerances may result in variations to these curves.





3- Filter garnet

Standards: **European: EN12910** **American: AWWA B100**

Specification: **Filter Media Specifications**

Curves: **Backwash & Expansion curves**

Standard Grades

SG	Specific Gravity	tone/m3
BD	Bulk Density	kg/m3

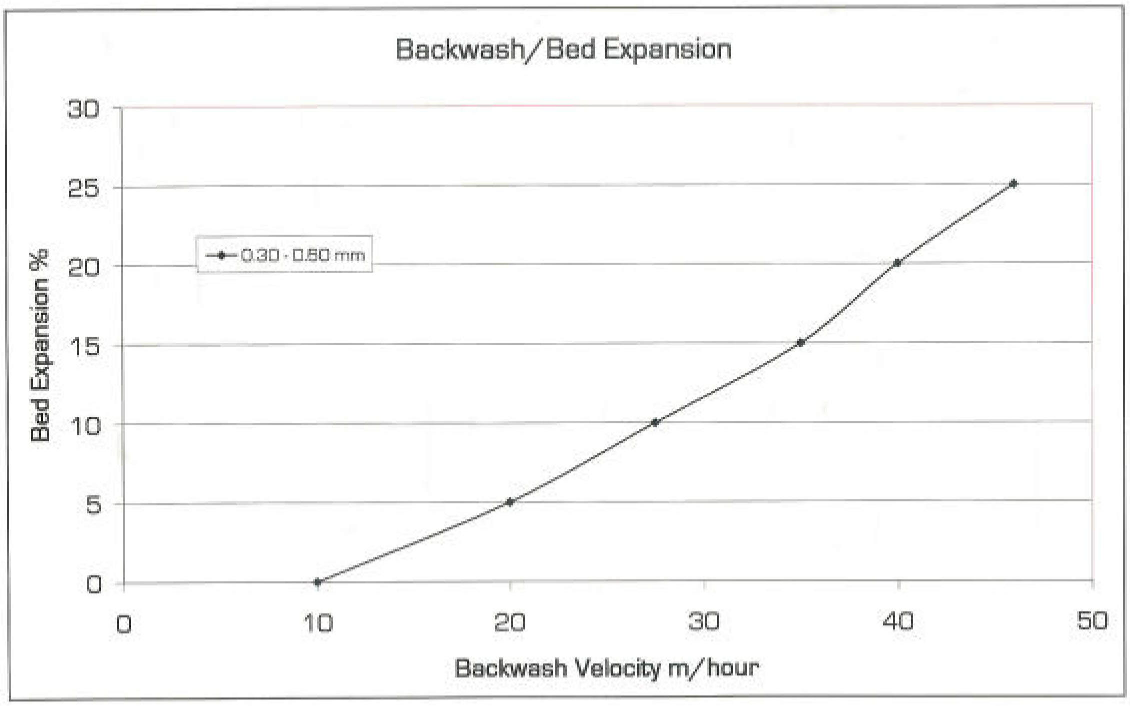
Grades	Size	SG	BD
Fine	0.30 - 0.60 mm	3.98	2250
Coarse	1.40 - 2.36 mm	3.98	2250

Characteristics of Garnet	
SiO_2	36%
FeO	31.1%
CaO	26.6%
Al_2O_3	2.9%
Hardness	7 - 8 Moh
Attrition Loss	below 1% in 100 hours backwashing
Acid Solubility	below 2% [24hours in 10% HCl]

Garnet curves

This curve gives a good indication of the backwash characteristics of garnet filter media.

However, allowable production tolerances may result in variations to this curve.



4- Support gravel

Standards: **European: EN12904** **American: AWWA B100**

Specification: **Filter Media Specifications**

Curves: **Backwash & Expansion curves**

MSDS: **Health & Safety data sheet**

Standard Grades

<table>
<tr><td>SG</td><td colspan="2">Specific Gravity</td><td>tone/m3</td></tr>
<tr><td>BD</td><td colspan="2">Bulk Density</td><td>kg/m3</td></tr>
<tr><td>Grades</td><td>Size</td><td>SG</td><td>BD</td></tr>
<tr><td>6 mm</td><td>3 - 8</td><td>2.65</td><td>1620</td></tr>
<tr><td>10 mm</td><td>6 - 12</td><td>2.65</td><td>1620</td></tr>
<tr><td>14 mm</td><td>10 - 20</td><td>2.65</td><td>1620</td></tr>
<tr><td>20 mm</td><td>15 - 30</td><td>2.65</td><td>1620</td></tr>
<tr><td>40 mm</td><td>30 - 50</td><td>2.65</td><td>1620</td></tr>
</table>

Characteristics	
Shape	Rounded
Hardness	6 - 7 Moh
Silica Content	95 - 97%
Aluminum Oxide	1.40%
Ferrous Oxide	0.40%
Acid Solubility	below 2% [24hours in 20% HCl]

5- Manganese dioxide

Standards European EN12911 American AWWA B102

Specification Filter Media Specifications

MSDS Health & Safety data sheet

Standard Grades

SG	Specific Gravity	tone/m3	
BD	Bulk Density	kg/m3	
Grades	Size	SG	BD
18/44	0.35 - 0.85 mm	c3.70	2000
16/30	0.50 - 1.00 mm	c3.70	2000

Characteristics	
Color	Dark Brown
MnO_2	70 - 80%
Fe	max 5%
Al_2O_3	max 4%
SiO_2	max 6.5%
Hardness	5 - 6 Moh

Media installation

Correct Installation of media is vital to ensure the successful operation of the filter.

Filter Media Placement:-

Pattern Test: Before placement a pattern test must be carried out to the satisfaction of all parties.

Support Gravels: Great care must be taken with the placement of the first layer of gravel in order to prevent any damage to the filter floor. It is common practice to conduct a second pattern test after the first layer of gravel has been installed and levelled to test for any nozzle breakage. Each support layer is levelled by hand after placement.

Sand Filter Media: Initial care should be taken when placing the sand not to disturb the support layer. Any irregularity left in the gravel will remain there for the life of the filter media. The sand layer may be levelled during backwashing. Once clean, the filter is completely drained down to allow for the fines to be scraped from the surface of the layer. The level is the checked and if required topped up.

Anthracite Filter Media: Finally the anthracite layer may be installed. This is then backwashed to clean and level the layer. As the top bed of media it is not always necessary to scrape any fines that may remain after backwashing.

Several Methods of installation are available each with its advantages and disadvantages.

Filter Media Installation:

1-Media Pump:

Special pumps are available which can place all medias, including the support gravels, into the filter

Advantages:

a- Can place media into a building.

b- Uses little water that can be recycled

c- Does not require a minimum water pressure

d- Clean and dust free

e- Can place gravels

f- Can accept bulk loads eliminating the need for tote bags

g- Quick [30 tones/hour] and the most economical for large installations

Disadvantages:

a-Requires a specialist company

b- Not that economic for very small installations

2- Ejector:

Again these use water to install the media but without all the advantages of a filter media pump.

Advantages:

a- Can place media into a building.

b- Clean and dust free

Disadvantages:

a- Requires a minimum water pressure.

b- Requires a high volume of water that cannot be easily recycled.

c- Slower than a pump.

d- Usually requires a specialist company.

3- Crane:

In some situations a crane may be used to lift tote bags of media into the filter.

Advantages:

a- A (**DIY**) ((Do it yourself)) method of installation and may therefore be the cheapest option.

Disadvantages:

a- The filters must be open air and within easy reach.

b- Tote bags have to be used.

c-Tends to be labour intensive.

d- May be subject to weather conditions.

4- Hand Installation:

Another **DIY** method of installation

Advantages:

a- This method may be economic for very small installations [below 15 tones]

b- Flexible if on site labour is used.

Disadvantages:

a- Manual handling is no longer a safe option.

MULTI-MEDIA WATER FILTERS

Multi-media filters represent a significant improvement over single-media filters. This is due primarily to improved filter bed action based on the innovative use and selection of filter media. Multi-media filtration permits delivery of high quality filtered water at much faster flow rates, as compared to a conventional sand filter.

In a conventional sand filter, lighter and finer sand particles are found at the top of the filter bed, and coarser, heavier sand particles remain at the bottom after backwashing. Filtration takes place in the top few inches of the filter bed.

The multi-media filter is radically different. The multi-media filter bed, in comparison to the sand filter bed, is upside down. Coarse, but lighter particles place to the top, whereas finer, but heavier, particles remain at the bottom of the bed. The innovation lies in the selection of suitable media. This configuration has many advantages. The entire bed acts as a filter, rather than only the top few inches. Turbidity is trapped throughout the bed, enabling the filter to hold far more solids filtered from the water before backwashing is necessary.

Typically, the filter bed is made up of three layers of filter media. The total bed depth is about 70 to 100 centimetres. In a three layer filter the top layer is made up of large, lighter weight particles of anthracite coal and is from 38 to 46 centimetres in depth (particle size 1.0 to 1.5 millimeters, density 1.35 to 1.75). The middle layer contains from 20 to 38 centimetres of heavier and smaller particles of calcined aluminium silicate or sand (particle size 0.5 to 0.6 millimeters, density 2.65). The bottom layer contains from 8 to 15 centimetres of heavier garnet (particle size 0.2 to 0.3 millimeters, density 4.0 to 4.2). This semiprecious red silicate mineral is 50 to 60% heavier than sand.

A multi-media filter is backwashed in the same manner as a sand filter, using reverse or upward flow of water through the filter bed. The various layers of media retain their stratification because each material has a different density.

In a four-media filter a fourth or top layer contains from 3 to 6 inches of lighter and larger plastic pillows (particle size 2.0 to 4.0 millimeters, density 1.1 to 1.2). Their density is slightly above the density of water which is (1.0).

Advantages

The multi-media filter can operate for much longer periods of time (five or more times as long at the same filtration rate), before backwashing is necessary because the bed can hold more turbidity. Turbidity is trapped and held throughout the entire bed depth, rather than the top one or two inches.

Multi-media filtration is much better suited for use in a closed pressure tank since cracking of the bed, and subsequent breakthrough of turbidity is virtually eliminated and the need for visual inspection is unnecessary. The use of pressure tanks, rather than open basins or filters, is an obvious advantage for point-of-use filtration and could also be of real importance in the filtration of small community water supplies. More rapid filtration flow rates in multi-media filtration allow the use of smaller diameter tanks with equal or better results.

A very high degree of clarity is achieved in the filtered water because of the fact that the finer particles of garnet at the bottom trap finer turbidity particles.

Another important advantage is that the multi-media filter can clarify water at a much higher flow rate than a single-media sand filter (21 to 30 litres per minute, as compared to 6 to 9 litres per minute in a 12 inch diameter tank). This is 53 to 57 litres per minute per square foot of bed area, as compared to 8 litres per minute per square foot of bed area. This is a very important difference in the production of filtered water.

In the multi-media filter the traditional feed of alum as a coagulant is reduced. At the same time it is supplemented with a polymer (polyelectrolyte) which forms a stronger flock and is applicable over a broader turbidity range.

Typical results for multi-media systems include reduction from 200 NTU to 0.42 NTU on high turbidity water, and from 25 NTU to 0.15 NTU on a low turbidity water.

As mentioned Multimedia Filtration have advantages over a single media system.

-Higher flow rates.

-Longer filtration runs between backwashes.

-Reduced consumption of backwash water.

The Ideal grain distribution in a filter bed is for the largest grains to be at the top with progressively smaller grains below. This can be achieved by placing a lower density but larger grained media on top of the filter. The most common combination is to place Anthracite on top of sand.

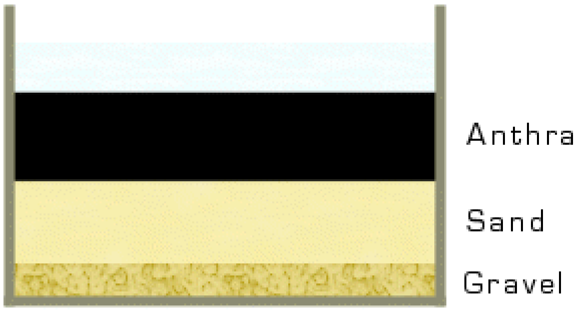
To ensure that the beds will backwash correctly the media types must be matched to have the same backwash characteristics. These may be obtained from the backwash curves.

Backwash Rate 35 m/hour			
Media	Grade	S.G.	Expansion
Anthracite	1.40 - 2.50 mm	1400 kg/m3	8%
	1.18 - 2.50 mm	1400 kg/m3	10%
Sand	0.60 - 1.18 mm	2650 kg/m3	11%
	0.50 - 1.00 mm	2650 kg/m3	13%
Garnet	0.30 - 0.60 mm	4100 kg/m3	12%

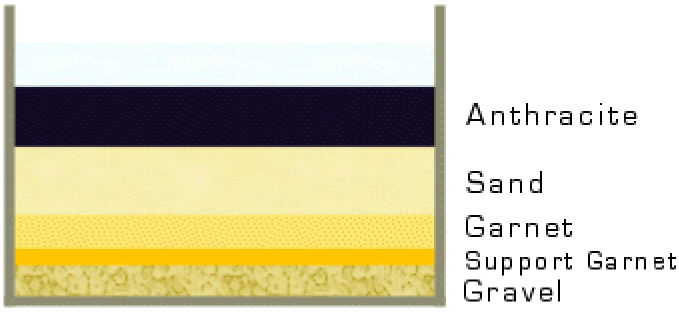
The above Medias all have approximately the same backwash Expansion rates and would be suitable in a multimedia filter.

Filter Media Examples

Single Media Filter



Duel Media Filter



Triple Media Filter

Examples of filter media installations

		Bed Depth mm		
Filter Media	Grade mm	Single	Duel	Triple
Anthracite	1.18 - 2.50		400	300
Sand	0.60 - 1.20	900	500	400
Filter Garnet	0.30 - 0.60			200
Support Garnet	1.40 - 2.50			50
Gravel	6.0 - 12.0	150	150	100

Media specification:

Filter Media is specified by its grain size distribution. This is based upon a Sieve Analysis.

Equipment required for sieve analysis:-

1. Vibrating table
2. Stack of sieves
3. Calibrated scales

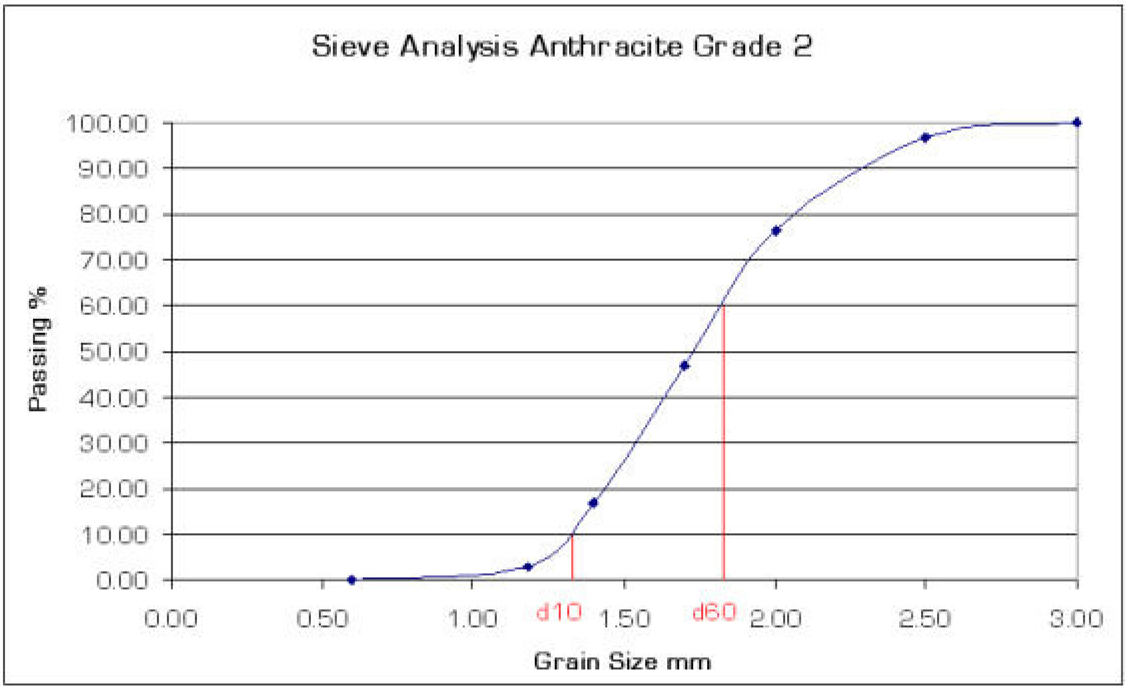
Example Anthracite Filter Media

Grade 2 [1.18 - 2.50]

Sample	132 grams			
Sieve	Retained	Retained	Retained	Passing
mm	grams	%	acc %	acc%
2.50	4.1	3.1	3.1	96.9
2.00	26.9	20.4	23.5	76.5
1.70	39.1	29.6	53.1	46.9
1.40	39.7	30.1	83.2	16.8
1.18	18.2	13.8	97.0	3.0
Tray	4.0	3.0	100.0	0.0
	132.0	100.0		

The result of the sieve analysis is plotted on a graph and a curve Drawn between the points [AWWA B100-01]

Specification		Example	Comments
Top Size	d95	2.50 mm	Specification for grade 2 Anthracite
Bottom Size	d5	1.18 mm	Specification for grade 2 Anthracite
Over Size		3.10%	Maximum 5% oversize allowed
Under Size		3.00%	Maximum of 5% undersize allowed
Effective Size	d10	1.33 mm	10% of the grains passing this size
Uniformity Coefficient		1.37	Ratio of d60 divided by d10 [Max 1.50]
Hydraulic Size		1.67 mm	See Hydraulic Size page
Minimum Size	d1	0.95 mm	1% passing. Criteria not in common use
Size Ratio	.	2.12	d95 divided by d5
	d60	1.83 mm	Used to calculate uniformity coefficient



From the graph the specification of the filter media may be determined

There are two ways to specify filter media [AWWA B100-01]

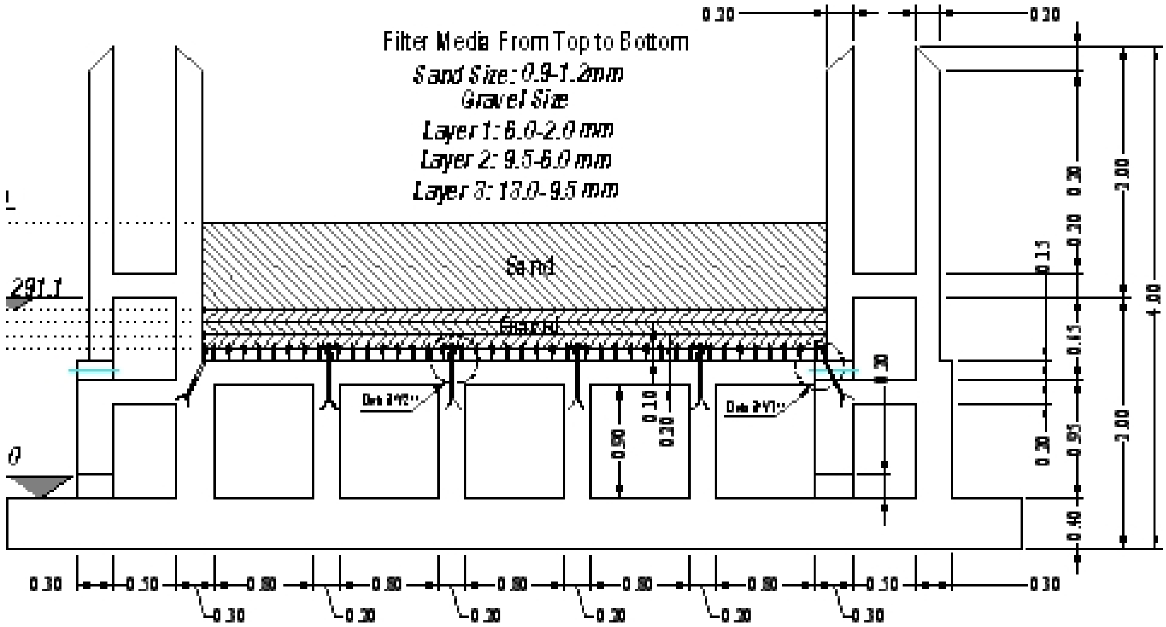
1- Top size, bottom size, over size and under size
2- Effective size and uniformity coefficient

So it is strongly advisable to specify a media that is in common use with a standard specification.

In the new constructed water treatment plants in Sulaimaniyah districts, the filters show different depths of single filter media (Sand) and different filter rates .In order to decrease the costs of Maintenance and water production as well as to improve the water quality, and depending on the criteria of surface water source in each of the below plants, redesign, capping and converting to multimedia filter type will be necessary in the near future. Below examples describe each filter in four water treatment plants in the area.

Kalar Water treatment:

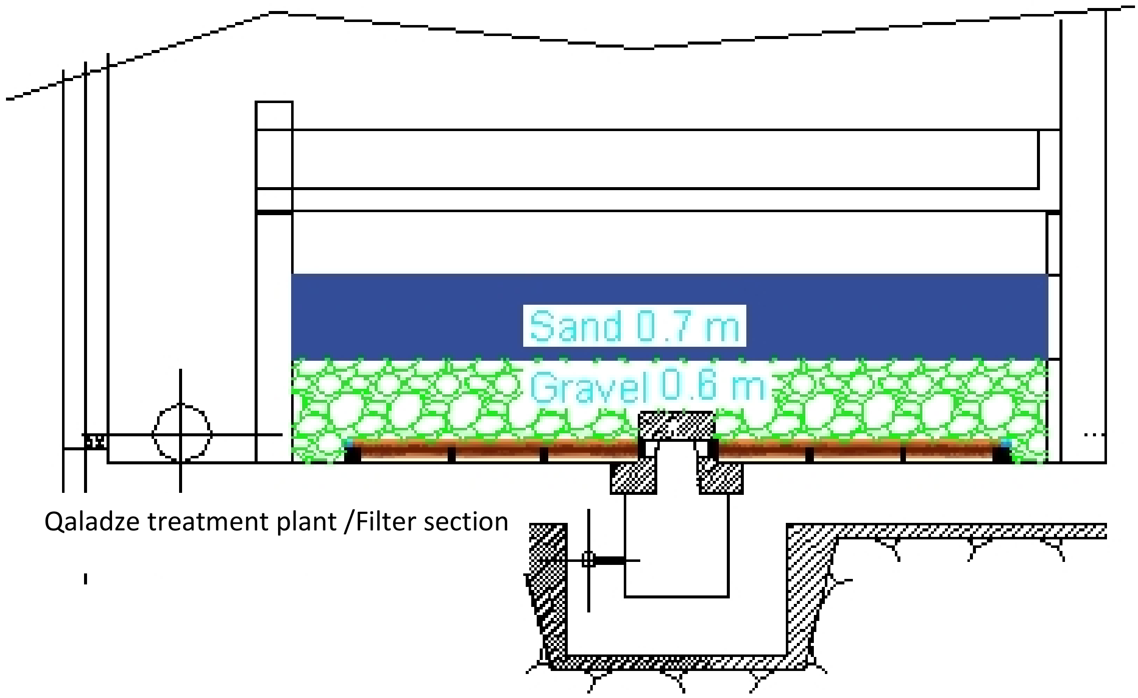
Design data : Open rapid gravity sand filters, each filter chamber has a size of(12x5)m total flow rate (1800m3/hr.), number of filter chambers(8), flow rate per each filter when all filters are in operation (2100m3/hr.), filter rate (5m3/m2/hr, filter area (60m2), Total filter area(480m2),Filter sand thickness (70 cm), Sand Nominal Size (0.9-1.2 mm) , three support gravel layers , each (10 cm) thick , Size (2-6 mm), (6-9.5 mm) and (9.5-13 mm). Wash rate (25m3/m2/hr), air scour rate (50m3/m2/hr.), wash water: flow (1500m3/hr.), total consumption (375m3) , air scour: flow (3000m3/hr.), total consumption (500m3), duration of back washing: with air (5)min, with water and air (5min), with water a lone (10)min .



Kalar water treatment filter Drawing

Qaladze Water treatment filters:

Consist of 10 numbers gravity open rapid sand filter each (9*6 m), (0.7 m) depth filter sand Size (0.5-1.5 mm),three layers of each (20 cm) depth of support gravel , size (2-6 mm),(6-9.5 mm) and (9.5-13 mm).



Qaladze treatment plant /Filter section

Raniya water treatment filters:

Design Data :Open rapid gravity sand filters each filter chamber has a size of(12x5)m total flow rate 2.750m3/hr) number of filter chambers(9) flow rate per each filter when all filters are in operation (295.4m3/hr) filter rate (4.92 m3/ m2/hr, filter area (60m^2). Filter material: Total depth (100 cm) consisting of gravel size (13-9.5) mm.(9.5-6)mm,(6-2)mm (10 cm) sand size (0.9-1.2)mm (70cm),water depth a above sand (120) cm.

Koya water treatment:

Design Data :Open rapid gravity sand filters each filter chamber has a size of(6x8)m total flow rate 1200m3/hr) number of filter chambers(8) flow rate per each filter when all filters are in operation (150m3/hr) filter rate (3.2 m3/ m2/hr, filter area (48m^2). Filter material: Total depth (100 cm) consisting of gravel size (13-9.5) mm. (9.5-6) mm, (6-2mm) (Total depth 60cm) sand size (0.5-1.5 mm) (40cm) depth, water depth above sand (120) cm.

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