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ALTERNATIVE FILTER MEDIA: AN OVERVIEW

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ABSTRACT

Filter media is one of the most important components of filtration unit. An important property of filter media is it should neither too coarse nor too fine. If filter media is too coarse then water passes too quickly through the filter media without having sufficient treatment. If filter media is too fine then movement of water through it is very slow resulting in reduction in aeration within the media and chance of clogging increase. The most commonly and widely used filter media is sand but in recent years typical filter unit using mulit-media in filtration process to improve performance of the filter. This paper reviewed and compared various alternative filter media available and their impact on performance of the filtration unit

Keywords: Filtration, Filter media, Dual media, Turbidity.

I. INTRODUCTION

The purpose of water treatment and purification process is to collect water from best available source and process it to ensure that water of good quality, free from unpleasant taste or odor and contains nothing which might be detrimental to health. To achieve this, the water should undergo a series of treatment processes. Filtration is part of such treatment process where water is cleaning and purification is done by passing it through a bed of filter media which remove and/or reduce suspended particles present within it. Therefore, any improvement in performance of filter media, will improve the performance of filtration unit.

In a multi media filtration system, the main challenge is selection of different filter media. For example, in a dual media filtration system the two filter media must be compatible to each other so that they fluidize at approximately the same backwash rate. In this paper, we discussed and reviewed various alternative filter media in terms of their size, shapes and performance

II. ALTERNATIVE FILTER MEDIA

The literature survey shows that many good and easily available alternate filter media are there which can be used in filtration unit. For example, use of clay ball and recycled crushed glass [1]-[2], broken bricks and sand [3]-[5] are used as alternative filter media in PMF unit. Some of the most promising filter media which are easily available and having good performance are discussed below:

Sand

It is still a one of the preferred filter media in multi-media filtration system due to its low cost, easy availability and predictable performance because of extensive experience and already available results. Graded and washed filter sand consists of silica and calcium. Some of the important properties of filter sand are:

- Density : 1.60 kb/dm^3
- Bed depth : 450-750 mm
- Service flow : 7-12 m/h
- Backwash flow : 35-50 m/h

An ideal sand media has both large surface area to permit water to have maximum contact with the zoogleal film on the particles where most of the treatment is accomplished and sufficient pore space to allow aeration and unsaturated flow. Because sand media treatment is aerobic in nature, the exclusion of fines from the filter media is extremely important to maintain open passages for air. Concrete sands are designed to minimize voids, and usually have a high U_c between 4-6 to pack and offer strength and stability. Developed for the manufacturing of concrete, sands meeting the ASTM C-33 specification have a fairly broad and even size distribution. This size distribution allows the smaller sand particles to fill interstices between large particles, resulting in smaller and more convoluted pores spaces. When used for filter media, this condition encourages clogging of remaining void spaces with suspended solids and biological growth. Sands with higher U_c values have a more tortuous path *i.e.* smaller and more convoluted pores spaces for water to move through and will have lower infiltration rates or permeability. Usually the water retention is also greater with sands that have a higher U_c due to smaller pore volumes and higher bulk densities. These conditions run counter to the objective for a good filter media, which should have sufficiently large pore spaces to allow ample oxygenation and unsaturated flow around the sand particles.

Anthracite

Crushed and graded anthracite coal is an ideal medium weight filter media. Because of non uniformity in shape and size, sediment penetrates deeper into the bed and provide longer service runs. Some of the important properties of anthracite which make them preferable filter media for dual or multi-media filter are:

- Density : 0.80kg/dm^3
- Bed depth : 600-900 mm
- Service flow : 12.5 m/h
- Backwash flow : 30-45 m/h

Fibrous media

It is in the form of nonwoven filters have been widely used in water treatment systems as pre-filters or to support the medium that does the separation. Nonwoven media are composed of randomly oriented micron-size fibers and provide a one step separation as a substitute for conventional processes comprising chemical addition, flocculation, sedimentation, and sand filtration. At present, the use of nonwoven filter media is limited to pre-filters and is not used further downstream as high performance filters. However, it is expected that by reducing the fiber size in the nanometer range, higher filtration efficiency can be achieved. With the advent of nanotechnology, the ease of producing high quality nano-scaled fibers is now a reality. Recent advancements in nano-fibrous media through surface modifications have shown that nonwoven media can be used beyond the pre-filter stage. Furthermore the pore size of the filter media can be controlled through modification of fiber size and thickness of membranes. These nano-fibrous membranes possess high surface area and large porosity leading to high flux, low pressure membranes. Performance of microfiber and nano-fiber are compared in [6] for biological, chemical and nuclear filter application.

Multi grade fibrous media

Multi grade fibrous media is the layers of different fiber structures combined together as result higher service flow rates and finer filtration down to 10 micron can be achieved. In multi grade fibrous media layers are arranged based on their density and reverse grading. The densest media with the smallest mesh size is loaded first and the least dense with the largest mesh size is loaded last with intervening media layered in the same manner as result, larger particles adsorbed by the top layers and relatively smaller particles are filtered in succeeding layers. Multi grade fibrous media have better performance as compared to single fibrous media. The performance of fibrous media is determined by its fiber structure. The characteristics of these fibrous structures have been studied for a long time. Major work was contributed by [7]. Recently, new methods have been applied such as MRI and XCT [8], both illustrating the apparently random fiber configuration. Some of the important parameters are:

- Density :1.47 kg/dm^3
- Bed depth :900mm
- Service flow :25m/h
- Backwash flow :35m/h

Crushed Glass

Experimental analysis show similar, reductions in coliforms was observed in filters containing crushed glass as filter media as compared to sand. Granulated rock wool has been shown to be more effective than sand in removing the bacterial plant pathogen Xanthomonas campestris in slow sand filters intended for irrigation water purification. [9] states that crushed glass is a potential alternative filter media and can replace sand. [10]- [12] studies the role of crushed glass as a filter media in rapid gravity filter for filtration of drinking water. The various properties of crushed glass as a filter media for rapid gravity filtration are evaluated in [11] and compared to sand with varying coagulant types and dosages. Performance of recycled glass in a dual media filter with anthracite above either the sand or glass is evaluated in [12].

Structured peat beads

It is commonly used in bio filters having 30 % of mineral materials. The inert carriers present in it provides several advantages but also some inconveniences when compared to the more conventional natural media. Although inert filter beds are, in most cases, more expensive than natural ones, the higher investment costs are often diluted by their longer lifetime and high performance. It is chemically and physically inert and basically do not suffer aging or biodegradation over time.

Sponge and Foam media

Sponge and foam inserts/filters media can be effectively used as mechanical and biological media. They are not very dense and do not have as much bio capacity. The Hydro Sponge line has patented sponges of different porosity. The reticulated sponges found in the Filter Max #3, Hydro Pond and other is both dense (for good bio filtration) and medium in mechanical ability. The smaller model sponges (such as the Filter Max #2 and smaller, the Hydro Sponge #3 and smaller are actually a fine filter media (not as fine as poly pads and micron cartridges) comparable to filter fiber however with much more bio capacity. It require more rinsing due to their fine mechanical filtration.

Filter-Ag

Clack Filter-Ag consists of non-hydrous silicon dioxide media and commonly used for removal of suspended matter in filter [15]. It has

- Bulk Density : 24–26 lbs/cu. ft.
- Specific Gravity : 2.25 gm/cc
- Mesh Size : 12 × 30
- Effective Size : 0.67 mm
- Uniform Coefficient : 1.8
- Hardness : 6 (Mohr scale)

Filter-AG granules have irregular surface characteristics allowing maximum removal of suspended matter throughout the filter bed. Filter-AG can be used in either pressure or gravity flow filter systems. It typically removes normal suspended particles between 20–40 micron ranges. Advantages of Filter-AG include less pressure loss than most other mediums. It is lightweight and requires lower backwash rates.

It has many outstanding advantages as compared to the more common granular media used for removal of suspended particles. Its fractured edges and non uniform surface gives high surface area and provide complex flow path for better removal of suspended particles throughout the filter bed. Larger particle sizes of Filter-Ag's form less pressure loss through the filter as a result deeper sediment penetration into the filter bed for higher sediment loading is possible and have longer filter runs. Large and non uniform shape of Filter-Ag's reduce rapid buildup of head loss and blinding problems by prevents the screening and caking of sediment in the top several inches of the filter bed which is common to typical sand filter. Light weight of Filter-Ag's reducing backwash rates and provide better bed expansion to release trapped sediment.

Clack Corosex

It is specially processed hard, bead-like magnesia, adapted for use in filters to neutralize free carbon dioxide in water by increasing the pH value and therefore, can correct acidic water conditions and render it less corrosive. It is commonly used where high pH correction is substantial or high flow conditions are in use. Media consumption and pH correction are affected by a number of water chemical variables. Being soluble to acidity, it will slowly dissolve and will need to be replenished periodically. On a per weight basis, magnesium oxide can neutralize five times more acidity than can calcium carbonate. Therefore, less amount of chemical is required for the same pH correction. For certain hardness conditions, pH correction may cause hardness minerals to precipitate out of solution, resulting in cementing or solidification of the media. As it neutralizes the water the hardness will increase and a softener is required after the neutralizing filter. Its limitations include the propensity to overcorrect in low flow or intermittent use applications [15]. Its physical properties include:

- Bulk Density : 75 lbs /cu. ft.
- Mesh Size : 6 × 16
- Specific Gravity : 3.6 gm/cc
- Effective Size : 1.4 mm
- Uniformity Coefficient : 1.7
- Composition : MgO = 97% min.
- Backwash flow : 25–30 m/h

Pyrolox

It is a naturally mined ore having manganese dioxide. It is a granular water filtration media used for iron, manganese and hydrogen sulfide reduction. Through a natural chemical reaction, Pyrolox has the ability to produce clean, high-quality water. As a filter media it works by oxidizing manganese, iron and hydrogen sulfide in contaminated water. During the backwash cycle the trapped particulate is removed from the filter media bed. It is important that Pyrolox media is backwashed properly for proper bed expansion and continued service life. It is recommended that it should be installed with an under bed and be backwashed daily [15]. Its physical properties include:

- Bulk Density : 120 lbs/cubic foot
- Mesh Sizes : US 8 ×20, US 20×40, UK 18/44
- Specific Gravity: 3.8

Coconut shell- high activated carbon (CS-HAC)

It is used for the reduction of tastes, odors, chlorine and dissolved organic chemicals from municipal and industrial water supplies. Manufactured from select grades of coconut shell coal to produces a high density, durable granular product which is capable of withstanding the abrasion and dynamics associated with repeated hydraulic transport, backwashing and mechanical handling. Activation is carefully controlled to produce exceptionally high internal surface area with optimum pore size for the adsorption of a broad range of low molecular weight organic contaminants and oxidizing agents like chlorine and ozone. Clack has for many years provided activated carbon to the OEM and replacement market as a pre-treatment for other water purification systems as well as for use in individual treatment equipment for the removal of specific impurities. CS-HAC requires periodic backwashing to eliminate accumulated suspended matter and to re-grade the filter bed. CS-HAC has an extremely high capacity but must be replaced when the filter bed loses the capacity for reduction of taste and odor. CS-HAC may be used in either domestic or industrial applications using gravity flow or pressurized filter vessels. It can be used for filtering waters having a wide range of pH levels. Because of large surface area it has an exceptionally high capacity and efficiency and balanced pore structure gives a more efficient adsorption range. The losses due to attrition are kept to a minimum. Its physical properties include:

- Mesh Size : 12 × 40
- Bulk Density : 28 lbs/cu. ft.
- Effective Size : 0.55–0.75 mm
- Ash Content : 2.5%
- Iodine Number : 1,000 mg/g
- Moisture as packed : 3%
- pH : 10

Others

A range of additional materials have been considered which can be used as filter media such as pumice [13], expanded aluminosilicate (Filtralite®), lime stone, crushed shells of apricot stones [14]. Comparison of different filter media [15] is given in Table 1.

III. CONCLUSION

The purpose of this paper is to review previously published research on alternative filter media. A number of alternative filter media studies were found referred and compared here. However, detail of the influence of fundamental properties of the filter media on performance of filter are not discussed here. In particular, the literature review suggested there were possibilities to adapt alternative filter media for optimization and performance enhancement of filter system.

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Table I. Comparison of different filter media

Media	***Density (kg/dm^3)***	***Service (m/h)***	***Delta P (bar)***	***Peak Service (m/h)***	***Delta P (bar)***	***Bed Depth (mm)***	***Backwash (m/h)***	***Use***	***Limits***
Sand	1.6	7.5	0.1	12	0.1	450-700	45	Sediment	
Anthracite	0.80	12	0.1	12.5	0.1	600-900	35	Sediment	
Corosex	1.60	12	0.1	15	0.15	600-700	25	Neutralization	Hardness and alkalinity
Filter AG	0.40	8	0.1	12	0.2	600-900	20	Sediment	Alkalinity
Multi-media	1.47	25	0.4	40	0.8	900+	35	Sediment	
Pyrolox	2.0	12	0.1	15	0.1	600+	65	Fe, Mn, H_2S	Dissolved oxygen BW GPM