International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.6, pp 910-918, 2017

Optimizing the Expended Polystyrene (Al-Fillen) with Low Density Polyethylene on The Performance Of Floating Media Filter

Alaa Hussein AL-Fatlawi, Eng.Huda Zaidan Khlaif AL-Mamori*

Engineering college, Babylon University, Hilla. Iraq

Abstract : A Floating media filter has been studying with contact-flocculation filtration operating in the upflow mode due to its higher retention capacities and lower head loss development, cost savings gained by less area requirements and less water and energy required for backwashing. The aim of this study is to evaluate two media: Expand Polystyrene (EPS) picking up from municipal solid wastes(Al-Fillen) comparing with Low Density Polyethylene (LDPE)as standard media commercially available as floating media. Optimization of the filter removal efficiency, headloss development and the energy required for backwashing, under different design parameters (different flowrates, and different depths). With use alum as coagulant at an optimum dose for each different influent turbidity. EPS present very acceptable performance considerably to turbidity removal and head loss development compare with that of LDPE, that matches with Iraq standard less than 5 NTU. The optimal removal efficiencies achieved for LDPE and EPS after 3 hours under 40cm medium depth, 80 L/hflowrate and 60 NTU influent turbidity, were(90.12%) and (98.70%)respectively.

Keywords : Floating media filter, Expand polystyrene (EPS), Low Density Polyerhyelene (LDPE), Contact-flocculation, Upflow, Water treatment.

Introduction

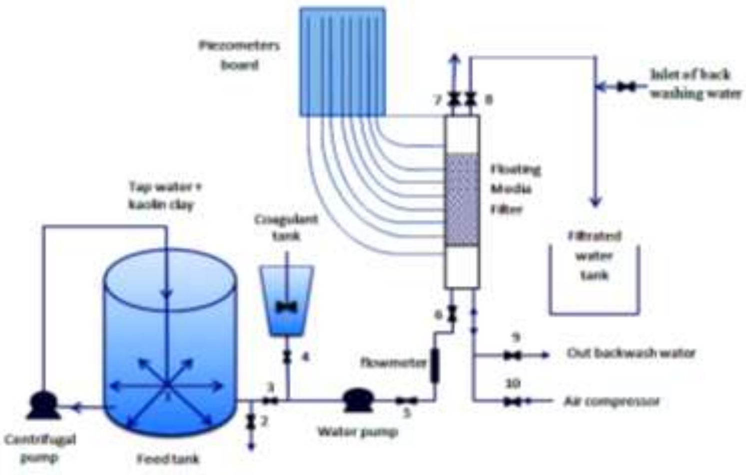
During the last decade a great deal of effort has been expended to study and improve water treatment technology. With the implementation of more stringent turbidity standards and the consideration of health impacts of microbial contaminants in drinking water, much of this effort has focused on water filtration[1]. Although the conventional treatment offer high product water capacity and quality, but unfortunately sand filters have a number of limitations and drawbacks such as high energy requirements for backwashing, one of the most serious problems involves maintaining bed homogeneity during operation [2].

A Floating media filter is an effective alternative to traditional heavy filtering materials such as sand, clay, anthracite, etc. to overcome the conventional filtration shortcomings [3].The basic concept of the floating medium filter involves the flow of suspension with flocculant through a packed bed of floating medium to remove the flocs in suspension. In direct in-line filtration both flocculation and the entire solid –liquid separation takes place within the filter bed itself. The flocculation occurs during the contact of raw water and flocculant within the pores of the medium. This is followed by the separation of particles and flocsof the filter medium . Thus, this has the dual function of flocculation and solid –liquid separation [4].

2. Experimental Work

2.1 The Design and Construction of Pilot Plant

A schematic diagram of the pilot plant setup is shown in Fig.1. The main components of the pilot plant are:raw water feeder system; chemical dosing system;f ilter unite, and back-wash air / water feeder system.



1-Nozzles for mixing synthetic water; 2-Outlet valve used for taking samples (inlet turbidity); 3-Gage valve for open or close the flow to filter unite; 4-Gage valve used for control the operation of coagulant tank ;5-Gage valve used for control the flow in the flowmeter; 6-Gage valve used to open or close the inlet flow; 7-Gage valve open to release air backwashing; 8-Gage valve to outlet the filtrate water ; 9- Gage valve to outlet water backwashing ; 10- Gage valve to inlet the air comperes.

Fig.1: Schematic diagram of pilot plant

2.1.1 Raw water mixing and feeding system

A synthetic water (suspension of kaolin clay and tap water), was first prepared in a constant concentration for each run, Before pouring into the tap water tank kaolin clay was thoroughly mixed in a beaker, using a magnetic stirrer. This prevented the sticking of kaolin clay and made it uniformly distributed. The suspension was added to the tap water tank (capacity 500 L) that facilitate a 6 hour filter running without replenishment at a maximum flowrate used (120 L/h).

The mixture was stirred for 30 minutes to obtain the homogeneous solution by using centrifugal pump (Q. Max 30 L/min capacity). The raw water at feeding tank are continuously stirred, while the pilot plant were in operation to prevent the suspend solid from settlings, and then suspension are transferred from this tank to a filter column by using a mono pump, with (Q. Max 35 L/min capacity). The flow meter(16−160 L/h) is used to measure and controlled water flow in the floating media filter system.

2.1.2 Chemical dosing system

The suitability of different coagulant doses have been determine by jar testing. The coagulant is added directly to stock solution preparation tank(40 L capacity). The preparation of alum solution with concentration of optimum dose by mixing with tap water. The coagulant is pumped by dosing (capacity 8 L/h) in line to system.

2.1.3 Filter unite

(a) Filter column

The filter column was a 1.5 m high, acrylic column of diameter 12 cm (external), and10 cm (internal). The acrylic column used for the construction of filter columnbecause it is allowed the operator to inspect the bed visually while it is in operation. Visual inspection can help identify the level of the media, formation of mud particles, media expansion during backwash, and excessive flow accumulation on the surface of the media. The column had 8 piezometer taps, that placed at 10 cm intervals. The filter column was fixed vertically with raw turbid water entering from the bottom, for the upflow mode of operation.

(b) Filter bed

The volume of the medium filter was calculated based on the quantities of the materials (medium) to be used as well as the filter cross-sectional area.

2.1.4 Backwash feeder system

Backwashing of filter media was carried out at the end of each experimental runs for further used. The backwashing process begins by introducing air, using an auto air compressor (12 V, pressure range from 0-140 psi.), through the air-distribution pipe that is designed to distribute air evenly across the bottom of the filter. Expansion of the media permits entrapped particles to become released and flushed downward, and out of the media. Backwashing water is introduce into the top of the filter by gravity flow. Water flows down at the rate of 80-100 L/h for about 3 min.

2.2 Materials

2.2.1 Filter medium type (LDPE and EPS)

Two types of filter media were investigated in this research for comparing the floating media performance.Fig.2showthe medium used in these experiments. The specific gravity and method of preparation of each medium used weresummarized in table 1.

Fig.2: Images of the media used in this study: (a) LDPE, (b) EPS.

Table (1): The specific gravity and method of preparation of each media used

Media	Specific gravity	Source /method of preparation
LDPE	0.543	Commercially available
EPS	0.0145	From the Styrofoam wasted

2.2.4 Influent turbidity

The turbidity of the suspension was kept at 60,120 and 160 NTU for each run. The usage of asynthetic suspension facilitated the comparison of various parameters while keeping the other conditions uniform. The concentration of kaolin clay required to get a given turbidity varied linearly with the NTU value. This relationship is illustrated in Fig.3.

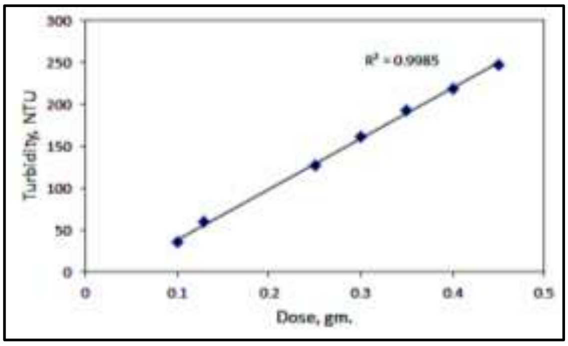


Fig. 3: Turbidity vs. Dosage of Kaolin Clay

2.2.5 Coagulant

The optimum chemical dosages were obtained based on the jar test experiments. The chemical designation for alum is $Al_2(SO_4)_3.18\ H_2O$. The concentrations of alum in the feed tank was changed according to filtration in order to maintain a constant flow rate of alum. The optimal alum dosing for each influent turbidity used was presented in table (2).

Table (2): The optimal alum doses for each influent turbidity.

Influent turbidity	Optimal alum dose
60 NTU	23 mg/L
120 NTU	25 mg/L
160 NTU	30 mg/L

3.Results and Discussion

3.1Turbidity removal efficiency

Fig.(4)shows the removal efficiency of LDPE and EPS at 80 L/h flowrate, 40 cm after 3hour of filtration time operation. The removal efficiencies were (90.12%), (90.39%) and (90.14%) for LDPE with 60, 120 and 160 NTU respectively (Fig. 4A), while (97.06%), (98.14%) and (95.26%) for EPS with 60, 120 and 160 NTU respectively(Fig. 4B).

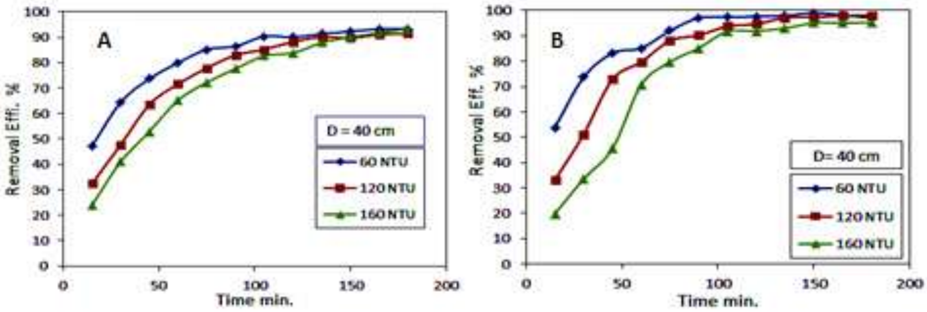


Fig.4: Removal efficiency of LDPE and EPS (flow rate 80 L/h), A) LPDE, B) EPS.

Fig.(5) shows the removal efficiency for LDPE and EPS at 120 L/h flow rate, 40 cm medium depth after 3hour of filtration time operation. The removal efficiencies were (90.98%), (88.24%) and (89.92%) for LDPE with 60, 120,and 160 respectively (Fig.5A), while (97.47%), (96.5%) and (94.9%) for EPS with 60, 120,and 160 respectively (Fig.5B).

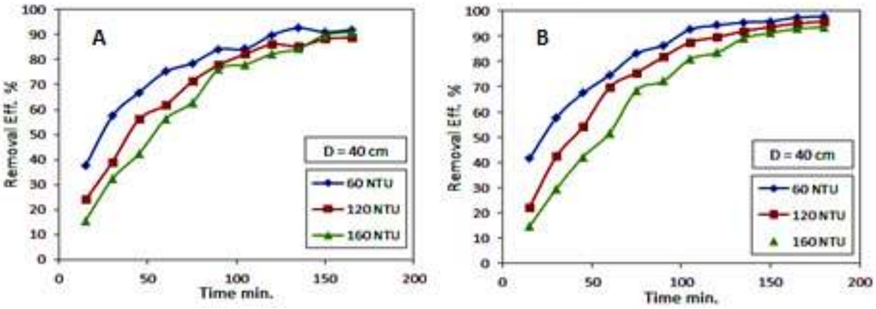


Fig.5: Removal efficiency of LDPE and EPS (flow rate 120 L/h),A) LPDE,B) EPS.

Fig.(6) shows the removal efficiency for LDPE and EPS at 80 L/h flow rate, 20 cm media depth after 2.5hour of filtration time operation. The removal efficiencies were(92.7%), (89.47%) and (87.68%) for LDPE with 60, 120 and 160 NTU respectively (Fig.6A), while(97.4%), (96.29%) and (94.15%) for EPS with 60, 120 and 160 NTU respectively(Fig.6B).

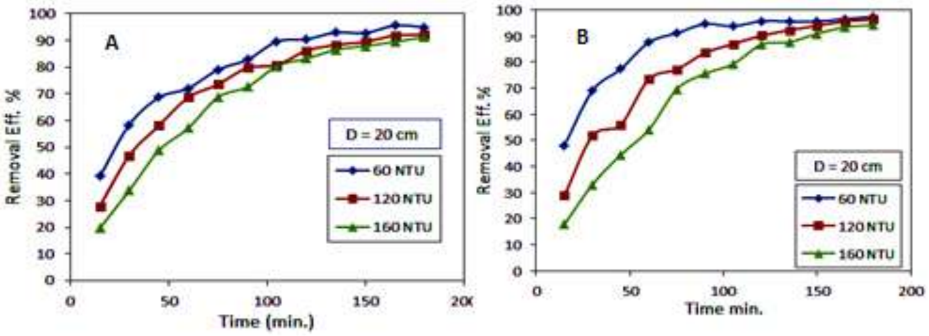


Fig.6: Removal efficiency of LDPE and EPS (flow rate 80 L/h),A) LPDE,B) EPS .

Fig.(7) shows the removal efficiency for LDPE and EPS at 120 L/h flow rate, 20 cm media depth after 3hour of filtration time operation. The removal efficiencies were (90.84%), (87.5%) and (86.7%) for 60, 120,and 160 respectively(Fig.7A), while (98.01%), (93.98%) and (90.84%) for 60, 120,and 160 respectively (Fig.7B).

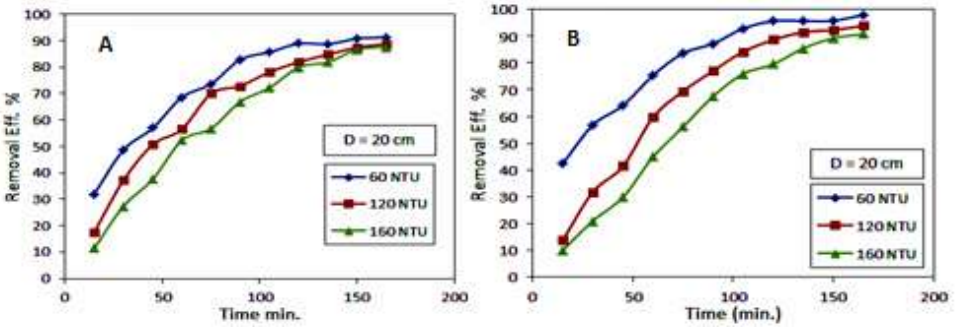


Fig.7: Removal efficiency of LDPE and EPS (flow rate 120 L/h),A) LPDE,B) EPS.

3.1.1 Effect of flowrate

The low flowrate presents much more removal efficiency compared with high flowrate as shown in Figs.(4) to (7). The low flowrate has better removal efficiency.

When the low flowrate was applied, the lower quantity of solids suspends catch within the media compare with higher flowrate.

The higher flowrate forces the particles deeper into the filter bed. When the velocity of the interstitial is higher, shear force tested by set in particles at filter media is greater lead to no uniform distribution of particles along filter media, these results shown decreased filter efficiency. At lower flowrate much better effluent quality is achieved, while high flowrate afford good quality filtrated and higher rate produced water. The lower flowrate offers longer retention time that provide better opportunity for particles depositions. While, the attachment efficiency of particle will decrease due to greater water blockage on particles, nearly of the surface area of medium, results of higher filtration flowrate .

The loading of particle distributed throughout media for low flowrate80 L/h was better than 120 L/h. These implications are fixed within the finding of Wegelin,[5], and Visvanathan, [6],where they explicated the same destination.

3.1.2Effect of medium depth

The performance of the deepest depth filter media (40 cm) was present better removal efficiency for all turbidities used by compared to20 cm as shown in Figs.(4)to (7).This proposed, that the increase of medium depth gives earlier significant removal efficiency compared with 20cm, and betimes the effect of the depth became the same approximately but significant removal efficiency achieved by the deepest filter bed for longer time without breakthrough occur compared with 20 depth.

The increase of the media depth produces the better removal efficiency consideration to turbidity, with the fact that where particles in the water have the opportunities for possibility interaction within more grains, and thusly the opportunity of particle deposition onto a medium grain was larger, that agreed with Moharram [7].

In the experimental work (with 20 cm depth) was observe that some particles flocs deposited above retentions mesh that was requested in the floating media filter for inhibits wastage of media filter, this give mentioned to two important parameters, the one is the sedimentation mechanism was continuously along filter, and the second that possibly of using much deeper filter media could be has more efficiency in capturing the particles that leads to more efficiency of floating media filter removal turbidity.

3.1.3 Effect of influent turbidity

It is clearly noticed that the turbidity removal efficiency decrease with the increase of the influent tubidity for constant media depth and flowrate. This indicted that the influent turbidity have influence on the removal efficiency, that can be observed from Figs.(4) to (7). It is also clearly noticed that for high influent turbidity (120 and 160 NTU), this is due to higher values of influent turbidity that carried high amount of the suspended solid. Also, the effluent turbidity decrease slightly with time, and after 1-2 hours, the effluent turbidity seems to be constant during the remaining time of the filtration run. This is due to the first hours (after about 2 hours) of run, the bed is normally clean and the spacing between medium particles is larger enough to pass most of suspended solids. But, with the time running, the individual particles may block the pores. So, as the porosity of the filter media decrease, the effluent turbidity decreases untile a certain time and the effluent turbidity increase again.

3.2 Headloss development

Filter head loss Measured clean filter head loss across the filter media as a function of flowrate, media depth and influent turbidity is shown in Figs. (8) to (9).

3.2.1Effect of flowrate

Flowrate show great influences on the total head loss (HL); a higher flowrate lead to greater headloss as they contributively to higher solid loading. This finding agreed with Carmen, [8].

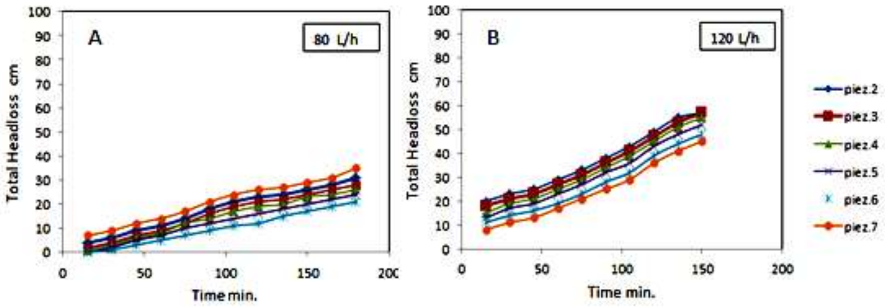


Fig.8: Effect of flowrate at headloss development with EPS (40 cm medium depth).

In the case of low flowrate the headloss development is very slow, This phenomenon commonly for all runs in different parameters that used in this study, that shown in (Fig.8). And this agreed with findings by Sundarakumar, [9] and Brika, [10].

Head loss of clean bed media filter across filter media increased as flowrate increase. Headloss of clean floating media is a function of flowrate, higher initial headloss were noted for higher flowrate.

In the floating media filter, the headloss increases fivefold when the filtration flowrate increasing threefold, thusly the initial headloss is not linearly considered in the filtration flowrate. This findings is agreed with the result obtains by Clark, [11],has reported that the increasing of flowrate produces a lower additional headloss. But this suggestion should be seen only on display of lower retained particle with higher filtration velocity. Where the fluid passes through a clean filter bed, the energy losses or pressure drops occur because of both the form drag frictions at the surface area of media filter grain, and because of continuous contraction and expansion assayed with water as it passes through interstitial spaces among media filter grains.

3.2.2 Effect of influent turbidity

Headloss increase as a result of increased of turbidity influent to the filter bed, resulted from sludge accumulation(Fig.9).That cause the filter headloss occurs rapidly than that at smaller values of influent turbidity, knowing that the headloss is function of the porosity of filter media, the headloss increase as the porosity decrease.

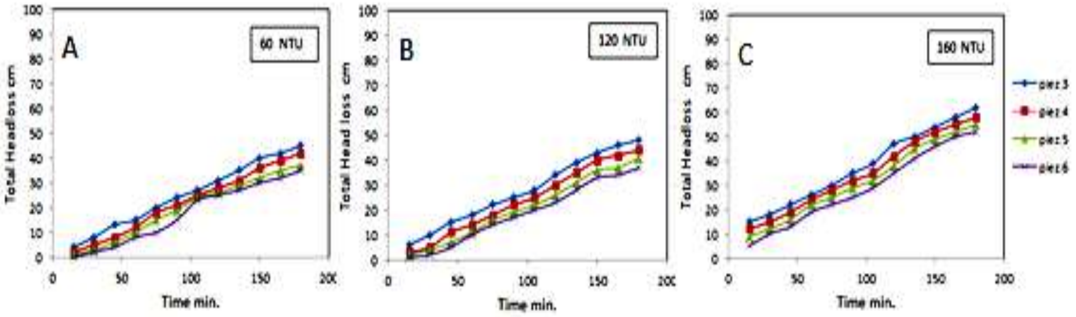


Fig.9:Effect of influent concentration athead loss development with LDPE (80 L/h flow rate, 20 cm medium depth)

3.2.3 Effect of depth

As filtration practical advancements, more particles bracketed into the filter media and that cause headloss development along media filters (Fig. 8Aand Fig.9A), that the increase in media depth results in increased headloss development.

In the case of medium depth (40 cm) the piezometer points 2 and 7 connect below and above filters media, while 3to 6 sited to filter bed for each (10 cm), respectively. In the case of the (20 cm) the piezometer points 4 and 6 under and up the filter bed, while, piezometer points 5and 6 connected to the filter bed.

Fig.(8A) proved that, the mechanisms of the particle removal occurred in filter media completely. However, a greater part of removal were actualized on a bottom layer (below point 6) and that could be inferred from the remarking a higher headloss difference between points, while the development of headloss in the upper layer was no noticeable near to be closely relatively. This present that most particle removal took place in area between point 1- 5 that representative from first 20 - 30 cm of filters media without either significant little's penetrations of particle on upper layers (above point 6) as headloss appeared for been stably.

The increase in headloss development is a squarely results of deposition of particles on filter bed. The particle catch by filter bed might be auxiliary in an exposit collection of particles.

3.3 Backwashing

The backwashing effluent water turbidity was checking by measured the turbidity for every one minute intervals and the backwashing performance was also remarking optically through viewing acrylic column pipe.

The efficiency of backwashing was comparison with the water needs for filter backwashing, the standard for backwashing efficiency was regarded as the effluent water required must be close to the influent water for backwashing as possible.

The relative low density of floating media was advantage that leads to the backwashing could be easily expanded with low velocity of backwashing, also the suspended solids are pushed down with the force gravity in filter media.

The backwashing method carried out with water backwash alone for comparison purpose with air/water backwashing performance. The water required for backwashing with air was less than with water alone. The agitation of the media was very good at air backwashing and some more the captured suspended solid was separated and drop down, this situation was visibly observed. These finding agreed with Sundarakumar, [9].

The floating media filter is carried byair followed water backwashing. The air a courted in the upflow trend for 2 minutes duration, then the water was submitted downwards for 3 minutes, accomplish expansion is about 100 % of EPS and LDPE media filter bed with air following water, and 50-70 % for EPS, 90-100 % for LDPE (with water alone). This proposed that air following water is better than water alone to enhance backwashing performance. This agreed with finding by Schwarzkopf, [12].

The floating media filter expansion get because of their specialize of it is low density. By using the system of backwashing air followed water would able to achieve complete of the bed without spending large quantities of water, until without an air flow, the water swilling was adequate to clean the floating media.

4. Conclusions

The conclusions are obtained from this study: The results from the experimental work present acceptable turbidity removal efficiency that matches with Iraq standard less than 5 NTU.The best flowrate was 80 L/h compared with 120 L/h flowrate because these lower flowrate permitted decelerated interstitial spaces clog with grains of the medium and ,thusly allowable longer filter time. The better removal efficiency was when the influent turbidity was 60 NTU, compared with 120 and 160 NTU. Visual observation indicated that removal of solids took place primarily in the first 20-30 cm of 40 cm floating media, but that solids removal took place over the full depth of 20 cm of floating media. It was found that bed depth had the strongest influence on performance for a given medium type.

References

1. WHO, 2004, "Guidelines for Drinking – Water Quality", Third Edition, volume1, WHO Library Geneva.
2. Brika, B.,Bradshaw, S.M., Jacobs, E.P., 2015, "Investigation of Geometric Properties of Media Particles for Floating Media Filter", Journal of Desalination and Water Treatment,54, - Issue 8.
3. Hassas, I., 2012, "New Process for Effective removal of iron from groundwater", Environmental Science & Engineering magazine, www.esemag.com.

4. Ngo, H.H., and Vigneswaran, S., 1995a, "Application of floating media filters in water and wastewater treatment with contact-flocculation filtration arrangement", Water Research, 29(9), 2211-2213.
5. Wegelin, M., 1986, "Horizontal Flow Roughing Filtration, a Design Construction and Operation Manual", IRCWD Report No 06/86, Switzerland.
6. Visvanathan, C.,Werellagama, D.R.I.B., and Ben Aim, R., 1996, "Surface Water Pretreatment Using Floating Media Filter", Journal of Environmental Engineering, Vol. , No. January 1996.
7. Fouad, M., Barakat R., and Fadel, A., 2005, "A Simplified Empirical Model For The One-Stage Direct Filtration", Ninth International Water Technology Conference, IWTC9, Sharm El-Sheikh, Egypt.
8. Carmen, P.C., 1937, "Fluid flow through granular bed", Transactions Institution Chemical Engineers, 15, 150-166.
9. Sundarakumar, R., 1996, "Pilot Scale Study on Floating Media Filtration for Surface Water Treatment"., M.Sc. Thesis, EV-96-31, Asian Institute of Technology, Bangkok, Thailand.
10. Brika, B.,Bradshaw, S.M., Jacobs, E.P., 2010, "Investigation of Geometric Properties of Media Particles for Floating Media Filter", M.Sc. Thesis, University Of Stellenbosch.
11. Clark, S. C., Lawler, D. F., and Cushing, R, S., 1992," Contact Filtration, Particle Size and Ripening ".J. AWWA, 84(12), 61-71.
12. Schwarzkopf, S.H., 2006, "Liquid Filtration Apparatus and Method Embodying Super-Buoyant Filtration Particles", European Patent EP1680362.

*****