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Environmental Assessment of a Unique Filtration Process for Treatment of Polluted Storm Water

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ABSTRACT
As a result of poor human activities, storm water is now contaminated, notably in the Middle East. The filtering process is a physical separation with no chemical reactions occurring throughout the operation. The goal of this research is to use three distinct types of filters to improve the quality of storm water: sand, sand with granular activated carbon (GAC), and sand with cotton. Before and after treatment, the pH, turbidity, electric conductivity, TDS, and temperature of storm water are all monitored. In addition, the water quality index (WQI) was computed. The parameters of treated storm water varied depending on the filter media used, such as sand (turbidity = 83 NTU, TDS = 585 mg/L, conductivity = 1190 S/cm, pH = 7.1 and temperature =17.8 °C), sand with GAC (turbidity = 12NTU, TDS = 540 mg/L, conductivity = 910 S/cm, pH = 7 and temperature =18 °C) and sand with cotton (turbidity = 6.4 NTU, TDS = 490 mg/L, conductivity = 1090 µS/cm, pH = 7.2 and temperature =17.6 °C). Sand has a treatment efficiency of 63.6 percent, sand with GAC has an efficiency of 84.9 percent, and sand with cotton has an efficiency of 84.2 percent at a flow rate of 0.66 L/min, when WQI is clean. With GAC, it is clear that the dual media filter is the finest special sand.

Keywords: WQI, sand, GAC, cotton, Storm water, filtration.

INTRODUCTION

Water treatment involves a series of successive operations which ensure that drinking water is available at the end and conforms to the approved international standards and specifications. Filtration is one of the most widespread and used processes in both purification plants (in small plants, small units, and large essential treatment) [1, 2]. Secondary treatment of the home and which is concerned with secondary treatment. Filtration: is a physical process involving the removal of suspended substances through a porous media defect that allows the solution to enter without the suspended material [3]. Therefore, the filter process is a physical separation comes where no chemical reaction occurs during the separation process and the separation process is done through two phases: the liquid phase is the solution and the solid phase is the suspends material. In the case of treatment of water, the liquid phase is the water and the solid phase is the suspended solids [4]. The most important characteristic of the filtration process is the separation of the suspended without dissolve (which pass through the porous media). The main purpose of filtration is to remove impurities in the water, which can be one of the following materials: Precision parts with water when passing through soil layers or during pumping, transport and storage processes [5, 6]. Gluten, which is organic waste resulting from the decomposition of animal and plant residues in water. Organic substances that cause coloration of water such as pigment, squid and others. Filtration mechanism can be explained as the adhesion process of some suspended materials on the surface of granules – granules of sand and anthracite – and this helps the chemical properties of suspended materials due to the coagulation factors added to the filter [7, 8]. The sand holes act as a filter that traps the relatively large suspended materials. A layer of helium on the sand surface of the fine suspended materials and the possible 4 organisms is accurate and helps to hunt and hold the suspended materials. Most filtration takes place in this layer of the brain, which plays an important role in filtration [9, 10]. Crisp. Electric charges vary. The static on the surfaces of each of the granules of sand and minutes of suspended materials, which leads to the attraction and thus adhesion and seizure. Rapid sand filter have graded (layered) sand in a bed [11, 12]. The sand grain size distribution is selected to optimize the passage of water while minimizing the passage of particulate matter. Rapid sand filters are cleaned in place by back washing. Rapid sand filters are the most common type of filter in service in water treatment plants today. Traditionally, rapid sand filters have been designed to operate at a loading rate of 120 $m^3/d.m^2$ (5 m/h). Filters now operate successfully at even higher loading rates through the use of proper media selection and improved pretreatment [13, 14]. In early times, a slow sand filter was used. It is still proved to be efficient. It is very effective for removing protozoa, such as Giardia and Cryptosporidium. Rapid filtration has been very popular for several decades [15]. Dual-media filters (sand and anthracite, activated carbon, or granite) give more benefits than single-media filters and becomes more popular, even triple-media filters have been used. Activated carbon or activated coal is a charcoal that is made in a special porous form, which has a very high surface area and is therefore more chemically capable of capturing harmful or unwanted gases, activated carbon non-porous and highly porous material containing fine grains of graphite, treated in special ways to make it porous [16]. In the form of small granules or fine powder, activated carbon is a non-polar material. The main objectives are to treat the storm water and to enhance its quality using a unique filter.

MATERIALS AND METHOD

Components of treatment process

The system of filtration consist of main resource to collect stream water, oil sweeper, sand filtration, granular activated carbon and cotton filter as shown in Figure 1.

The systems involve materials which it is cheap and available:

- The sand media is available in the laboratory with several gradations starting from. Three gradients were used in the form of medium mixed in equal sizes for the purpose of absorbing heavy rain.
- Activated carbon is obtained from water filtration systems in the cities of Najaf, Karbala and Diwaniyah in Iraq. It is available in several forms including granular, powder and block. The granular was selected after studying the characteristics of each species where

Figure 1. Experimental setup of treatment

Figure 2. Spun polypropylene filter

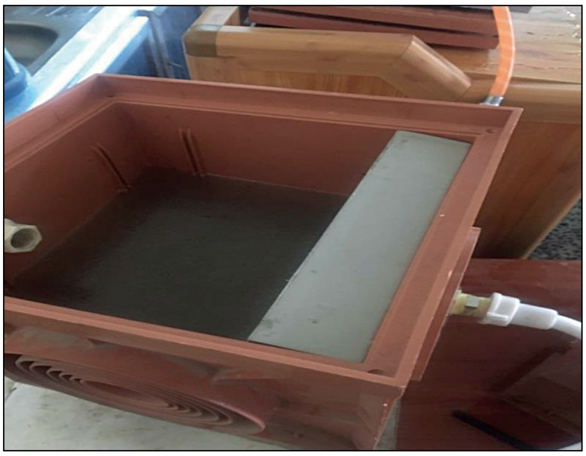

Figure 3. First stage of treatment

the powder causes a color problem, granular removes unwanted color, test and odor and Block is usually used to remove chlorine.

- Spun polypropylene filter cartridge for removal of sand, silt, dirt and dust particles. High flow rates at low pressure drop. High dirt-holding capacity and long life. For water use only maximum water temperature 52 °C, it is cheap and Available frequently in commercial centers and be in one form, called "Block" as shown in Figure 2.

Another contents, the system of treatment have three plastic boxes with dimensions (24x24x-30cm) contains a hole that allows the entry of raw water and another at a level lower than the first hole allow the exit of filtered water. Valves, located at the beginning and end of each box to control the discharge. Four pipes with diameter 0.5 in and linking tools. Four aluminum plate with dimensions equal to the dimensions of the box, placed inside the box to hold the media and also have holes of equal size and distributed regularly on the total area of the section to help regulate the entry of water to the media for the purpose of benefiting from all the surface area of the filter. The container contains laboratory-prepared water and vials for collection of treated samples. The system of treatment have three stages. The parts of the system were connected in the first stage as in the picture. The purpose of this stage as mentioned previously is to remove oil by the principle of density difference between oil and water and since the density of the oil is less than the density of water, then according to this principle the oil float to the top. To complete this process water-resistant plastic plate has been placed which it is allow water to pass through a space in the bottom as shown in Figure 3. This part of system with a level from the ground to provide a suitable hydraulic gradient for easy flow of water. Flow in this stage is faster than other stages.

In the second stage, the sand filter is used which its mixed filter using three gradients (0.4–1.2), (1.2–1.8) and (1.7–3.15).The above gradients were chosen after execution some tests.The three gradients were the best from where the balance between permeability and pollution. The best filter should have a high discharge and acceptable quality to avoid flooding and accumulation of rain water. The Mixing were varied in equal quantities. The water entries the box in the beginning passing through a hallo plate regularly to help regulate the flow of water through the filter and to use the entire surface area of the filter. Then the water passes to the sand filter which is trapped between the two plates to ensure the stability of the sand particles, the water passes through the Second plate to the exit hole,it is now less polluted, the level of the fund in this stage. In the third stage, one of the following filters is used. GAC which the mechanism of entering the water to the filter at this stage is similar to the mechanism of entering the water in the second stage. The difference from the previous stage is that the plate holes should have a smaller diameter than the plate used in the previous stage. Carbon granules were graded in size. Cotton filter which it's not put in a box as in the previous filters, because the use of this filter is conditional to put it in a special cylinder, specially made to contain the filter. The cylinder has two inlet and outlet openings, but the openings are of the same level as the filter working principle depends on the fullness of the water.

Samples analysis

Storm water samples were analyzed for physco-chemical properties immediately after collection. These parameters are pH value, turbidity; electric conductivity, TDS and Temperature as listed in Table 1. The pH (model pHM84 meter), conductivity (HANNA HI-99301 and EC400 ExStik from Extech Instruments), and turbidity (HACH 2100P) were also investigated in this study. The TDS were measured by TDS meter (TDS-EZ, HM Digital). Total active chlorine was measured by colorimetry meter (AQUAfast AQ3700, Thermo Scientific Orion) using chlorine HR (KL) with the tablet method. The additional tablets used in this test were one chlorine HR (KL) tablet and one acidifying GP tablet mixed and crushed with 10 mL of the wastewater sample inside the adapter of instrument. Temperature was done by the same device of pH and TDS.

Calculation of WQI

The parameters with the IQS standards are listed in Table 2. The water quality index (WQI) is one of the instruments for assessing water quality for a variety of purposes, including drinkable, agricultural, recreational, and industrial. The WQI can be calculated from the following equation [16, 17]:

$$\text{WQI} = \sum (ci\ /\ si)/n \qquad (1)$$

where: Ci – concentration of each parameter in each water sample in (mg/L), Si – Iraqi drinking water standards for each chemical parameter n – is the number of parameters.

Table 1. Characteristics of storm water

Parameters	Value
pH	7.2
Conductivity (µS/cm)	1305
Turbidity (NTU)	315
Temperature (C)	17.8
TDS (mg/L)	1626

Table 2. Iraqi standards of the water quality for aquatic ecology [15]

Tests	Standard Value
pH	6–9.5
Conductivity (µS/cm)	400
Turbidity (NTU)	10–18
Temperature (C)	≥35
TDS (mg/L)	1500

The efficiency (E %) Storm water treatment type was calculated by determining the WQI of the raw water and treated water supplied by using the formula given below [17]:

$$\text{E\%} = \frac{\text{WQI of raw water} - \text{WQI of treated water}}{\text{WQI of raw water}} * 100 \qquad (2)$$

RESULTS AND DISCUSSION

Parameters and WQI of treated storm water

Table 3 illustrated the tested parameters and WQI for treated storm water using three types of filter. According to these results, dual media filters sand either with GAC or cotton are the best. This finding is confirmed with previous studies [18, 19].

Variation of temperature parameter of treated and raw storm water

According to the Figure 4 and the Table 4, the change in temperature was not clear and that the use of various types treatment did not have a clear effect on changing the temperature of water. The main reason is the filters used do not contain substances that affect the heat and did not occur chemical reactions that would raise the temperature [19].

Variation of pH for treated and raw storm water

According to the Figure 5 and Table 5 for the pH parameter, significance change in pH value is noted when using the sand filter and the sand and cotton filter. pH value increase with increasing discharge due to the interaction with the silica in the sand, which makes a slight change to the acidity, while adding the activated carbon [18].

Variation of conductivity for treated and raw storm water

According to the Figure 6 and Table 6, The conductivity decreases with the use of various type of treatment, and also decrease with reduce the discharge, because it is common knowledge that the efficiency of any filter increases by reducing the passing discharge. In addition, the conductivity means the presence of salts and impurities. The sand filter and activated carbon have high ability to separate the suspended.

Table 3. Parameters and WQI of treated storm water quality in three types of treatment

Turbidity	TDS	Chlorine	Conductivity	pH	Temp.	Treatment type	Flow rate
NTU	mg/L	mg/L	µS /cm	-	°C	-	L/min
83	585	0.2	1190	7.1	17.8	Sand	0.66
5.928	0.39		2.38	0.916	0.508	WQI	
12	540	0.2	910	7	18	Sand & GAC filter	
0.587	0.36		1.82	0.903	0.514	WQI	
6.4	490	0.2	1090	7.2	17.6	Sand & cotton filter	
0.457	0.323		2.18	0.929	0.502	WQI	
88	610	0.2	1200	7.2	17.7	sand	1.056
6.285	0.406		2.4	0.929	0.505	WQI	
13.5	550	0.2	970	7.1	17.9	Sand & GAC filter	
0.964	0.366		1.94	0.916	0.511	WQI	
8.25	519	0.2	1160	7.4	17.8	Sand & cotton filter	
0.589	0.346		2.32	0.954	0.508	WQI	
93	630	0.2	1240	7.3	17.8	Sand	1.38
6.642	0.42		2.48	0.941	0.508	WQI	
17.02	600	0.2	1040	7	18	Sand & GAC filter	
1.215	0.4		2.08	0.903	0.514	WQI	
8.02	560	0.2	1190	7.5	17.7	Sand & cotton filter	
0.572	0.373		2.38	0.967	0.505	WQI	
117	650	0.2	1300	7.4	17.9	sand	2
8.357	0.433		2.6	0.954	0.514	WQI	
20.42	620	0.2	1100	6.9	18	Sand & GAC filter	
1.458	0.413		2.2	0.89	0.508	WQI	
9.37	590	0.2	1270	7.5	17.8	Sand & cotton filter	
0.669	0.393		2.54	0.967	0.508	WQI	
135	770	0.2	1330	7.4	17.9	Sand	2.568
9.642	0.513		2.66	0.954	0.511	WQI	
24.42	690	0.2	1130	7.1	17.9	Sand & GAC filter	
1.744	0.46		2.26	0.916	0.508	WQI	
11.49	640	0.2	1290	7.5	17.8	Sand & cotton filter	
0.82	0.426		2.58	0.967	0.511	WQI	

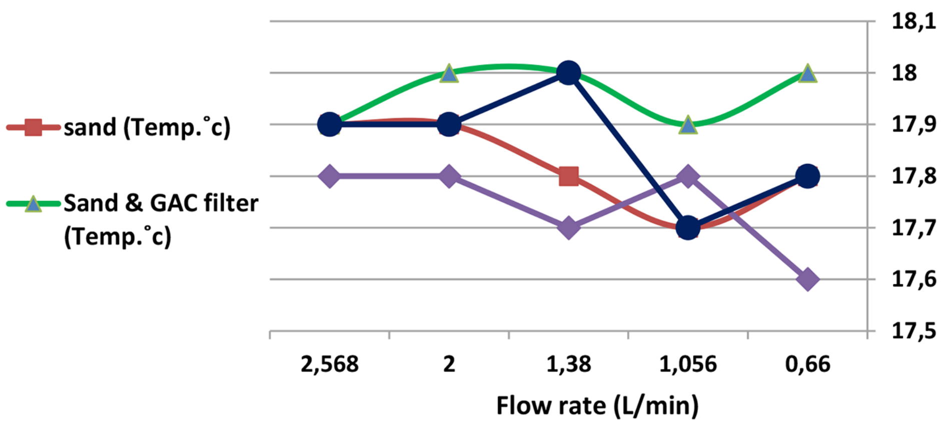

Figure 4. Variation in temperature parameter with flow rate of treated and raw storm water

Table 4. The variation in temperature parameter of treated and raw storm water (C)

Flow rate	Sand	Sand & GAC	Sand & cotton filter	Raw water
0.66	17.8	18	17.6	17.8
1.056	17.7	17.9	17.8	17.7
1.38	17.8	18	17.7	18
2	17.9	18	17.8	17.9
2.56	17.9	17.9	17.8	17.9

Table 5. Variation of pH for treated and raw storm water

Flow rate	Sand	Sand & GAC	Sand & cotton filter	Raw water
0.66	7.1	7	7.2	7.2
1.056	7.2	7.1	7.4	7.2
1.38	7.3	7	7.5	7.2
2	7.4	6.9	7.5	7.2
2.568	7.4	7.1	7.5	7.2

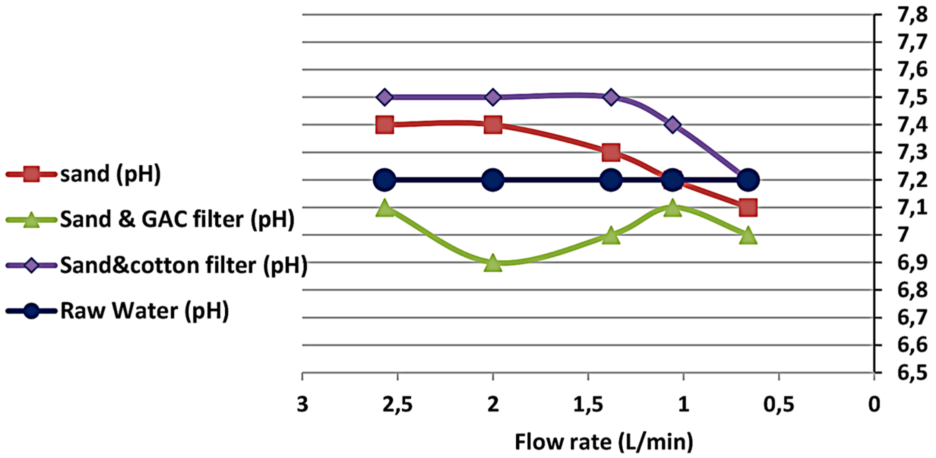

Figure 5. Variation of pH with flow rate of treated and raw storm water

Table 6. Variation of conductivity for treated and raw storm water (µS/cm)

Flow rate	Sand	Sand & GAC	Sand & cotton filter	Raw water
0.66	1190	910	1090	1305
1.056	1200	970	1160	1305
1.38	1240	1040	1190	1305
2	1300	1100	1270	1305
2.568	1330	1130	1290	1305

Variation of TDS for treated storm water

According to Figure 7 and Table 7, high efficiency of the types of treatment used and more effective the filter the less discharge. The best types of treatment in terms of filtration was the filter sand and cotton cause the cotton filter contains very fine pores that prevent the entry molecules of small soluble salts that may pass from Sand filter or active carbon filter [17].

Variation of turbidity for treated and raw storm water

According to Figure 8 and Table 8, high efficiency of the filters used and the more effective the filter the less discharge. The best type of treatment in terms of filtration was the filter sand and cotton cause the cotton filter contains very fine pores that prevent the entry molecules of small suspended solid that may pass from sand filter or activated carbon filter [19].

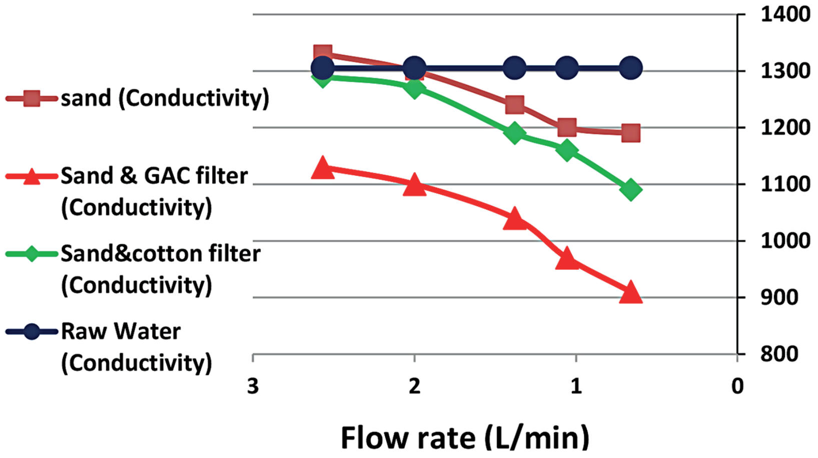

Figure 6. Variation of conductivity with flow rate of treated and raw storm water

Table 7. Variation of TDS for treated storm water (mg/L)

Flow rate	Sand	Sand & GAC	Sand & cotton filter
0.66	585	540	490
1.056	610	550	519
1.38	630	600	560
2	650	620	590
2.568	770	690	640

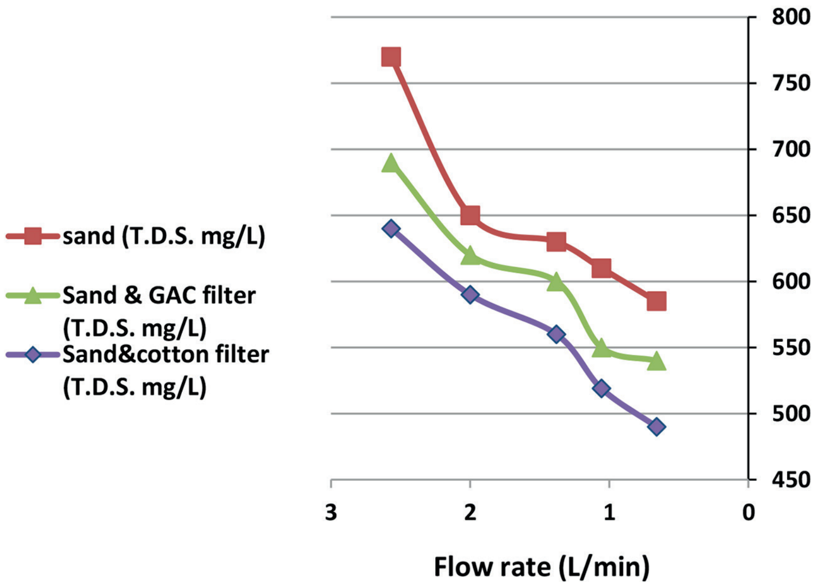

Figure 7. Variation of TDS with flow rate for treated and raw storm water

Table 8. Variation of turbidity for treated and raw storm water (NTU)

Flow rate	Sand	Sand & GAC	Sand & cotton filter	Raw water
0.66	83	12	6.4	315
1.056	88	13.5	8.25	315
1.38	93	17.02	8.02	315
2	117	20.42	9.37	315
2.568	135	24.42	11.49	315

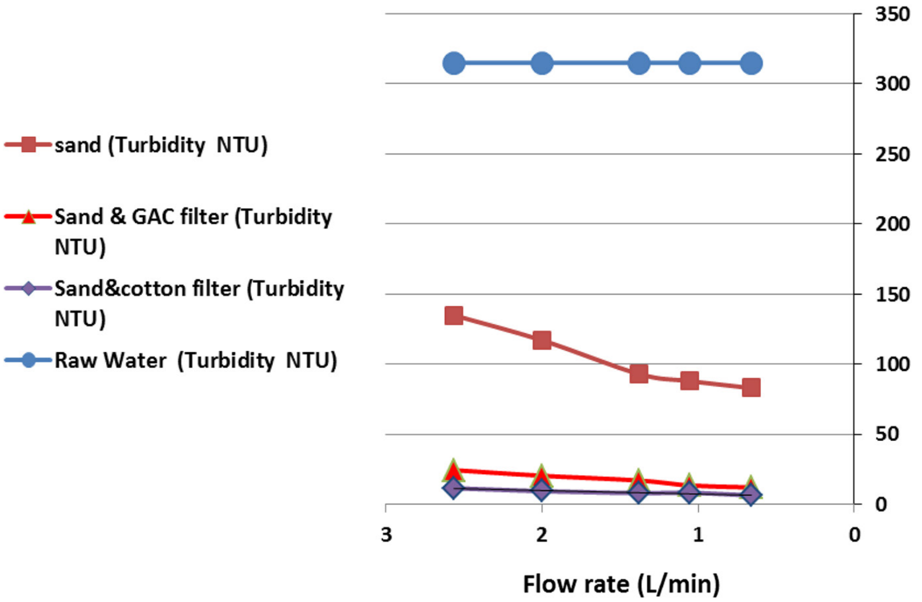

Figure 8. Variation of turbidity with flow rate of treated and raw storm water

WQI of treated and raw storm water at variation of flow rates

Water Quality classification in listed in Table 9. The results showed in Table 10 that the worst water quality for raw and treated water according to the values of WQI for raw water heavily polluted for three types of water treatment and clean water for Sand & AGC and Sand & Cotton at flow

Table 9. Water quality classification

WQI value	Water quality
≤0.3	Very clean
0.31–0.89	Clean
0.9–2.49	Slightly polluted
2.5–3.99	Moderately polluted
4–5.99	Heavily polluted
≥ 6.0	Dirty water

Table 10. Values of WQI for treated and raw storm water

Discharge	Raw water	Sand	Sand & GAC	Sand & cotton
0.66	5.5608	2.024	0.836	0.878
	Heavily polluted	Slightly polluted	Clean	Clean
1.056	5.5608	2.105	0.939	0.943
	Heavily polluted	Slightly polluted	Slightly polluted	Slightly polluted
1.38	5.5608	2.198	1.022	0.959
	Heavily polluted	Slightly polluted	Slightly polluted	Slightly polluted
2	5.5608	2.571	1.093	1.054
	Heavily polluted	Moderately polluted	Slightly polluted	Slightly polluted
2.568	5.5608	2.856	1.177	1.06
	Heavily polluted	Moderately polluted	Slightly polluted	Slightly polluted

Table 11. Efficiency for three types of filter by the side of variation flow rates

Discharge	Sand (E%)	Sand & GAC (E%)	Sand & cotton (E%)
0.66	63.602	84.966	84.210
1.056	62.145	83.114	83
1.38	60.473	81.621	82.754
2	53.765	80.334	81
2.568	48.640	78.833	80.937

rate (0.66 L/min) while slightly polluted for three types of water treatment at flow rates (1.056 to 2.568 L/min) [17]. The efficiencies of the filter types are listed in Table 11. It's clear that dual media filter is the best special sand with cotton.

CONCLUSION

Three types of filters are used to treat storm water. The effect of various types of treatment on altering the temperature of water was not evident, and the usage of various types of treatment had no clear effect on changing the temperature of water. While adding the activated carbon, the pH value increases with increasing discharge due to the interaction with the silica in the sand, which causes a little shift in acidity. The conductivity diminishes when various types of treatment are used, as well as when the discharge is reduced. The filter sand and cotton provided the best filtering because the cotton filter has very fine pores that restrict the entry of molecules of small suspended solids that might pass through a sand or activated carbon filter. Dual media filter is clearly the best special sand with GAC.

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