Adsorption of Coliform Bacteria from water by Activated Carbon

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ABSTRACT

Usually chlorine added ratio during the treatment process is directly proportional to the microorganisms in water, so the use of any technique that will lead to reducing the amount of microorganisms in the water will lead to use of low concentrations of chlorine. Therefore, this study aimed to using commercial activated carbon to adsorb the rate of microorganisms such as coliform bacteria. The use of continuous adsorption system (fluidize bed) under different operating conditions and in field conditions. The results showed that the best percentage removal of coliform bacteria was 91.3% within 24 hours under the operational condition bed depth 15 cm, filtration rate 15.3 $m^3/m^2/h$ and particle size 1 mm, removal rates gradually decreased with time until it reached 15% after 168 hours and went to zero after 192 hours. The results that obtained in this study proved the feasibility of the use of commercial activated carbon to remove coliform bacteria from water.

INTRODUCTION

The microorganisms pollution is one of the dangerous contaminants in the water, and remove these contaminants from water is very important to human and animal health. Therefore, this study used commercial activated carbon to adsorption microorganism's pollution from water such as coliform bacteria. Adsorption is often used at the end of a treatment sequence for pollution control due to high degree of purification that can be achieved. Activated carbon is the most popular adsorbent used for the application of adsorption technique (1). The adsorption process can be described as the ability of certain solid called (adsorbent) to concentrate a specific substance called (adsorbate) from solution onto their surfaces, and, the most widely used adsorbents are activated carbon, activated alumina, silica gel (2). Granular carbon filters have been used for several hundred years and are considered one of the oldest means of water purification (3). Activated carbon is favored for water supplies because adsorbs a wide in both waste waters and source waters for drinking water (4). In fact, activated carbon filters are used today in drinking water treatment to remove the natural organic compounds that produce carcinogenic chlorinated by-products during chlorine disinfection of water(5).

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Activated carbons are complex and heterogeneous material made of wood، coconut shells, coal, etc. with unique adsorptive characteristics mainly influenced by the porous structure، surface area and chemical structure of the surface (6). Granular activated carbon (GAC) has an extremely large amount of adsorption surface area; approximately one gram of carbon has a pore surface area of 800 – 2500 m² and this massive surface area gives it an exceptional ability to adsorb gases, liquids and many kinds of materials on to its surface. This high surface area permits the accumulation of a large number of contaminant molecules (7,8). Activated carbon has a high efficiency of adsorption depends on the pore size, the small pore size increased surface area of activated carbon and thus will increase its efficiency of adsorption. Granular activated carbon filters are used as a final polishing step in drinking water treatment to remove compounds that are usually present in the water at high concentrations (algae toxins, pesticides, taste, odors and industrial micro pollutants) (9). In addition, this treatment is recognized as an effective process for removing naturally occurring organic material formed by the environment. Nevertheless, this process can result in bacterial colonization of GAC (10). The use of activated carbon to remove pollutants from waters is widely extended, because of their high surface area micro porous character and the chemical nature of their surface (11), fig. (1).

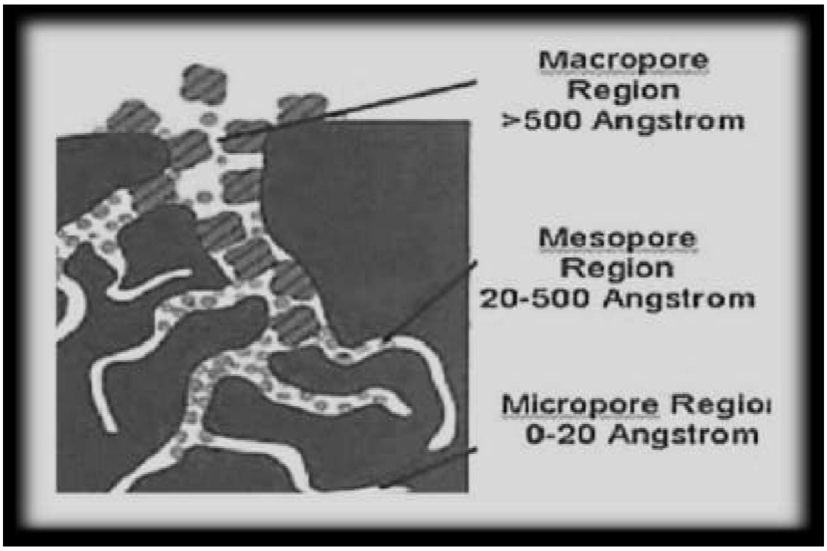

Figure (1) Pore of activated carbon

So the present study conducted to test GAC to absorption of bacteria coliform from Municipal water at Al-Hashmia treatment plant because bacteria coliform are good indicator organisms of water contamination. The experimental work was lead to investigate the effects of the activated carbon in removing of bacteria coliform in fluidized bed by adsorption system. Experiment was performed during duration from Jun to August. In these months the weather is hot; it's suitable for the growth of bacteria and increase. This experiment depended on the filed condition in the water treatment plant.

Material & Methods

Bio-plant system

Bio-plant system used in the present study was consisting of following components:

1- Major tank -1000 Liter.
2- Minor tank -20 liter. (to ensure a constant flow of water).
3- Cylindrical column Glass - Plastic (length 60 cm, internal diameter 5cm).
4- Flow meter to ensure a constant flow of water.
5- Commercial granular activated carbon.
6- Centrifugal pump type (zemzem) with (H=30m, Q=30 L/min).

Bio-plant,(fig.2), was placed in Al-Hashmia treatment plant before chlorination unit, to reduce the microbiology (bacteria coliform) before adding chlorine, that lead to reduces the volume of chlorine added for water purification. In this adsorption column (fluidized bed), water enters from the bottom of the column and leaves from the top (up flow). However, the adsorbent bed, in expanded form, remains in the column until it is exhausted and breakthrough occurs. The fluidized-beds offer a high available surface area, because there is no contact between particles adsorbent.

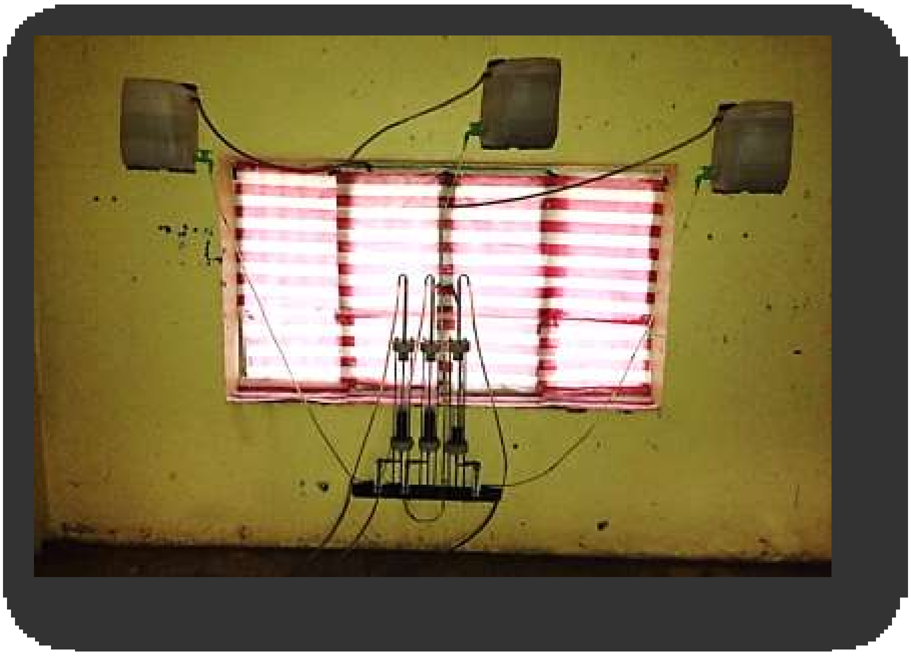

Figure (2) pilot-plant

Bacterial counts and identification

Total counts and identification of bacteria coliform was performed by using of the plate count method on differentiation and selective media which are Brilliant Green Bile Agar (12), and then incubation at 37Cº for 24 hours depends on colony properties (13). Bacteria coliform colonies were confirmed by using VITEK 2-Compact microbial identification system (bioMerieux).

Adsorption Studies

The performance of a fluidized bed column was described through the concept of the breakthrough curve. In Continuous Experiments of bacteria coliform to be adsorbed from solution in a fluidized bed is usually expressed in term of Ce/Co as a function of volume or time of the effluent for a given bed height, giving a breakthrough curve. The time for breakthrough appearance and the shape of the breakthrough curve are very important characteristics for determining the operation and the dynamic response of an adsorption column.

Bacteria coliform numbers were counted before and after GAC bed filter to explore the absorption activity of GAC bed filter to Bacteria coliform through using of different operation condition such as flow rate, bed depth and particle size. Absorption calculated by the Mathematical formula: **Absorption %** = $\{(C_o - C)/C_o\}\times 100$ (C_o(cfu/ml) = number of bacterial before carbon filter, C(cfu/ml)= number of bacterial after carbon filter).

Results and discussion

Effect of flow rate

The flow rate is one of the major parameters in the design of adsorption column. The effects of flow rate was varied(15.3, 30.6, 45.9) $m^3/m^2/h$ on the adsorption of coliform bacteria was studies with constant bed height of (15cm), particle size(1mm), and pH (7.4-8.6), initial concentration and temperature (27-34 Cº) depended on field conditions in treatment plant, shown the breakthrough curves in Fig. (3).

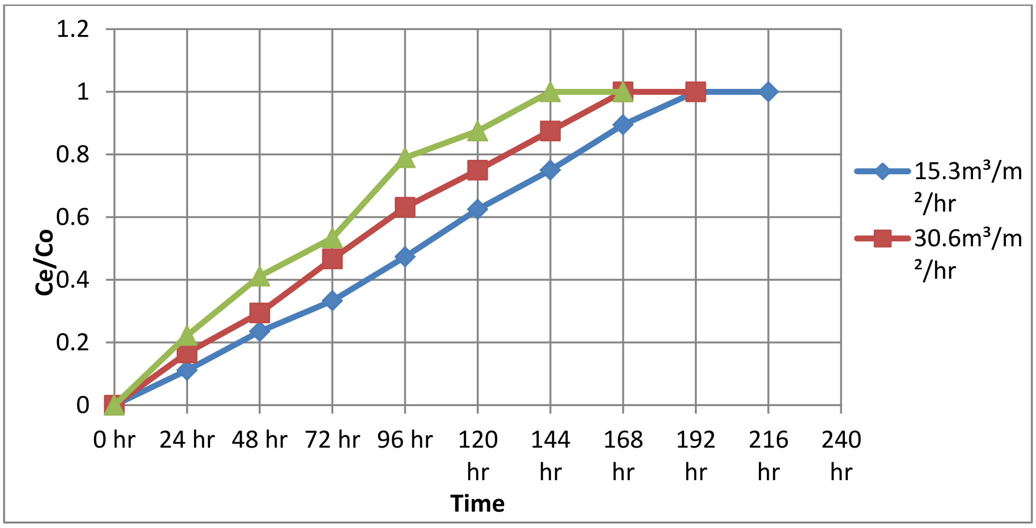

Figure (3) the experimental breakthrough data for adsorption of coliform bacteria onto treated activated carbon at different filtration rates, bed depth 15cm, particle size (1mm).

It can be seen from figure (3), that the breakthrough is generally occurred faster with a higher flow rate. This is due to decreased contact time between the bacteria coliform and the sorbent, at higher flow rate, which results in lower bed utilization. Breakthrough time reaching saturation was increased significantly with a decrease in the flow rate. When the flow rate increases, the breakthrough curves become steeper. The breakpoint decreases due to the residence time in the column. The flow rate increases the time of breakthrough point decreases, this is because the residence time of solute in the bed decreases, as the flow rate increases and therefore there is not enough time for adsorption equilibrium to be reached which results in lower bed utilization and the adsorbate solution leaves the column before equilibrium. At time 192 hr, the adsorption capacity of bacteria coliform for (15.3 $m^3/m^2/hr$) will be equilibrium, while adsorption capacity for (30.6 $m^3/m^2/hr$) will be equilibrium after 168 hr, and adsorption capacity of bacteria coliform at (45.9 $m^3/m^2/hr$) will be equilibrium after 144 hr.

Effect of bed depth

The bed depth is one of the major parameters in the design of fluidize bed adsorption column. The investigated by varying the bed depth (5, 10, 15) cm, at a constant flow rate of (15.3) $m^3/m^2/h$, particle size 1mm, and pH (7.4-8.6), initial concentration and temperature (26-32 C°) depended on field conditions in treatment plant. Fig. (4) shows the breakthrough curves..

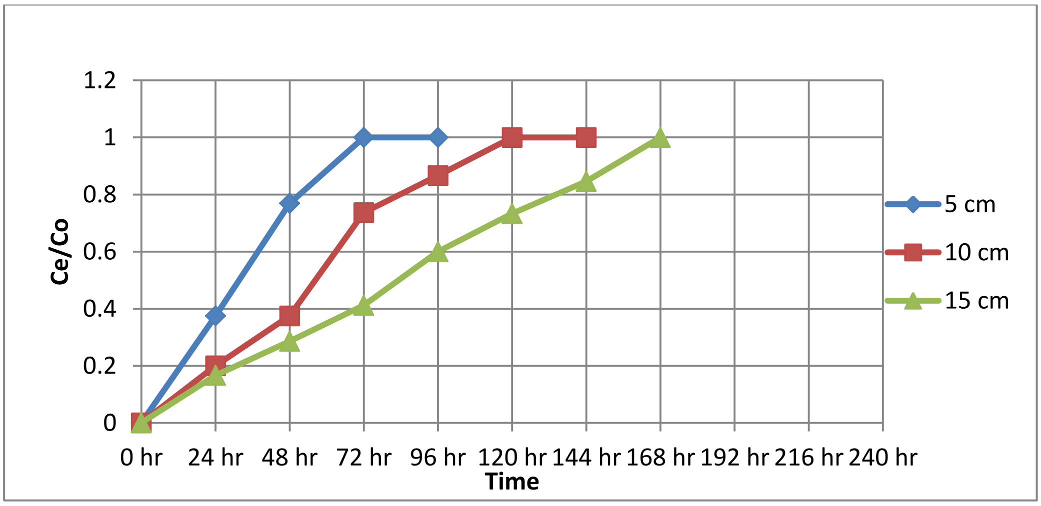

Figure (4) The experimental breakthrough data for adsorption of coliform bacteria onto treated activated carbon at different bed depth, filtration rate15.3 $m^3/m^2/h$, particle size (1mm).

From the figure (4) it can be observed that as the bed height increases, the breakpoint increases. The increasing of the bed height will increase the contact time of the solute in the bed, and these improving the solute removal efficiency. The capacity for adsorption of bacteria coliform for (15cm) bed height is greater than for others bed height because there will be a longer path for the movement of bacteria through the column. At time 168 hr, the adsorption capacity of coliform bacteria for (15cm) will be balanced, while adsorption capacity for (10cm) will be balanced after

120 hr, and adsorption capacity of bacteria coliform at (5cm) will be balanced after 72 hr.

Effect of Activated carbon size

The effect of the activated carbon particle size (0.6, 1 and 0.2-2.5 mm) on the breakthrough curve were plotted by keeping the parameters constant flow rate (15.3m³/m²/h), bed height of(15cm), and pH(7.4-8.6), initial concentration and temperature (25-32 C°) depended on field conditions in treatment plant. This curve is presented in Fig.(5).

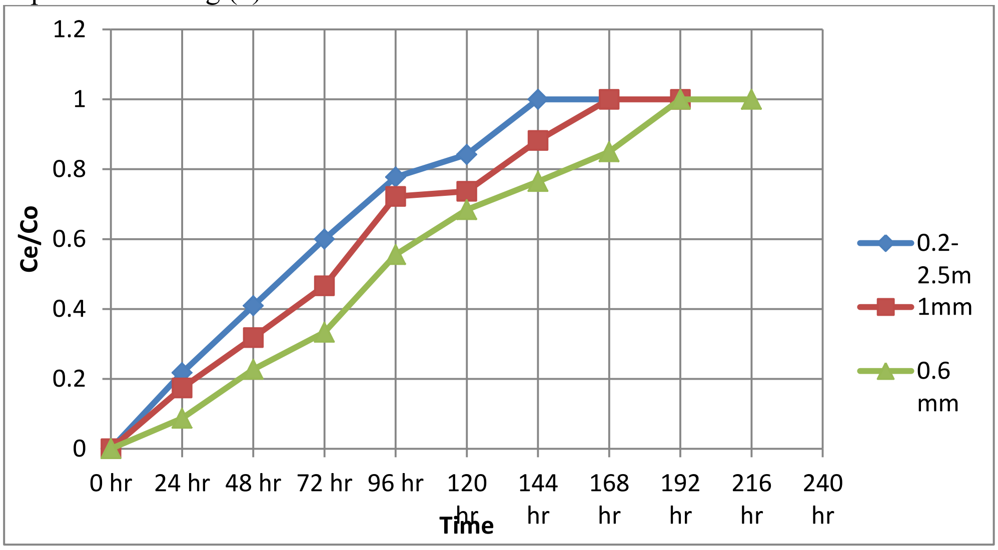

Figure (5) the experimental breakthrough data for adsorption of coliform bacteria onto treated activated carbon at different particle size, bed depth 15cm, filtration rate.3 m³/m²/h.

It is clear from the figure (5), that increasing of the particle size will decrease the capacity of the activated carbon adsorption. The breakthrough curves show that the time required for reaching the breakpoint increases as the particle size decreases. In decrease of the particle size the capacity of the activated carbon adsorption will increasing, because of the large surface area in decrease of the particle size of activated carbon. The fact is that when the particle size decreases surface area available for adsorption will increase i.e., providing more vacant sites for the solute molecules to occupy the surface, therefore it will increase the time for saturation. At time 192 hr, the adsorption capacity of bacteria coliform for (0.6 mm) will be balanced, while adsorption capacity for (1mm) will be balanced after 168 hr, and adsorption capacity of bacteria coliform at (0.2-2.5 mm) will be balanced after 144 hr.

CONCLUSIONS

The ability of using commercial activated carbon for adsorption bacteria coliform was studied, based upon experimental results in continuous systems(fluidize bed). The following points can be concluded based on the results discussed earlier:

1- The present results showed that the commercial activated carbon is efficient for the removal of coliform bacteria from water.

2- Adsorption in continuous system (fluidizes bed), Proved good efficient in removing bacteria coliform from water, because it provides a high surface area for adsorption, and because there is no contact between the particles adsorbent.
3- The breakthrough curve becomes steeper with increase flow rate, decrease bed height and increase particle size.
4- From result, longer breakthrough curve when the particle size (0.6mm), flow rate(15.3 $m^3/m^2/h$) and bed depth(15cm), the Ce/Co equal to 0.85 after (168)hour.

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