

Comparison of Granulated and Powdered Activated Carbon in the Removal of Organic Matter from River Water

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Abstract— River or lake water is seldom clean enough for human consumption if not treated. Water is found in nature in varying degrees of purity. Water must contain a high level of Purity, free of organic matter, color, odor, unwanted taste; we often resort to so-called "water treatment", which aims primarily to protect the health of society. Two types of activated carbon (GAC, PAC) were taken into this work and compared with some in river water treatment with a view to achieving COD, TOC removal. Activated carbon (AC) is an adsorbent substance for the absorption of organic matter from water. Water is passed through activated carbon material; the pollutant is attracted to and held (adsorbed) on the surface of the carbon particles. GAC is used by filter, which contains a column of (GAC), consists of different particle size of carbon granules inside a column. The effectiveness of GAC in the absorption of organic matter depends on Increasing GAC concentration, contact time. On the other hand, PAC is used by the jar test and consists of adding PAC to the water, this leads to PAC reacts with contaminants and mixes well and then remove the contaminants conjoined on the surface PAC by filtration. The effectiveness of PAC in the absorption of organic matter depends on adequate mixing, contact time. The results confirmed that the treatment of GAC and PAC can be effective in organic matter removal. The samples were analyzed before and after treatment and carbon weights ranged from 1 to 15 gm/L. The maximum COD and TOC removal is found at 15 gm/L, and contact for 24 hours where gave 90 % and 85 % ratio removal from COD, TOC in the GAC and gave 87 % and 80 % ratio removal from COD, TOC in the PAC.

Keywords— Organic matter, GAC, PAC, river water, adsorbent.

I. INTRODUCTION

Increased industrial activities have led to accelerated environment pollution as well as make water a limited resource [1, 2]. Once the surface water and river water are contaminated, its quality cannot be restored back easily. Pollution is major concern that threatens many [3]. Increased pollution of organic compounds is major problems in water treatment, there is no way to decompose biologically, and resist the process of self-purification of rivers [4,5,6]. The presence of organic substances including chemicals compounds in the water source of concern and leaving negative effects on the environment [7, 8]. Therefore, it is necessary to significantly remove these pollutants to protect drinking water sources and also the environment [9]. However, traditional treatment processes such as (coagulation, sand filtration) cannot be given significant protection against organic pollutants [5, 10]. Adsorption is the most effective and economical method and it has aroused great interest in recent

years from among a number of conventional treatment technologies for treating river water contaminated with organic matter [11, 12]. The GAC column should contain low organic content for effective adsorption of organic matter [10, 11]. Most studies have confirmed modern methods that treat appropriately the elimination of organic matter [12, 13]. The adsorption process is through activated carbon and it is physical and chemical process. Adsorption by activated carbon is vital because dissolved organic matter that is difficult to dispose of can be removed by activated carbon [9]. The more effective for control of organic load is activated carbon (AC) and the AC filter is always used for water treatment [12, 13]. Adsorption through AC has been widely applied to the partial or complete removal of different materials [14, 15]. The adsorption of various materials on carbon surface has been discussed to solve the water quality problem [16]. The adsorption through granular activated carbon (GAC) has proven from advanced treatments to be a technique capable on removal. [17, 18, 19] Adsorption performance has been greatly improved through using the size of small particles from GAC [20, 21, 22, 23]. GAC is used for treatment because more effective in decrease organic matter, so that the contact time is sufficient to allow the adsorption of many [24]. GAC filters remove organic matter by developing a biofilm on their surface. This film breaks easily biodegradable organic matter, with TOC removal up to 38% [25]. The organic matter affects the adsorption capacity of the GAC and so affects their work. The benefit of organic matter in the GAC filter is biomass growth associated with GAC molecules. GAC roughness and high porosity have properties that promote the growth of microbial [26]. Adsorption processes by powdered activated carbon (PAC) in water treatment can effectively control the problems associated with organic materials and synthetic organic compounds [27, 28]. Studies have shown that the organic removal micro-pollutants using (PAC) as an additional step for wastewater treatment [29, 30, 31]. The waste water consists from TOC; COD is the main components it and removed by the adsorption process on PAC [28]. Pollution rate decreased with increased PAC concentration, these results indicate COD removal stability increased with increased PAC concentration [32, 33, 34, 35, 36]. COD is a measure of the oxygen required; it is an inexpensive and quick way, making COD a useful measure of water quality, used widely to determine the amount of organic

pollutants present in surface water or wastewater which are subject to oxidation by strong chemical oxidation, including reduced inorganic compounds. This is expressed in milligrams per liter (mg / L). work [37] established that the minimum dose of PAC up to 50 mg/L is required to decrease the level of TOC by 25% , and that more decreases in the TOC level by PAC dose will be costly. Total organic carbon is a measure of organically bonded carbon, also includes the carbon in poorly biodegradable compounds. This study focused on Comparison between (GAC) and (PAC) for the removal of COD, TOC of river water.

II. MATERIAL AND METHOD

1- The Study Area

Samples were collected from in the east of Tehran. From a canal called "Abazar canal". Water from Alborz Mountain flows through this canal, which is also, collects rain water and surface waters. During water flow, sewage and polluted water run into the canal causing wide spread contamination.

2- Sample Collection

Water samples were collected in a plastic bottle during different periods. The samples have been brought in to Lab to measure Physical- Chemical parameters. The pH and EC and T have been measured by using Thermometer and Pocket Digital pH Meter at the site and the other parameters have been analyzed in the laboratory.

3- Experimental Work

1- Activated carbon granules were used in the laboratory experiment. The experiment was conducted to study the effect of GAC on the removal organic matter. Activated carbon granules filter consists of a length 25 cm and diameter 2.5 cm as shown in the figure (1) below. Activated carbon granules were added to the filter with different amounts (1, 2, 5, 10, 15 gm) at room temperature with contact for 24 hours. Samples were taken from the inlet and outlet of the filter and then tested to determine the decreases in organic matters based on [31] and parameter analyzed for COD, TOC. COD, TOC were measured using spectrometer, analyzed organic carbon and according to the Standard Method methods for the Examination of Water and Wastewater [38, 39].

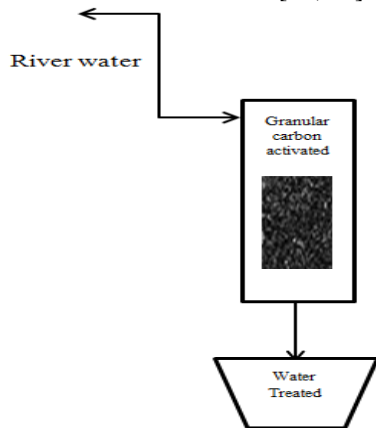


Figure 1. Granules activated carbon filter

2- Standard jar test was used in the laboratory experiment. The experiment was conducted to study the effect of PAC on the removal organic matter, the jar test simply consists of 5 beakers one liter each providing with multiple stirrer units. The weights of PAC (1, 2, 5, 10, 15 gm) per 1L of the river water sample were added at room temperature. The procedures included rapid mixing using stirrers, followed by slow mixing and settling, the settling time was considered 24 hours as shown in the figure (2).

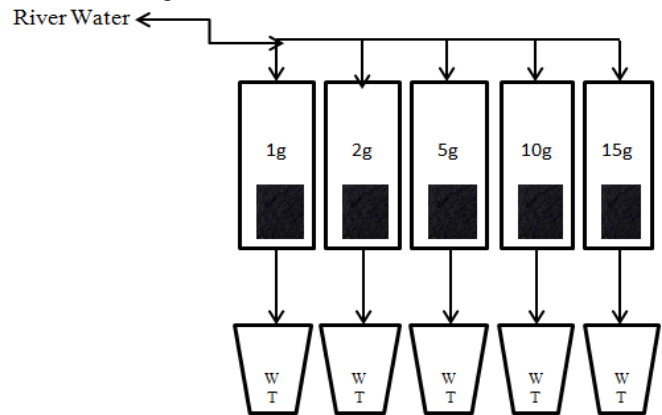


Figure 2. Standard jar test was used in the laboratory experiment

Samples were taken before mix and after mix and then tested to determine the decreases in organic matters and parameter analyzed for COD, TOC. COD, TOC were measured using spectrometer, analyzed organic carbon and according to the Standard Method methods for the Examination of Water and Wastewater [40].

COD removal was measured by using spectrophotometer wavelength (420 nm) is manufactured by UNICO America, model UV-2100. Moreover, hot COD meter HACH model DRB 200. TOC removal was measured by using total organic carbon analyzer; the manufactured in Australia (S.G.E) model ANA TOC. Both were measured (COD, TOC) in Sharif University of Technology/ Iran.

4- Specification of GAC used in the laboratory

The GAC characteristics used in the experiment were as shown in Table (1) below.

Merck KGaA 64271 Darmstadt, Germany Tel. +49(0)6151 72-2440 www.merck.de	
Specifications	
Identity	conforms
Substances soluble in nitric acid	≤ 5 %
Chloride (Cl)	≤ 200 ppm
Cyano compounds (CN)	passes test
Pb (Lead)	≤ 20 ppm
Zn (Zinc)	≤ 100 ppm
Polycyclic aromates	passes test
Tar products	passes test
n-Hexane adsorption	≥ 30 %
Residue on ignition (600 °C)	≤ 8 %
Loss on drying	≤ 10 %

III. RESULTS OF ACTIVATED CARBON

In this paper, emphasis is placed on COD and TOC parameters for river water treatment with low cost from (PAC, GAC) materials.

1- Effect of granular activated carbon on removal efficiency COD, TOC

The filter of GAC was used to study the effect on river water. Initially, adsorption by the GAC can lead to the removal of organic matters significantly, after a time the GAC adsorption capacity will decrease and then exhausted [41, 42, 43]. These results prove that GAC can significantly improve the removal of organic compounds. All samples, which were treatment by GAC, achieved different removal efficiencies for samples after treatment by the GAC [44- 48]. Figure 3, 4, 5 shows the relation between GAC with TOC, COD removal. The COD removal ratio was 55% to 90 % and TOC from 37% to 85 %, Increases with increase in GAC weight from 1 gm to 15 gm. COD, TOC are removed more effectively with Increasing GAC weight, contact time where providing high removal efficiency. When the water passes through the granular activated carbon filter, there will be adhesion of organic pollutants on the surface of carbon granules and trapped inside through the process known "adsorption", where

it has a positive charge which makes it more attractive to pollutants that have a negative charge. Activated Carbon (AC) and organic molecules (OM) are a similar material, for this tends to bond with each other. Adsorption process can be affected by the concentration of organic contaminants; activated carbon (AC) may react chemically with organic molecules (OM). Ion exchange or adsorption is the result of electrical forces between activated carbon and chemical nature of pollutants. Thus, organic materials will therefore be stronger in the association with activated carbon (AC) rather than being dissolved in water. The greater the amount carbon and increased the time of the adhesion of pollutants on the surface, the greater the number of contaminants that will be removed, where absorption and removal of organic compounds occurs better, some organic matter require more exposure time to be removed. The bacteria that multiply in GAC filters may be responsible for breaking part of the removal of organics matter in the filter. The results were consistent with previous studies on that the GAC filtration was able on the disposal of organic pollutants [49, 50, 51- 52]. [33] Even though GAC filtration can achieve significantly removal of all organic pollutions, but there must be strict control over the long time.

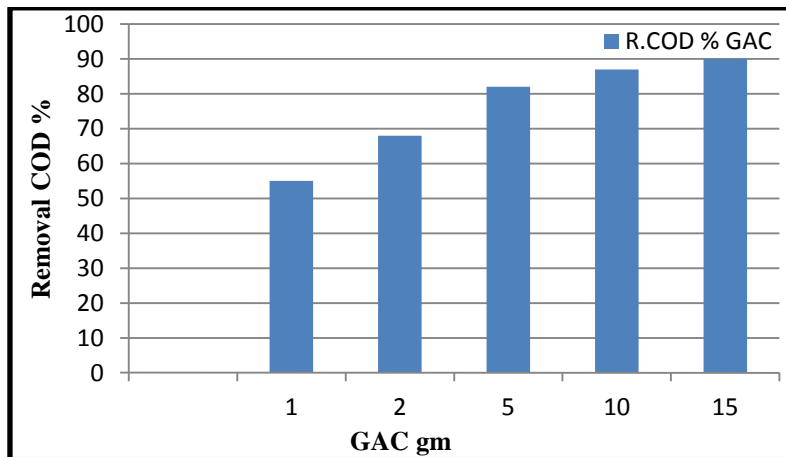


Figure 3. shows the relation between GAC with COD removal

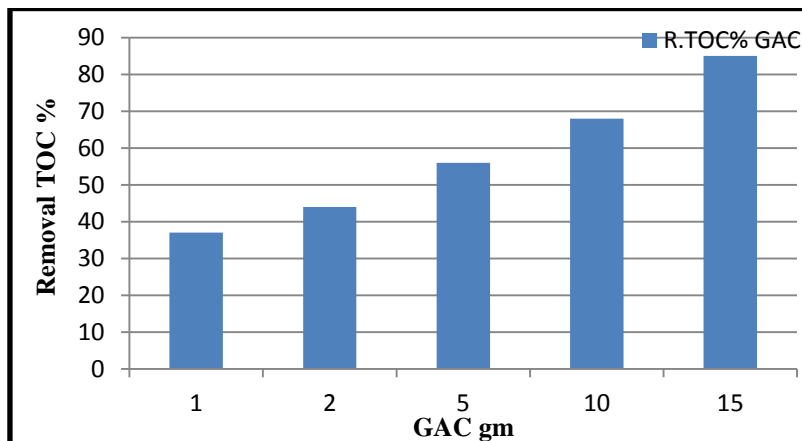


Figure 4. shows the relation between GAC with TOC removal

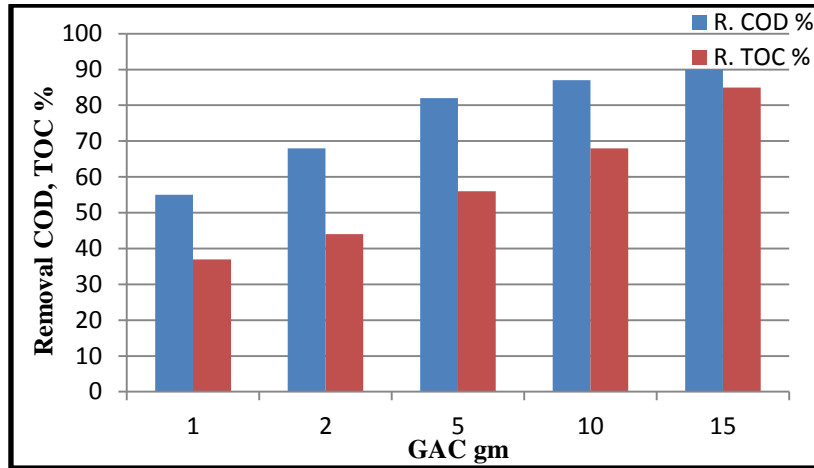


Figure 5. shows the relation between GAC with TOC, COD removal

2- Effect of powder activated carbon (PAC) on removal efficiency COD, TOC

The jar test was used to study the effect of PAC on river water. Figures 6, 7, 8 illustrate the relationship between PAC with TOC, COD removal. It can be observed that the removed ratio of COD from 47% to 87% and TOC from 35% to 80%, Increases with increase in PAC weight from 1 gm to 15 gm. The adsorption process has been effective in all weights of PAC. Removal of the dissolved organic matter between certain weight of PAC means that the ability to adsorb carbon has been used effectively. In addition, the adsorption efficiency was significantly at a longer contact time. Adsorption depends on the type of contaminants to be removed. A large portion of large organic contaminants may lead to block PAC work, thus cannot reach the smaller organic contaminants [53, 54, 55]. Treatment is to add PAC to water, thus PAC react with pollutants and mix well by jar test and where this water come into contact with powder activated carbon and then remove the contaminants conjoined on the surface PAC by filtration. The effectiveness of PAC in the absorption of organic matter depends on adequate mixing, contact time. Absorption occurs so that the dissolved

substance remains concentrated in the solution and dissolved substance concentration on the internal surface for adsorbent substance reaches the dynamic balance [42, 43]. Activated carbon (AC) and organic molecules (OM) are a similar material, thus will tend to bond with some. Activated carbon (AC) may interact chemically with organic molecules (OM). Ion exchange or adsorption is the result of electrical forces between activated carbon and chemical nature of pollutants. Thus, organic materials will therefore be stronger in the association with activated carbon (AC) rather than remaining dissolved in water. Low organic matter are adsorbed rapidly on the surface of the PAC, In case of large organic matter need a longer period. The greater the amount carbon and increased the time of the adhesion of pollutants on the surface, the greater the number of contaminants that will be removed, where absorption and removal of organic compounds occurs better, some organic matter require more exposure period for removed.

Adsorption was analyzed with (GAC) and (PAC) and compared with some in river water treatment; emphasis was placed on COD and TOC parameter. Results showed that (GAC) gave greater removal than (PAC) as shown in Figure 9.

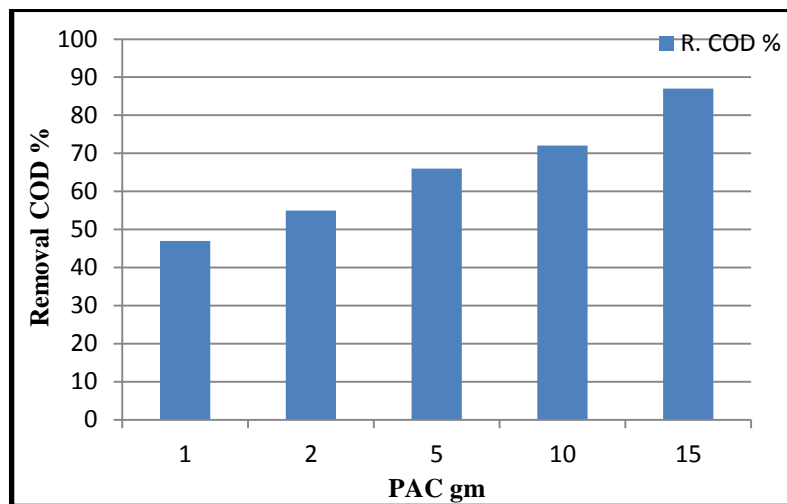


Figure 6. shows the relation between PAC with COD removal

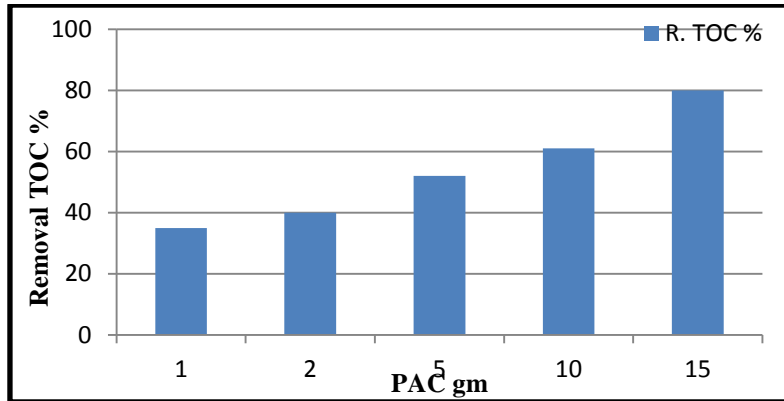


Figure 7. shows the relation between PAC with TOC removal

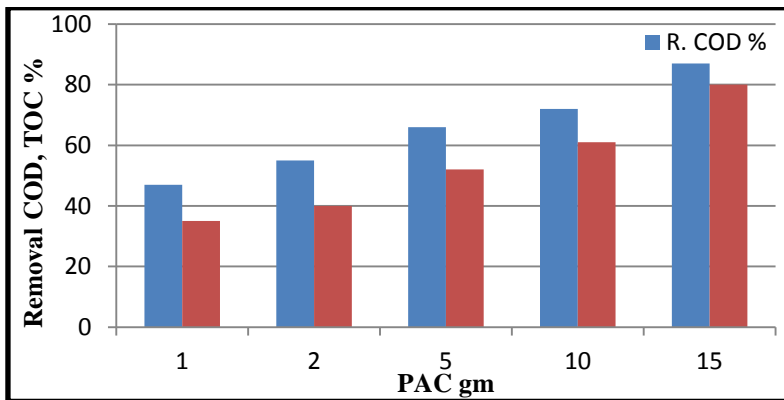


Figure 8. shows the relation between PAC with TOC, COD removal

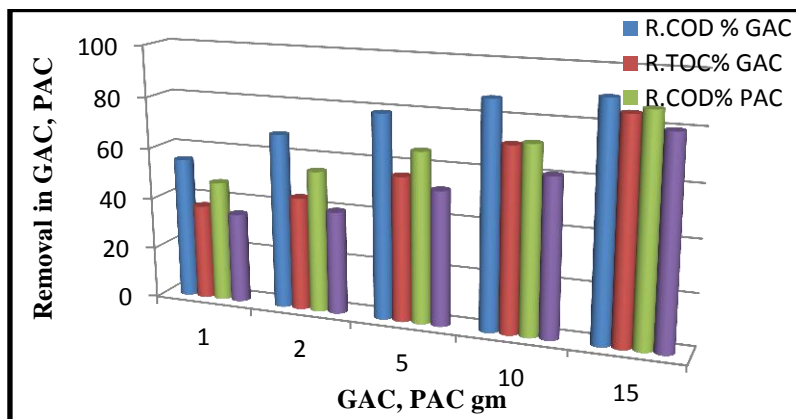


Figure 9. shows the relation between GAC, PAC with TOC, COD removal

Comparison between GAC, PAC

PAC	GAC
1- Powdered activated carbon (PAC) has a smaller particle size than the GAC.	1-The granular activated carbon (GAC) contains a larger particle size than the PAC.
2- PAC can apply at the quick mix unit; It is usually used on a one time basis.	2- The GAC filter works for months or years.
3- 3treatment is to add PAC to water, thus PAC react with pollutants, PAC remove become by filtration.	3- Treatment involves passing water through the GAC filter to remove of the organic micro pollutants.
4- The cost of operating the PAC has a high when used continuously.	4 - High cost to buy the filter.
5- Can be in contact with water only a short period, it is very likely does not support biological activity.	5- The tendency of the GAC filter to grow bacteria, regular examinations must be performed.
6- Allows the PAC to deal with variable pollutants, due to the low cost.	6- Larger systems. GAC are more economical.
7- Low cost PAC from granular activated carbon (GAC) [58, 59].	7- GAC contains high porosity, easy to handle and easy to a activate after its exhaustion [56, 57].

IV. CONCLUSIONS

The focus of this work was to determine the possibility of using (GAC, PAC) and compared with some in organic matter removal such as (COD, TOC) and whichever is better in removing these compounds. Carbon has an important impression on water treatment and waste water, especially for organic matter. We know that carbon is the main component of organic matter, because organic compounds consist of hydrogen and carbon, thus the carbon works well with these types of pollutants. According to the results obtained, we conclude the following that the GAC has given a greater removal than (PAC), contact time and amount of carbon have a direct relationship with organic matter removal. Results after treatment were good to reduce of COD and TOC (90 %, 85 %) in the GAC and (87 %, 80) in the PAC. However, the low level of total organic carbon leads to lower chemical oxygen demand. Elimination of pollutants using activated carbon was very effective; it could be considered a reliable, flexible, efficient and economical method. Treatment must be more to make surface water usable.

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