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Original Article

Surface water treatment using activated carbon filtration

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ABSTRACT

Bangladesh is a floodplain nation situated on the Ganges River's delta, one of the world's main rivers. Although, the country is abundant in water resources, with many rivers, canals, lakes, and vast water-bearing aquifers, the rural regions of Bangladesh suffer from a lack of safe drinking water. The main objective of this study was to secure the drinking water quality by focusing on activated carbon (AC) filtration process and its applicability. Water samples were collected from four different locations, namely, Rampura, Baksibazar, Malibag, and Hatirjeel which are located at Dhaka city of Bangladesh. Major water quality parameter such as pH, color, turbidity, alkalinity, chloride, and carbon dioxide was analyzed to characterize considered water samples. Those water quality parameters were also tested before and after adopting AC filtration methods. Water sample characterization showed the improved condition after using the AC filtration process. Results of using AC filter for all water parameters were satisfactory. pH values of all considered water samples found to be reduced up to the Bangladesh standard. The concentration of turbidity changed significantly and it went <1 nephelometric turbidity unit after the treatment. Alkalinity and carbon dioxide reduction were also observed by following the treatment. AC filtration was found to be convenient as using for the purpose of maintaining the water quality of considered locations with satisfactory results.

Keywords: Activated carbon, filtration, quality, turbidity, water characterization

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INTRODUCTION

"Water everywhere, but not a single drop to drink," from the rhyme of the ancient manner, may be an apt depiction of the mindset of many urban consumers today, who are increasingly turning to bottled water to satisfy part or all of their daily needs. As fresh water resources are increasingly depleted to satisfy the needs of industry, agriculture, and an ever-increasing population, a lack of clean and accessible drinking water will become a significant problem in many areas of the globe. Following numerous significant food and water outbreaks, there is an increasing concern about the safety and quality of drinking water. While bottled water is readily accessible in both developed and developing nations, it may be expensive for the user. Consumers may purchase bottled drinking water for a variety of reasons, including taste, convenience, or fashion, but for many, safety and possible health advantages are significant concerns. Because such concerns are often not based on facts, they will be addressed explicitly here.

Water is the most vital resource on the planet and a lifeline for all living beings. The availability of water in Bangladesh, both regionally and seasonally, as well as the quality of surface and groundwater, has a significant impact on the country's ecology, economics, and development.[1] The availability of surface and groundwater in the nation is mostly determined by the sub-tropical climate and geographical features in terms of space and season. Upstream withdrawal has an impact on availability for both consumptive and non-consumptive uses. When it comes to water quality, the country's surface water is vulnerable from untreated industrial effluents, municipal wastewater, chemical fertilizer and pesticide runoff contamination, and oil and lubricant spills in the coastal region from sea and river port operations.[2] The effluent types and amount discharged by various sectors, as well as the kinds of agrochemicals used in

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agriculture, and the seasonality of water flow are all factors that influence water quality.[3] Bangladesh is the low-lying coastal nation for three main river systems: The Ganges-Padma, Brahmaputra-Jamuna, and Meghna (GBM), with around 8% of the total catchment area. Bangladesh gets around 92% of the annual runoff generated in the GBM catchment areas.[4] During the driest months (March–April), the combined flow of the Ganges and Brahmaputra varies from <5000 m^3/s to 80,000–140,000 m^3/s in late August and early September.[4]

"Drinking water" or "potable water" refers to water that is fit for human consumption. Drinking water is water that is designed for human consumption.[5] In poor nations, 80% of all illnesses are caused by water. A quarter of infants born in poor nations die before reaching the age of five as a result of contaminated water. As a result, the availability of drinkable water to humans is the most critical element of the contemporary civilized world. Access to clean drinking water is vital to one's health, is a fundamental human right, and is a component in the success health-protection policy strategy.[6] Several worldwide policy forums have produced outcomes that highlight the significance of water, sanitation, and hygiene for human health and development. Clean drinking water is a global, regional, and local health and development problem. Water and sanitation expenditures may be beneficial economically in certain areas, as the decrease in adverse health impacts and health-care expenses exceed the cost of the measures. This is true for large water infrastructure expenditures as well as household water treatment. Increasing access to clean water has also been proven to benefit the poor, whether in rural or urban settings, and to contribute to poverty reduction.

The rural regions of Bangladesh suffer from a lack of safe drinking water. In many parts of the country, surface water sources are usually polluted, and groundwater, which had previously been the greatest source of clean drinking water is poisoned with arsenic.[7] Islam *et al.*, 2017 conducted a study in rural region of Bangladesh and discovered that a sample of tube well water included zooplankton and germs.[6] Due to unsanitary and unplanned latrines, as well as the carelessness of rural residents, certain ground water reserves are getting polluted. Significant groundwater withdrawals for agriculture have also reduced the water table below the practical reach of hand tube wells in many places. Seepage of agricultural pesticides into shallow aquifers may also contaminate drinking water for humans and animals. In the southwest region of the country, salinity incursions from saltwater are making groundwater unsuitable for human consumption. Cities and metropolitan regions, too, are grappling with a falling water table as a result of intensive groundwater exploitation. These water supply and sanitation issues have clear public health consequences. Diarrheal illnesses, which are mostly caused by poor drinking water, are a major cause of mortality in rural regions. In metropolitan regions, illnesses are mostly caused by a lack of appropriate sanitation and drainage infrastructure, insufficient water supply, and poor health and hygiene education. Lack of access to clean water in rural regions is particularly difficult for women, who must carry water great distances, wreaking havoc on their health and productivity. Ground water in metropolitan areas of Bangladesh also included certain chemical characteristics that above the standard's maximum limit, rendering it unfit for drinking and domestic use.[7]

Bangladesh is a floodplain nation situated on the Ganges River's delta, one of the world's main rivers. The nation is abundant in water resources, with many rivers, canals, lakes, and vast water-bearing aquifers. Every year, the nation receives an abundance of rain. As a result, water treatment is critical for both sources since it may quickly become contaminated. Carbon (activated carbon [AC]) filters have traditionally been used in household water purification systems to eliminate taste and odor.[8] Although unpleasant, taste, and odor are not usually regarded as harmful, Dhaka is mostly reliant on surface water, which must be cleaned before being distributed to the population. Since the 19th century, filtration has been extensively employed in the water treatment process as one of many water purifying methods. Dhaka's water supply is heavily reliant on groundwater extraction, with over 87% of water provided originating from this source.[9] Such widespread reliance accelerates the decline of the groundwater table. The groundwater table of this city has dropped by more than 20 m in the past 7 years, at a rate of 2.81 m/year (m/y).[10] Given the current pace of depletion, the research projects that the groundwater table would drop at 120 m by 2050.

However, in recent years, AC filters have been used to remove some of the contaminants that have been discovered in water supplies.[11] AC filters are used to eliminate unpleasant tastes and smells, as well as radon and certain man-made volatile organic pollutants, from drinking water. The unit's efficiency is determined by the kind of AC used, the depth of the filter bed, the type of pollutants in the water and their concentration, and the contact period between the water and the carbon filter. AC filters are not equally effective in adsorbing various types of contaminants. Carbon filters are simple to install and maintain, with most running expenditures restricted to filter replacement.[12] In this study, water samples were collected from four selected locations in Dhaka city. Drinking water treatment by AC was the focal point for this research. Therefore, water samples were collected from four different locations, namely, Rampura, Baksibazar, Malibag, and Hatirjeel located in Dhaka city of Bangladesh. Major water quality parameter such as pH, color, turbidity, alkalinity, chloride, and carbon dioxide was measured in laboratory experiment before and after application of carbon activated method to check the quality of water as drinking and other uses. The study's key objective was to assure

and guarantee the quality of drinking water, with a particular focus on the AC method and its application.[13]

METHODOLOGY

Water Sample Collection

Water samples were collected from four different individual places which is located at Dhaka city in Bangladesh named as Rampura, Baksibazar, Malibag, and Hatirjeel. Locations for sample collection were selected considering the importance of water using pattern of locality. Table 1 and the Figure 1 represent the sample collection points and collected water samples, respectively.

Characterization of Collected Water Samples

The collected water samples were analyzed for pH, color, turbidity, alkalinity, chloride, and CO_2. pH meter, spectrophotometer, and turbidity meter were used for measuring pH, color, and turbidity of water, respectively. Furthermore, alkalinity, chloride, and CO_2 were measured by titration method. Turbidity and alkalinity were measured in nephelometric turbidity unit (NTU) and mg/l of $CaCO_3$, respectively.

AC Filtration Process

This study was performed by four samples of different areas of surface water with different concentration of impurities. Alkalinity, chloride content, color, and pH of the raw surface water were initially analyzed to determine the quality of the water before the treatment. Therefore, AC filters have been used to improve the water quality of the untreated water. In this research, charcoal was finely ground to enhance the surface area of the carbon content, which resulted in a larger capacity for aborting and adsorbing. The tiny carbon substances have been used to prepare the filter bed. In contrast, the filter's output was collected, and the water quality criteria mentioned above were also examined.

Table 1: Different places of sample collection

Collection point	Address
Collection point (S1)	Rampura, Dhaka
Collection point (S2)	Baksibazar, Dhaka
Collection point (S3)	Mailbag, Dhaka
Collection point (S4)	Hatirjeel, Dhaka

Figure 1: Collection of water samples to be characterized

RESULTS AND DISCUSSION

Characteristics of Collected Water Samples

The water samples were collected from four different locations of Dhaka city and collected water samples were analyzed for pH, color, turbidity, alkalinity, chloride, and CO_2. Table 2 shows the results of the particular water sample with respect to the considered characterizing parameter.

pH

It is essential to measure the pH of water to determine its acidity or alkalinity. The pH value of water might indicate the presence of contaminants. As a result, monitoring the pH of water is a significant public health precaution. Figure 2 illustrates the pH concentration before and after AC filtration. The maximum pH was observed at sample 4 as 10.21. According to Bangladesh Environment Preservation Act (1997), standard pH for drinking value is 6.5–8.5. However, it can be seen that pH of all samples was not within the permissible range. pH values were found as 7.59, 7.42, 6.95, and 7.17 after AC filtration for the sample-1, sample-2, sample-3, and sample-4, respectively. After treatment with AC filtration, it was noticed that the pH of all collected samples decreased. All of the results obtained from various water samples meet both the Bangladesh guideline (6.5–8.5) and the WHO guideline value (6.5–8.5).

Turbidity

The turbidity of water samples before and after carbon activated filtration is shown in Figure 3. A water supply system's ability

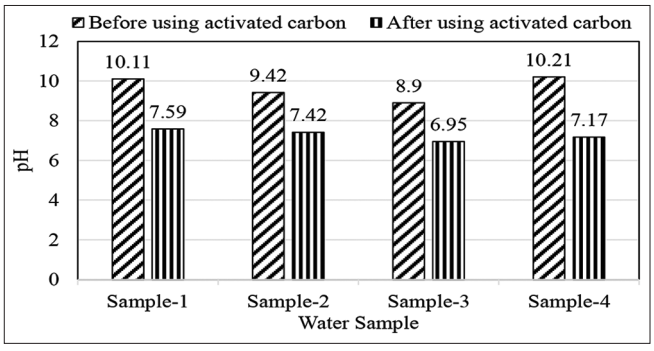

Figure 2: pH concentration before and after activated carbon filtration

Table 2: Results of parameter test of sample water

Parameter	Sample	S_1	S_2	S_3	S_4
P^H	100 ml	10.11	9.42	8.9	10.21
Color (Pt-co)	100 ml	Under range	Under range	Under range	15.0
Turbidity (NTU)	100 ml		0.72	0.91	2.41
Alkalinity (mg/l as $CaCO_3$)	100 ml	93	114	22	99
Chloride (mg/l)	50 g	18	36	94	10
CO_2 (mg/l)	100 ml	36	59	23	47

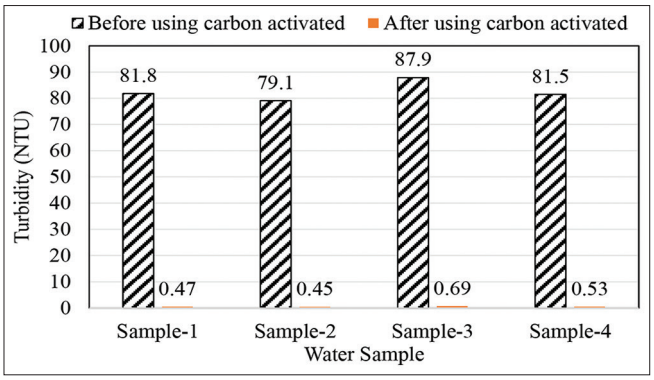

Figure 3: Turbidity before and after activated carbon filtration

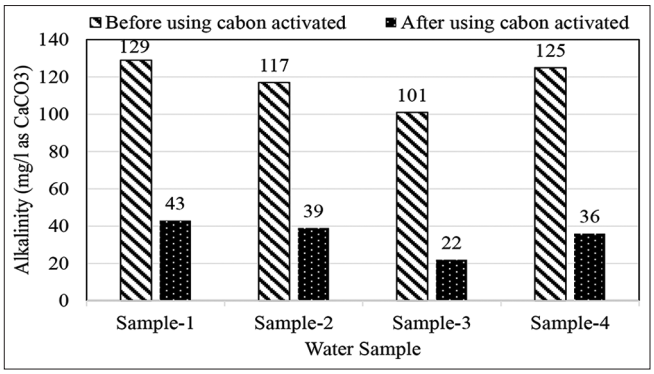

Figure 4: Alkalinity before and after activated carbon filtration

to remove turbidity is essential since turbid water is unappealing to humans. In addition, the word turbid is used to describe water having suspended particles that impede light transmission or restrict depth perception. The values of turbidity of water samples from collection points were as 81.8, 79.1, 87.9, and 81.5 NTU for the sample S_1, S_2, S_3, and S_4, respectively. The readings of several water samples did not meet the Bangladesh standards (10 NTU) or even the WHO guide line value (0.5-1.0 NTU).It is notable that the values of turbidity in all sample were reduced significantly after applying AC. Result revealed the turbidity as 0.47, 0.45, 0.69, and 0.53 NTU for the sample of S_1, S_2, S_3, and S_4, respectively, after carbon activated filtration which satisfied both Bangladesh and WHO guideline.

Alkalinity

The ability of water to neutralize acids is measured by its alkalinity. The salts of week acids are mostly responsible for alkalinity in natural waters; however, weak or strong bases may also play a significant role. A few organic acids, resistant to biological oxidation, synthesized from salts contribute to natural water alkalinity. As far as researchers know, water alkalinity has no health implications. Waters that are extremely alkaline are typically unpalatable. Figure 4 exhibits the alkalinity concentration of different water sample before and after passing the AC filtration. Result reveals that maximum and minimum alkalinity was found before passing the water through AC for sample 1 and sample 3 which were 129 and 101 mg/l, respectively. In addition, alkalinity was decreased in four samples after filtering through an AC bed. Average efficiency of alkalinity is >60% found in all sample. Alkalinity was found as 43, 39, 22, and 36 mg/l after passing the water through carbon activated bed consecutively.

Chloride

Chlorides may be found in different concentrations in all-natural water. As the mineral concentrations increase, the chloride content emerges as well. Upland and mountain water supplies are often low in chlorides, while river and ground water supplies are actually quite high. Sea and ocean waters are the remnants of partial evaporation of natural fluids that flow into them, and their chloride levels are quite high. Chlorides at acceptable amounts are not harmful; nonetheless, concentrations more than 250 mg/l give water a salty taste, which is unpleasant to humans. Many individuals find it offensive. Metal is corroded by high chloride concentrations. Figure 5 illustrates the change of chloride concentration in water before and after passing the AC bed. The highest chloride concentration was observed in sample 3 as 99 mg/l, where the lowest chloride was recorded for sample 1 as 24 mg/l before passing the water through activated bed. In all sample, the value of chloride was increased after passing the water sample through AC bed except sample 3. It was found 56, 49, 76, and 53 mg/l chloride concentration for sample S1, S2, S3, and S4, respectively. The chloride concentrations were far lower than the WHO guidelines for drinking water, which allowing for up to 250 mg/l.

Carbon Dioxide

The carbon dioxide content of water samples before and after carbon activated filtration is shown in Figure 6. It was measured using titration method and expressed as mg/l. A phenolphthalein

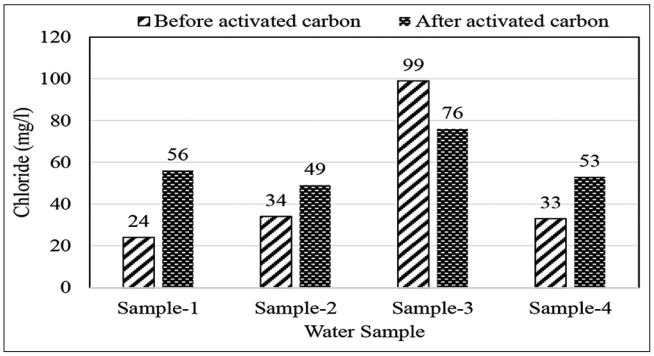

Figure 5: Chloride before and after activated carbon filtration

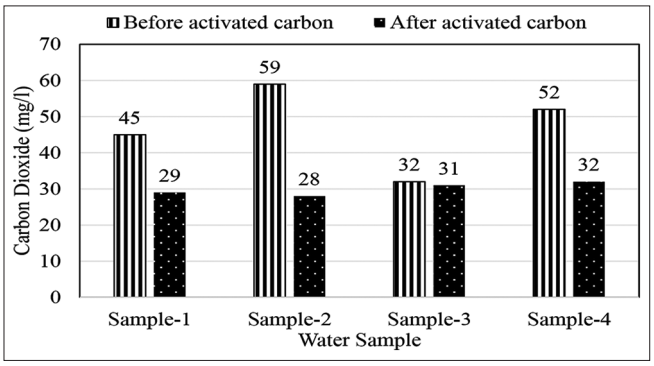

Figure 6: Carbon dioxide before and after activated carbon filtration

indicator and carbonic acid were used in measuring carbon dioxide concentration. The values of CO_2 were found as 45, 59, 32, and 52 mg/l before passing the water through the activated filtration for the sample of S1, S2, S3, and S4, respectively. Reduction of CO_2 concentration was observed for all the samples after passing the carbon activation filtration and it was found as 29, 28, 31, and 32 mg/l of CO_2 consecutively.

CONCLUSIONS

The aim of this study was to measure the drinking water quality by focusing on AC filtration process and its applicability. Water samples were collected from four different locations of Dhaka city and characterized into major water quality parameter such as pH, color, turbidity, alkalinity, chloride, and carbon dioxide. The considered water quality parameters were also measured before and after using AC filtration process. The major findings of this study are listed as below:

- Results of using AC filter for all water parameters were satisfactory as all the selected parameters of water found to be shown positive results after passing AC filtration as a water treatment process.
- pH values of four water samples were reduced and satisfy the Bangladesh standard (6.5–8.5) as well as the WHO guideline value (6.5–8.5).
- Alkalinity and carbon dioxide reduction was observed for all the considered water samples due to engaging AC process.
- The concentration of turbidity changes significantly and it goes <1 NTU due to use of AC filtration. The results in change of chloride concentration were also satisfactory.
- Although analyzed parameters were not most significant to make sure and secure of drinking water quality, these are enough considerable for which people got demotivated to use surface water for drinking and other uses purposes.
- However, the following method of filtration was found to be efficient in reduction of major parameters in certain extent of drinking water.

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