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SURFACE WATER QUALITY ASSESSMENT IN TERMS OF FILTER DEVELOPMENT: A CASE STUDY IN BAGERHAT CITY

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ABSTRACT

Although it contains numerous physical, chemical, and biological impurities, fresh water—the most important component of all living forms—is essential for life, just as oxygen is, and everything depends on it to survive. Rivers, lakes, ponds, glaciers, and rainfall are the primary sources of surface water. This study focuses on the assessment of the water quality index (WQI) at three selected locations in Bagerhat, Bangladesh. Water samples were taken for three months from the main stations, which were split into ten sub-stations, for laboratory analysis. Various water-quality parameters were examined from the collected samples, where the maximum values of parameters before filtration were pH (7.75), total dissolved solids (500mg/l), total suspended solids (700mg/l), total solids (1200mg/l), chloride (230mg/l), dissolved oxygen (6.1mg/l), biochemical oxygen demand (2.7mg/l), and alkalinity (155mg/l). Based on the correlation study, significant parameters, including TDS, TSS, TS, chloride, and DO, are somewhat associated with one another.

Keywords: *Water Quality Index, Surface Water, Laboratory Analysis, Water Quality Parameters, Filtration.*

INTRODUCTION

Different properties of water are important for users, though it depends on the purposes for which it is used. The properties of drinking water must be suitable for health. Safe drinking water is also considered a pre-requisite for developing public health and economic growth. To satisfy their bodies' needs, all people who are thirsty look for safe, pure drinking water that contains micronutrients. Modern urbanization, increasing population, household waste, and industrialization are all degrading water quality by introducing vast quantities of contaminants. Hence, the demand for drinking water is increasing in all cities in Bangladesh. One cannot think about life without water. Everyone uses water in their daily lives for drinking, washing, flushing, bathing, and cooking. In addition, water is widely used in irrigation, building construction, electricity generation, steam generation, etc. To satisfy this need, pond sand filters (PSF) were the major (44%) drinking water sources, followed by ponds (33%), rainwater harvesting (RWH) systems (13%), and others (10%) at Sarankhola Upazila, Bagerhat (Hossain et al., 2017). Bangladesh is a low-lying flat country with vast island water bodies, including some of the biggest rivers in the world, and is extremely vulnerable to climate change because of its geophysical characteristics. The surface water quality of Bangladesh's ponds is becoming increasingly polluted. Human health is harmed by the contaminating presence of trace metals in water. According to a WHO assessment from 2008, almost one-fourth of Bangladesh's population, mainly in the coastal districts, lacks access to clean drinking water. Potable water is required for humans to live a normal everyday existence. In underdeveloped nations like Bangladesh, sadly, more than one in six individuals still does not have consistent access to this priceless resource (USAID, 2014). About 15 million people are already forced to drink saline water, and 30 million are unable to collect potable drinking water due to a lack of available safe water sources (Hoque, 2009). Khulna, Satkhira, and Bagerhat districts in Bangladesh's southwest have been designated as the most climate-induced, hazardous, and hardest-to-reach areas of the country (Ghosh et al., 2015), and they are having a very tough time getting access to clean drinking water (Quazi, 2006). Due to high salinity, the groundwater in some regions is unfit for human consumption (WHO, 2004), and there are some locations where neither the groundwater nor the surface water is saline-free (Rahman et al., 1997). Most of the rivers in the southern zone contain much higher salinity as compared to the drinking water standard or domestic use (PUB, 2010). Additionally, the Farakka effect causes nearly none of the rivers in this region to flow during the dry season (Ali and Syfullah, 2012). The present water supply in Khulna is mainly from groundwater sources drawn from both deep and shallow tube wells (Hossain, 2017). Conjunctive usage of groundwater and surface water will be necessary in the long run as demand rises, even if surface water may experience saline intrusion during the dry season (KWASA, 2010). Trivedi (1990) examined river water pollution. He revealed that the pollution of a river first affects its chemical quality and then systematically destroys the community's delicate food web. The purpose of this study was to determine the water quality parameters of Bagerhat City. Subsequently, compare the values with WHO and Bangladeshi standards and decide whether the water from those sources can be drunk or not.

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METHODOLOGY

Description of Study Area

Bagerhat city is famous for its mosques, and it is one of the rising cities in Bangladesh. Three major points in Bagerhat, namely Sixty Dome Mosque Pond, Khan Ali Dighi, and PC College Pond, were chosen as the selected areas because the combined population of them is over ten thousand. There are more than 2,000 households in this community. There is no appropriate water distribution system for Bagerhat WASA, and tube well quantity is very low for this community. Hence, pond water is mainly used in those stations for various purposes such as drinking, washing, and bathing in many communities.

Figure 1: Study Area Points

Preliminary Test on Waste Water

The collected water from the selected points had a foul smell and appeared gray; it was also found to be unfit for any purpose. Physical, chemical, and biological tests were conducted on the collected samples to cleanse the water for drinking and other purposes. To purify the water, a filter was developed from scratch in the laboratory and used to conduct tests such as pH, total dissolved solids, total suspended solids, total solids, chloride, dissolved oxygen, biochemical oxygen demand, and alkalinity. The water quality analysis was done as per the IS specifications. We decided to create a 6-layered filter based on the results. The required materials and preparation procedure for the filter apparatus are given as follows:

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Filter Development

Natural filter means the material adjacent to the screens in Type II wells that is part of the screened formation and that is relatively free of fine-grained material because of well development. The pipe for the filter is separated into six layers and filled with coarse and fine aggregate, respectively, from top to bottom.

*4 inches of soil or silt
*6 inches of sand or small gravel
*3-inch-large gravel

Filter Materials

Coarse Aggregate: River gravel, crushed stone
Fine Aggregate: local sand 3-inch; Kushtia sand 5-inch; Sylhet sand 6-inch
50 mm PVC pipe
3 buckets
Iron stand
Sieve net

Working of the Filter

Six layers make up the waste water filter, and there are four distinct materials in each of these layers. The addition of the materials—coarse and fine aggregate—is done to get rid of different biological, chemical, and physical traits of the water. An iron platform and 50mm PVC pipe are used to build the filter. The coarse aggregate is applied to the topmost layer and is more successful at reducing acidity than other types of aggregate. The second layer is made of fine aggregate, while the third layer is made of cactus powder. Applying cactus can decrease the amount of dissolved oxygen and biochemical oxygen demand.

Figure 2: Water Filtration Device

Sand fills the lowest layer, which serves as a support layer for the upper levels. A reducer is connected to the pipe's lowest section by a sieve net. The flow rate has been determined for various material thicknesses. The most useful case is chosen after conducting column study in many cases. It is taken into consideration which material qualities and thickness provide the best flow rate. From January through March 2022, every laboratory test for assessing the parameters of water quality was performed. In the end, a prepared Water Quality Parameter (WQP) index and Bangladesh Standards (BS) value were utilized to compare the findings.

RESULTS AND DISCUSSION

The research was carried out using standardized lab test procedures. The objective of the tests was to determine the quality of the water in the selected samples from the three locations. All tests were conducted at the Environmental Laboratory at North Western University, Khulna.

Determination of pH of Collected Water Sample

The measurement of hydrogen ion activity in the solution is referred to as "pH." pH indicates the sample's acidity but is actually a measurement of the potential activity of hydrogen ions (W) in the sample. The pH scale ranges from 0 to 14, with 7.0 being regarded as neutral. Acidic solutions are those with a pH value lower than 7.0, and bases are substances with pH values greater than 7.0 but less than 14.0. Every organism is influenced by the degree of acidity in stream water and performs optimally within a specific range. Since the pH scale is logarithmic, a change in pH of one unit corresponds to a ten-fold change in acidity. In other words, pH 6.0 is ten times more acidic than pH 7.0, and pH 5 is one hundred times more acidic than pH 7.0.

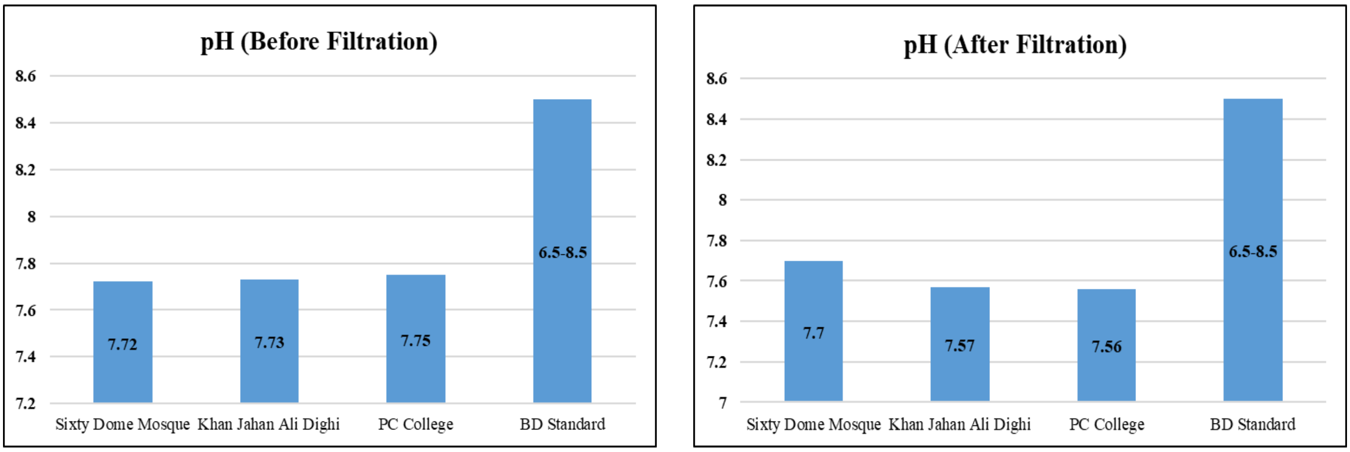

Figure 3: pH before (left) and after (right) filtration

Figure 3 illustrates that the assessed pH value of the collected water sample before the filtration was 7.72 for the Sixty Dome Mosque, 7.73 for Khan Jahan Ali Dighi, and 7.75 for PC College. After the samples were filtered, the pH values changed to 7.7, 7.73, and 7.75, respectively. So according to the Bangladesh standard, which is 6.5–8.5, the water can be considered for use.

Total Dissolved Solids (TDS) of Collected Water Sample

By passing a measured volume of the sample through an ordinary glass fiber filter in a lab setting, the total dissolved solids are ascertained. A pre-weighed ceramic dish is then filled with the filtrate (i.e., filtered liquid), and the dish is then placed in a drying oven set to 103 C. The temperature is raised to 180 °C after the sample has dried in order to remove occluded water or water molecules entrapped in the mineral matrix. Total dissolved solids are the total dissolved (filterable) solids as determined by the method specified in Title 40 of the Code of Federal Regulations (40 CFR) Part 136.

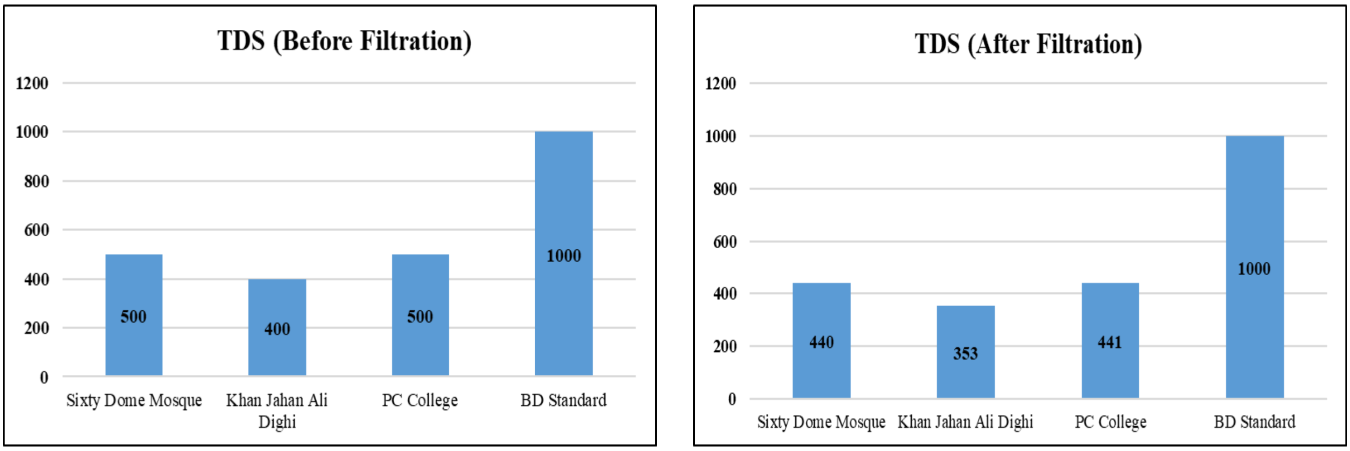

Figure 4: Total dissolved solids before (left) and after (right) filtration

Figure 4 depicts that the evaluated total dissolved solids (TDS) value of the collected water sample before the filtration was 500 for the Sixty Dome Mosque, 400 for Khan Jahan Ali Dighi, and 500 for PC College. TDS values were 440, 353, and 441 after the samples were filtered, respectively. So according to the Bangladesh standard for TDS, which is 1000, the water can be considered for use or drinking purposes.

Total Suspended Solids (TSS) of Collected Water Sample

Total suspended solids, expressed as milligrams of solids per liter of water (mg/L). Suspended sediment is also measured in mg/L. By filtering and weighing a water sample, TSS can be determined with the greatest degree of accuracy. This is often time-consuming and difficult to measure accurately due to the precision required and the potential for error due to the fiber filter. The results of laboratory tests on river, pond, and tube well water samples were 900 mg/l, 550 mg/l, and 1000 mg/l, respectively. According to the Bangladesh Standard, the acceptable value is 10 mg/l. So, the results are not acceptable. Algae

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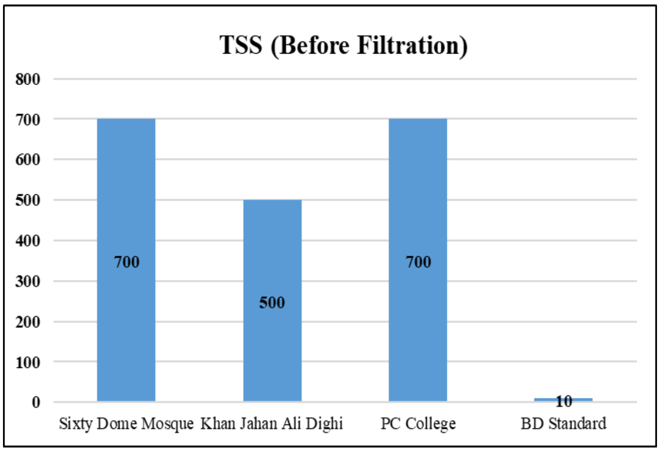
in particular can prevent sunlight from reaching submerged plants when it is suspended in the water. Since the plants rely on respiration (eating oxygen) rather than photosynthesis, this may result in a decrease in the concentration of dissolved oxygen.



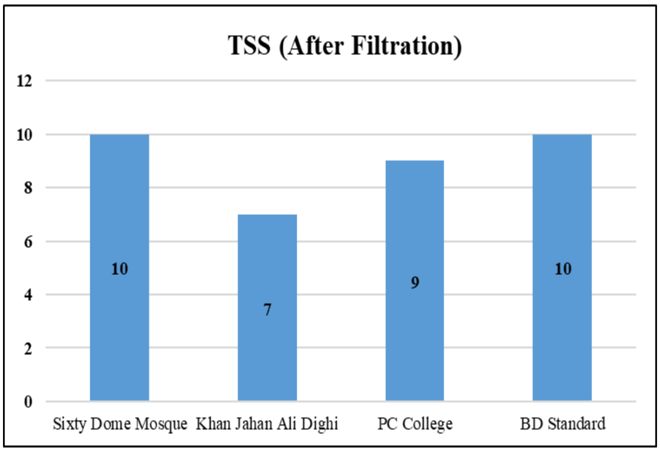
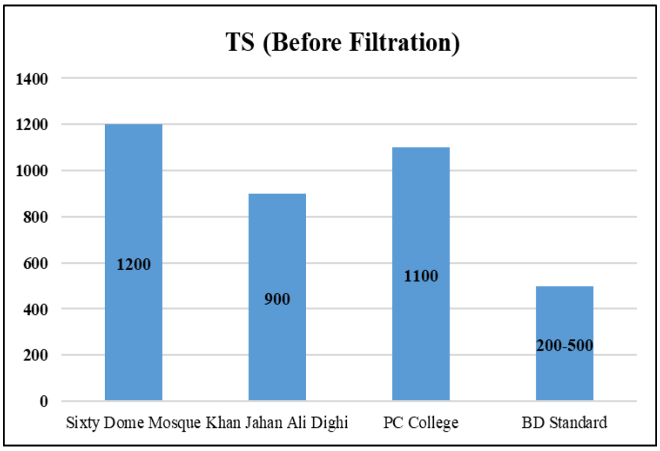


Figure 5: Total suspended solids before (left) and after (right) filtration

According to figure 5, the determined total suspended solids (TSS) value of the collected water sample before the filtration was 700, 500, and 700 for the Sixty Dome Mosque, Khan Jahan Ali Dighi, and PC College, respectively. After the samples were filtered, the TSS value changed to 10, 7, and 9, respectively. So according to the Bangladesh standard, which is 10, the water can be considered for use.

Total Solid (TS) of Collected water Sample

Total solids are the results of TDS and TSS. So, after testing the river, pond, and tube well water samples in the laboratory, the results were 1400 mg/l, 1300 mg/l, and 400 mg/l, respectively. According to the Bangladesh Standard and the World Health Organization, no value is shown.



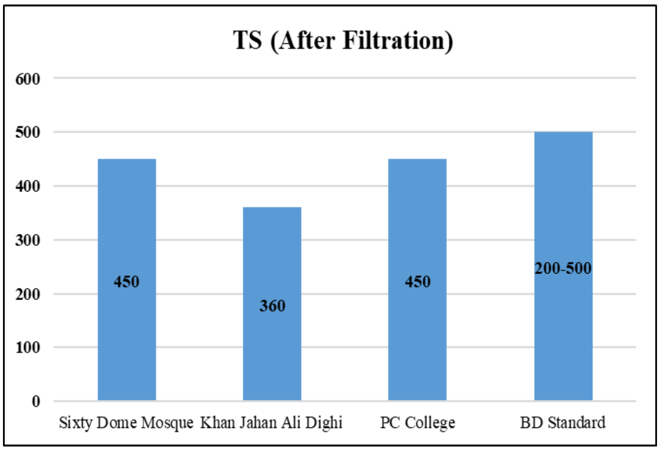


Figure 6: Total solid before (left) and after (right) filtration

The above figure 6 delineates that the assessed total solid (TS) value of the collected water sample before the filtration was 1200 for Sixty Dome Mosque, 900 for Khan Jahan Ali Dighi, and 1100 for PC College, which is tremendously high compared to the standard value. Consecutively, the samples were filtered, and the pH values changed to 450, 360, and 450, respectively. So according to the Bangladeshi drinking standard, which is 200–500, the water can be used or drunk.

Determination of Chloride of Collected Water Sample

Silver ions (Ag+) can precipitate chloride ions (Cl-) as AgCl in a neutral or slightly alkaline solution. Potassium chromate can be used to determine the point at which silver nitrate titration of chloride results in neutral or slightly alkaline solutions. This approach can be used to detect the presence of chlorides in water. If silver nitrate is added to a solution containing chloride ions (Cl-) and chromate ions (CrO4–), silver chloride (AgCl) of white color precipitated first. After all chloride ions are precipitated, silver starts to react with chromate ions to form silver chromate (AgCrO4) of a reddish-brown color. This can be taken as the end point, and chloride can be quantitatively estimated. Take 50 mL of the sample (V) and dilute it to 100mL. If the sample is colored, add 3 mL of aluminum hydroxide, shake well, allow to settle, filter, wash, and collect the filtrate. The

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sample is brought to pH 7–8 by adding acid or alkali as required. Add 1 mL of indicator (potassium chromate). To obtain a reddish-brown precipitate, titrate the solution against a standard silver nitrate solution. Recorded the volume (V1) and followed the same steps to blank and record the volume (V2).

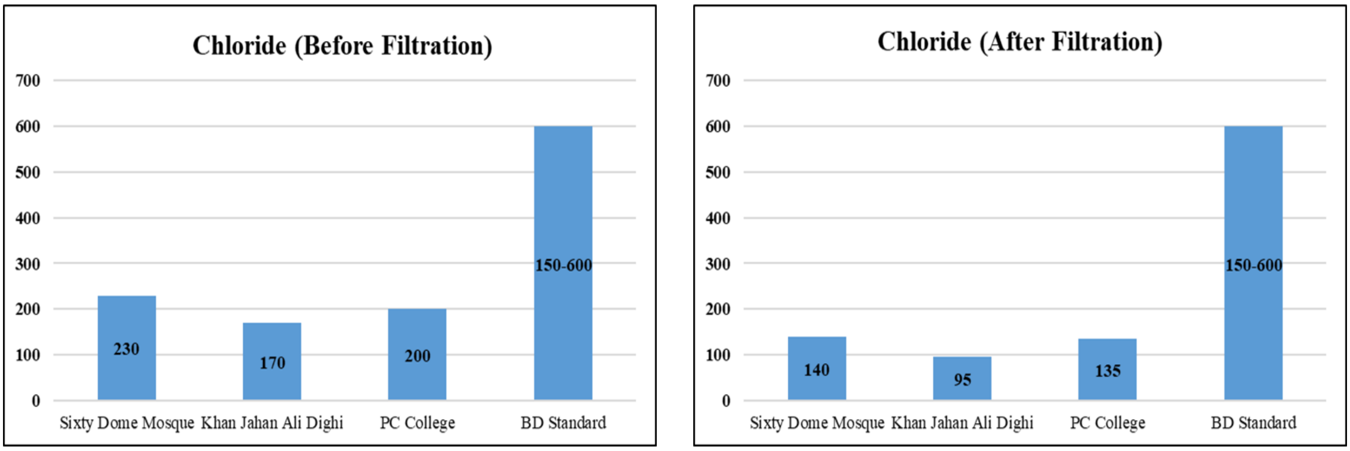

Figure 7: Chloride before (left) and after (right) filtration

Figure 7 illustrates that the assessed chloride values of the collected water samples before the filtration were 230, 170, and 200 for the Sixty Dome Mosque, Khan Jahan Ali Dighi, and PC College, respectively. The chloride values after filtration were 140, 95, and 135, respectively. So, according to the Bangladeshi standard of 150-600, the water is safe to use.

Dissolved Oxygen (DO) of Collected Water

By introducing a sequence of reagents that result in the formation of an acid compound, which is then titrated with a neutralizing chemical to produce a color shift, the dissolved oxygen in the sample is then fixed. The endpoint, which corresponds with the dissolved oxygen level in the sample, is the point at which the color changes. It is ideal to analyze dissolved oxygen in the field since atmospheric equilibrium will have less of an impact on the specimen. It is important to measure dissolved oxygen as promptly and accurately as possible. Ideally, samples should be measured in the field immediately after collection. Carefully fill a 300-mL glass Biological Oxygen Demand (BOD) stopper bottle brim-full with sample water. Just below the liquid's surface, insert the calibrated pipette to add 2 mL of manganese sulfate to the collection container right away. The sample will be contaminated with oxygen if the reagent is put above the sample surface. To prevent the introduction of bubbles, slowly squeeze the pipette. Titrate gradually until the sample becomes transparent. By the time this experiment reaches its conclusion, the blue color will no longer be there with just one drop of the titrant. Make sure that every drop is thoroughly incorporated into the sample before adding the next. To verify the disappearance of the blue tint, it can occasionally be beneficial to hold the beaker up to a white piece of paper. The amount of titrant in milliliters used is comparable to the concentration of dissolved oxygen in the sample. In the subsequent steps, the amount of sodium thiosulfate added equals 1 mg/L of dissolved oxygen.

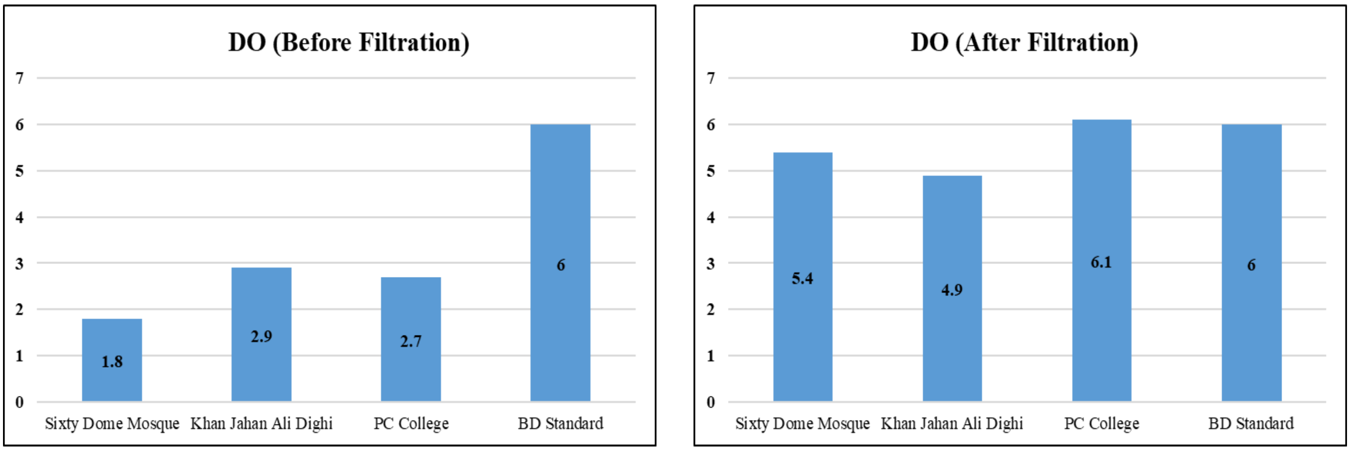

Figure 8: Dissolved oxygen before (left) and after (right) filtration

According to the above pictorial 8, the determined dissolved oxygen (DO) values of the collected water samples before the filtration were 1.8 for the Sixty Dome Mosque, 2.9 for Khan Jahan Ali Dighi, and 2.7 for PC College. After the samples were filtered, the DO values turned to 5.4, 4.9, and 6.1, respectively. So according to the Bangladeshi drinking standard, which is 6.0, the water can be considered for drinking as well as using.

Biochemical Oxygen Demand (BOD) of Collected Water

The biochemical oxygen demand (BOD) test quantifies how much oxygen bacteria need in order to metabolically oxidize organic material under aerobic conditions. Although it can also be stated in lbs/day, biochemical oxygen demand (BOD) is often expressed in mg/L. The bacteria consume the organic substance as food, and the cell uses it as energy when it is being oxidized. Calculating the amount of BOD, or food for the bacteria, requires monitoring how much oxygen is absorbed by the bacterium. The term "biochemical oxygen demand" (BOD) refers to a chemical process used to estimate the amount of dissolved oxygen that aerobic biological organisms in a body of water will require to decompose organic material present in a given water sample at a particular temperature over a certain time period. Then, how is BOD determined? Despite being commonly employed as a gauge of water's organic quality, it is not a precise quantitative test. It is typically stated as milligrams of oxygen used per liter of sample over the course of five days (BOD5) of incubation at 20 °C and is frequently used as a reliable surrogate for the level of organic pollution in water.

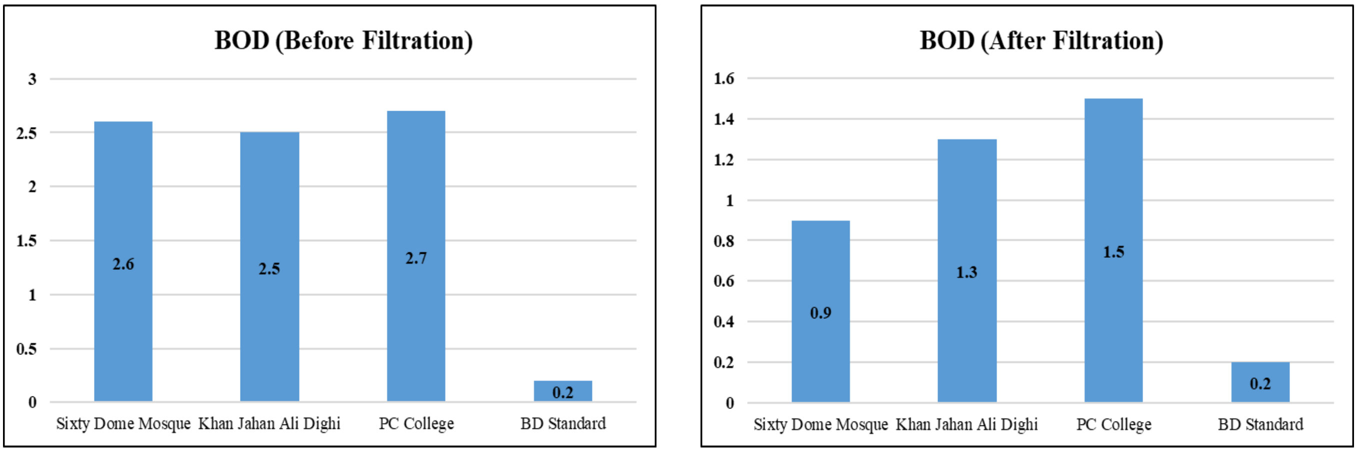

Figure 9: Biochemical oxygen demand before (left) and after (right) filtration

Figure 9 delineates that the evaluated biochemical oxygen value of the collected water sample before the filtration was 2.6 for the Sixty Dome Mosque, 2.5 for Khan Jahan Ali Dighi, and 2.7 for PC College. After the purification was done, the BOD values changed to 7.7, 7.73, and 7.75, respectively. So according to the Bangladesh standard, which is 0.2, the water cannot be considered for either drinking or using.

Determination of Alkalinity of Collected Water Sample

Alkalinity measures how well water can neutralize acid or H+ ions. Most alkalinity in water comes from calcium carbonate leached from rocks and soil. The term "buffering capacity" is frequently used to describe this capacity. For instance, if the same weak acid solution is added to two vials of water, one of which has no buffering power (for example, zero alkalinity) and the other of which has buffering power (for example, an alkalinity of 50 mg/l), the pH of the zero-alkalinity water will instantly decrease while the pH of the buffered water will alter very little or none whatsoever. When the buffering capacity of the solution is overwhelmed, the pH of the buffered solution will change. Alkalinity refers to water's ability to neutralize acid. This is essentially a buffering capacity statement. A buffer is a solution to which an acid can be added without changing the concentration of available H+ ions (without changing the pH) appreciably. It essentially absorbs the excess H+ ions and protects the water body from fluctuations in ph. In most natural bodies of water, the buffering system is carbonate-bicarbonate (H2C03, HC03, and C03).

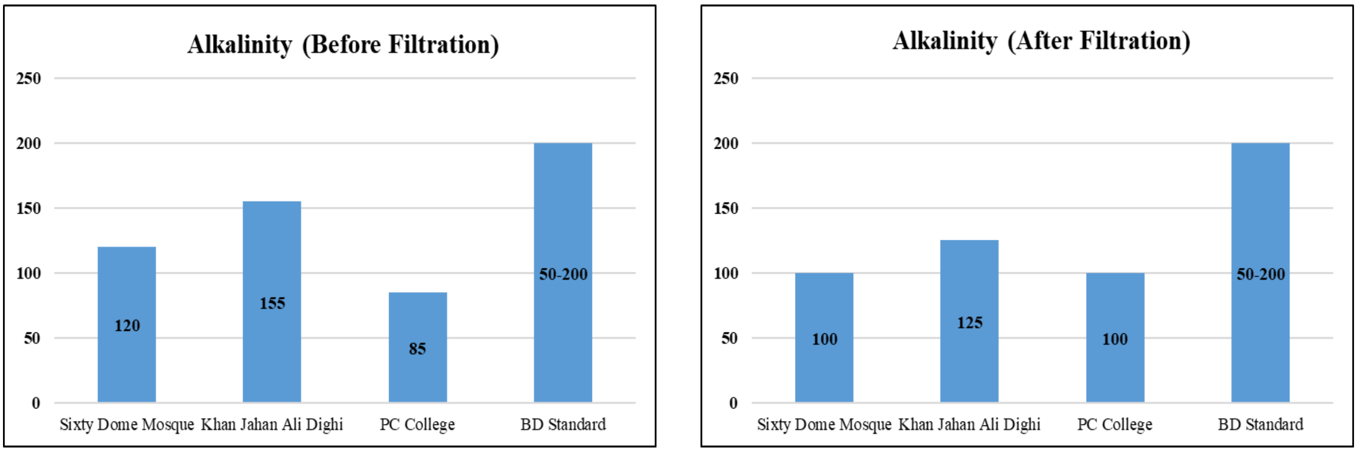

Figure 10: Alkalinity before (left) and after (right) filtration

According to the above pictorial 10, the determined alkalinity values of the collected water samples before the filtration were 120, 155, and 85 for the Sixty Dome Mosque, Khan Jahan Ali Dighi, and PC College, respectively. After the collected water samples were cleansed, the alkalinity values changed to 100, 125, and 100, respectively. So according to the Bangladeshi drinking standard, which ranges from 50 to 200, the water can be considered for either drinking or using.

CONCLUSION

The residents in the study region have been striving to get access to clean drinking water as the water sources are being polluted on a daily basis, yet a sizeable number of them are still drinking directly from microbially contaminated pond water without sufficient treatment. The bulk of the studied water quality metrics, including pH, total dissolved solids, total suspended solids, total solids, biochemical oxygen demand, dissolved oxygen, chloride, and alkalinity, were found to be substantially exceeding Bangladeshi and WHO drinking guidelines, according to this study. The highest values were pH = 7.75, TDS = 500 mg/l, TSS = 700 mg/l, TS = 1200 gm/l, chloride = 230 mg/l, and DO = 6.1. Therefore, the water from these sources cannot be utilized or consumed without filtering. Despite the fact that most people don't know how to properly filter water or that the government hasn't built any water treatment facilities, they mostly drink and use contaminated water, which makes them sick and spreads new diseases. Thus, the water from these sources needs to be filtered before being used or even consumed. The results of this investigation demonstrated that it is possible to filter water using inexpensive construction materials and common chemicals. While it is not possible to completely disinfect the water after cleaning it with this filter, the majority of the pollutants can be brought down to a negligible level. Furthermore, the government must provide water treatment facilities to the residents of these coastal areas, and local NGOs and humanitarian groups must enlighten the populace about the risks associated with drinking and utilizing dirty water.

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