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REMOVAL OF PATHOGENIC BACTERIA PRESENT IN LOCAL WATER BODIES IN DHAKA CITY USING ACTIVATED CHARCOAL: AN EASY AND ECONOMICAL WAY OF WATER PURIFICATION

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Abstract

Benjamin Franklin said, "When the well is dry, we know the worth of water". Localities of Bangladesh specially in Dhaka city are deprived of clean water. Due to extensive urbanization and industrialization along with zero investment in wastewater management the dearth of clean water is now a harsh reality. The rivers flowing over the heart of Dhaka and the large water bodies are stacked with wastes, exposing the localities to contaminants containing waterborne disease endorsing bacteria too. Moreover, the underground water quality has withdrawn. By the time the water purification processes became complex and expensive. Although, charcoal in this time of crisis can be an economic substance to eradicate this dearth. Charcoal has a phenomenal adherent property which can be incorporated to remove bacteria. In the following, it has been attempted to remove the bacteria using the Petri dish method in agar plates in the microbiology lab. By using a specific amount of charcoal once for each water sample the study has shown that charcoal is 95% successful to remove bacteria. However, after the filtration process of purification technique if the contaminated charcoal us left indisposed the bacteria starts to proliferate inside the pores of charcoal.

Keywords: *Activated Charcoal, Water bodies, Pathogens, Contamination, Vibrio cholera, Escherichia coli*

List of Abbreviation:

icddr,b: International Centre for Diarrhea Disease Research, Bangladesh
SEM: Scanning Electron Microscope
ETP: Effluent Treatment Plant
DBPs: Disinfection By-Products
BOD: Biochemical Demand of Oxygen
COD: Chemical Demand of Oxygen
FIB: Fecal Indicator Bacteria

Introduction

The developing populace, the expansion of industrialization and the Agricola generations require adequate water meeting the requirements of clean water. In some areas of there is a lack of surface water. The shallow groundwater stored are highly tainted. Hence, that water is of inadequate quality and over-misused. It is high time to mull over all the demonstrated water purifications that could decrease the existing debacle.

Water is a crucial resource that is required for the survival of all types of living being. Safe water intended to be harmless for drinking or utilizing it. To avoid inconveniences like sickness the water must be a contaminant-free or significantly low concentration of contaminants to be on the safe side. Safe water is evaluated with analysis which looks for conceivably unsafe contaminants and at the same time guaranteeing the certain administrative norms [1].

Water holds parts of disintegrated chemicals and since ground water moves through rocks and subsurface soil, it needs considerable chances to dissolve different substances. Water is the practically abundant substance on earth and important for the survival of living tissue. (About 25% about living organic entities are dependent upon about solid matter remaining 75% of water). Water cover 75% of the Earth's surface. 97.5% of it is the salty seawater, 2.4% of it is in underground and 0.001% is held by the atmosphere. 2% of the water on earth is frozen. Only and only 1% of drinking water is available on earth [2].

Safe drinking water is characterized as water with microbial, chemical and physical aspects that help the World Health Organization (WHO) has some guidelines of standards on drinking water. Water Pollution occurs mainly in two ways, either by a natural process (because of catastrophes like tsunami, tornadoes, increasing depth of groundwater, drought) or by anthropogenic activities (sewage, wastewater, ETP) [3]. There are 56 pathogens contributing to contamination. Furthermore, as parasites are "communicable" they easily spread from person to person. Typhoid, paratyphoid, salmonella, giardiasis and obviously cholera are the most observed water-borne diseases. The safety of potable water is greatly hampered by sanitation and limited garbage collection [4].

Bangladesh is a developing country with a growing population. There are many water bodies around the locality which are ill-treated and stacked with wastes. By natural processes like rainfall, the water bodies are filled with plentiful of water which washes away the wastes or sedimentation takes place ensuring clean water on the surface. Well, the water looks clean on the surface although when examined in the lab a good number of bacterial growth has been observed. The scenario is pretty common in cities like Dhaka. A huge population of Dhaka lives under the poverty line who cannot afford safe water for utilization which is becoming a threat to them. If these available water bodies are treated well and if an easy way is figured out to clarify the available source of water, then people living under the poverty line can help themselves managing clean water. Charcoal is an ancient and economic mean for water purification.

Adherent material, Charcoal is an ancient medium used to clarify water. The use of Charcoal is an inexpensive method. Charcoal has a porous structure, so when finely divided it gives a good adhering surface for to contaminants to get attached to this pure carbon molecule and thus removed easily from water.

Charcoal has antibacterial property. The porous structure of Charcoal is the key reason. In the following study, experiments had been performed to visually inspect the nature of the antibacterial property.

Charcoal is extensively produced in the household of Bangladesh by the people living under the poverty line. They can use Charcoal for water purification and meet the need for water.

Evolution of Charcoal Use

Since 3750 B.C charcoal has been used by different civilizations. The Egyptians used charcoal to prevent wood rot [5]. For antibacterial and antifungal property water was stored in charred barrels in ships. In 1786, charcoal was first used as decolorizer [6]. Later this decolorization process was implemented in English sugar refinery in 1794 [5].

In the 19th-century charcoal air filters were used for vapor and gas removal in sewage systems of London. In 1881, Kayser first termed the “Adsorption

property" of charcoal demonstrating the gas uptake property of charcoal.

In the First World War Granulated Activated Carbon (GAC) was manufactured to be used in gas masks for air purification because GAC has a greater adsorption range than Powdered Activated Charcoal (PAC) [7].

Industrial wastewater contains pesticides, herbicides (Disinfection By-Products), amines, acids, phenolics, aromatic solvents which are mostly chlorinated (Synthetic Organic Compound). These can be of High Molecular Weight (HMW) or of Low Molecular Weight (LMW) [8]. These make water more complex and not easy to be purified. However, the use of GAC made it easier in purification and sterilization of water.

Clean Water Crisis in Bangladesh

One of the most overpopulated countries, Bangladesh, where 60% population is deprived of safe water [9]. As a result, unsafe water gas endorsed water-borne diseases like diarrhea, typhoid, cholera and many more.

Fecal Indicator Bacteria (FIB) like Vibrio cholera and Escherichia coli helps to clarify the fecal pollution scenario and has proven that this certain situation is prevailing in Bangladesh [10]. Before introducing tubewell in a rural area the reason behind the mortality rate of adolescent kids was diarrhea. Although prologue of tubewell assured cheaper means of safe water but failed to assure proper sanitation. Later Oral Rehydration Treatment (ORT) has been used to treat diarrhea that had resolved the problem to some extent but extensive public awareness is also required [11].

If tubewell and proper sanitation can be implemented, then the diarrhea rate can be reduced to 65%. Only by tubewell, the problem will be resolved to 20.8% only [12].

Again over pumping groundwater could jeopardize groundwater supply specially in Dhaka. In 50 years the groundwater level has dropped to 200 feet in Dhaka [13].

Charcoal is used in the purification of water; it will not only resolve the safe water problem but also reduce the demand for groundwater.

Morphological analysis of samples by SEM

The SEM images of charcoal flour and the WPC sample Type A, and polypropylene filled with charcoal sample, taken at different magnifications are presented in **[Figure 1]**. The images revealed, the average particle size of charcoal flour is within 80-100 µm and is highly porous. The estimated range of average size of the elliptic pores can be of 5-15 µm. The SEM images reveal that the wood fibres are equally and homogeneously distributed in the polymer matrix. In this figure, strong interfacial adhesion between the wood fibres and polymer matrix can also be clearly seen. As a result of intense mixing and shear forces, while melting processes, the porous charcoal particles formed irregular stacks possibly due to the collapsing and restructuring of porous structure [14].

Material and Method

Area of Study

Water samples are collected from 5 water bodies located in Dhaka. They are Gulshan Lake, Niketan lake, Hatirjheel Lake, Dhanmondi Lake, and Bonosree Lake. Surrounding these lakes, a large number of populations settled down. By the time, these settlements have turned to society with domestic and nondomestic infrastructures. These lakes are the sources of fresh water. Unfortunately, all of them are ill-treated. The BOD value of the water samples is within the 10mg/L (standard 0.2mg/L). The COD value of the samples is within the range of 280-600mg/L (standard 200-500mg/L). The visual observation bacteria removal on agar plates will be done using these water samples. The pH of the samples is measured. The normal range of pH for safe water is within 6 to 8.5 [Table 1].

Collection of Charcoal

The charcoal that is used in the experiment is the domestically produced charcoal in mud stoves. The charcoal comprises of old bamboo and other firewoods. The Charcoals are crushed and sieved. Before using the powdered charcoal, it is dry heated in the dry heat oven at 70°C for 15-20 minutes making it moisture-free. The powdered form of Charcoal is used in the following experiment.

The activity of Charcoal on Referential Bacterial Strains

4 strains of bacteria (2 gram-positive and 2 gram-negative bacteria) are taken as a reference to visualize the activity charcoal at different quantity. 4 strains are Vibrio cholera (-), Bacillus subtillis (+), E. coli (-) and Stapylococcus aureas (+).

For each bacterium, 3 different amounts are taken viz. 800mg, 500mg and 200mg. For each bacterium, 4 test tubes have been prepared. In each of them contains 8mL of distilled water, bacteria strains stirred in it with the loop that is used to take a small amount of strain and adding a specific amount of charcoal out of 3 in the test tube (these steps should be done under laminar flow). The test tubes are vortexed by 5 minutes each to disperse the powder of charcoal in the water. After vortexing the bacterial water containing test tubes, it has been filtered using filter paper. This process is repeated for the other two quantities of charcoal. One test tube out of four should be charcoal free as it will be the blank in the agar plate. The agar plate is divided into 4 divisions. Divisions are individually marked as Blank, 200mg, 500mg, and 800 mg respectively. The 4 filtered bacterial water is then swapped using a cotton swab on the marked agar plate medium accordingly. The agar plates with swapped filtrate are left in the incubator overnight. Successive results have been observed. Charcoal successfully removed most of the referential bacteria. The most prominent result has been observed in filtrates treated with 800mg of charcoal. Note that, every apparatus should be properly sterilized.

The activity of Charcoal on Water Samples

Before using the water samples for charcoal activity examination it should be primarily filtered by filter paper removing the insoluble substances like moss, lichen, algae, etc. Then the filtrate water is placed aside for later use. From the filtrate water samples, taken 8mL with each of the three Charcoal quantities (200mg, 500mg, and 800mg) along with a blank (untreated water sample). For each water samples, 4 test tubes are prepared. In each of them contains 8mL of any specific water samples and adding a specific amount of charcoal out of 3 in the test tube. The test tubes are vortexed by 5 minutes each to disperse the powder of charcoal in the water sample. After vortexing the water sample containing test tubes, it has been filtered using filter paper. This process is repeated for the other two quantities of charcoal. One test tube out of four should be charcoal free as it will be the blank in the agar plate. The agar plate is divided into 4 divisions. Divisions are individually marked as Blank, 200mg, 500mg, and 800 mg respectively. The 4 filtered bacterial water is then swapped using a cotton swab on the marked agar plate medium accordingly. The agar plates with swapped filtrate are left in the incubator overnight. The swapping should be done under Laminar Flow.

Result and Discussion

After leaving overnight, the Petri dishes have been observed carefully. It showed that the Charcoal treatment has been successful to remove bacteria from the water samples because of its adhering property and porous structure [Figure 2-7].

The charcoals are not reusable. Used charcoals can be hazardous as the surface area of each particle of charcoal is covered with the bacteria that it had absorbed from the water samples. As a result, there are some possibilities of microbes to proliferate within the waste charcoal powder solution. It is to be mentioned that Charcoal does not kill bacteria. Rather it just carries the bacteria with itself during filtration. The pH of the water samples is measured after charcoal treatment. The pH remains within the range of safe water. The color of the water samples is improved. The color seems to be close enough to crystal clear. No particle found to be floating or suspended in the water samples.

Conclusion

The study has revealed the old ancient facts of charcoal that it is useful and economic for using in the water filtration process. The study has been performed with powdered charcoal. By visibility, it is evident that charcoal has a unique adhering property and porous structure that is able to captured minute ingredients within its structure. These minute ingredients are most hazardous for health, making that water fail the requirements of safety. The result is about 95% success in the removal of bacteria but not killing them. Leaving the contaminated charcoal will help the bacteria to proliferate. This study can be implemented in the urban area, where a good number of the population is living under the poverty line and are unable to ensure safe water for use due to economic circumstances. For this very reason, they are the first to suffer from water-borne

diseases. Charcoal is a very common ingredient to them and it is produced domestically on a daily basis. Thus, implementing the study here, at least a type of water can be ensured which is free from bacteria.

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Table-1: pH of the collected water samples.

Sample	pH
Gulshan Lake	7
Niketon Lake	6.93
Bonosree	6.93
Hatirjheel	7.1
Dhanmondi Lake	7.2

Figure 1: The Scanning Electron Microscope (SEM) images of Charcoal.

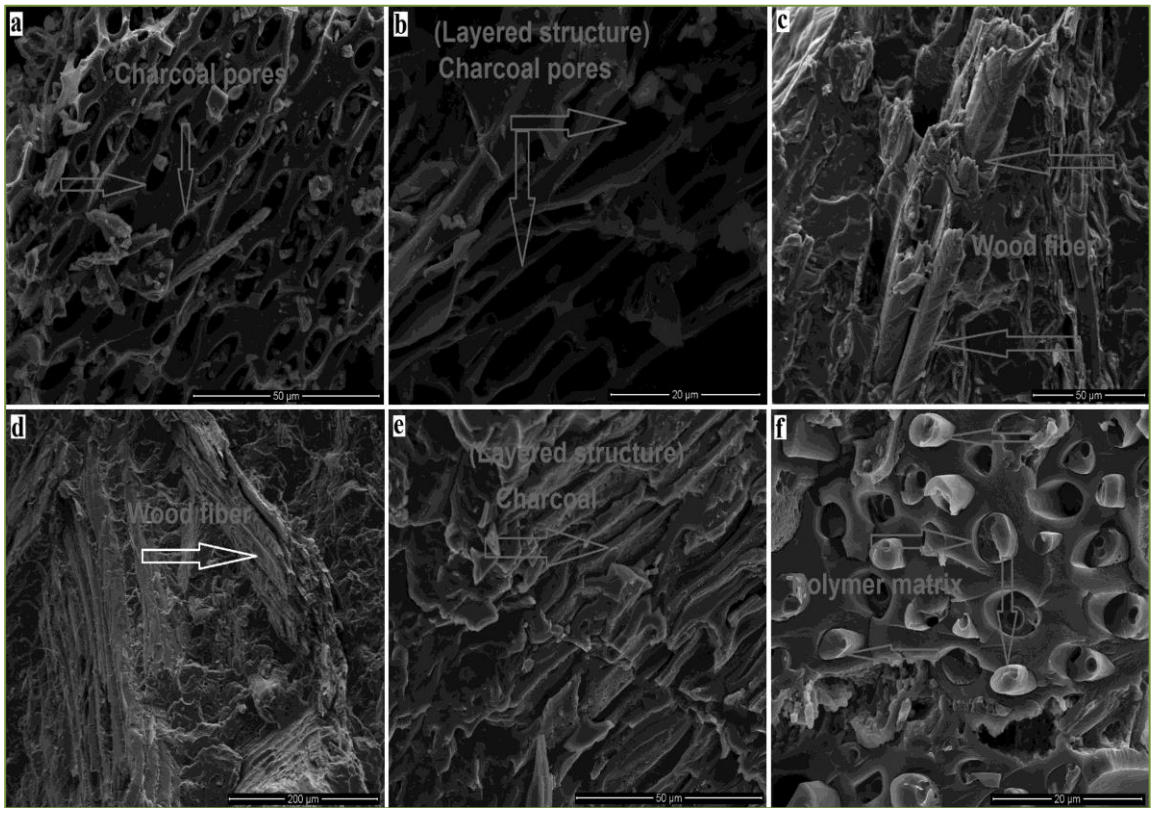

Figure-2: Removed Bacterial from Gulshan Lake sample.

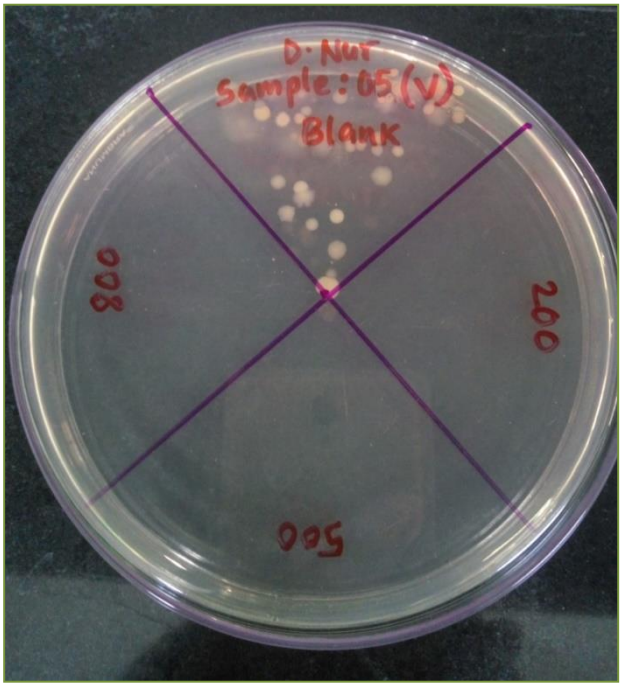

Figure 3: Removed Bacterial from Niketon Lake sample

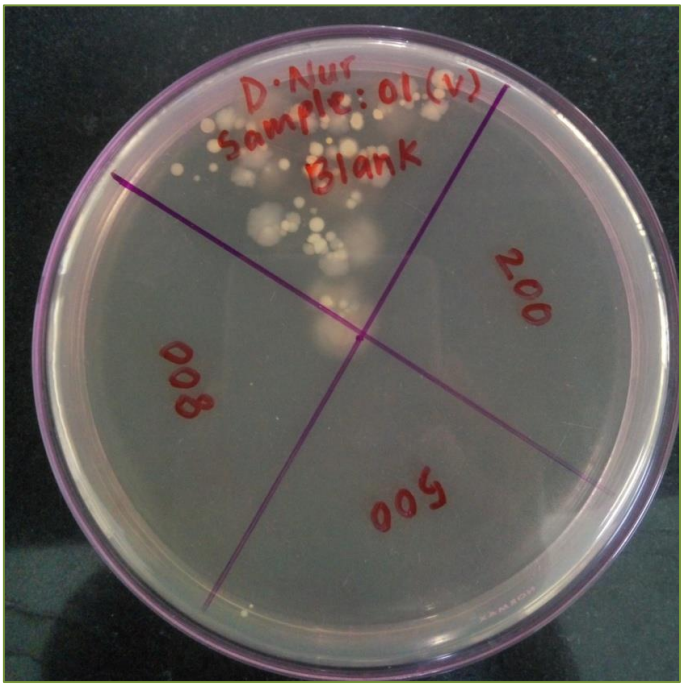

Figure 4: Removed Bacterial from Bonosree Lake sample

Figure 5: Removed Bacterial from Hatirjheel Lake sample

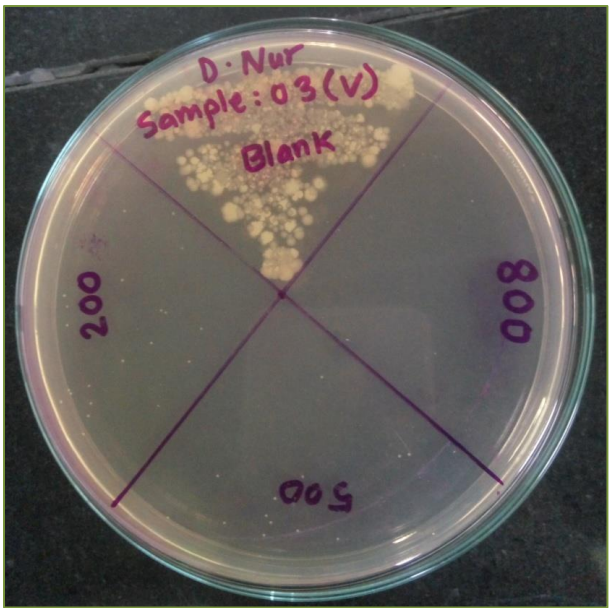

Figure 6: Removed Bacterial from Dhanmondi Lake sample

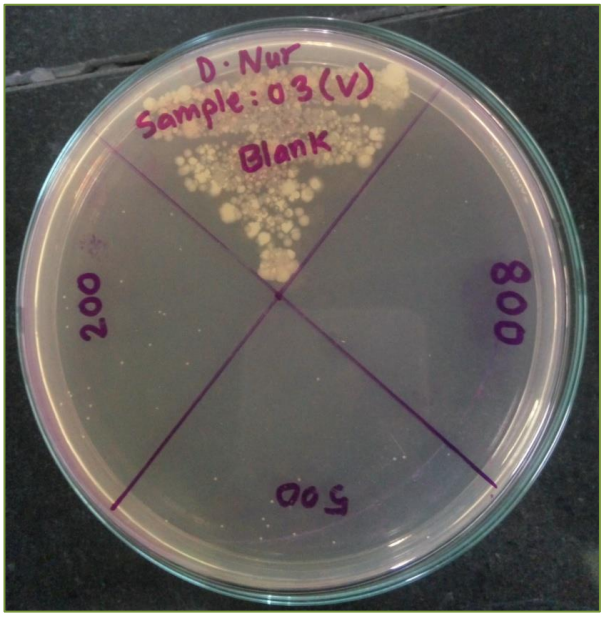

Figure 7: Growth of bacteria in water treated with charcoal and left for 4 nights observed in the agar plate