QUALITY ASSESSMENT OF THE RAIN WATER SAMPLE COLLECTED FROM COASTAL TERRITORY AND DIFFERENT LOCATION OF CHATTOGRAM CITY

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Roll no: 0119/11

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Master of Science in Applied Human Nutrition and Dietetics

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June,2022

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DEDICATED TO MY BELOVED

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Abstract

Water plays a crucial role in the daily lives of all living beings. The sources could come from the earth or the surface. Although rainwater is known to be pure, its usage may be limited because of contamination from other natural sources, including those used in agriculture, industry, and transportation. In order to offer information on the results for use in policymaking and monitoring, numerous research projects on the assessment of rain water quality have been conducted. The purpose of this study was to evaluate the physicochemical parameters of the rainwater quality (August–September, 2021) and identify any potential health risks associated with drinking rainwater.The easiest and cleanest type of water source available to big groups of people, groundwater is often a dependable supply of water for households. However, owing to ecological changes and the effects of urbanization, this cleanest source of water has suddenly become polluted. The industrialization process makes this situation worse as well. Untreated industrial waste that is thrown straight onto the ground without any treatment seeps into the ground and taints nearby groundwater sources. Dumping of domestic garbage and poor drainage systems may also be to blame(G. Venkatesan*, 2013). The assessment process employed conventional techniques. The outcomes held up well when compared to other used references and WHO criteria. One of the most populous cities in Bangladesh, Chattogram has been plagued by issues like chaotic urbanization, overpopulation, water scarcity, waterlogging, and other issues. Of these, water scarcity is one of the most significant.Utilizing rainwater for storage and conservation is a cutting-edge method of reducing the problem of water scarcity. Humans can use this rainwater for a variety of things, hence it is important to determine its chemical. The nine zones of Chattogram City were used to collect the samples of rainwater. Around the world, people are increasingly using rainwater collected from roofs as a cost-effective substitute for commercially manufactured drinking water. Rainfall is initially free of microbial contamination, but it can be contaminated by people and animals, or it can proliferate human pathogens in stored rainwater, posing a serious risk of infectious diseases to people.In this study,PH of collected rain water sample found from the range of 5.7- 6.8. Total dissolved solid is comparatively higher in Cox'sBazar than any other places which is 359mg/L. TDS range found 2-68mg/L except Cox'sBazar. Nitrate and Sulphate did not found in collected rain water sample. Chloride present in the rain water sample of bandar, Cox'sBazar, patenga and raozan respectively 3.55,35.5,21. 3 and 10.6.Sodium present in the range of 103.5-777.4 mg/L.

KeyWords: P^H, TDS, Water-Harvesting, WHO, Pathogen, Urbanization, Rainwater, Chemical Composition

Chapter 1: Introduction

Background

In many nations, rainwater is the primary natural water used as a backup source of water for sustaining human life. Although rainwater is generally safe, the local environment and atmospheric conditions can have an impact on the chemical composition at the time of collection. As a result, different areas may have various elements concentrations, which are crucial to the effectiveness and acceptability of usage. The intricate interactions between cloud dynamics, microphysical processes, and a number of rainout and washout atmospheric chemical reactions culminate in the intricate chemistry of rainwater. The strength of the ingredients' physical characteristics into hydro geological, chemical transformation during cloud formation, and below cloud scavenging determine the acidity and chemical concentration in rain. Truly, the makeup of rain actually reflects the makeup of the environment it falls through (Al-Khashman, 2009). Understanding and researching the soluble components present in rainwater is made easier by understanding the chemistry of the atmosphere through which it falls. Additionally, the chemical makeup of rainwater sheds light on the relative contributions of different pollutants in the atmosphere as well as their regional distribution. Anthropogenic sources like SOx, NOx, and other acid precursors are the main culprits behind the acidic precipitation. It also helps to look into site-specific characteristics, such as the influence of emissions from industrial, urban, and agricultural sectors, and the biogeochemical factors that elaborate the physical processes regulating the chemical characteristics of the atmosphere in a given location. On the other hand, neutralization of acidity in rainwater can either be due to $CaCO_3$ in airborne dust (Munger, 1982) or or ammonia released from industrial, agricultural, and other natural sources (&, 2012).For instance, anthropogenic, terrestrial, and marine sources all have an impact on the chemical composition of rainwater in a sub-urban area of Spain (Jorge Moreda-Pineiro, 2014). Despite continuous monitoring of public water supplies by governmental agencies, little is done for monitoring the water quality of cisterns and tanks receiving rainwater. For this reason, it is very important to evaluate the quality of rainwater collected in these cisterns and storage tanks(a, 2009).Water resources development remains the primary key to open up the vistas of sustainability of agriculture and the standard of living by way of industrialization or urbanization. Technological advancements and industrial growth warrant an addendum of existing water resources that are primarily exploited by the agricultural sector. Though rainwater harvesting help to stabilize the supply-demand equilibrium for water, the quality of water as required for the multi-facets of the water usage arena consistently undergo validity criteria for a fearless consumption. The quality criteria required for domestic purposes are quite different when compared to those for irrigation or industrial applications. At the same time the water quality indices of inlet water alsovary depending on its source of origin, type of flow andmethod of collection. The qualitative assessment of different types of watersupplies at different stages inevitably helps in effective management of rainwater in its various forms. Thisstudy assumes great significance in view of increasing importance of rainwater harvesting worldwide(Manoj P. Samuel, 2012).Moreover, the impact of secondary aerosols, industrial dust, car exhaust, and sea salts on the chemical composition of rainfall. Given the likelihood that the local environment and important to analyze its chemical makeup in order to pinpoint the potential sources of various precipitation ingredients in a given area. Even if heavy metals and other pollutants are removed by rainwater, accumulation of heavy metals in the form of rain would be detrimental to the ecosystem. Because some trace elements, which are nutrients, can also behave as toxins if they are present over legal limits, it is imperative to monitor and accurately determine the levels of these contaminants. Numerous studies have been carried out in different parts of the world to show the presence of heavy metals in rainwater. On Earth, rain is a significant source of fresh water. It is naturally occurring water in its purest state. Therefore, it is believed to have been created through a natural distillation process. It does, however, include dissolved gases from the atmosphere, including ammonia, carbon dioxide, sulphur dioxide, nitrogen dioxide, and ammonia (D K Asthana, 1998). Large volumes of pollutants are released into the atmosphere by industrial processes, fossil fuel burning, mining, waste incineration, motor vehicles, and other human activities. Heavy metals are one of the most significant categories of atmospheric contaminants (Yuko Itoh, 2006).

Water Cycle:

We first know about 'Hydrological Cycle' in Iliad written by Homer. After that, at different times in the great writings of Thales, Plato, Aristotle, Leonardo the Vinchi, we get references to the Hydrological Cycle. The great philosopher Aristotle says, 'Militas's Thales has thought that 'everything is water'. In the opinion of Thales, the primary or primitive cause of all things of the universe is water. Everything originates from water and everything ends in water. Water is the material cause of every object. Two questions arise out of this observation: (1) Why did Thales say that water is the material cause of everything? And (2) by what process water has turned into everything? Or how has the universe originated from water? Thales did not give any answer to these questions — or if answered, we do not have any scope to know it. In this context, what Aristotle has said depending solely on inference is that at the root of nutrition of all kinds there is moisture that emits heat and all living beings eke out their living with the help of water. Moreover, in all kinds of seeds, there is present some moisture, and what is damp or wet results necessarily from water. By observing this, Thales, perhaps, came to the conclusion that water in the root cause of everything. Nothing is known from Thales about how has the universe evolved out of water. In this context, Zeller says that Thales perhaps thought that element and velocity were directly connected with each other.Burnet says that the inference of Aristotle may be influenced by some matter and that was Anaximenes; the philosopher after Thales has described the air as the root cause of every object — the very air which is thought to be the inseperable part and parcel of the evaporating condition of water. In truth, air has been regarded as the power and more transparent condition of moisture. 'Everything is water' or 'everything originates from water' — this view expressed by Thales was not so important but it was really landable that he, instead of explaining the existence of the universe by means of gods and goddesses, applied natural and scientific theory for it (Paul, 2014).

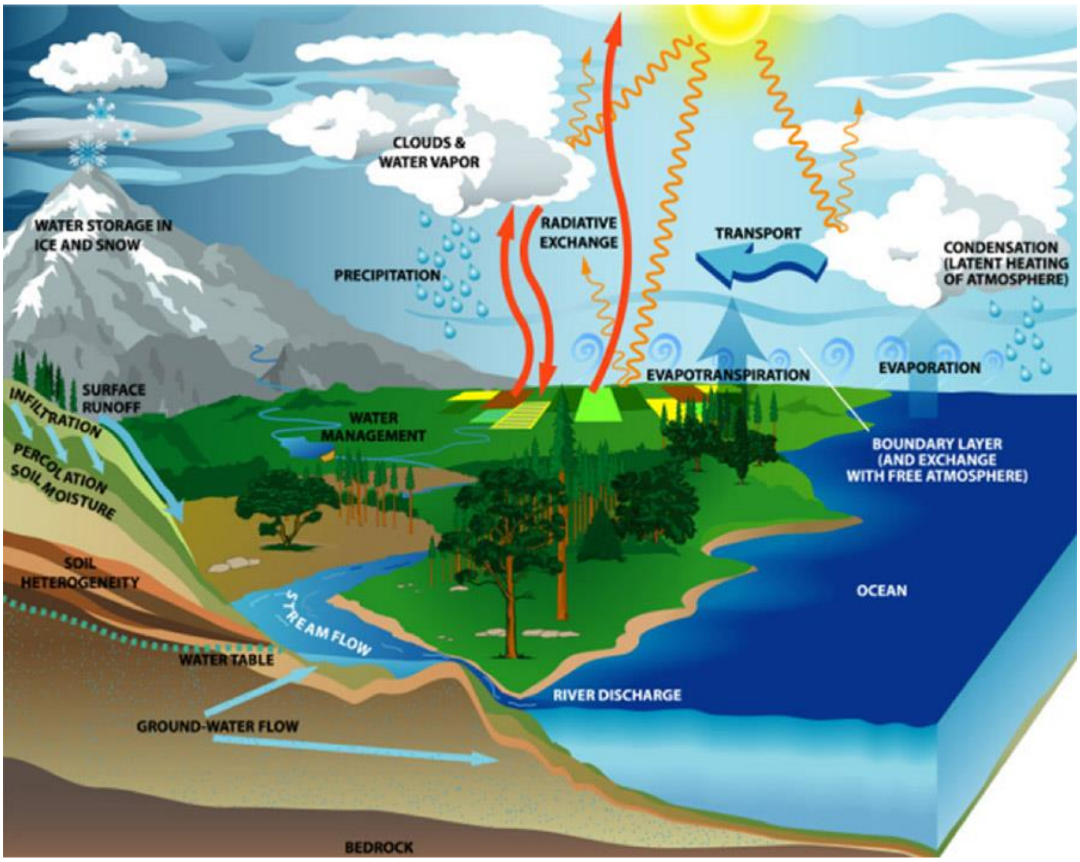


Figure 1: Water Cycle

The constant circulation of water on Earth and in the atmosphere is known as the water cycle. It is a complicated system with a wide range of processes. Water vapor is created when liquid water evaporates, and this water vapor then condenses to form clouds and falls back to earth as rain and snow. Different stages of water flow through the atmosphere (transportation). Runoff, infiltration, and percolation are three ways that liquid water moves across land and through the earth (groundwater). Plants absorb groundwater, which then evaporates from the plants and enters the atmosphere (transpiration). Ice and snow that is solid can instantly turn gaseous (sublimation). When water vapor solidifies, the inverse can also occur (deposition).

Evaporation:

When a liquid transforms into a gas, evaporation takes place. It is simple to picture when puddles of rain "vanish" on a hot day or when wet clothing dries in the sun. In these instances, the liquid water is evaporating into a gas known as water vapor rather than really dissipating. Global evaporation takes place. Evaporation is one of the three primary processes in the Earth's water cycle, along with condensation and precipitation. 90% of the moisture in the Earth's atmosphere is due to evaporation, and the remaining 10% is brought on by plant transpiration. There are three main states in which substances can exist: solid, liquid, and gas. A substance, like water, can transition between various phases through evaporation as one example. Other methods include melting and freezing. A sufficiently low temperature causes liquid water to freeze and solidify into ice. Water that has reached a solid state will melt if given enough heat. Further heating causes the water to evaporate and turn into water vapor, a gas. Melting, freezing, and evaporation occur as a result of the molecules in a substance starting to move more quickly or more slowly depending on the temperature. The molecules of a solid are closely packed and only vibrate in opposition to one another. The molecules in a liquid move freely but remain close to one another. They move erratically and are separated widely from one another in a gas. Evaporation happens during the water cycle when sunshine warms the water's surface. The sun's heat causes the water molecules to move faster and faster until they are moving so quickly that they become a gas and escape. A water vapor molecule stays in the atmosphere for around ten days after it has dissipated. .(John evans,USGS)

Condensation:

Water vapor starts to cool back down as it ascends higher in the atmosphere. The water vapor condenses when it becomes cold enough, turning it back into liquid water. Eventually, these water droplets will condense into clouds and precipitation. Making fresh water requires ocean evaporation, which is essential. Oceans are the main contributor to the atmosphere's water content because they span more than 70% of the Earth's surface. The salt remains behind once that water evaporates. Afterwards, the vaporized fresh water condenses to form clouds, many of which float over land. These clouds provide precipitation, which produces fresh water for lakes, rivers, and streams. Water vapor turns into liquid through a process called condensation. The process is the opposite of evaporation, in which liquid water turns into a vapor. Condensation in one of two ways: Either the air is chilled to its dew point or it becomes so saturated with water vapor that it cannot hold any more water. .(John evans,USGS)

Dew Point

Water vapor turns into liquid through a process called condensation. The process is the opposite of evaporation, in which liquid water turns into a vapor. Condensation in one of two ways: Either the air is chilled to its dew point or it becomes so saturated with water vapor that it cannot hold any more water. Water droplets can also form from condensation on the outside of soda cans or cold water glasses. Warm air reaches its dew point and condenses when it comes in contact with a cold surface. Water puddles are left on the glass or can as a result. Clouds develop when a pocket of air becomes saturated with water vapor. Cumulus clouds, which have flat bottoms, make it simple to see where condensation begins. Vapor starts to condense into water droplets at those flat bottoms.(John evans,USGS)

Saturation

Simply put, clouds are large collections of airborne water droplets. Water vapor molecules are spread widely apart from one another. Clouds may become saturated with water vapor as more water vapor gathers inside of them. Clouds that are saturated can carry no more water vapor. The density, or proximity, of the molecules increases when clouds become saturated with water vapor. Rain is created when the vapor condenses. Compared to warm air, cold air has less water vapor. Because water vapor doesn't condense into rain, it stays in the air, making warm areas frequently more humid than cold ones. Because water vapor condenses more readily in colder climates, rain is more likely to fall there. Climate variability and change intensity are influenced by water. Extreme events like droughts and floods depend heavily on it. For addressing the needs of society and ecosystems, its availability and prompt supply are essential. Water is used by people for drinking, industrial purposes, irrigating crops, producing hydropower, getting rid of waste, and having fun. Water sources must be safeguarded for both human needs and ecosystem health. Water resources are being reduced in many locations as a result of development, pollution, and population increase. Climate change and modifications that have an impact on the hydrologic cycle have made these strains harsher. Where, when , and how much water are all being impacted by climate change. Water resources may be impacted by extreme weather conditions like droughts and excessive precipitation, which are anticipated to become more frequent as a result of climate change. Civilization has been impacted by inadequate water supplies, flooding, and deteriorating water quality both today and throughout history. These difficulties may have an impact on the economy, the use and production of energy, human health, agriculture, transportation, national security, natural ecosystems, and leisure. .(John evans,USGS)

Bangladesh Perspective:

In Bangladesh's eastern coastal region, Chattogram, the country's commercial center, is one of the country's biggest and busiest port cities. The population of the city is close to 8.7 million, and the water supply is a combination of surface and groundwater. However, because of the infrequent rainfall and the presence of arsenic in some shallow tube wells, groundwater close to the coastal belt experiences significantly increased salinity during the dry season (Jabed, 2018). Accordingly, people largely depend on water supplied by the Chattogram Water Supply and Sewerage Authority (CWASA) for both residential and drinking uses that are sporadic and only cover roughly 69 percent of the demand of city population.

Due to a lack of wastewater treatment facilities and an inadequate solid waste management system, the quality of the river water close to the city is unacceptable. As a result, CWASA must seek further upstream for surface water that is considered adequate for the treatment of wastewater but is relatively less contaminated (Hossen, 2018). Rainwater is currently the only practical option for the area given the area's poor surface and groundwater quality and high salinity and arsenic concentrations in comparison to the levels recommended by Bangladesh drinking water quality standards and WHO guidelines. This is especially true given Bangladesh's annual mean precipitation of 2,488 mm during the monsoon season. Zones along the coast are where the land and the sea converge. Different methods are used to define Bangladesh's coastline zone. The three primary natural system processes and events that control the opportunities and vulnerabilities of Bangladesh's coastal zone are tidal variations, salinities, and the danger of cyclones and storm surges, according to five years of empirical study (2001–2006). The coastal region of Bangladesh comprises 19 districts and encompasses an area of 47,201 km2, or 32% of the nation (Figure 2:Coastal Region Of Bangladesh). The coastline region is home to 35 million people, or 29% of the total population.Jessore,Narail,Gopalganj,Shariatpur, Chandpur,Satkhira,Khulna,Bagerhat,Pirozpur,Jhalakathi,Barguna,Barisal, Patuakhali, Bhola, Lakshmipur, Noakhali, Feni, Chittagong, and Cox's Bazar are the 19 coastal districts that make up Bangladesh's coastal zone. The Cox's Bazar and Chattogram regions were chosen for this study because they share similar climatic conditions and rainwater quality with other coastal areas. In the coastline region, 58 million people are expected to live in 2050. Approximately 34,775 km^2—or 28% of Bangladesh's total agricultural land area of 122,954 km^2—is used for agricultural purposes. The flat Ganges Delta, which includes Bangladesh's coastline region, is cut through by huge tidal rivers that empty into the Bay of Bengal. Through several estuaries and water inlets that are connected to the main rivers, the saltwater front along the 720 km of coastline has encroached more than 100 km inland into home ponds, groundwater sources, and agricultural land. Due to seasonal variations between rainfall and the upstream withdrawal of freshwater (due to the operation of the Farakka Barrage, which the Indian government employs to control flow on the Ganges), salt levels have a distinct seasonal pattern. In the southern districts of Patuakhali, Pirojpur, Barguna, Satkhira, Bagerhat, and Khulna, river salinity has increased by 45% since 1948.

Because of further decreased river flows, increasing upstream extraction, and longer-term declines in dry season rainfall and sea level rise brought on by climate change, salinity intrusion is anticipated to worsen in the future (Aneire Ehmar Khan, 2011). For washing, bathing, and getting drinking water, Bangladesh's coastal population mainly relies on rivers, tube wells (groundwater), and ponds. Domestic ponds are mostly rain-fed but can also combine with salty water from rivers, soil runoff, and shallow groundwater. Domestic ponds make up 10% of the total land area (excluding rice fields) (A Atiq Rahman, 2003). Salinity levels in drinking water derived from diverse natural sources have an impact on about 20 million people who live near the coast [Ministry of Environment and Forest,2006].

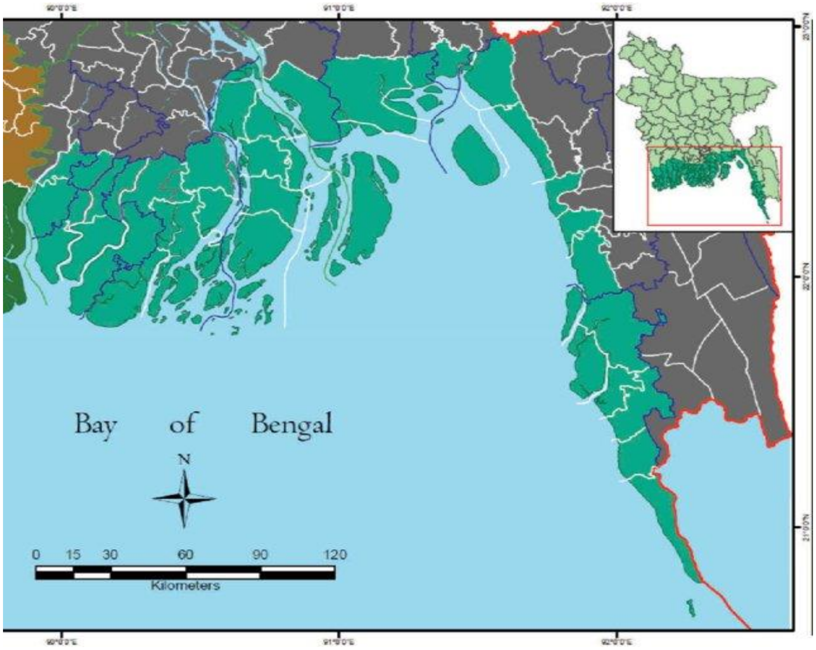


Figure 2: Coastal Region of Bangladesh

The World Health Organization (WHO) has developed recommendations for dietary salt intake, but no recommendations have been made for safe salinity levels in drinking water, with the exception that sodium levels > 0.2 g/L are unacceptably salty (WHO 2008). Numerous direct and indirect effects on health may result from high salt levels in drinking water. The WHO designated the examination of the health effects of consuming extremely salty waters as a priority under its public health programs in 2002. (WHO 2003). In a 2008 study, it was theorized that salt pollution of drinking water was to blame for the increased prevalence of pre-eclampsia and gestational hypertension in pregnant women living along Bangladesh's southwest coast compared to pregnant women who did not live along the coast.Life depends on water, which is also the foundation of sustainable development. However, Bangladesh, a country with a high population density, has difficulties providing its citizens with this resource. The water issue is worse in coastal areas, which include 19 districts that are either next to or front the Bay of Bengal. Bangladesh's coastal regions are regarded as a vulnerable and opportunity zone due to their characteristics. Due to its closeness to the Bay of Bengal, this region is more susceptible than others to natural and man-made calamities such cyclones, salt intrusion, arsenic poisoning, sea level rise, and floods. The coastal population has, nevertheless, benefited from things like beaches, coral reefs, estuaries, sea grass beds, mangrove swamps, transportation, water, fish, and other natural resources.Both potential and hazards abound in Bangladesh's coastline region. These chances and weaknesses all stem from one thing: water. The main source of livelihood for those living along the coast is water, including seawater, rivers, canals, floodplains, marshes, and ponds. This water is essential to the livelihood of those living in coastal areas. However, the economy and those who depend on this water are vulnerable due to salinity alone. The causes of water crises include tidal surge, storm surge, clogged drainage, water logging, and salty water aquaculture. Despite extensive measures, water emergencies continue to be a problem.People living along the shore always struggle with a lack of freshwater in terms of aquaculture, health, drinking water, agriculture productivity, and other areas. The biggest issues facing the coastal zone in managing water are uncertainties brought on by storms, river erosion, and the effects of foreign initiatives. People who live by the coast are tenacious, tough, adaptable, and powerful in conflicts over managing water resources for their lives. They use their capacity for rebuilding to take advantage of the opportunity.Although the entire impact of climate change is unknown, there is growing worry that one of the first and most significant repercussions will be on the world's freshwater resources.(R.John,2006) Seawater intrusion from the Bay of Bengal threatens Bangladesh's coastal rivers and groundwater supplies, which are natural sources of drinking water.The Intergovernmental Panel on Climate Change (IPCC) predicts that as a result of climate change effects, increased tidal waves and storm surges would cause groundwater, crop soils, and numerous rivers to become more salinized.The development of water resources continues to be the key to securing the future of agriculture and the level of life through industrialisation or urbanization. Existing water resources, which are mostly used by the agricultural sector, need to be added to due to technological development and industrial expansion. When compared to those for irrigation or industrial uses, the quality standards needed for home purposes are very different.In addition, the source of origin, type of flow, and technique of collecting all affect the water quality indices of incoming water. Effective management of rainwater in all of its forms unavoidably benefits from the qualitative assessment of various types of water sources at various stages. Given the growing relevance of rainwater collection globally, this study acquires enormous significance. The safest source of water is, in principle, rainfall. Rainwater is often pure when it first touches the ground, unless there is air pollution from industry, even if it can become contaminated by the absorption of atmospheric contaminants. But after being transferred to a storage tank, the rainwater may become polluted on the rooftop.

Organic materials, inert particles, animal and bird feces, tiny levels of various metals, and even complex organic molecules can all be added as pollutants to roof runoff. Surface storm water is frequently polluted by the direct discharge of household and industrial effluents into bodies of water and the land surface, as well as by pesticide and agrochemical runoff from fields. Due to fertilizer and pesticide residues in the air and/or crops, precipitation in agricultural regions may include a greater quantity of pollutants. Because there are more particulates in the air in industrial regions, rainfall samples may have somewhat higher suspended solids concentration and turbidity values (P.THomas, 1993).

By catchment type, runoff quality also varies. Ground catchments are vulnerable to pollution from a variety of sources, including as decaying plants, human and animal waste, and the soil itself.There is a strong argument that the world's water shortage will put increasing strain on one of the planet's richest freshwater ecosystems. Water tension in the Great Lakes has already started, as it has in many other big water basins, and it has been increasing in Bangladesh's southwest coastal region. Ecosystems of all kinds were operating organically as long as coastal water was handled by the locals utilizing their expertise.The ecosystems of freshwater and tidal salt water were as active as was physically conceivable in the southwest coastal area of Bangladesh prior to the advent of rigid civil engineering developed plans (since 1961). Under the Coastal Embankment Project, these structures are commonly referred to as "Polder." Their goal was to prevent salty water infiltration into the wetlands so that farmers could cultivate rice for at least two seasons each year. However, these shoddy water projects brought with them problems like the lack of water, the crisis, the stress, and the disputes in the coastal area. One after another structurally designed projects were constructed under the government's policy justifications to solve the problems caused by the immediately preceding projects, although this did little more than exacerbate the problems.Water has been a sensitive topic in the area for thousands of years, but recent initiatives with a structural engineering focus have made matters worse for the many stakeholders, including farmers, fishers, conservationists, sociologists, and many more. Is it possible to free the millions of people who live in this region from these misunderstandings? The public is required to comprehend water concerns, it is said (Ibid), because water is the cornerstone of the environment that sustains human life. But throughout the years, the effects of water shortage have transformed the region's wealth of freshwater into scarcity and uncertainty. It is crucial to assist the general population in focusing on the water.In order to conserve the region's internationally significant waterways for the ensuing century and beyond, efforts must be made to include the public as well as young scientists, scholars, and professionals.Identifying the physicochemical quality of rainwater throughout the world has received a lot of attention in recent years. While research on rainwater harvesting techniques, dependability, and opportunities is expanding throughout Bangladesh, little is known about the chemical makeup of rainwater and the relative contributions of various air pollutants to various land uses. This is surprising given how valuable and useful rainwater is.

No similar study is now available in Bangladesh, particularly in the southern-eastern area of the nation (like Chattogram). Due to these shortcomings and gaps, a thorough examination of the chemical properties of rainfall in the Chattogram region across diverse social and economic zones of the city is required (e.g., industrial, commercial, residential, coastal and urban areas). Therefore, the main goal of this study is to better understand the physicochemical characteristics and trace metal content of rainfall across various Chattogram geographic areas as well as to pinpoint probable sources of various precipitation elements in the area.

The monsoon season, which lasts from July to September, is when it rains the most in the Chattogram division. Samples were taken from several locations in the city, outside of the city, in an industrial region, and from the coastal territory for the evaluation of physicochemical features and mineral concentration. Water samples from nine distinct Chattogram division locations were gathered for the comparative investigation. The samples were examined for the chemical elements chloride (Cl-), sodium (Na), nitrate (NO3-), and sulfate (SO42-). Water is unquestionably essential to all living things, including humans. Rainwater, which is regarded as clean water with no negative environmental consequences, is one of the many ways that water may be collected.

The pollutants that contaminate rainwater must be removed in order for it to be used. As a result, the quality of the water is extremely important, according to (H.S. Al-Aizari 1, 2018). The lithology of the basin, atmospheric, climatic, and human inputs can all have an impact on the quality of water coming from the ground or the surface. Water is contaminated by anthropogenic inputs, which are man-made and include transportation, urban, industrial, and agricultural activities, as well as by natural processes such as erosion, weathering of crustal minerals, and variations in precipitation inputs.

Rainwater that has been contaminated cannot be used for recreational, industrial, agricultural, or drinking reasons. Typhoid fever, cholera, hepatitis A, influenza, dengue fever, and leptospirosis are all linked to water contamination in people, along with pneumonia, morbidity in young children, and gastrointestinal illnesses including nausea, vomiting, and/or diarrhea. Good health and well-being (Goal 3) and clean water and sanitation are also components of the 2030 Agenda (Goal 6). These requirements call for the availability of clean, drinkable water at all times of the year. If rainwater is not collected and kept clean, this objective cannot be accomplished. Not all waterways can be preserved, especially if they are physically, chemically, or microbiologically polluted; ongoing surveillance is required.

The quality of the water must be determined before it can be collected and stored for later use because there are no records of the rainfall that was collected in this research region. Based on this concept, our research examined how rainwater is collected before evaluating its quality using physicochemical characteristics.

Objective:

It entails catching the runoff in your own town or hamlet or catching the rain where it falls. and taking steps to prevent polluting activities from occurring in the watershed in order to keep that water pure.

- Reducing the amount of water lost through runoff.
- Road flooding should be prevented.
- Meeting the growing water demand.
- Reducing pollution of the ground water.
- During the dry season, make more water accessible.
- Rainwater harvesting is a technique for gathering and preserving water during wet spells for usage when there is little or no rain.
- To reduce erosion and floods.

Rainwater collection aims to stop downhill water flow and control how it travels over the terrain. The goals of rainwater collection depend on the environment where the water will be used. There are numerous methods for managing water supply all year round and controlling water flow. To avoid or lessen the effects of erosion and floods, as well as to produce hydroelectricity, rainwater may also be retained. There are several ways to store rainwater. It may be kept in ponds, water tanks, and barrels on a modest scale. On a wider scale, it can be poured into subterranean aquifers or stored in dams and reservoirs. Water-retaining earthworks are used in regenerative farming methods such as perm culture to store water in the soil profile.

Why Is Rainfall Harvesting Important?

For drinking and bathing, agriculture, and industrial applications, access to water is crucial. Additionally, it is necessary for the wellbeing, preservation, and provision of natural ecosystems and the services they offer. Rainfall provides a large amount of the water required for these uses.

Around the world, there are several types of rainfall patterns, ranging from lush jungle habitats with frequent rainfall to barren desert regions that might go for years without receiving any. Seasonal rainfall patterns affect many ecosystems and settings, with rainy years followed by many months of dry weather. The goal of rainwater collection is to preserve extra water produced during rainy seasons for later usage.

Household Use

Large volumes of rainwater can be intercepted and redirected by flat, impermeable surfaces made by buildings and other structures. It is possible to direct this water into water storage facilities. Aluminum tanks, plastic drums, and other water storage containers may all be used to collect rainwater from rooftops. This water may be used directly for a variety of tasks around the house and yard and, if necessary, it can be sanitized to make drinking water.

Use in Agriculture

To maintain crops and cattle during dry spells, many agricultural regions rely on rainwater gathering. Large water tanks or dams are typically used to store water in agricultural regions. Sprinkler systems may be used to spray water over crops, irrigation canals and fields can be flooded, or water can be pumped into a trough for animals to drink.Dyes and canals are used in permaculture and other natural agricultural methods to restrict water flow. This lessens the water's ability to erode the soil and provides it more time to soak in, slowing the water's movement downward. Water may be used for pastures and crops by being retained in the soil, which also lowers evaporation.

Reduce Flooding and Erosion

It is possible to lessen the amount of runoff, erosion, and flooding in low-lying areas by collecting and storing rainwater in dams and reservoirs. These can be as basic as stream diversion ditches and rock barriers or as large as vast reservoirs that can contain millions of gallons.

One such is Lake Mead, which was built in 1935 as a result of the building of the Hoover Dam. Significant harm to people, property, and agricultural regions can be lessened or prevented by investing in water barriers, re-vegetating upland areas, and strategically using levees and other flood-control engineering solutions.

The following are the main goals and benefits of rainwater harvesting:

- To satisfy the rising demand for water
- To supplement groundwater supplies in times of scarcity
- To recharge groundwater in order to increase the water table.
- Reducing groundwater contamination.
- Reduce soil erosion and floods.
- Keeping roads safe from floods.
- Water Sustainability

It is difficult to fulfill the rising demand for water because of groundwater table decline and water contamination. A growth in consumption, which is a result of increased population and development, is what is behind the rising demand.

Although water covers 70% of the earth's surface, much of it is in seas and oceans that cannot be utilised owing to their high salinity content. The cost of the desalination plants is quite high. As a result, the following are some of the methods employed to fulfill the demand for water:

Development of a watershed

- Harvesting rainwater
- Water reuse and recycling.

Chapter 2: Review of Literature

Water Pollution:

Life is in the water. Water is undoubtedly one of our most valuable resources because it covers about 70 percent of the planet. Our aquatic bodies have become a toxic pool due to the invasion of rubbish, which ranges from floating plastic bags to synthetic waste. In the simplest possible phrase, water pollution is implied by the defiling of water bodies. Water contamination results from improper management of lakes, oceans, rivers, wetlands, and so forth.

Sources of Water Pollution:

Water pollution occurs regularly because of human exercises. The significant ones are unpredictable transfer of mechanical, civil and household wastes in water channels, waterways, rivers and lakes, and so on. An assessed 2 million tons of sewage and different effluents are released into the worlds waters each day. In creating nations the circumstance is more regrettable where more than 90% of crude sewage and 70% of untreated mechanical wastages are dumped into surface water sources. The two main wellsprings of water pollution can be viewed as Point and Non-Point sources. Point sources are moderately simple to recognize, measure and control. Point sources of water pollution incorporate release from metropolitan sewage treatment plant and modern plant. While Non-Point implies poisons radiated from different sources .the pollution can't be followed to a solitary purpose of release, hard to screen and control. Non-point source pollution is water pollution that influences a water body from diffuse sources, for example, human land utilize and dirty spillover from rural regions depleting into a river. Contaminated water after downpours that has gone through a few locales may likewise be considered as a Non-Point wellspring of pollution. Utilization of concentrated mineral composts related with tainting of rural groundwater prompts expanding level of supplements in ground and surface waters, particularly from non-point sources and hard to anticipate contrasted with point sources. Horticultural movement is major non-point sources pollution including utilization of nitrogen composts, use of domesticated animals excrement, vegetable obsession and mineralization of soil nitrogen (Md. Arman Arefin, 2018).

- Effluent from waste water (Municipal and industrial).
- Leachate and runoff from a garbage disposal site.

- Runoff and inflation from livestock feeding operations.
- Runoff from unplanted industrial areas, oil fields, and mines.
- A combined sanitary and storm sewer overflow.
- Construction site runoff exceeds 2 hectares.
- Agriculture runoff (including return flow from irrigated agriculture).
- The pasture and rangeland runoff.
- Urban runoff in places with a population of 100,000 in both drained and undrained zones.
- Leachate from septic tanks and septic system discharge.
- Deposition of atmospheric material over a body of water
- Land-use practices that produce contaminants, such as logging,
- The development of land and waterways and the conversion of wetlands.

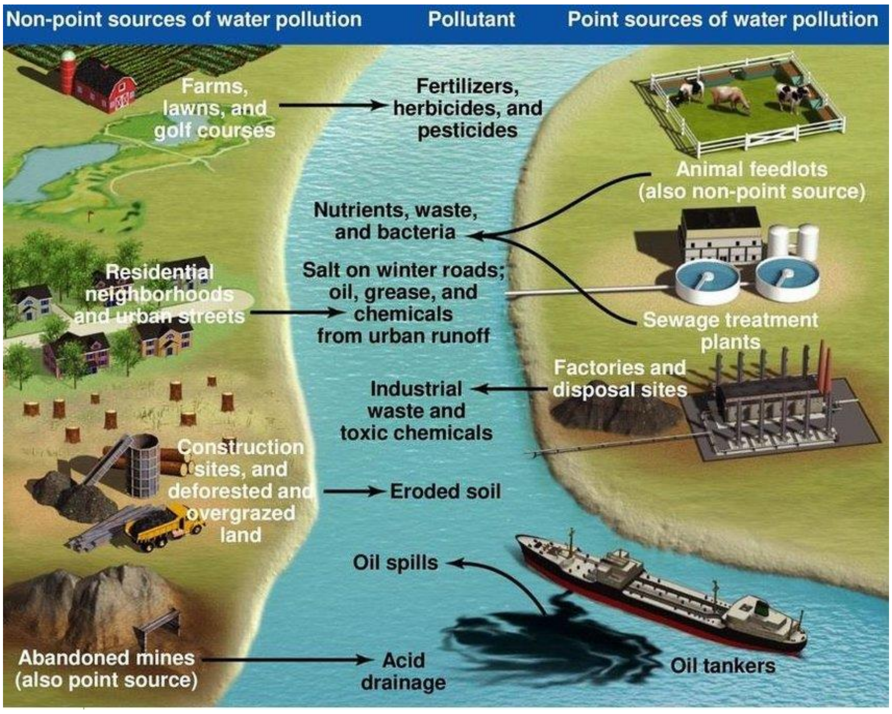


Figure 3:Water Pollution Cycle

Salinity:

The amount of salt present in water or soil is referred to as "salinity." Primary salinity (also known as natural salinity), secondary salinity (sometimes known as dry land salinity), and tertiary salinity are the three different types of salinity that can exist (also called irrigation salinity).

Sources of Salinity:

Our water resources typically get their salt from three different places. First, as ocean water evaporates, little quantities of salt (mainly sodium chloride) are transported by rainclouds and dispersed by rainfall throughout the terrain. Thirdly, salt may be found in the sediments left behind by retreating oceans during periods when ocean levels were considerably higher or the land surface was much lower. Second, certain landscapes may also include salt that has been liberated from rocks during weathering (gradual disintegration).

Primary salinity:

The build-up of salt from rainfall over a long period of time or the weathering of rocks are two examples of natural processes that contribute to primary salinity. When rain falls on a landscape, part of it evaporates off the soil, vegetation, and water bodies, while some seeps into the earth and the soil and some of it runs into streams, rivers, lakes, and oceans. Raindrops carrying trace levels of salt have the potential to accumulate over time in soils, particularly clayey soils, and to migrate into groundwater.

Large volumes of water penetrating soils, entering and exiting groundwater, and leaving the catchment through streams and rivers create a flushing effect in locations that receive a lot of rain, keeping the salinities of the soil and groundwater relatively fresh. However, there is less flushing and a greater percentage of the water that falls on a landscape is lost through evaporation and transpiration from plants in arid regions with natural vegetation. Here, salts have a tendency to collect over extended periods of time to reach high levels in the soil and groundwater. Salinities in groundwater can also be quite high, especially if salts have also been produced during bedrock weathering.

Secondary salinity:

When groundwater levels rise, salt that has accumulated due to "primary" salinity processes is brought to the surface and causes secondary salinity. This is brought on by the removal of perennial (long-lived) vegetation in dry locations, i.e., places where salt tends to gradually build up in the soil profile and groundwater. The salt in the groundwater dissolves in the previously unsaturated area of the soil profile as groundwater levels rise, bringing it with them. The volume and duration of flow in streams and rivers may eventually rise, and low-lying valley floors may eventually become completely inundated (particularly during the winter). Saline groundwater that is discharging combines with fresher surface water to produce flows that range from marginal to brine.

Salt crystals may be left behind as these soaked regions dry up following the wet season, leading to a salt scald. The state government has engaged in engineering work under controlled settings to provide workable methods to manage the consequences of stream salinity, as well as experiments to understand the implications of land use change. The salt tolerance of plants is projected to become a problem due to increased salinity and flow in streams and wetlands. Many plants can endure greater salinities for brief durations, but they cannot withstand prolonged flooding (Lennard, 2003). In addition to endangering ecosystems and the species that make up those ecosystems, salinization of streams and rivers can make the water unfit for human consumption.

The criteria for water that is deemed suitable for public drinking water supply, irrigation, and industry are shown in the salinity categorization table below.

Table 1:Salinity status classifications, by total salt concentration

Salinity Status	Salinity (miligrams of salt per litre)	Description and Use
Fresh	<500	Drinking and all irrigation
Marginal	500 –1000	Most irrigation, adverse effects on ecosystems become apparent
Brackish	1000 – 2000	Irrigation certain crops only; useful for most stock
Saline	2000 – 10000	Useful for most livestock
Highly saline livestock	10000–35000	Very saline groundwater, limited use for certain
Brine	>35 000	Seawater; some mining and industrial uses exist

Tertiary or irrigated salinity

Tertiary salinity occurs when water is reapplied to crops or horticulture over many cycles, either directly or by allowing it to filter into the groundwater before pumping it out for re-application. Each time the water is applied, some of it will evaporate and the salts in the water remaining will become more concentrated; very high salt concentrations can result from multiple cycles of reuse.

Tidal Surge:

An unusual,often destructive rise in sea level above normal high-tide level in a coastal area, caused by a combination of low atmospheric pressure and strong onshore winds during a storm.

Storm Surge:

Storm surge is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore. The amplitude of the storm surge at any given location depends on the orientation of the coast line with the storm track; the intensity, size, and speed of the storm; and the local bathymetry.

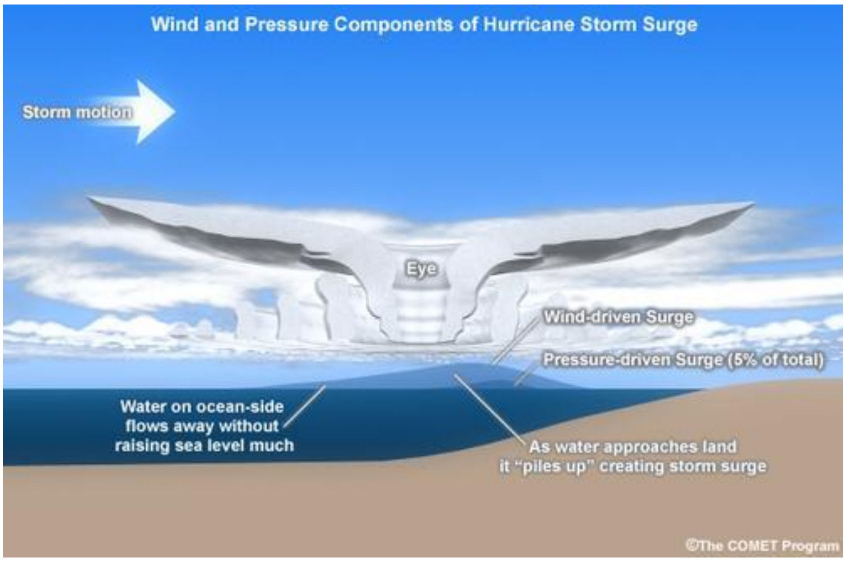


Figure 4:Storm Surge

Storm tide is the total observed seawater level during a storm, resulting from the combination of storm surge and the astronomical tide. Astronomical tides are caused by the gravitational pull of the sun and the moon and have their greatest effects on seawater level during new and full moons—when the sun, the moon, and the Earth are in alignment. As a result, the highest storm tides are often observed during storms that coincide with a new or full moon.

Water Harvesting:

It means capturing rain where it falls or capturing the run off in your own village or town. And taking measures to keep that water clean by not allowing polluting activities to take place in the catchment. Therefore, water harvesting can be undertaken through a variety of ways-

- Capturing runoff from rooftops
- Capturing runoff from local catchments
- Capturing seasonal floodwaters from local streams
- Conserving water through watershed management
- These techniques can serve the following the following purposes:
- Provide drinking water
- Provide irrigation water
- Increase groundwater recharge
- Reduce storm water discharges, urban floods and overloading of sewage treatment plants
- Reduce seawater ingress in coastal areas.

The act of directly collecting rainfall is often referred to as water harvesting. In terms of agricultural production, the problem is more the intensity and timing than the scarcity of rainfall(Seth Cook, 2000). The rainfall that is collected can be used immediately or returned into the groundwater. Rain is our main source of water since it is the first type of water we are familiar with in the hydrological cycle. Secondary sources of water include rivers, lakes, and groundwater. These secondary sources of water are our only supply of water now. While doing so, it is forgotten that rain is the primary source that supplies all of these secondary sources and we continue to be unaware of its importance. Water harvesting entails appreciating the worth of rain and making the most use of the water where it falls.

How much water can be harvested?

Urban scenario:

The area's "rainwater endowment" refers to the overall quantity of water that the area receives in the form of rainfall. The quantity that can be successfully retrieved from this is known as the water harvesting potential.

Water harvesting potential = Rainfall (mm) x Collection efficiency

The collection efficiency takes into consideration the inability to efficiently gather all of the rainfall that falls over an area due to evaporation, spillage, etc. When estimating collection efficiency, factors like runoff coefficient and first-flush waste are taken into consideration.

The theoretical calculation that follows serves as an illustration of the vast possibilities for water collection. Using rainfall statistics for the region, the same process may be used to determine the potential for any piece of land or rooftop.

Think about your own home, which has a 100 square meter flat patio. Assume that your region receives 600 millimeters of rain on average each year (24 inches). Simply put, this indicates that after a year, there will be 600 mm of rainfall on the terrace floor if the terrace floor is believed to be impermeable and all rain that falls on it is held without evaporation.

Plot size is 100 square meters (120 square yards)

Rainfall height: 0.6 meters (600 mm or 24 inches)

Volume of rainfall over the plot equals plot area times rainfall height

Considering that approximately 60% of the total rainfall is actually used for harvesting

36,000 litres of water were gathered in total (60,000 litres x 0.6)

This volume is roughly equivalent to a family of five's annual drinking water needs. Each person needs 10 litres of drinking water each day on average.

Rural scenario:

The paradigm of the past, community-based rainwater gathering in rural India, is still as strong now as it was before. In reality, people's ability to exist in water-scarce locations depends entirely on this primitive technology. Our forefathers had learned to gather water in a variety of methods because they were aware of this fact:

Direct raindrop harvesting was done. They gathered water from roofs and stored it in tanks constructed in their courtyards. They gathered rain from communal open fields and kept it in man-made wells.

By collecting water from overflowing streams during the monsoon season and storing it in various types of water bodies, they gathered monsoon runoff.

From flooded rivers, they collected water.

Direct pumped, indirect pumped, and indirect gravity are the three basic types of rainwater collecting systems. Though these occurrences are uncommon, there may occasionally be a system that relies just on gravity.

Water Butt:

Garden water butts are the most simple type of harvesting. Water from drain pipes and/or natural rainfall gathers in the container and is mostly used to water garden plants. The amount of mains water utilized will decrease for those with gardens that are of a reasonable size. The quality of the collected rainwater may be raised by combining the water tank with a rainwater filter.

Direct-Pumped (Submersible)

This sort of more sophisticated rainwater collecting system is the most popular and often the simplest to install, especially for home premises. Harvested water is easily pushed to the toilets or other appliances using the pump that is housed inside the subsurface tank. A little amount of mains water is delivered to the tank to sustain supply if the tank should be in risk of running dry. Such systems often have two pump configurations for commercial installations (duty standby).

Direct-Pumped (Suction)

The difference in this arrangement is that the pump is housed inside a control unit rather than the tank itself (e.g. utility room). There is no need to transfer mains water down to the tank because the machine also handles backup from the main water supply.

Indirect Gravity

This kind of system is unique in that the collected water is pushed to a high level tank (called a header tank), where it is then left to feed the outputs only by gravity. The pump only has to operate under this setup if the header tank needs to be filled. Additionally, the header tank receives water from the mains directly rather than the main harvesting tank.

Indirect Pumped

The internal tank may be located at any level of the structure with this system, which is similar to the one above but does not rely on gravity to feed the outputs. To provide a pressured feed, a booster pump set is employed instead. This system has the advantage that the subterranean tank does not need to be supplied with mains backup water, and it also provides excellent flexibility because the booster pumps may be adjusted to meet the building's specific flow and pressure needs.

Gravity Only

It would be conceivable in some circumstances to create a system that runs entirely on gravity, requiring no pump and using no energy. This layout allows for the collection of rainwater from a portion of the roof that has gutters above the filter and collecting tank, which are in turn above all the outlets. This solution is only ever feasible when the storage tank can be positioned higher than the outlets it will serve and lower than the gutters. It is an extremely energy-efficient solution since all that is required to distribute collected and filtered water to various sections of the house for consumption is gravity.

Methods of Rooftop Rainwater Harvesting

This section provides examples of several roof top rainwater gathering techniques.

1. Direct Use Storage

With this technique, rainfall that has accumulated on the building's roof is directed to a storage tank. The water demand, rainfall, and catchment availability must all be taken into account while designing the storage tank.

Before connecting to the storage tank, each drainpipe should have a filtering system, a first flush device, and a mesh filter at the mouth. An excess water overflow mechanism should be installed in each tank.

The recharge system might receive more water. Water from storage tanks may be utilized for extracurricular activities like gardening and washing. The most economical method of collecting rainwater is this one.

The primary benefit of collecting and using rainwater during the rainy season is not just to conserve water from traditional sources but also to reduce energy costs associated with water distribution and transportation. If groundwater is being taken out to fulfill demand during rainy seasons, this also helps to save groundwater.

2. Adding water to underground aquifers

To guarantee that precipitation percolates in the ground rather than draining away from the surface, many types of structures can be used to replenish groundwater aquifers. The following are typical recharge techniques:

- Recharging of bore wells
- Recharging of dug wells.
- Recharge pits
- Recharge Trenches
- Soakaways or Recharge Shafts
- Percolation Tanks

3. Bore well refueling

Through drainpipes, rainwater collected on the building's roof is sent to a settlement or filter tank. Filtered water is transferred to bore wells after settlement to replenish deep aquifers. Bore wells that have been abandoned can also be recharged. Based on the catchment area, rainfall intensity, and recharge rate, the settlement tank's/filtration tank's ideal capacity may be constructed. Entry of floating debris and silt should be prevented during recharge since it might choke the recharge structure. To prevent contamination, the first one or two showers should be cleaned off using a rain separator.

4. Power Pits

Small pits with a weep hole placed at regular intervals that are contracted with a brick or stone masonry wall are known as recharge pits. Perforated coverings can be used to cover the pit's top. Filter media have to be poured into the pit's bottom.

The catchment area, intensity of the rainfall, and rate of soil recharging may all be used to determine the pit's capacity. Depending on the depth of the preceding strata, the pit's dimensions are typically 1 to 2 m in width and 2 to 3 m in depth. Small dwellings and shallow aquifers can be recharged in these holes.

5. Recharge or Soakaway Shafts

Where the topsoil is alluvial or less porous, soakaway or recharge shafts are supplied. These are the 30 cm-diameter bored holes that may reach depths of 10 to 15 m, depending on the thickness of the pervious layer. To stop the vertical sides from collapsing, the bore should be lined with slotted/perforated PVC/MS tubing.

To capture runoff before it filters through the soakaway, the necessary size sump is built at the top of the soakaway. Filter media should be placed in the sump.

6. Filling of Deep Wells

Wells that have been dug can act as recharge structures. After going through the filter bed, rainwater from the rooftop is directed to drilled wells. Regular cleaning and desalting of dug wells is necessary to increase the rate of recharge. One option is to employ the filtering technique indicated for bore well recharge.

7. Replenishing Trenches

Where the upper impermeable layer of soil is shallow, a recharge trench is supplied. Using porous medium like pebbles, boulders, or brickbats, the recharge trench was dug on the ground and filled. It is often designed to gather surface runoff.

In order to improve percolation, bore-wells can also be installed inside the trench as recharge shafts. Depending on the anticipated quantity of runoff, the trench's length is chosen.

Small homes, playgrounds, parks, and roadside drains may all be cleaned with this technique. The recharging trench can range in size from 0.50 to 1.0 meters in width to 1.5 meters in depth.

8. Percolation Tank

Percolation tanks are man-made pools of surface water that submerge a patch of land with enough permeability to allow for enough percolation to replenish the groundwater. These can be constructed on sizable campuses where there is accessible land and suitable topography.

This tank may be used to collect surface runoff and roof top water. To increase the groundwater, water that has built up in the tank percolates through the solid.

Direct planting and raw usage of the stored water is possible. Urban greenbelts, parks, and gardens should all have percolation tanks installed.

Chapter 3: Materials and Methods

Site and Period of Sample Collection

Samples were gathered at nine distinct sites around the Chattogram Division's coastal regions of Rangamati and Cox's Bazar. August 2021 to September 2021 comprised the two-month sample collecting period.

Chattogram

On the southeasterly side of Bangladesh, the seaside city of Chattogram serves as a major commercial center. The Chattogram City Corporation (CCC) region is four times bigger than the Chattogram Metropolitan area (CMA). At 22°20′06″N 91°49′57″E, Chattogram is located. In southeast Bangladesh, it crosses the Chittagong Hill Tracts' coastal foothills. The Bay of Bengal, the Halda River, and the Karnaphuli River all encircle the city on its western, northern, and eastern borders, respectively. The estuary of the Karnaphuli River is home to Bangladesh's busiest seaport (MdAslam Mia a, 2015). The city is business-friendly due to the port facility's location, and many of Bangladesh's oldest and greatest enterprises have established themselves here (BBS 2013).With a population of over 8.7 million, a density of 19,800/km^2, and an annual growth rate of 2.8 percent, the CMA is one of the crucial coastal areas of the nation.

Chittagong experiences a tropical climate. With a brief dry season, Chittagong receives heavy rainfall in the majority of the months. This climate is categorized as Am by Köppen and Geiger (Peel1, 2007). (Monsoon). Chittagong's average temperature is 25.3 °C/77.6 °F. Annual precipitation amounts to about 2777 mm/109.3 inches.

Figure 5: Sample Collection Districts

Figure 5:Sample Collection Districts above shows the three districts that were selected for this study. For this investigation, nine locations were chosen from the chattogram division. Five of such locations are located inside the city of Chattogram. Nasirabad (urban area), Colonelhat (urban area), Sagorika (industrial region), Bandar (urban area), and Patenga are the five sites (Coastal territory). There were two places that weren't in Chattogram. Both of these localities, Anowara and Raozan, are in rural areas. Cox's Bazar and Rangamati were the other two locations. The world's longest sea beach is located in Cox's Bazar, a Bangladeshi coastal region. The hilly region of Chattogram division is called Rangamati district.

Rangamati

The district of Rangamati is rich in both natural and cultural beauty. The Chittagong Division includes Rangamati. It is situated at 91o 00' 56" and 92o 00' 33" East and 22o 00' 27" and 23o 00' 44" North. It shares borders with the Indian states of Tripura to the north, Bandarban District to the south, Mizoram State to the east, Chin State to the east, Khagrachari District to the west, and Tripura State to the north. The only district in Bangladesh that has international boundaries with both India and Myanmar is Rangamati. The district's total area is 6116 km^2, of which 1292 km^2 are riverine and 4825 km^2 are covered in forest.

Figure 6:Rangamati District(Hill tract area)

Cox's Bazar

2,491.86 km^2 make up the Cox's Bazar District (962.11 sq mi). It is bordered on the north by the Chittagong District, on the south by the Bay of Bengal, on the east by the Bandarban District, and on the west by the Bay of Bengal. The Matamuhuri, Bakkhali, RejuKhal, Naf River, Maheshkhali channel, and Kutubdia channels are major rivers. Cox's Bazar is a city with a 6.85 km^2 area (2.64 sq mi). Cox's Bazar is a popular tourist attraction in Bangladesh and is frequently referred to be the longest beach in the world.

Figure 7: Cox's Bazar District(Coastal territory)

Samples of the rainwater were taken from each of the nine zones. In an open area with a platform that is about 20 feet above the ground, plastic buckets that have already been cleaned are used to collect rainwater samples. This water was then placed into pre-distilled water sample vials for storage.

P^H Test

The concentration of hydrogen ions in the solution is shown inversely by the pH scale, which is logarithmic.

P^H = -log[H+] = -log(a H+).

Solutions with a pH below 7 are acidic, and those with a pH above 7 are basic/alkaline at 25 °C. At this temperature, solutions with a pH of 7 are neutral (e.g. pure water). The pH's neutral range is temperature dependent, falling below 7 as the temperature rises. For highly strong acids, the pH value can be less than 0; for very strong bases or alkalines, it can be higher than 14.The pH of typical rainfall is 5.6. (slightly acidic). This occurs as a result of its exposure to atmospheric carbon dioxide. Rainwater contains carbon dioxide that dissolves to create carbonic acid (H_2CO_3).Acid rain is defined as precipitation having a pH value below 5.6. Materials that alter the pH of rainwater can come from both natural and artificial sources. Acid rain is a result of increased pollution. Sulfur dioxide and nitrogen oxide are the main air pollutants. Burning fossil fuels, such as coal, is one of the main drivers of these pollutants' emission into the atmosphere.

In general, rainfall is clean and suitable for drinking. Drinking water has a pH that ranges from 6.5 to 8.Rainwater's pH varies from location to location as well. This is brought on by areas with high pollution levels and others with pure air. Urbanization has enhanced its acidity in the current situation. However, rain that typically has a pH of roughly 5.6 is drinkable but also slightly acidic and caustic. However, rainfall is extremely acidic in and around cities and other industrially developed places where the pH of precipitation tends to decrease dramatically, making the water unsafe for ingestion.

P^H impact on health

The P^H of drinking water is not regulated by the U.S. Environmental Protection Agency (EPA). It is categorized as a secondary drinking water pollutant with an aesthetically pleasing effect. However, the EPA advises public water systems to keep P^H levels between 6.5 and 8.5, which is a helpful reference for private well owners.

Low P^H water has the potential to be caustic, acidic, and naturally soft. Metals like copper, lead, and zinc may be removed from pipes and fixtures by using acidic water. In addition to causing aesthetic issues like a metallic or sour taste, laundry stains, or blue-green stains in sinks and drains, it can also harm metal pipes. In addition to the previously stated copper, lead, and zinc, water with a low P^H may also include other metals.

High levels of alkalinity minerals are found in water that has a pH level above 8.5, making it safe to drink. High alkalinity does not constitute a health danger, but it can have an unfavorable impact on aesthetics. For example, it can give coffee a bitter flavor and cause scale to build up in the plumbing and lessen the effectiveness of electric water heaters.

The United States Environmental Protection Agency (EPA) advises maintaining public water within a pH range of 6.5 to 8, even though it does not control the pH of drinking water.

Acidic water may be advantageous for skin, hair, and washing produce since it is thought to have antibacterial properties. It can also have a lot of unfavorable and perhaps harmful side effects.Acidic water has a pH of 6.5 or below, in contrast to alkaline water, which has a pH greater than 7. Low pH water can have a variety of reasons, including organic ones like acid rain. Tree roots, soil microorganisms, and certain rock formations may all produce acids that make the water in the area acidic. Low pH water is frequently found next to mining sites, chemical dumps, power stations, restricted animal feeding operations, and landfills. Acidic water is frequently caused by industrial pollution.

Risks and potential adverse effects

Drinking acidic water is not advised because of the potential health risks associated with its high acidity and heavy metal concentration. The presence of significant levels of heavy metals in acidic water is one of the key issues. Low pH solutions are more prone to absorb heavy metals from the environment, according to research. Lead, arsenic, copper, nickel, cadmium, chromium, and zinc can all be particularly high in acidic water. This is alarming since exposure to heavy metals may be harmful and may result in heavy metal poisoning and toxicity, which might manifest as the following symptoms:

- Diarrhea
- Nausea and vomiting
- Abdominal pain

- Weakness
- Shortness of breath
- Suppression of the immune system
- Organ damage

Age, sex, personal vulnerability, as well as the exposure route, dose, and frequency, all affect how severe these side effects are. Your entire oral health is greatly influenced by the pH of the foods and beverages you consume. Acidic beverages can specifically harm tooth enamel, the tough outer layer of your teeth that guards them against disease. Drinks with a pH of 4.5 or below have been proven to increase the risk of tooth decay, even though acidic groundwater hasn't been particularly investigated in this regard. As a result, drinking acidic water on a daily basis may gradually erode your tooth enamel and result in cavities.It has been suggested that drinking acidic water will eventually cause bone loss by preventing the absorption of calcium.

However, neither a consistent preventive benefit of consuming alkalized water nor a substantial relationship between your diet's pH and your risk of bone loss have been demonstrated by study. As a result, over time, consistent exposure to acidic water that is rich in certain heavy metals may harm bone health. Acidic water may destroy pipes in addition to damaging your health. Low pH water has a high acidity, which over time can begin to dissolve metal pipes, leading to leaks and raising the level of heavy metals in your drinking water.

It has been demonstrated that exposure to heavy metals can have more severe adverse effects on children, including a higher chance of developmental delays, respiratory problems, behavioral disorders, some types of cancer, and heart disease.

Apparatus and Materials

1. 50ml glass beaker
2. A pH meter, suitable for laboratory or field analysis, with either one or two electrodes
3. Standard buffer solutions of known pH values - standards to be used are pH of 4.0, 7.0, and
10.0.
4. Distilled Water
5. A glass stirring rod

Procedure

1. Stir the water sample vigorously using a clean glass stirring rod
2. Pour a 20 mL ± 5 mL sample into the glass beaker
3. Standardize the pH meter by means of the standard solutions provided
4. Immerse the electrode(s) of the pH meter into the water sample and turn the beaker slightly to obtain good contact between the water and the electrode(s)
5. The electrode(s) require immersion 30 seconds or longer in the sample before reading to allow the meter to stabilize
6. Read and record the pH value and Temperature
7. Rinse the electrode(s) well with distilled water, then dab lightly with tissues to remove any film formed on the electrode(s). Caution: Do not wipe the electrodes, as this may result in polarization of the electrode and consequent slow response
8. Repeat this procedure for another 8 samples and record the P^H value and temperature.

TDS Test

The inorganic salts and trace quantities of organic materials that are dissolved in water are referred to as total dissolved solids (TDS). The main components are often carbonate, hydrogen-carbonate, chloride, sulfate, and nitrate anions, as well as calcium, magnesium, sodium, and potassium cations and anions. The mineral content of the water is represented by the dissolved solids in it. Absolute purity and almost no dissolved particles make deionized water taste flat and potentially acidic (low pH of roughly 5.5).

The majority of the solute load in water near the Earth's surface, including precipitation, snow, lakes, streams, and shallow groundwater, is primarily made up of inorganic ions and compounds. A solid residue will remain in the sample container if a sample of this water is filtered to remove suspended particles and then kept in a low-humidity setting long enough for the solids to entirely evaporate. Total dissolved solids is a measurement that is obtained by dividing the mass of that residue by the initial volume of the solution (TDS). TDS is measured in mg/L, or milligrams per liter.TDS in rainwater is generally 20 mg/L or less.

Apparatus and Materials

1. 50ml glass beaker

2. A TDS meter, suitable for laboratory or field analysis, with either one or two electrodes
3.Distilled Water
4. A glass stirring rod

Procedure

1. Stir the water sample vigorously using a clean glass stirring rod
2. Pour a 20 mL ± 5 mL sample into the glass beaker
3. Immerse the electrode(s) of the TDS meter into the water sample and turn the beaker slightly to obtain good contact between the water and the electrode(s)
4. The electrode(s) require immersion 30 seconds or longer in the sample before reading to allow the meter to stabilize
5. Read and record the TDS value
6. Rinse the electrode(s) well with distilled water, then dab lightly with tissues to remove any film formed on the electrode(s). Caution: Do not wipe the electrodes, as this may result in polarization of the electrode and consequent slow response
7. Repeat this procedure for another 8 samples and record the TDS value.

Chloride Determination

Principle: Mercuric thiocyanate is converted into thiocyanate when chloride ions interact with free mercuric ions. A reddish-brown ferric thiocyanate complex is created when the released thiocyanate mixes with the ferric ions. The amount of chloride contained in the sample directly correlates with how intense the color is.

$$2Cl^- + Hg(SCN)_2 \rightarrow HgCl_2 + 2(SCN)$$

$$3(SCN) + Fe^{3+} \rightarrow Fe(SCN)_3$$

Reagent Composition:

1.Chloride Reagent(L1): Mercuric Thiocyanate, Ferric Nitrate, Nitric Acid, Non Reactive Stabilizers and Preservatives.

2.Chloride Standard

Procedure:

1. Three dry clean PCR tubes(small plastic tubes) were taken and labelled as Blank(B),Standard(S) and Test(T) for each sample.
2. After that the pipetting was done by using micro pipette.

3. Into the tube Blank(B), 1.0 mL of chloride reagent (L1) and 0.01 deionized water were taken.

4. In the tube Standard (S), 1.0mL of chloride reagent (L1) and 0.01 chloride standard were taken.

5. Into the tube Test(T), 1.0mL of chloride reagent(L1) and 0.01 of samples were taken.

6. After pipetting they were mixed well and incubated at room temperature for 2 minutes.

7. Finally the absorbance of the standard and Test sample against blank were measured within 60 minutes.

8. This was done by using spectrophotometer at a wavelength of 505nm (Hg 546)/Green.

9. Repeat this procedure for another 8 samples and record the value.

Nitrate Determination

A chemical test called a nitrate test is performed to find out whether nitrate ions are present in a solution. Since practically all nitrates are soluble in water, testing for the presence of nitrate using wet chemistry is often more challenging than testing for other anions. On the other hand, many common ions produce insoluble salts, such as halides with silver and sulfate with barium. Numerous tests for the nitrate anion are based on the fact that it is an oxidizer. Other oxidants in the analyte, however, might interact and provide false readings.

All organic and inorganic nitrogen in oxygenated surface waters should be in the form of nitrate as nitrate is the oxidized state of nitrogen. Industrial waste waters, home sewage, runoff fertilizers, soil organic matter, etc. are the main sources of these two types. For many photosynthetic autotrophs, it is a necessary nutrient, and in certain cases, it has been found to be the nutrient that limits development. Nitrates, in the levels typically present in food or feed, are promptly eliminated in the urine until they are converted to nitrites, which is when they become poisonous.

Apparatus and Materials

1.Test tube

2.Dropper

3.Di-phenyl amyl Solution

Procedure

1.8-10 drops of sample were taken into the test tube

2.8-10 drops of Di-phenyl amyl Solution were mixed with the sample

Observation

Color did not change. Presence of nitrate ion in rainwater will give violet color.

Sodium Determination

Principle: With magnesium and uranyl acetate, sodium precipitates as a triple salt. In an acidic solution, ferrocyanide reacts with uranyl ion ions to produce a brownish hue. The amount of sodium present in the sample has an inverse relationship with the color intensity that results.

Uranyl ions + Mg ions +Na^+ → UranylMgNa precipitate

Free Uranyl ions + $K_2Fe(CN)$ → Brown colored complex

Apparatus and Materials

1.Test tubes

2.Pipette

3.Centrifugal machine

4.Incubator

5.Spectrophotometer

6.Precipitating Reagent

7.Na^+ standard

8.Acid Reagent

9.Color Reagent

Procedure

Precipitation:

Pipette into a clean dry test tubes labelled as standard(S) and Test(T).

Table 2: Standard and Test Sample Development

Addition Sequence	S	T
Precipitating Reagent(L1)	1.0	1.0
Na^+ Standard	0.02	-
Sample	-	0.02

Mix well and let stand at R.T. for 5 mins with shaking well intermittently. Centrifuge at 2500 to 3000 RPM to obtain a clear supernatant.

Color development:

Pipette into clean dry test tubes labelled as Blank(B),Standard(S) and Test(T).

Table 3:Color Development

Addition Sequence	B	S	T
Acid Reagent	1.0	1.0	1.0
Supernatant from step 1	-	0.02	0.02
Precipitating Reagent(L1)	0.02	-	-
Color Reagent(L3)	0.1	0.1	0.1

Incubate for 5 minutes at R.T. after thoroughly mixing. Within 15 minutes, compare the absorbance of the blank (Abs. B), standard (Abs. S), and test sample (Abs. T) to distilled water.

Sulphate Determination

Almost all natural water contains sulphate (SO_4^{2-}), which is a naturally occurring substance. The oxidation of sulphite ores, the occurrence of shales, and municipal or industrial discharge are the main sources of sulfates. Sulfate is mostly produced when damaged leaves fall from trees and float through natural water (river) where they interact with rocks and soil that contain gypsum-type sulfate minerals. As a result, the sulphate content in the water may be measured once the sulphate mineral dissolves in it.

The turbidimetric technique for sulfate determination is based on the idea that sulfates are transformed into colloidal barium sulfate precipitate. A turbidimeter is used to measure the barium sulphate solution's absorbance, and the sulphate content is determined by comparing the measurement to a standard curve.

Apparatus and Materials

1. Test tube
2. Dropper
3. Nitric Acid
4. 5% $BaCl_2$ Solution

Procedure

1.1mL of sample were taken into the test tube

2.2-3 drops of Nitric acid were mixed with the sample

3.Few drops of 5% $BaCl_2$ Solution added into the test tube

Observation

All the sample gave negative result.

Chapter 4: Results and Analysis

According to the World Health Organization (WHO) standard and Bangladesh Standard for rainwater quality, the findings of this study provide baseline data on the physicochemical quality and indicators of light metals of rainwater from a rural community, urban area, industrial area, and coastal territory. The Chattogram Veterinary and Animal Sciences University's "Applied Chemistry and Chemical Technology Laboratory" and "Biochemistry Laboratory" were used for all experiments.

Physicochemical analysis

Table 4:Bangladesh Standards and WHO Guidelines

Standards	P^H	Temperature	TDS,mg/L	Chloride,mg/L	Nitrate,mg/L	Sodium,mg/L	Sulphate,mg/L
Bangladesh Standards	6.5-8.5	20-30	1000	150-600	10	200	400
WHO Guidelines	6.5-8.5	-	-	-	50	-	-

Table 5:Test Result

Location	P^H	Temperature	TDS	Chloride,mg/L	Nitrate,mg/L	Sodium,mg/L	Sulphate,mg/L
Sagorika	6	28.4^{o}C	36	0	N/A	N/A	N/A
Colonelhat	5.9	28.6^{o}C	35	0	N/A	N/A	N/A
Bandar	6.1	28.5^{o}C	68	3.55	N/A	103.5	N/A
Rangamati	6.2	28. 8^{o}C	2	0	N/A	354.2	N/A
Cox'sBazar	6.8	28.9^{o}C	359	35.5	N/A	777.4	N/A
Anowara	5.9	28.5^{o}C	5	0	N/A	427.8	N/A
Nasirabad	5.7	28.6^{o}C	28	0	N/A	384.1	N/A
Patenga	6.1	28^{o}C	86	21.3	N/A	326.6	N/A
Raozan	6.1	29^{o}C	31	10.6	N/A	N/A	N/A

In this study, it was discovered that, in all of the chosen land-use regions, the average concentration of all physicochemical parameters tested was compared to both the Bangladesh standard and WHO recommendation. The Table 5:Test Result above tabulates the descriptive statistics of the physicochemical parameters. All samples examined had average p^H values that fell between 5.7 and 6.8, which is mildly acidic. The fact that the P^H in the industrial region was lower than average suggests that the rainfall there contains acidity. Everywhere save Cox's Bazar, TDS was discovered in a comparable range.

When the atmosphere is clean and pollution-free, natural rainfall is typically regarded as having butNasirabad, an urban and commercial center, had the lowest pH value (5.7). The watershed in Cox's Bazar was found to be reasonably clean with no nearby input sources and to demonstrate a wide range of pH in comparison to other sites with urban, commercial, and industrial surrounds, given the variability of anthropogenic input at the different sites. The relatively noticeable difference between urban, commercial, coastal, and industrial catchments and sub-urban catchments shows how anthropogenic input (road traffic and industrial emissions during precipitation followed by dry deposition between rain events) influences site-specific characteristics. The following figure shows the results of the comparison of P^H and TDS across all nine sites.

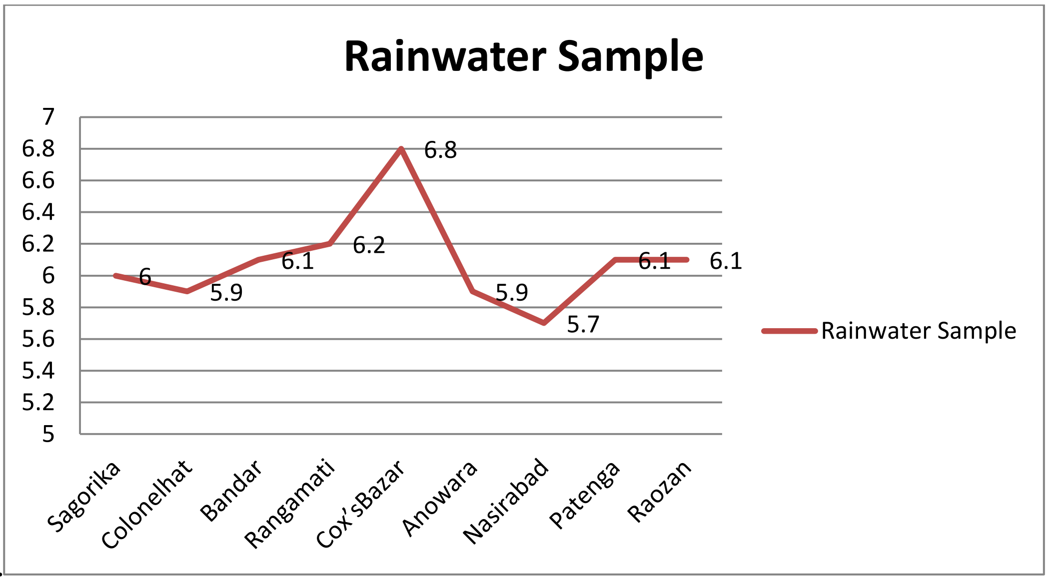


Figure 8: P^H of Rainwater Samples

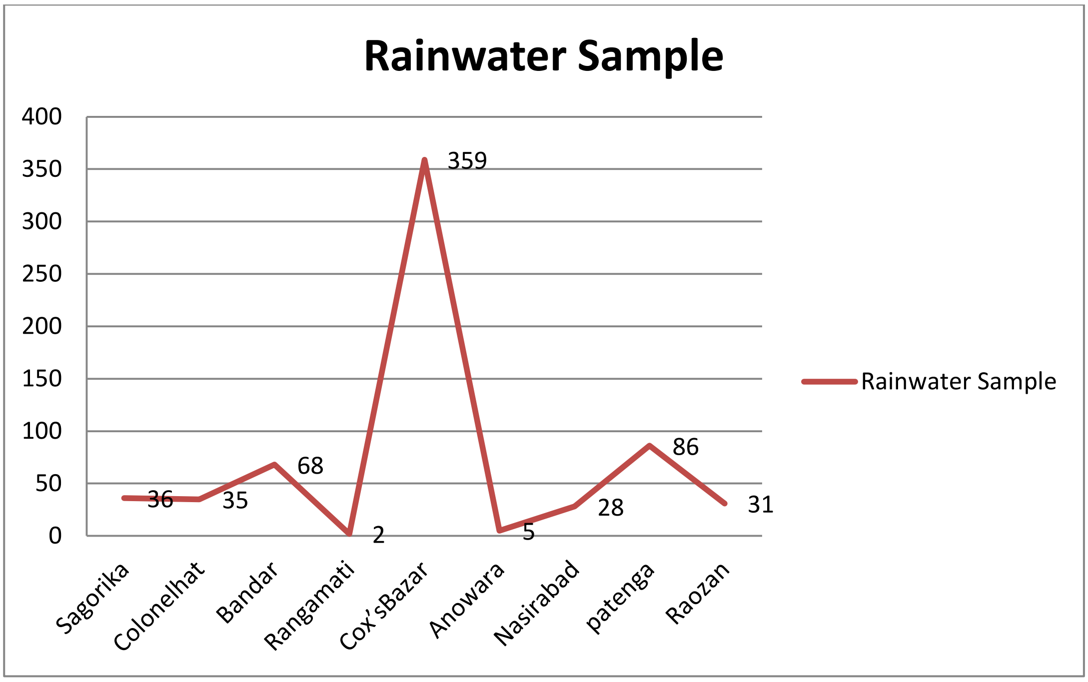
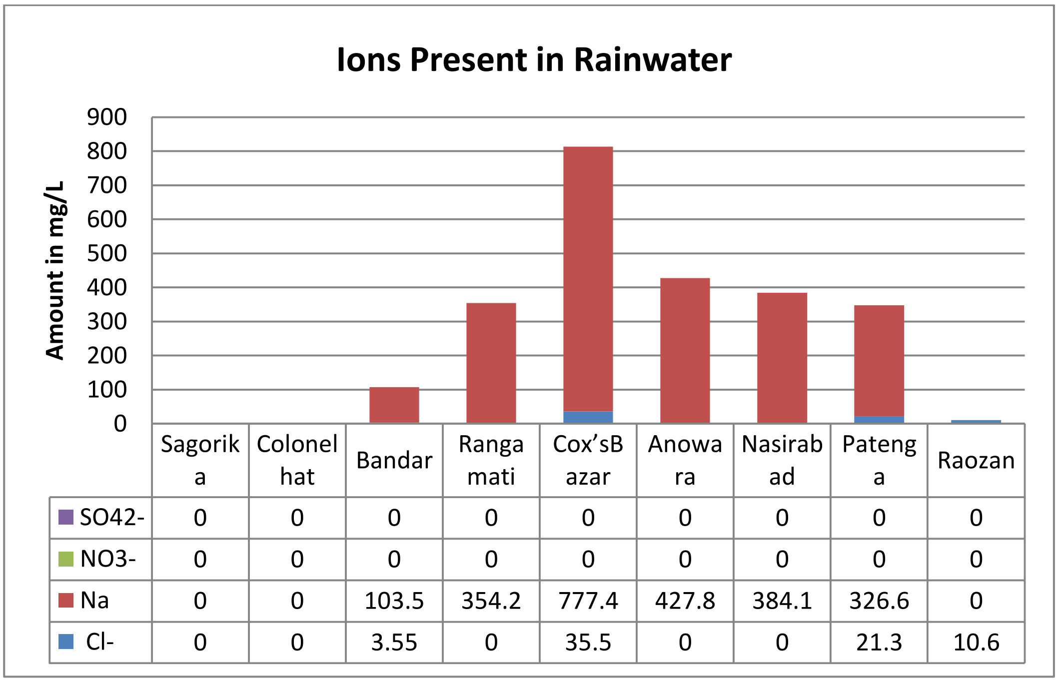


Figure 9: TDS of Rainwater Sample

Table 4:Test Result presents descriptive data for the principal ions found in rainwater from the various locations. The coastal region of Cox'sBazar contained the highest quantity of and. All nine samples lacked nitrate (NO3-) and sulfate (SO42-). The sample taken from the coastal region of Cox's Bazar had the highest concentration of sodium (Na). Figure 10:Chart of Amount Ions present in the Rainwater Sample below provides a statistical picture of the presence of ions in the rainwater sample.



	Sagorika	Colonelhat	Bandar	Rangamati	Cox'sBazar	Anowara	Nasirabad	Patenga	Raozan
SO42-	0	0	0	0	0	0	0	0	0
NO3-	0	0	0	0	0	0	0	0	0
Na	0	0	103.5	354.2	777.4	427.8	384.1	326.6	0
Cl-	0	0	3.55	0	35.5	0	0	21.3	10.6

Figure 10: Chart of Amount Ions present in the Rainwater Sample

Chapter 5: Conclusions

Rainwater samples from coastal and hill tracts were determined to be clean and suitable for use as drinking water after the quality of rainwater from various locations, including rural, urban, industrial, residential, and commercial, was evaluated. The purest kind of water is said to be rainwater. Rainwater's chemical makeup is influenced by a wide range of variables, including geographic location and influences, current meteorological conditions, and anthropogenic activities (such as agriculture, industry, motor vehicle emissions, and the like). As a result, it differs significantly by location, season, and even storm type. When tested and compared to Bangladeshi drinking water regulations and World Health Organization (WHO) standards, samples of rainwater collected from several areas in Chattogram City were found to be unsuitable for use for potable purposes without treatment. So, in order to collect rainwater from rooftop surfaces and utilize it for drinkable purposes, the essential actions must be completed.

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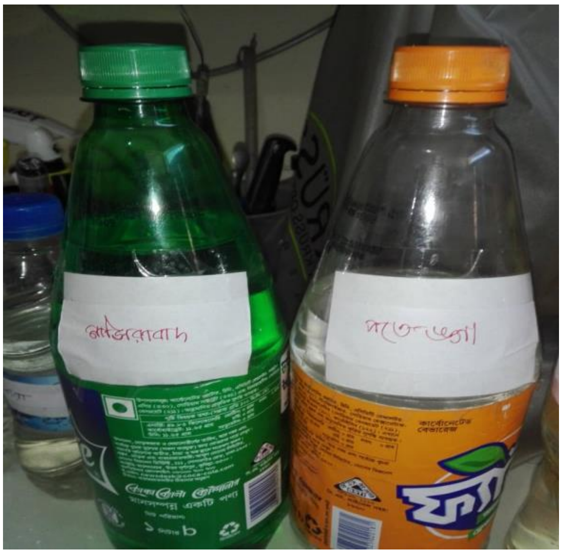
Appendix: Photo Gallery

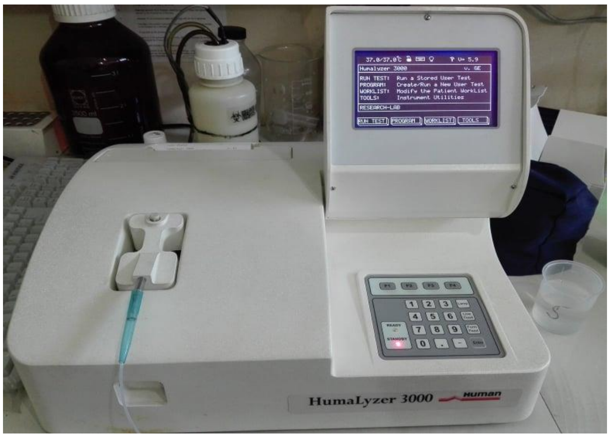
Collection of Rain Water Sample from different location of Chattogram



Collection of Rain Water Sample from different location of Chattogram

P^H measurement of Rain Water Sample

TDS measurement of Rain Water Sample



Spectrophotometer

Centrifuge Machine

Sample prepared for Spectrophotometric test