POTENTIAL OF RAINWATER HARVESTING AND REUSING INDUSTRIAL EFFLUENT IN A TEXTILE INDUSTRY

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The thesis titled “POTENTIAL OF RAINWATER HARVESTING AND REUSING INDUSTRIAL EFFLUENT IN A TEXTILE INDUSTRY” submitted by Sabab Rashid, Md Shoriful Islam with Student ID: 160051029 and 160051088 has been found as satisfactory and accepted as partial fulfillment of the requirement for the Degree, Bachelor of Science in Civil Engineering.

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DECLARATION

We hereby declare that the undergraduate research work reported in this thesis has been performed by us under the supervision of Professor Dr. Md. Rezaul Karim and this work has not been submitted elsewhere for any purpose (except for publication).

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DEDICATED TO

OUR BELOVED PARENTS

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"In the name of Allah, Most Gracious, Most Merciful"

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ABSTRACT

Groundwater is the water trapped underground in the cracks and gaps in dirt, sand, and rock. It is deposited in and eventually travels through aquifers, which are geologic formations of dirt, sand, and rocks. Groundwater is frequently less expensive, more accessible, and less pollutable than surface water. As a result, it is widely used in municipal water sources. Textile industries consume a lot of groundwater on a daily basis which is alarming to the welfare of the environment. In Bangladesh, the daily consumable amount of groundwater is very threatening and is increasing day by day.

The objective of this study is to reduce the load on groundwater caused by textile industries via suggesting alternatives. Two of the water sources – rainwater and industrial effluent were considered to play that role. Their potential is analyzed via laboratory tests and statistical analysis. This study aims to find out the potential of rainwater harvesting for a textile industry, determine the usability and quality of industrial effluent and to find out whether we can use the effluent as supplement and if so, what treatment procedures are to be considered. For rainwater harvesting, a time period of 1953-2014 was considered in Gazipur area, as the industry considered in this study is placed there. Standard parameters to determine the quality of industrial effluent for reusing in textile industry was tested and water quality was analyzed.

The primary results show that via rainwater harvesting only, up to 5.95% of groundwater can be supplemented – 54% if the industrial effluent supplementation is combined.

Key words: Rainwater harvesting, water supplementation, water quality, effluent, treatment.

CHAPTER 1
INTRODUCTION

1.1 Background of the study

Water that persists underground in flooded areas under the soil surface is referred to as groundwater. The water table is the uppermost portion of the flooded field.

Groundwater does not form underground ponds, contrary to common opinion. In the same way as water fills a sponge, it fills the pores and cracks in underground materials like sand, gravel, and other rock. Aquifers are formed as groundwater flows spontaneously out of rock materials or when it can be extracted (in useful amounts) by pumping. In an aquifer, groundwater flows steadily, at 7-60 centimeters (3-25 inches) a day on average. As a result, water could remain in an aquifer for hundreds or thousands of years.

Many residential colonies and industries are extracting ground water to fulfill their daily demands. Groundwater level is declining by 2-3 meters each year. *Considering the existing depletion rate, the study predicts that the groundwater table will go down to about 110 to 115 meters by 2050* (Anwar Zahid, 2011).

Groundwater table is going down, affecting the environment in these ways: Reduction of water in water streams and lakes, land subsidence, deterioration of water quality etc. (Source: USGS)

Textile is a flexible material made by creating an interlocking network of yarns or threads, produced by spinning raw fibres into long and twisted lengths. Textile industry is one of those industries that consumes a huge amount of water every day. Textile industry of Bangladesh is more than 500 years old. It is one of the oldest and most successful industries with its rich history. Moreover, in recent years there has been a substantial development in yarn and fabric production. The spinning capacity has increased four times in ten years which is a commendable job. In current scenario, the textile industry employs almost 4 million people in Bangladesh. 45% of the industrial employment is the result of textile industry According to the latest reports, Bangladesh exports apparels worth $5 billion annually to the US, European countries, Canada and other nations. *Textile industries consume high volumes of water per unit fabric for processing, which cause depletion of ground water levels at a high rate. In addition, in many cases textile effluents are discharged into rivers or wetlands without proper treatment* (Laila Hossain, Sumit Kanti Sarker 2018). To produce just one cotton shirt requires approximately 3000 litres of water. *Textile productions (including cotton farming) uses around 93 billion cubic meters of water annually, representing 4% of global freshwater withdrawal*. (source: Water and Clothing, n.d.). This huge amount of water withdrawal can result in many catastrophic disasters i.e., reduction of water in water streams and lakes, land subsidence, deterioration of water quality etc. For all these reasons, finding out an alternative to groundwater usage in textile industries is much needed.

1.2 Purpose and Objective of this study

The purpose of this study is to find out the reliability of rainwater harvesting and industrial effluent reusing as supplement to groundwater usage in textile industries.

The specific objectives of this study are:

- Find out the amount of rainwater that can be used as supplement via rainwater harvesting
- Find out the potential of industrial effluent reusing in a textile industry
- Analyze the physical and chemical parameters of industrial effluent
- Suggest treatment procedures for removing impurities of effluent

1.3 Scope of the study

- Defining a study area for conducting research
- Study and analyze rainfall of that particular area
- Find out the amount of supplement provided by rainwater harvesting
- Test the quality of industrial effluent by testing chemical and physical parameters
- Provide suggestion on removing impurities based on test results

1.4 Organization of the thesis

The rest of the thesis has been organized as follows:

Chapter 2 : **Literature Review –** this chapter discusses about the past works on similar type of study and will give idea on how the work plan should be done

Chapter 3 : **Study area and data collection -** identifying the location of the study and collection of data from various locations of the study area

Chapter 4 : **Methodology** – in this chapter the procedural steps of the study will be described thoroughly

Chapter 5 : **Results and Discussions** - analysis of the data collected from field observation and through laboratory testing

Chapter 6 : **Conclusions and Recommendations -** this chapter will discuss the effectiveness of the study, and recommendations of the future studies

CHAPTER 2
LITERATURE REVIEW

There is not much works done on industrial rainwater harvesting in general, but we can get a general idea of rainwater harvesting as some works were done on rainwater harvesting.

As stated on a research done by V.Jothiprakash on 2009, the literature contains a vast range of RWH processes. Each process, however, is site and demand specific. The RWH scheme is influenced by topography, land use patterns, rainfall, demand patterns, and stakeholder economic position. Each structure necessitates a thorough examination of hydrology (rainfall and demand), pography, and other factors. A careful assessment of RWH systems is needed for implementation in each case, including hydrology, topography, and other factors such as site availability and economics; however, a general approach may be developed.

In another study done by X.Jhang on 2013, a thorough research was done on the feasibility of rainwater harvesting in runoff volume reduction in a planned industrial park. In this report, a rural district with an area of 13.39 km2 in Changting was chosen to estimate the capacity of collectable rainwater and the degree to which runoff volume can be mitigated by rainwater harvesting. The results showed that rainwater harvesting in the planned industrial park has great potential. The findings also revealed that there is a lot of room for rainwater collection from underlying surfaces in the proposed industrial park. Rainwater harvesting from underlying surfaces in the research region plays a significant role in reducing runoff level, lowering flood risk and reducing flood losses.

On industrial wastewater reuse, there are a lot of work done. In a study done by C. Vishvanathan (2001), treatment of wastewater for a range of industrial reuse is now feasible thanks to technical advances. Even in developed countries, most companies are heading toward wastewater reuse, and source isolation and treatment of differentiated effluents are becoming more common. The capacity for wastewater reuse in various industries is determined by waste volume, concentration, and characteristics, best available treatment methods, operating and repair costs, raw water supply, and effluent standards. Industrial wastewater reuse must undergo radical improvements to account for increasingly depleting infrastructure, environmental pollution, public perception, and worker health threats. Advanced technologies such as membrane processes, ion exchange, and adsorption are capable of producing water of any required quality.

Textile industries represent an important environmental problem due to their high-water consumption. In the production of a ton of textile product 200–350 m3 of water are consumed. (Goz{\'a}lvez-Zafrilla, 2008)

In a research done by Mohsen on 2013, it can be seen that in the chosen sectors, there is a need for cleaner technologies to be introduced. This may include raw and auxiliary material substitutions, water and energy conservation, water recirculation, solvent recycling, better process management, waste minimization, and good housekeeping. Any commercial drainage can, in theory, be drained into the sewage system. Disposal by drainage or immediate injection to the ground should be phased out and only permitted after an environmental impact assessment. Water and waste discharged from industry should be compensated. Food waste can be collected by the authorities for free. This scheme would reduce the amount of chemical compounds in wastewater discharged from industry.

CHAPTER 3
STUDY AREA AND DATA COLLECTION

This chapter discusses about the study area and the method of collection of data related to the study.

3.1 Study Area

Gazipur was selected as the study area for rainfall analysis. Gazipur is a city in Bangladesh's central region. Gazipur is the district in which it is situated. It is a major manufacturing city about 25 kilometers north of Dhaka, Bangladesh's capital. It is a hub for Bangladesh's textile industry. A textile industry named “Masco Concept Knitting” was selected as the textile industry to be studied. Bangladesh is one of the world's largest textile exporting countries, and Masco has been a leader in knit garment export since July 2001. It is a vertically set up knit composite factory with all in-house equipment and new machineries that are controlled by diverse manpower to offer the best possible services. The daily production of this knitting industry is about 10 tons of cloths.

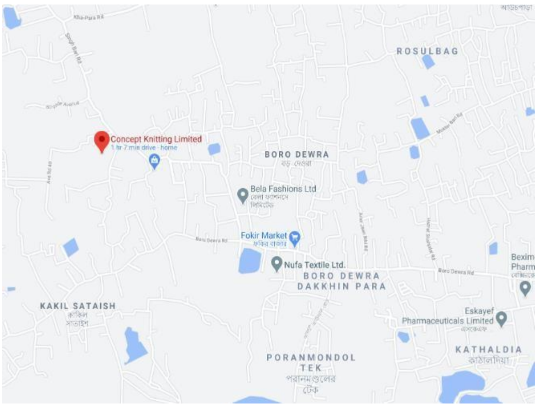

Figure 1: Location of Masco Concept Knitting

3.2 Data Collection

In this study, for rainwater analysis, Gazipur area was selected as the industry is in Gazipur.

The daily water demand of this industry is 2200 m^3 of groundwater.

Types of Use	Volume (m^3)
Dyeing and Washing Purpose	1400-2000
Miscellaneous	200-800

Table 1: Water Demand of MASCO Concept Knitting

To collect the industrial effluent, a certain procedure had to be followed. The detailed procedure of the study will be described on the next chapter.

CHAPTER 4
METHODOLOGY

4.1 Rainwater Harvesting

4.1.1 Catchment Area Calculation

For the rainwater harvesting, a catchment area is considered to calculate rainwater volume. Rainwater harvesting can be divided into two categories: land runoff harvesting and rooftop rainwater harvesting. Rainwater recycling is the process of collecting and storing rainwater for on-site reuse rather than letting it wash off. The water is used for a variety of uses, including gardening, irrigation, and so on. This article addresses a variety of rainwater collection techniques. For our study, only the rooftop rainwater harvesting is considered.

Rooftop harvesting is a rainwater collection device that captures rainwater when it falls. The roof becomes the catchment of rooftop irrigation, and rainwater is obtained from the roof of buildings. It may either be contained in a tank or diverted to a man-made replenishment system. This approach is less costly and very useful, and it aids in augmenting the area's groundwater level if properly applied.

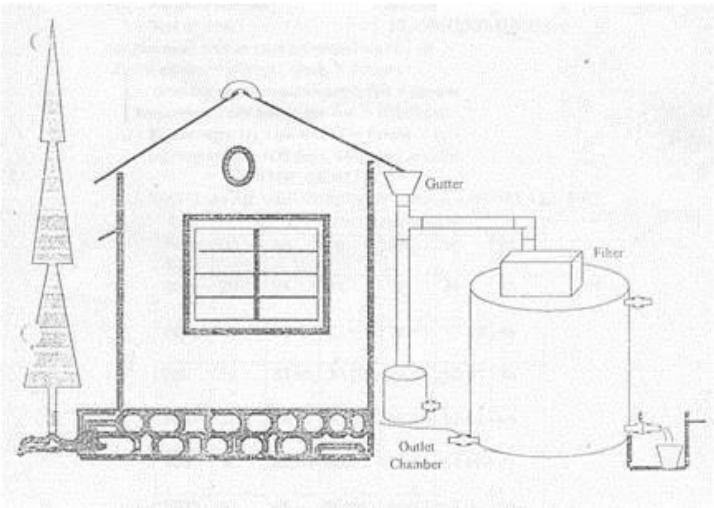

Figure 2: Components of Rooftop Harvesting
(source: (G, n.d.)

The system mainly constitutes of following sub-components:

1. **The catchment area:** The catchment of a rainwater harvesting scheme is the surface that collects runoff directly. It may be a terrace, a courtyard, or open land, paved or unpaved. A flat RCC/stone roof or a sloping roof may be used for the terrace. As a result, the catchment is described as the region that contributes rainwater to the rainwater harvesting system.
2. **Transportation:** Rainwater from the roof should be brought down to the storage/harvesting system through water pipes or drains. UV-resistant water pipes (ISI HDPE/PVC pipes) with the appropriate capacity should be used. Rainwater from sloping roofs could be collected in gutters and channeled down the drain. Wire mesh should be installed at the mouth of each drain on terraces to prevent floating material.
3. **First Flush:** The first flush is a system that removes the water from the first tub. The first rain shower should be washed out to prevent pollution from the environment and the catchment roof from contaminating storable/rechargeable water. During dry seasons, it will also aid in the removal of silt and other debris from the roof. At the outlet of each drainpipe, first rain separators should be mounted.
4. **Filter:** Filters are used to filter water such that turbidity, color, and microorganisms are easily removed. Water can flow into filters after the first flushing of rainfall. On top of the storage tank, a dirt, sand, and ‘netlon' mesh filter is built and installed. This filter is critical for keeping rainwater clear in the storage tank. Silt, dust, leaves, and other organic matter are kept out of the storage tank with this device. After each rainfall case, the filter media should be cleaned on a regular basis. Filters that are clogged make it difficult for rainwater to reach the storage tank, and the filter can leak. Until replacing the sand or gravel media in the filter, it should be removed and cleaned. A standard filter photograph is shown in figure 3.

Figure 3: Photograph of Typical Filter in Rainwater Harvesting

From the industry, we got the amount of catchment area to be in total of 169837 square feet.

Catchment	Area(sft)
Utility	11019.00
Wash Building	19035.27
Dyeing Building	47338.90
Garments Building	56930.34
Store Building	10373.72
Dining Building	13459.62
Admin building	11681.96
Total	**169837**

Table 2: Catchment Area Summary

4.1.2 Rainfall Data Collection and Analysis:

Rainfall data was collected from Bangladesh Meteorological Department. Only the rainfall data of Gazipur was considered as it is the study area.

Year	Yearly rainfall (mm)	Year	Yearly rainfall (mm)
1953	1832.0	**1985**	2053.0
1954	2152.0	**1986**	3028.0
1955	1577.0	**1987**	2500.0
1956	2495.0	**1988**	2187.0
1957	1554.0	**1989**	2482.0
1958	1258.0	**1990**	1627.0
1959	2453.0	**1991**	2103.0
1960	1834.0	**1992**	2850.0
1961	2170.0	**1993**	2819.0
1962	1677.0	**1994**	1169.0
1963	1971.0	**1995**	1540.0
1964	2332.0	**1996**	1751.0
1965	2117.0	**1997**	2044.0
1966	1814.0	**1998**	1896.0
1967	2053.0	**1999**	2310.0
1968	1900.0	**2000**	2374.0
1969	1540.0	**2001**	2104.0
1970	1995.0	**2002**	1679.0
1971	2276.0	**2003**	1795.0
1972	1808.0	**2004**	1693.0
1973	2083.0	**2005**	2347.0
1975	2145.0	**2006**	2637.0
1976	1975.0	**2007**	1919.0
1977	1861.0	**2008**	2757.0
1978	2251.0	**2009**	2385.0
1979	1837.0	**2010**	1931.0
1981	2218.0	**2011**	1523.0
1982	1865.0	**2012**	1776.0
1983	1805.0	**2013**	1329.0
1984	2388.0	**2014**	1590.0

Table 3: Yearly Rainfall from 1953-2014 for Gazipur Area

The analysis was mainly done for 3 years – wet year, dry year and average rainfall year. As the names suggest, the wet year has the most amount of rainfall, the dry year has the least, while the average rainfall year has approximately the average rainfall of the collected data. In our case, the wet year, average rainfall year and dry year is respectively 1986, 1967 and 1994.

Name	Year	Yearly Rainfall (mm)
Wet Year	1986	3028.0
Avg Rainfall Year	1967	2053.0
Dry Year	1994	1169.0

Table 4: Rainfall data for wet, average rainfall and dry year

4.1.3 Rainwater Volume Calculation

The following equation was used to calculate rainwater volume/

$$Rainfall\ volume\ (m^3) = \frac{Total\ yearly\ Rainfall\ (mm) * Area\ (m^2)}{1000}$$

As we found in section 4.1.1, the total catchment area of our industry is 169837 sft, or 15778.37 m^3. For this area, the maximum amount of rainwater, the minimum and the average amount of rainwater is calculated for the analysis period. All the amounts are expressed in volume.

Name	Year	Rainfall (mm)	Rainfall Volume in year (m3)
Wet Year	1986	3028	47776.8947
Avg Rainfall Year	1967	2053	32392.98706
Dry Year	1994	1169	18444.9108

Table 5: Rainwater Volume (maximum, average and minimum)

4.2 Industrial Effluent Reuse

To use the industrial effluent, a certain standard has to be upheld as the textile is very sensitive to water quality. For dyeing purpose, list of desirable water quality parameters for textile wet processing is given below. (Source: http://dyeingworld1.blogspot.com/2009/11/water-quality-parameters.html)

Parameters	Standard Value
Color	5 pt-co unit
pH	6.5-7.5
TDS	300 mg/L
Total Hardness	30 mg/L as $CaCO_3$
COD	Nil
Turbidity	Nil
Suspended Solids	Nil
Copper	0.01 mg/L
Iron	0.01 mg/L
Chromium	0.01 mg/L
Manganese	0.05 mg/L
Aluminum	0.2 mg/L
Chloride	150 mg/L
Sulphate	150 mg/L
Nitrate	Nil

Table 6: Water quality parameters for dyeing purpose

4.2.1 Sampling Procedure

From the point of sampling to the time of examination, a sample may be affected by a variety of physical, chemical, and biological processes. These results can be avoided or minimized by using suitable sampling tools, containers, and storage procedures to protect sample integrity. Samples must also be evaluated under a set of time constraints. Contamination of the sample must be avoided during sampling, storage, and delivery to the laboratory.

In this case, grab samples were collected. Grab samples consist of either a single discrete sample or individual samples collected over a period of time not to exceed 15 minutes. The grab sample should be representative of the wastewater conditions at the time of sample collection. The sample volume depends on the type and number of analyses to be performed. Effluent samples should be collected at the site specified in the permit, or if no site is specified in the permit, at the most representative site downstream from all entering wastewater streams prior to discharge into the receiving waters. Some important considerations for obtaining a representative wastewater sample include:

• The sample should be collected where the wastewater is well mixed. Therefore, the sample should be collected near the center of the flow channel, at approximately 40 to 60 percent of the water depth, where the turbulence is at a maximum and the possibility of solids settling is minimized. Skimming the water surface or dragging the channel bottom should be avoided. However, allowances should be made for fluctuations in water depth due to flow variations.

• In sampling from wide conduits, cross-sectional sampling should be considered. Rhodamine WT dye may be used as an aid in determining the most representative sampling locations.

• If manual compositing is employed, the individual sample portions must be thoroughly mixed before pouring the individual aliquots into the composite container. For manual composite sampling, the individual sample aliquots should be preserved at the time of sample collection.

4.2.2 Laboratory Testing

To conduct the study, a total of 13 tests were carried out on the collected effluent. They can be categorized into physical and chemical parameters.

Physical Parameters:

The objective of these test was to find the physical condition of the water in various aspects. The tested parameters are:

1. pH: In terms of chemistry, pH is a scale used to specify how acidic or basic a water-based solution is. Acidic solutions have a lower pH, while basic solutions have a higher pH.

2. Color: Pure water has no color. However, in drinking water slight amount of color maybe visible due to the presence of various pigment particles. These particles are measured in the Pt-Co (Platinum - Cobalt) unit.

3. Turbidity: Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. It is measured in Nephelometric Turbidity Unit (NTU)

4. Total Dissolved Solid (TDS): Dissolved solids refer to any minerals, salts, metals, cations or anions dissolved in water. Total dissolved solids (TDS) comprise of two parts: Fixed Suspended Solids and Volatile suspended solids. In together, they comprise of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water. (Water Testing: Total Dissolved Solids Drinking Water Quality by Brian Oram, Professional Geologist (PG), Water Research Center, B.F. Environmental Consultants Inc., Dallas)

Chemical Parameters:

1. Chemical Oxygen Demand: the chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per liter (mg/L). A COD test can be used to easily quantify the amount of organics in water. The most common application of COD is in quantifying the amount of oxidizable pollutants found in surface water (e.g., lakes and rivers) or wastewater. COD is useful in terms of water quality by providing a metric to determine the effect an effluent will have on the receiving body, much like biochemical oxygen demand (BOD).

2. Biochemical Oxygen Demand: Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed (i.e., demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water. BOD reduction is used as a gauge of the effectiveness of wastewater treatment plants. BOD of wastewater effluents is used to indicate the short-term impact on the oxygen levels of the receiving water. BOD analysis is similar in function to chemical oxygen demand (COD) analysis, in that both measure the amount of organic compounds in water. However, COD analysis is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically oxidized organic matter.

3. Hardness (as CaCO3): Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per liter. Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard (McGowan, 2000).

4. Iron: Iron can be a troublesome chemical in water supplies. Water containing ferrous iron is clear and colorless because the iron is completely dissolved. When exposed to air in the pressure tank or atmosphere, the water turns cloudy and a reddish-brown substance begins to form.

5. Manganese: Manganese is a mineral that naturally occurs in rocks and soil and may also be present due to underground pollution sources. Manganese is seldom found alone in a water supply. (https://www.freedrinkingwater.com/water_quality/chemical/water-problems-manganese.htm)

6. Nitrate: Nitrate in water is undetectable without testing because it is colorless, odorless, and tasteless. A water test for nitrate (lab) is highly recommended for households with infants, pregnant women, nursing mothers, or elderly people.

7. Sulphate: In chemistry, a sulphate is a salt of sulfuric acid. The sulphate ion is a group of atoms with the formula SO4 and two negative charges. Sulfate minerals can cause scale buildup in water pipes similar to other minerals and may be associated with a bitter taste in water that can have a laxative effect on humans and young livestock.

8. **Free chlorine:** Free Chlorine is the amount of chlorine that has not yet combined with water to sanitize contaminants. In effect, free chlorine is the amount of chlorine that is free to kill harmful microorganisms in the water where it is present.

By method of processes/instruments used, the parameters can be divided into following categories:

Instruments/Process Used	**Name of Parameter**
Spectrophotometer	Colour, TSS, COD, Fe, Mn, Nitrate, Sulphate
Multimeter	pH, TDS
Titration	Chloride, Hardness
BOD Trak II Chassis, Incubator	BOD
Turbidimeter	Turbidity

Table 7: Parameters Tested for Industrial Effluent

CHAPTER 5
RESULTS AND DISCUSSION

In this chapter, the observational results and the laboratory tested parameter results have been discussed in details. From the data, minimum, maximum and average values have been calculated and remarks are made based on the results.

5.1 Rainwater Harvesting

In rainwater harvesting, we found that for the given catchment area of 169837 sft or 15778.37 m^3, the maximum amount of rainwater is 47776.8947 m^3 in year 1986, which is 5.95% of the total water demand of 803000 m^3 in the industry. The amount of rainwater volume is 32392.99 m^3 and 18444.91 m^3 for avg, rainfall and dry year, respectively. Maximum amount of supplement we can get is 5.95% of the total water demand; 4.03% in average year and at least 2.30% during dry year.

Name	Year	Rainfall (mm)	Rainfall Volume in year (m3)	Total demand per year (m^3)	% of supplement
Wet Year	1986	3028	47776.8947	803000	5.95%
Avg Rainfall Year	1967	2053	32392.98706	803000	4.03%
Dry Year	1994	1169	18444.9108	803000	2.30%

Table 8: Percentage of supplement by rainwater harvesting

5.2 Industrial Wastewater

For industrial wastewater reusing, first the water was analyzed for some specific parameters according to the guideline discussed in methodology.

Parameters	Units	Standard Value	Effluent
Color	pt-co	5	1370.63
pH		6.5-7.5	8.15
TDS	mg/L	300	1930.56
TSS	mg/L	0	67.63
Total hardness	mg/L as $CaCO_3$	30	51.25
COD	mg/L	0	124.63
BOD	mg/L	40	20.18
Turbidity	NTU	0	29.05
Mn	mg/L	0.05	0.32
Fe	mg/L	0.01	2.66
Cl	mg/L	150	185.91
SO_4	mg/L	150	362.50
NO_3	mg/L	0	0.10

Table 9: Parameter test results for industrial effluent

We found out that, most of the values are in range with the standard value. But there are some elements with alarming amounts such as color, TDS, turbidity, COD, sulphate etc. These are the parameters that actively determines the quality of water on dyeing purposes that means treatment procedures have to be conducted to get the value of these parameters within range. As for amount of supplementation, we can get up to 43% of supplement. This amount increases to 54% if we consider the combined supplement provided by rainwater harvesting and industrial wastewater reusing.

Month	Rainwater Volume (m3)	ETP treated water volume (m3)	Total Water Supply (m3)	Water Demand (m3)	% of Supplement (ETP)
1	362.9024367	27498	27860.90244	64000	42.97%
2	189.3404017	26343	26532.3404	64000	41.16%
3	2650.765624	26996	29646.76562	65000	41.53%
4	2918.99786	27986	30904.99786	65000	43.06%
5	3408.127231	27463	30871.12723	66000	41.61%
6	3802.586401	27653	31455.5864	68000	40.67%
7	5727.547152	26894	32621.54715	66000	40.75%
8	7952.296873	27531	35483.29687	66000	41.71%
9	4197.045572	27249	31446.04557	67000	40.67%
10	1167.599144	27537	28704.59914	66000	41.72%
11	15.77836681	26396	26411.77837	68000	38.82%
12	0	26153	26153	68000	38.46%

Table 10: Percentage of Supplement (ETP effluent only)

Month	Rainwater Volume (m3)	ETP treated water volume (m3)	Total Water Supply (m3)	Water Demand (m3)	% of Supplement (ETP+RWH)
1	362.9024367	27498	27860.90244	64000	43.53%
2	189.3404017	26343	26532.3404	64000	41.46%
3	2650.765624	26996	29646.76562	65000	45.61%
4	2918.99786	27986	30904.99786	65000	47.55%
5	3408.127231	27463	30871.12723	66000	46.77%
6	3802.586401	27653	31455.5864	68000	46.26%
7	5727.547152	26894	32621.54715	66000	49.43%
8	7952.296873	27531	35483.29687	66000	53.76%
9	4197.045572	27249	31446.04557	67000	46.93%
Month	Rainwater Volume (m3)	ETP treated water volume (m3)	Total Water Supply (m3)	Water Demand (m3)	% of Supplement (ETP+RWH)
10	1167.599144	27537	28704.59914	66000	43.49%

11	15.77836681	26396	26411.77837	68000	38.84%
12	0	26153	26153	68000	38.46%

Table 11: Percentage of GW Supplement (Combined)

Suggested Treatment Process

As the effluent has impurities and it is not feasible to use raw wastewater, treatments have to be done. There are some treatment processes recently carried out to remove impurities like color, turbidity, COD, hardness etc. Some processes like oxidation techniques, electrolytic precipitation and foam fractionation, photo catalytic degradation, adsorption and reverse osmosis (RO) are quite recommendable.

Oxidation Technique: A variety of oxidizing agents can be used to decolorize wastes. Sodium hypochlorite decolorizes dye bath efficiently. Though it is a low-cost technique, but it forms absorbable toxic organic halides (AOX). Ozone on decomposition generates oxygen and free radicals and the later combines with coloring agents of effluent resulting in the destruction of colors. Arslan et al. investigated the treatment of synthetic dye house effluent by ozonation, and hydrogen peroxide in combination with Ultraviolet light. The main disadvantage of these techniques is it requires an effective sludge producing pretreatment.

Electrolytic precipitation & Foam fractionation: Electrolytic precipitation of concentrated dye wastes by reduction in the cathode space of an electrolytic bath been reported although extremely long contact times were required. Foam fractionation is experimental method based on the phenomena that surface-active solutes collect at gas-liquid interfaces. However, the chemical costs make this treatment method too expensive.

Photo catalytic degradation: An advanced method to decolorize a wide range of dyes depending upon their molecular structure. In this process, photoactive catalyst illuminates with UV light, generates highly reactive radical, which can decompose organic compounds.

Adsorption: It is the exchange of material at the interface between two immiscible phases in contact with one another. Adsorption appears to have considerable potential for the removal of color from industrial effluents. Owen (1978) after surveying 13 textile industries has reported that adsorption using granular activated carbon has emerged as a practical and economical process for the removal of color from textile effluents.

Reverse Osmosis: Reverse osmosis membrane process is suitable for removing high salt concentrations so that the treated effluent can be re-used again in the processing. The presence of electrolytes in the washing water causes an increase in the hydrolyzed dye affinity (for reactive dyeing on cotton) making it difficult to extract. In the normal osmosis process, the solvent naturally moves from an area of low solute concentration (high water potential), through a membrane, to an area of high solute concentration (low water potential). The driving force for the movement of the solvent is the reduction in the Gibbs free energy of the system when the difference in solvent concentration on either side of a membrane is reduced, generating osmotic pressure due to the solvent moving into the more concentrated solution. Applying an external pressure to reverse the natural flow of pure solvent, thus, is reverse osmosis. The process is similar to other membrane technology applications. (Fibre2Fashion, 2013)

CHAPTER 6
CONCLUSION AND RECOMMENDATION

In this chapter the outcomes of the study have been summarized. The effectiveness of the study and how people can be benefitted from the study have also been discussed in short. Possible enhancements of this study have been discussed in short. Possible enhancement of the study and further recommendations have also been mentioned here.

6.1 Summary

The objective of this study was to find out the potential of rainwater harvesting and industrial effluent reuse in a textile industry. The main focus was to find out the amount of supplement rainwater harvesting and effluent reuse can provide to groundwater combined. The study focused on both observational data as well as experimental outputs.

From the experimental data, it has been found that the quality of industrial effluent is not good enough to be used directly for industrial purpose – but it can be used after performing certain treatment procedures to remove impurities such as hardness, color, COD, turbidity, SO_4 etc. Interestingly, other parameters were pretty much in range which allows the treatment procedure to be cheaper relatively.

For rainwater harvesting, if the supplement percentage is around 5 to 10 percent, then it is feasible to do rainwater harvesting and in the study the percentage of groundwater supplement by rainwater harvesting is found to be almost 6% which is a good amount of rainwater.

For industrial effluent reusing, that amount is almost up to 43% of groundwater supplement, which, upon combining can go up to 54% of groundwater supplement.

Certain treatment procedures are advised to be looked into such as oxidation, reverse osmosis, electrolytic precipitation and foam fractionation. Some of these procedures are very costly but they can be effective considering their output.

6.2 Recommendation

Based on the results obtained from the study and the limitations observed, some further study can be conducted on the following topics:

- Finding the optimum treatment for reusing industrial effluent in textile processing.
- Further work can be done on modeling and cost analysis of rainwater harvesting.
- Water distribution network model analysis in a textile industry based on their water consumption.

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